Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)

1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)

1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)

1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)

1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)

1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

The following list of formulae may be found useful :

For uniformly accelerated motion	$v = u + at$
	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
Equation of a straight line	$y = mx + c$

Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81\ \text{m s}^{-2}$ (close to the Earth)

Part A : HKCE examination questions

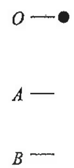
1. **< HKCE 1980 Paper II - 9 >**

A body is dropped from rest down a cliff on a planet X. After falling for 1 s, it is 4 m below the starting point. How far below the starting point will it be after a further 4 s ?

A. 40 m
B. 64 m
C. 80 m
D. 100 m

2. **< HKCE 1981 Paper II - 5 >**

A particle released from rest at O falls freely under gravity and passes A and B, as shown in the figure (not drawn to scale). If the particle takes 4 s to move from A to B, where AB = 100 m, how long does it take to fall from O to A ?



A. 0.55 s
B. 1.10 s
C. 2.20 s
D. 4.40 s

3. **< HKCE 1981 Paper II - 8 >**

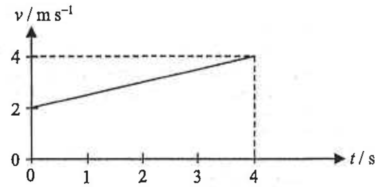
Which of the following statements concerning the motion of a body is/are correct ?

(1) A body has no acceleration when it is moving with a uniform velocity.
(2) A body can have zero velocity but also be accelerating.
(3) A body can have a constant speed but a varying velocity.

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

4. **< HKCE 1984 Paper II - 2 >**

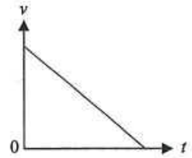
The diagram shows how the velocity of a body varies with time. What is the distance travelled in the first 4 s ?

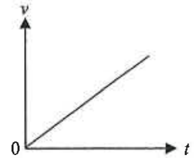


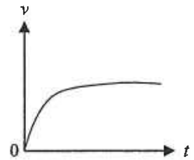
A. 4 m
B. 8 m
C. 10 m
D. 12 m

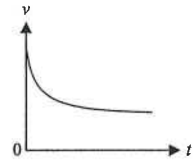
5. **< HKCE 1984 Paper II - 3 >**

Which of the following velocity-time graphs correctly shows the motion of a ping-pong ball falling freely in a vacuum ?

A.


B.


C.


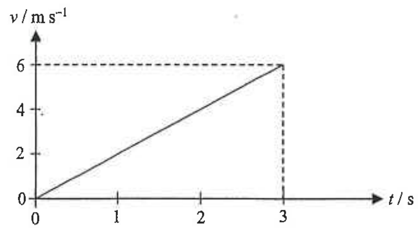
D.


6. **< HKCE 1985 Paper II - 2 >**

A car moving with speed 50 km h^{-1} can be stopped in a distance of 15 m. In what distance can the car be stopped when its speed is 70 km h^{-1} under the same condition ?

A. 10.9 m
B. 17.7 m
C. 21.0 m
D. 29.4 m

7. **< HKCE 1985 Paper II - 1 >**



The graph shows the variation of the velocity of a car with time. What is the acceleration of the car ?

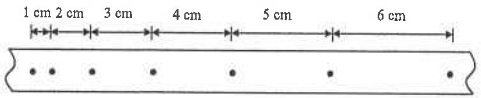
A. 0.5 m s^{-2}
B. 1.5 m s^{-2}
C. 2.0 m s^{-2}
D. 4.0 m s^{-2}

8. **< HKCE 1986 Paper II - 2 >**

A body falls freely from rest. What are the distances travelled in the first and third second ?

	First second	Third second
A.	4.9 m	14.7 m
B.	4.9 m	19.6 m
C.	4.9 m	24.5 m
D.	9.8 m	39.2 m

9. < HKCE 1986 Paper II - 1 >

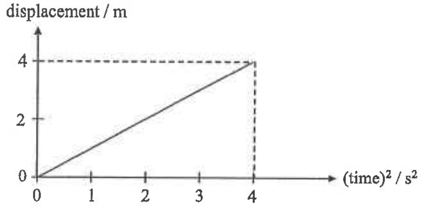


The diagram above shows a ticker-tape produced by a trolley being pulled by a rubber band. Which of the following statements about the trolley is/are true ?

(1) Its displacement increases uniformly with time.
(2) Its velocity increases uniformly with time.
(3) Its acceleration increases uniformly with time.

A. (1) only
B. (2) only
C. (1) & (2) only
D. (2) & (3) only

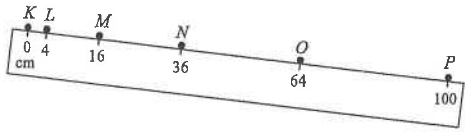
10. < HKCE 1987 Paper II - 6 >



An object is accelerated from rest along a straight line. The above graph shows the variation of its displacement with the square of time. What is the acceleration of the object ?

A. 0.5 m s^{-2}
B. 1.0 m s^{-2}
C. 2.0 m s^{-2}
D. 4.0 m s^{-2}

11. < HKCE 1988 Paper II - 1 >



The above figure shows the stroboscopic photograph of a ball rolling down a slope. If the stroboscope makes 2 flashes per second, in which region does the ball have an average speed of 40 cm s^{-1} ?

A. *LM*
B. *MN*
C. *NO*
D. *OP*

12. < HKCE 1989 Paper II - 2 >

An object is falling from rest with an acceleration of 9.8 m s^{-2}. Which of the following statements is/are correct ?

(1) It falls with a constant speed of 9.8 m s^{-1}.
(2) It falls 9.8 m every second.
(3) It has a speed of 19.6 m s^{-1} after 2 s.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

13. < HKCE 1989 Paper II - 3 >

A particle is thrown vertically upwards. When the particle is at the maximum height, its acceleration is

A. zero.
B. changing from upwards to downwards.
C. pointing upwards.
D. pointing downwards.

14. < HKCE 1989 Paper II - 4 >

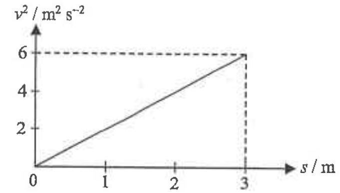
A coin and a feather are allowed to fall in a long vertical glass tube from which the air has been evacuated. Which one of the following combinations best describes the motion of the coin and the feather ?

	Coin	Feather
A.	uniform speed	same uniform speed
B.	uniform acceleration	same uniform acceleration
C.	uniform acceleration	smaller uniform acceleration
D.	uniform acceleration	greater uniform acceleration

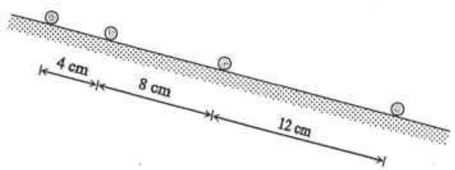
15. < HKCE 1990 Paper II - 1 >

The graph shows how the square of velocity of an object undergoing uniform acceleration varies with displacement. The object is initially at rest and travels along a straight line. The acceleration of the object is

A. 0.5 m s^{-2}
B. 1.0 m s^{-2}
C. 2.0 m s^{-2}
D. 4.0 m s^{-2}



16. < HKCE 1991 Paper II - 4 >



The above figure shows the strobe photograph of a ball rolling down a slope. The stroboscope is flashing at a frequency of 5 Hz. Find the acceleration of the ball.

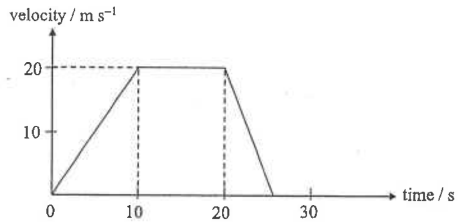
A. 0.20 m s^{-2}
B. 0.50 m s^{-2}
C. 0.67 m s^{-2}
D. 1.00 m s^{-2}

17. < HKCE 1991 Paper II - 5 >

The figure shows the velocity-time graph of an object. Which of the following statements about the object is/are true ?

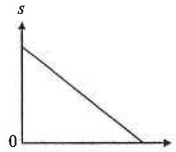
(1) Its acceleration in the first 10 s is 2 m s^{-2}.
(2) The total distance travelled is 250 m.
(3) It returns to its starting point after 25 s.

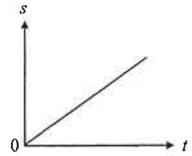
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

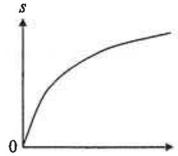


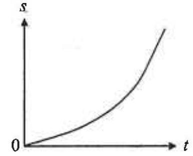
18. < HKCE 1992 Paper II - 1 >

Which of the following displacement-time graphs describes the motion of a particle moving in a straight line with uniform deceleration ?

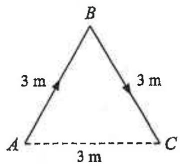
A.


B.


C.


D.


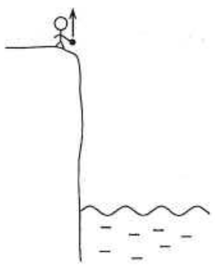
19. < HKCE 1992 Paper II - 2 >

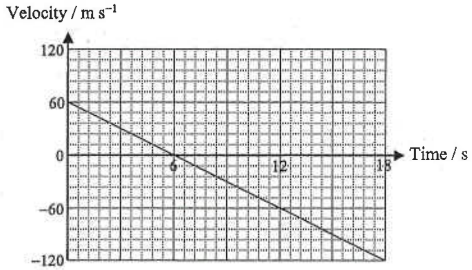


A man takes 2 s to walk from point A to point B, and then takes 3 s to walk from point B to point C, where ABC is an equilateral triangle of side 3 m. Find the magnitude of his average VELOCITY from A to C.

A. 0.60 m s^{-1}
B. 1.00 m s^{-1}
C. 1.20 m s^{-1}
D. 1.25 m s^{-1}

20. < HKCE 1992 Paper II - 4 >





The above figure shows a man near the edge of a cliff projecting a stone vertically upwards. The stone reaches the sea after 18 s. The graph shows the velocity ~ time for the motion of the stone. Find the height of the cliff. (Take g = 10 m s^{-2}.)

A. 180 m
B. 540 m
C. 720 m
D. 900 m

21. < HKCE 1993 Paper II - 3 >

An object is thrown vertically upwards from a point A. It travels to the highest point B and then falls back to A. Neglecting air resistance, which of the following statements is/are true ?

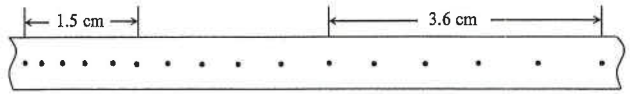
(1) The total displacement of the object is zero.
(2) The acceleration of the object is constant throughout the motion.
(3) The time for the upward motion is longer than the time for the downward motion.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

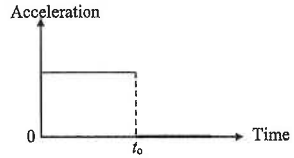
22. < HKCE 1993 Paper II - 2 >

The paper tape shown is obtained from a trolley moving with uniform acceleration. The frequency of the ticker-tape timer is 50 Hz. Find the acceleration of the trolley.

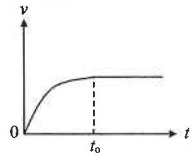
A. 0.21 m s^{-2}
B. 0.70 m s^{-2}
C. 0.73 m s^{-2}
D. 1.05 m s^{-2}

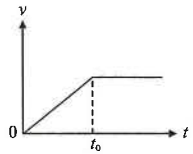


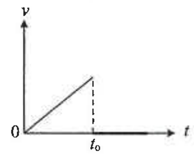
23. < HKCE 1993 Paper II - 5 >

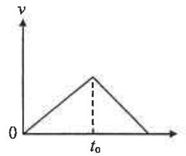


The above diagram shows the variation of the acceleration of an object which is initially at rest. Which of the following velocity-time graphs correctly describes the motion of the object ?

A.


B.


C.


D.


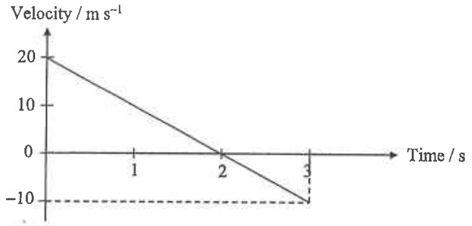
24. < HKCE 1994 Paper II - 5 >

A man takes 30 s to walk 80 m towards the east. He then takes 10 s to run 60 m towards the south. Which of the following statements is/are correct ?

(1) The magnitude of the resultant displacement of the man is 140 m.
(2) The average speed of the man is 4.3 m s^{-1}.
(3) The magnitude of the average velocity of the man is 2.5 m s^{-1}.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

25. < HKCE 1995 Paper II - 8 >

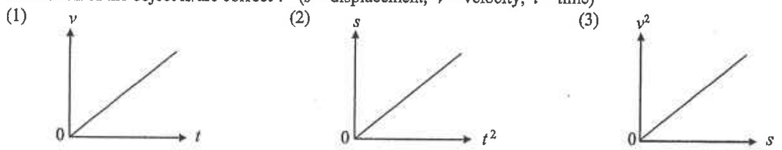


The above diagram shows the variation of the velocity of an object with time. What is the distance travelled by the object in the first 3 seconds ?

A. 5 m
B. 15 m
C. 25 m
D. 30 m

26. < HKCE 1995 Paper II - 4 >

An object starts from rest and moves with uniform acceleration along a straight line. Which of the graphs below concerning the motion of the object is/are correct ? (s = displacement, v = velocity, t = time)



A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

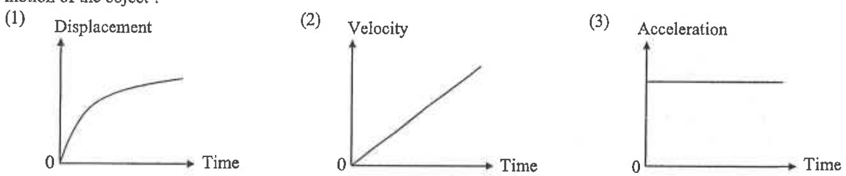
27. < HKCE 1996 Paper II - 2 >

A man walks 40 m towards the west. He then walks 40 m towards the south and lastly walks 70 m towards the east. Find the magnitude of the resultant displacement of the man.

A. 30 m
B. 40 m
C. 50 m
D. 70 m

28. < HKCE 1996 Paper II - 4 >

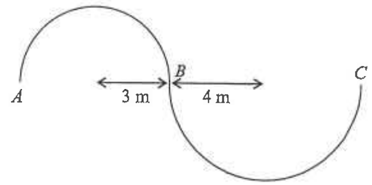
An object moves with uniform acceleration along a straight line. Which of the following graphs correctly describe(s) the motion of the object ?



A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

29. < HKCE 1997 Paper II - 2 >

A student walks along a curve ABC, which is made up of two semi-circular parts AB and BC of radius 3 m and 4 m respectively. He takes 2 s to walk from A to B and 5 s from B to C. Find the magnitude of the average velocity of the student from A to C.



A. 1.0 m s^{-1}
B. 2.0 m s^{-1}
C. 2.3 m s^{-1}
D. 3.1 m s^{-1}

30. < HKCE 1997 Paper II - 6 >

A particle is released from rest and falls vertically under gravity. If the distance travelled by the particle in the 1st second is x and that travelled in the 2nd second is y, find the ratio $x : y$.

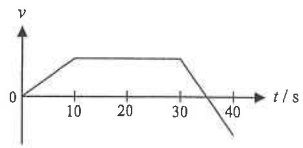
A. 1 : 1
B. 1 : 2
C. 1 : 3
D. 1 : 4

31. < HKCE 1998 Paper II - 2 >

A car undergoes uniform deceleration along a straight road. Its velocity decreases from 30 m s^{-1} to 20 m s^{-1} after travelling a distance of 100 m. How much further will the car travel before it comes to a rest ?

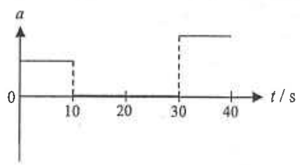
A. 50 m
B. 80 m
C. 180 m
D. 200 m

32. < HKCE 1998 Paper II - 4 >

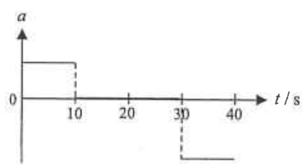


The velocity-time graph of a car travelling along a straight horizontal road is shown above. Which of the following graphs shows the variation of the acceleration a of the car with the time t ?

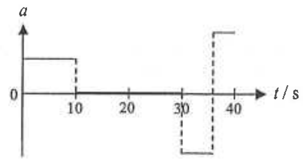
A.



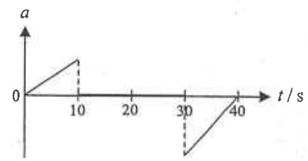
B.



C.



D.



36. < HKCE 2000 Paper II - 3 >

A racing car accelerates from rest to a speed of 100 km h^{-1} in 3.2 s. Find the average acceleration of the car.

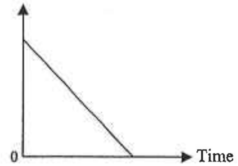
A. 4.34 m s^{-2}
B. 8.68 m s^{-2}
C. 15.63 m s^{-2}
D. 31.25 m s^{-2}

37. < HKCE 2001 Paper II - 2 >

A girl walks along a straight road from a point A to a point B with an average speed 1 m s^{-1}. She then returns from B to A along the same road with an average speed 2 m s^{-1}. Find the average speed of the girl for the whole journey.

A. zero.
B. 0.67 m s^{-1}
C. 1.33 m s^{-1}
D. 1.50 m s^{-1}

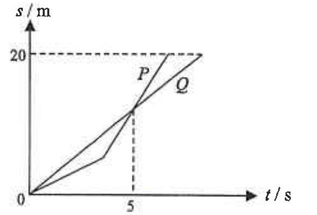
38. < HKCE 2001 Paper II - 1 >



A car travels along a straight road. The variation of the distance of the car from a fixed point P on the road with time is shown above. Which of the following statements is correct ?

A. The speed of the car is decreasing.
B. The car is moving towards P.
C. There is an unbalanced force acting on the car.
D. The area under the graph denotes the total distance travelled by the car.

39. < HKCE 2002 Paper II - 1 >



The figure above shows the distance-time graphs of two toy cars P and Q moving along linear track. Which of the following statements is/are correct ?

(1) Car P will reach the 20 m-mark first.
(2) Car P is overtaking car Q at $t = 5$ s.
(3) The average speed of car P in the first 5 s is smaller than that of car Q.

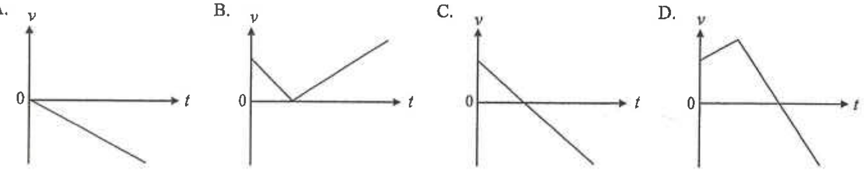
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

40. **< HKCE 2002 Paper II - 3 >**

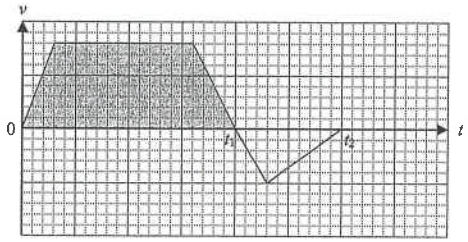
A piece of stone is hung from a balloon, which is rising vertically upward. If the string connecting the stone and the balloon suddenly breaks, which of the following velocity-time graphs represents the subsequent motion of the stone ?

(Note : Velocity pointing upward is taken to be positive.)

A. B. C. D.



Questions 41 and 42 : The figure shows the velocity-time graph of a car travelling along a straight road.



41. **< HKCE 2003 Paper II - 1 >**

What physical quantity does the area of the shaded region represent ?

A. energy
B. momentum
C. acceleration
D. displacement

42. **< HKCE 2003 Paper II - 2 >**

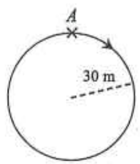
Which of the statements are correct ?

(1) The car changes its direction of travel at $t = t_1$.
(2) The car is farthest away from the starting point at $t = t_1$.
(3) The car returns to its starting point at $t = t_2$.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

43. **< HKCE 2003 Paper II - 3 >**

A car starts at point A and travels along a circular path of radius 30 m. After 15 s, the car returns to point A. Find the average speed of the car within this period of time.



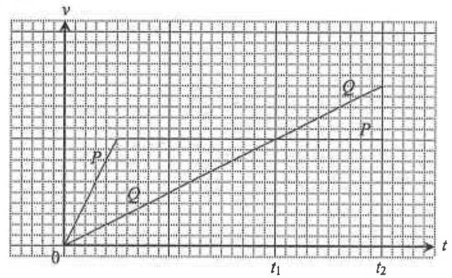
A. zero
B. 2 m s^{-1}
C. 6.3 m s^{-1}
D. 12.6 m s^{-1}

44. **< HKCE 2003 Paper II - 4 >**

A plane starts from rest and accelerates at 2 m s^{-2}. If the minimum take-off speed is 60 m s^{-1}, find the minimum distance travelled by the plane before it takes off.

A. 450 m
B. 900 m
C. 1800 m
D. 3600 m

45. **< HKCE 2004 Paper II - 3 >**

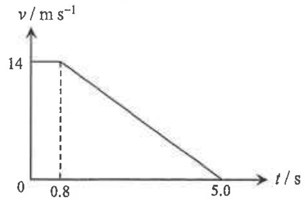


The figure shows the velocity-time graphs of two students P and Q running along a straight road. They start at the same point. Which of the following statements is/are correct ?

(1) The average speed of P between $t = 0$ and $t = t_1$ is larger than that of Q.
(2) At $t = t_1$, P and Q reach the same point.
(3) At $t = t_2$, Q is ahead of P.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Questions 46 and 47 :
Patrick is driving along a straight horizontal road. At time $t = 0$, he observes that an accident has happened. He then applies the brakes to stop his car with uniform deceleration. The graph shows the variation of the speed of the car with time.



46. **< HKCE 2005 Paper II - 1 >**

What is the reaction time of Patrick ?

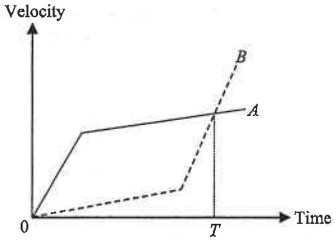
A. zero
B. 0.8 s
C. 4.2 s
D. 5.0 s

47. **< HKCE 2005 Paper II - 2 >**

Find the distance travelled by the car from time $t = 0$ to 5.0 s.

A. 29.4 m
B. 40.6 m
C. 46.2 m
D. 81.2 m

48. **< HKCE 2006 Paper II - 1 >**



Two cars A and B start from rest simultaneously and travel along the same straight road. The velocity-time graphs of the two cars are shown above. Which of the following statements about the motion of the two cars is/are always correct ?

(1) A and B have the same average velocity during the time interval 0 to T.
(2) A and B have the same average acceleration during the time interval 0 to T.
(3) A and B travel the same displacement during the time interval 0 to T.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

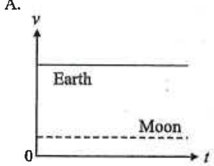
49. **< HKCE 2006 Paper II - 28 >**

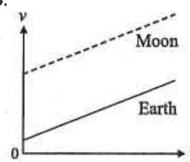
A car travels along a straight road from A to B with a uniform acceleration. The speed of the car is v_1 at the instant when half of the journey time from A to B is elapsed and its speed is v_2 at the mid-way of A and B. Which of the following is correct ?

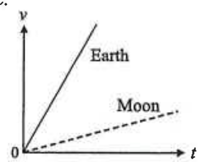
A. v_1 is always smaller than v_2.
B. v_1 is always greater than v_2.
C. v_1 and v_2 are always equal.
D. Whether v_1 is greater than or smaller than v_2 depends on the initial velocity of the car at A.

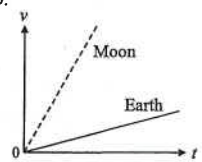
50. **< HKCE 2006 Paper II - 7 >**

The acceleration of objects due to gravity on the Moon is about 1/6 that on the Earth. Which of the following diagrams shows the correct velocity-time graphs for a free falling object dropping respectively on the Earth's surface and the Moon's surface ?

A.


B.


C.


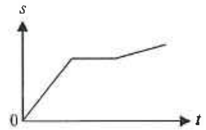
D.


51. **< HKCE 2007 Paper II - 1 >**

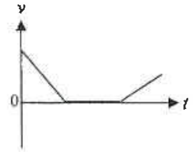
A bicycle finishes a 100-metre journey in 9.77 s. Assume that the bicycle starts from rest and moves with a uniform acceleration. What is the acceleration of the bicycle throughout the journey ?

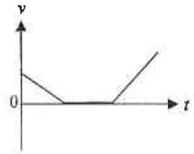
A. 1.05 m s^{-2}
B. 2.10 m s^{-2}
C. 10.2 m s^{-2}
D. 20.5 m s^{-2}

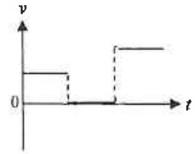
52. The displacement-time graph of an object moving along a straight line is shown below.
(07)

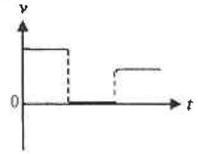


Which of the following graphs best represents the relationship between the velocity and time of the object ?

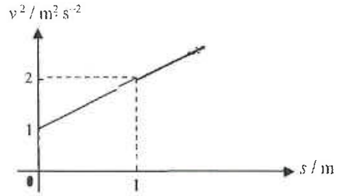
A.


B.


C.


D.


53.
(07)



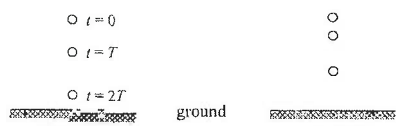
The above graph shows the variation of the square of velocity v^2 with the displacement s of a particle moving along a straight line. What is the acceleration of the particle ?

A. 0.5 m s^{-2}
B. 1 m s^{-2}
C. 1.5 m s^{-2}
D. 2 m s^{-2}

54. A fish jumps up vertically to a maximum height of 0.5 m above the water surface. What is the speed when it just leaves the
(08) surface ?

A. 3.13 m s^{-1}
B. 4.43 m s^{-1}
C. 6.26 m s^{-1}
D. 9.81 m s^{-1}

55.
(08)

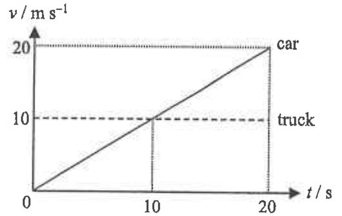


Picture (a) Picture (b)

An experiment is conducted by releasing a stone from rest to the ground. At constant time interval T, the positions of the stone are recorded. Picture (a) shows its positions at different time. Which of the following changes will give a path of the stone as shown in Picture (b) ? (Neglect air resistance.)

A. A shorter time interval is used.
B. A longer time interval is used.
C. A lighter stone is used.
D. A heavier stone is used.

56. **< HKCE 2008 Paper II - 6 >**

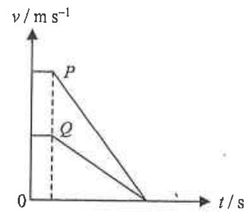


At $t = 0$, a car and a truck are at the same point on a horizontal straight road. Their velocity - time graph is shown in the figure above. Which of the following statements is correct ?

At $t = 10$ s, the car is 100 m behind the truck.
At $t = 10$ s, the car catches up the truck.
At $t = 20$ s, the car is 100 m behind the truck.
At $t = 20$ s, the car catches up the truck.

57. **< HKCE 2009 Paper II - 5 >**

John and Mary are driving two cars, P and Q, along a straight horizontal road respectively. At time $t = 0$, they both see an obstacle and apply the brakes to stop the cars with uniform deceleration. The variation of velocity with time of the two cars is shown in the figure below. Which of the following statements is/are correct ?



(1) The two cars have the same initial speeds.
(2) The reaction times of John and Mary are the same.
(3) The total stopping distances of the two cars are the same.

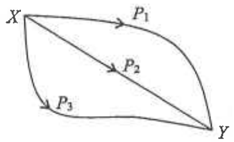
(2) only
(3) only
(1) & (2) only
(1) & (3) only

58. **< HKCE 2009 Paper II - 1 >**

A car is travelling at a constant speed of 50 km h^{-1}. How much time does it take to travel 500 m ?

0.1 s
10 s
36 s
360 s

59. **< HKCE 2009 Paper II - 2 >**



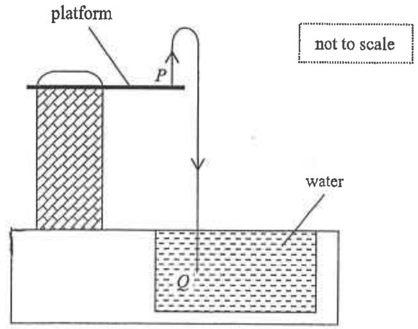
The figure above shows three paths P_1, P_2 and P_3 from X to Y on a horizontal plane. Three students take the same time to travel from X to Y via the three paths respectively. Which of the following physical quantities about their journey is/are the same ?

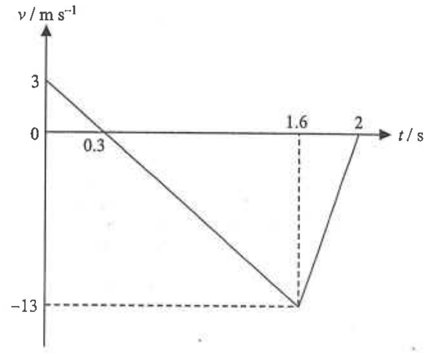
(1) displacement
(2) distance
(3) average speed

(1) only
(2) only
(1) & (3) only
(2) & (3) only

60. **< HKCE 2009 Paper II - 28 >**

A diver jumps up vertically in the air from a high platform and falls into water. The v-t graph below shows the variation of the velocity of the diver against time from the point he jumps (P) until he is at the lowest point (Q) in the water.

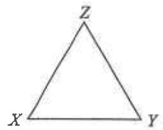




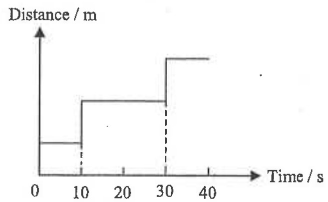
Which of the following is correct ?

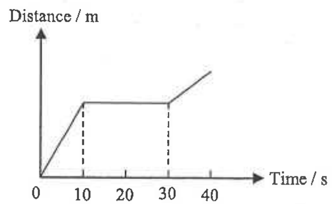
	total distance travelled from P to Q	height of the platform above water surface
A.	8.9 m	8 m
B.	10.6 m	10 m
C.	11.5 m	8 m
D.	11.5 m	10.6 m

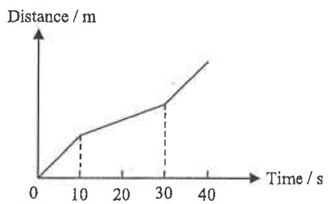
61. **< HKCE 2010 Paper II - 1 >**

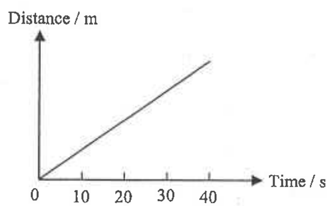


Mary walks along a triangular path XYZ where $XY = YZ = ZX$. It takes her 10 s, 20 s and 10 s to travel through XY, YZ and ZX respectively. Which of the following graphs best represents the variation of distance travelled with time ?

A.


B.


C.


D.


M62 An object of mass m, released from rest at height h above the ground, takes time t to reach the ground. If another object of
(11) mass $2m$ is released from rest at the same height, how long does it take to reach the ground ? (Neglect air resistance.)

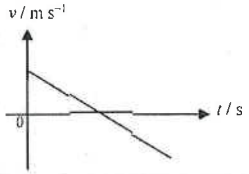
A. $\frac{t}{\sqrt{2}}$

B. $\frac{t}{2}$

C. t

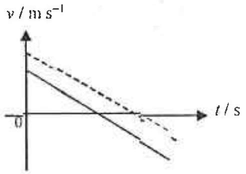
D. $\sqrt{2}\,t$

M63.
(11)

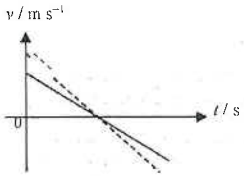


The graph above shows the velocity-time graph of an object which is thrown vertically upwards under gravity. If the object is thrown vertically upwards with a higher initial velocity, which of the following graphs (in dotted lines) best represents the expected result ? (Neglect air resistance.)

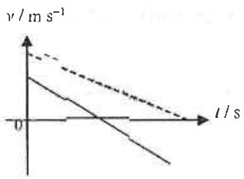
A.



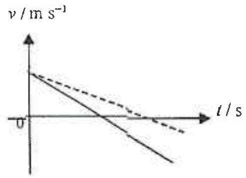
B.



C.



D.



M78. a ball is released from rest at a certain height above the ground. If air resistance is neglected, what is the ratio of
(6) the distance travelled by the stone in the second to that travelled in the third second?

A. 1 : 3
B. 1 : 5
C. 3 : 5
D. 5 : 8

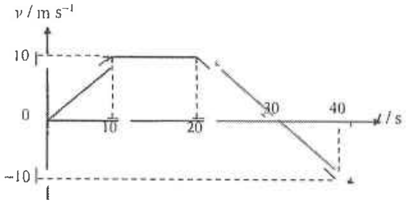
Part C:

The following questions are designed to give supplemental exercise for this chapter.

M69. A car travels with a speed of 18 m s^{-1}. The driver suddenly sees a girl standing at 36 m in front. If the reaction time of the driver is 0.5 s, what should be the minimum deceleration of the car in order to avoid collision with the girl ?

A. 3.0 m s^{-2}
B. 4.5 m s^{-2}
C. 6.0 m s^{-2}
D. 9.0 m s^{-2}

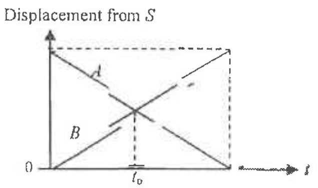
M70.



The figure shows the time variation of the velocity of a car travelling along a straight road, starting from rest at a certain point *P*. What is the maximum distance from the point *P* that the car would reach within the time shown in the figure ?

A. 100 m
B. 150 m
C. 200 m
D. 250 m

M71.



Two cars *A* and *B* move along the same straight road. The variations of their displacement from an oil station *S* with time are shown in the above figure. Which of the following statements is/are correct ?

(1) The cars travel with the same velocity.
(2) At time t_0, the two cars meet each other.
(3) The two cars have travelled the same distance from $t = 0$ to $t = t_0$.

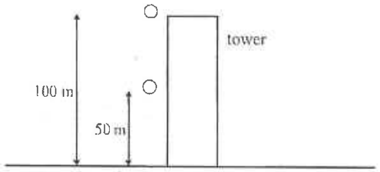
A. (2) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

M72 Peter walks along a straight road from point *P* to point *Q* with an average speed of 2 m s^{-1}. He then runs back from *Q* to *P* along the same road with an average speed of 4 m s^{-1}. Which of the following statements are correct ?

(1) The resultant displacement of Peter in the whole journey is zero.
(2) The average velocity of Peter in the whole journey is 0 m s^{-1}.
(3) The average speed of Peter in the whole journey is 3 m s^{-1}.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

M73. In the figure shown, one ball is released from rest at the top of a tower that is 100 m high. The other ball is released from rest at the mid-point of the tower. Which of the following quantities is the same for both balls as they fall in air ? (Neglect air resistance.)



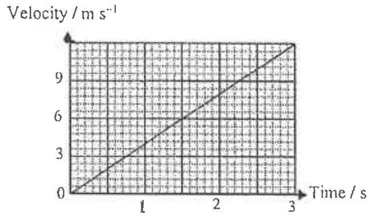
A. change of velocity just before reaching the ground
B. acceleration during the fall
C. final velocity just before reaching the ground
D. time of travel in the journey

M74. A boy wants to measure the height of building. He releases a stone at the top of the building from rest and starts to keep the time. If the stone takes 2 s to reach the mid-height of the building, which of the following statements is/are correct ? Take g to be 10ms-2.

(1) The height of the building is 40m.
(2) The stone takes 4s to reach the bottom of the building
(3) The stone reaches the bottom of the building with a speed of 40ms-1

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

M75. The graph shows the velocity of a body travelling in a straight line. What is the average velocity of the body during the first 3 s ?



A. 4 m s^{-1}
B. 6 m s^{-1}
C. 9 m s^{-1}
D. 12 m s^{-1}

M76. A car takes 20 s to travel the first 80 m, and another 10 s to travel a further 70 m. What is the average speed ?

A. 2.5 m s^{-1}
B. 4.0 m s^{-1}
C. 5.0 m s^{-1}
D. 5.5 m s^{-1}

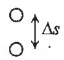
M77. Peter throws a ball downwards at an initial velocity of 5 m s^{-1} from the top of a building. After 3 s, the ball reaches the ground. What is the height of the building ?

A. 29 m
B. 44 m
C. 59 m
D. 88 m

78. A feather is dropped downwards with an initial velocity of 2 m s^{-1} at a height of 15 m above the surface of the Moon. It is known that the acceleration due to gravity on the Moon's surface is 16% of that of the Earth. Calculate the speed of the feather when it reaches the surface of the Moon.
A. 6.85 m s^{-1}
B. 7.15 m s^{-1}
C. 8.45 m s^{-1}
D. 9.25 m s^{-1}

79. Two balls of the same mass are dropped from the top of a tall building one after the other. Air resistance is negligible. The separation between the two balls
A. remains constant.
B. decreases with time.
C. increases with time.
D. depends on the mass of the two balls.

80. Two identical balls are held above the ground as shown. One ball is higher than the other ball by a separation Δs. Air resistance is negligible. Suppose the two balls are released at the same time. During the flight, their separation will



A. remain constant.
B. decreases with time.
C. increases with time.
D. increases and then decreases.

81. A fish jumps up with a certain initial speed to leave the water surface. It reaches a maximum height of 80 cm above the water surface and returns back to the water. Treat the fish as a particle and neglect the air resistance, what is the time interval that the fish is above the water surface ? (Take g to be 10 m s^{-2}.)
A. 0.2 s
B. 0.4 s
C. 0.8 s
D. 1.6 s

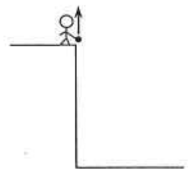
82. Ball P is thrown vertically upwards from the ground with an initial velocity of 25 m s^{-1}. At the same time, ball Q is thrown vertically downwards with an initial velocity of 15 m s^{-1} at the top of a building 80 m above the ground. Assume air resistance is negligible and their motions are along the same vertical line, determine the height that the two balls meet.

Take the acceleration due to gravity to be 10 m s^{-2}.
A. 30 m
B. 40 m
C. 50 m
D. 60 m

83. A particle accelerates from rest with a uniform acceleration a along a straight line. It travels a distance of x in the third second and travels a distance of y in the fifth second. Find the ratio of x to y.
A. 3 : 5
B. 5 : 9
C. 9 : 16
D. 9 : 25

84. A car travels with a constant speed of 50 km h^{-1} during a time interval. Which of the following values CANNOT be the possible average velocity of the car in this time interval ?
A. 0 km h^{-1}
B. 25 km h^{-1}
C. 50 km h^{-1}
D. 75 km h^{-1}

85. A boy throws a small ball upwards with an initial velocity of 15 m s^{-1} at the top of a building. The height of the building is 30 m. If air resistance is negligible, calculate the time taken for the ball to reach the ground.



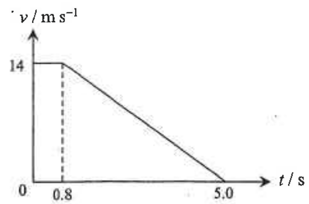
A. 2.22 s
B. 3.33 s
C. 4.44 s
D. 5.55 s

86. A particle moves with an initial velocity of 5 m s^{-1} on a straight line under a uniform acceleration of 2 m s^{-2}. What is the distance travelled by the particle in the fourth second ?
A. 12 m
B. 24 m
C. 36 m
D. 48 m

87. A ball is thrown vertically upwards with an initial velocity of 16 m s^{-1}. What is the total distance travelled by the ball when it returns to the original position.
A. 13 m
B. 18 m
C. 26 m
D. 32 m

Part D : HKDSE examination questions

88. < HKDSE Sample Paper IA - 7 >



Patrick is driving along a straight horizontal road. At time $t = 0$, he observes that an accident has happened. He then applies the brakes to stop his car with uniform deceleration. The graph shows the variation of the speed of the car with time. Find the distance travelled by the car from time $t = 0$ to 5.0 s.
A. 29.4 m
B. 40.6 m
C. 46.2 m
D. 81.2 m

89. < HKDSE Sample Paper IA - 12 >

Two small identical objects P and Q are released from the top of a building 80 m above the ground. Q is released 1 s after P. Neglecting air resistance, what is the maximum vertical separation between P and Q in the air ?

A. 5 m
B. 10 m
C. 35 m
D. 45 m

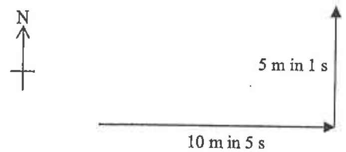
90. < HKDSE Practice Paper IA - 7 >

A stone falls from rest. Neglecting air resistance, the ratio of the distance travelled by the stone in the 1st second to that travelled in the 2nd second is

A. 1 : 1
B. 1 : 2
C. 1 : 3
D. 1 : 4

91. < HKDSE Practice Paper IA - 6 >

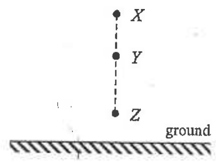
A toy car travelled due east for 10 m in 5 s, then immediately turned north and travelled 5 m for 1 s. What was the average speed of the car ?



A. 1.9 m s^{-1}
B. 2.2 m s^{-1}
C. 2.5 m s^{-1}
D. 3.5 m s^{-1}

92. < HKDSE 2013 Paper IA - 8 >

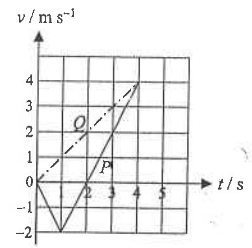
A particle is released from rest at X as shown. It takes time t_1 to fall from X to Y and time t_2 to fall from Y to Z. If $XY : YZ = 9 : 16$, find $t_1 : t_2$. Neglect air resistance.



A. 2 : 3
B. 3 : 4
C. 4 : 3
D. 3 : 2

93. < HKDSE 2013 Paper IA - 11 >

Two particles P and Q start from the same position and travel along the same straight line. The above figure shows the velocity-time (v-t) graph for P and Q. Which of the following descriptions about their motion is/are correct ?



(1) At $t = 1$ s, P changes its direction of motion.
(2) At $t = 2$ s, the separation between P and Q is 4 m.
(3) At $t = 4$ s, P and Q meet each other.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

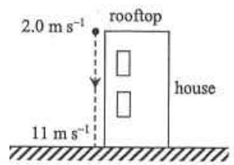
94. < HKDSE 2014 Paper IA - 5 >

A particle is moving along a straight line with uniform acceleration. It takes 4 s to travel a distance of 36 m and then 2 s to travel the next 36 m. What is its acceleration ?

A. 2.5 m s^{-2}
B. 3.0 m s^{-2}
C. 4.0 m s^{-2}
D. 4.5 m s^{-2}

95. < HKDSE 2014 Paper IA - 9 >

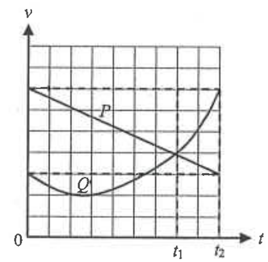
A particle is projected vertically downward with an initial speed of 2.0 m s^{-1} from the rooftop of a house. The particle reaches the ground with a speed of 11 m s^{-1} as shown. Estimate the height of the house. Neglect air resistance.



A. 3.3 m
B. 6.0 m
C. 6.5 m
D. 12 m

96. < HKDSE 2015 Paper IA - 4 >

The figure shows the velocity-time (v-t) graph of two cars P and Q travelling along the same straight road. At $t = 0$, the cars are at the same position. Which deductions about the cars between $t = 0$ and $t = t_2$ are correct ?



(1) P and Q are always travelling in the same direction.
(2) At $t = t_1$, the separation between P and Q is at a maximum.
(3) At $t = t_2$, Q lags behind P.

A (1) & (2) only
B (1) & (3) only
C (2) & (3) only
D (1), (2) & (3)

97. < HKDSE 2015 Paper IA - 9 >

A particle travels at 2.0 m s^{-1} due east for 1.5 s and then travels at 4.0 m s^{-1} due north for 1.0 s. What is the magnitude of its average velocity for the whole journey ?

A. 2.0 m s^{-1}
B. 2.8 m s^{-1}
C. 3.0 m s^{-1}
D. 5.0 m s^{-1}

98. < HKDSE 2016 Paper IA - 4 >

The speedometer of a car shown indicates the car's

A. instantaneous speed.
B. instantaneous velocity.
C. average speed of the whole journey.
D. average velocity of the whole journey.

99. < HKDSE 2017 Paper IA - 5 >

Which of the following statements about the motion of any two objects is correct ?

The object that takes a shorter time to complete the same path must have greater average speed.

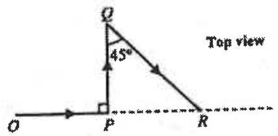
The object that travels a greater distance in 1 s must have greater average velocity.

The object with greater velocity must have greater acceleration.

If the two objects have the same acceleration, they must be moving in the same direction

100. <HKDSE 2019 Paper IA-4>

101 <HKDSE 2020 Paper IA-4>



A car takes 8 minutes to travel along a path $OPQR$ on a horizontal surface as shown. Given that $OP = PQ = 2$ km, find the magnitude of the average velocity of the car in this journey.

A. 30 km h^{-1}
B. 36 km h^{-1}
C. 41 km h^{-1}
D. 51 km h^{-1}

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. D	11. B	21. C	31. B	41. D	101. A
2. A	12. B	22. D	32. B	42. A	
3. D	13. D	23. B	33. C	43. D	
4. D	14. B	24. B	34. D	44. B	
5. B	15. B	25. C	35. B	45. A	
6. D	16. D	26. D	36. B	46. B	
7. C	17. A	27. C	37. C	47. B	
8. C	18. C	28. D	38. B	48. B	
9. B	19. A	29. B	39. A	49. A	
10. C	20. B	30. C	40. C	50. C	
51. B	61. C	71. D	81. C	91. C	
52. D	62. C	72. A	82. A	92. D	
53. A	63. A	73. B	83. B	93. B	
54. A	64. B	74. A	84. D	94. B	
55. A	65. A	75. B	85. C	95. B	
56. D	66. C	76. C	86. A	96. D	
57. A	67. D	77. C	87. C	97. A	
58. C	68. C	78. B	88. B	98. A	
59. A	69. C	79. C	89. C	99. A	
60. C	70. C	80. A	90. C	**100. D**	

M.C. Solution

1. D

$s = ut + \frac{1}{2}at^2 \quad \therefore (4) = (0) + \frac{1}{2}g(1)^2 \quad \therefore g = 8 \text{ m s}^{-2}$

$s = ut + \frac{1}{2}gt^2 = (0) + \frac{1}{2}(8)(1+4)^2 = 100 \text{ m}$

2. A

From A to B : $s = ut + \frac{1}{2}at^2 \quad \therefore (100) = u(4) + \frac{1}{2}(9.81)(4)^2 \quad \therefore u = 5.38 \text{ m s}^{-1}$

From O to A : $v = u + at \quad \therefore (5.38) = (0) + (9.81)t \quad \therefore t = 0.548 \approx 0.55 \text{ s}$

3. D

✓ (1) Uniform velocity ⇒ acceleration $a = 0$

✓ (2) Example : If a ball is projected upwards, its velocity is zero at the highest point, but $a = g \neq 0$

✓ (3) Example : If a car turns round with constant speed, as the direction is changing, the velocity varies.

4. D

s = area of the graph = $\frac{(2+4)\times 4}{2}$ = 12 m

5. B

In vacuum, there is no air resistance, the ping-pong ball would fall under the acceleration due to gravity.

$v = u + at = 0 + gt$

$\therefore\ v \propto t$

$\therefore\ v \sim t$ graph is a straight line through the origin

6. D

By $v^2 = u^2 + 2as$

$\therefore\ 0 = u^2 + 2(-a)s$ $\therefore\ u^2 = 2as$ $\therefore\ u^2 \propto s$

$\therefore\ \left(\frac{u_1}{u_2}\right)^2 = \left(\frac{s_1}{s_2}\right)$ $\therefore\ \left(\frac{50}{70}\right)^2 = \left(\frac{15}{s_2}\right)$ $\therefore\ s_2 = 29.4$ m

7. C

a = slope of the graph = $\frac{6-0}{3-0}$ = 2 m s^{-2}

8. C

By $s = ut + \frac{1}{2}at^2 = (0) + \frac{1}{2}(9.81)t^2 \approx 4.9\,t^2$

After falling for 1 s : $s_1 = 4.9 \times (1)^2 = 4.9$ m

After falling for 2 s : $s_2 = 4.9 \times (2)^2 = 19.6$ m

After falling for 3 s : $s_3 = 4.9 \times (3)^2 = 44.1$ m

Distance travelled in the first second = 4.9 m

Distance travelled in the third second = 44.1 − 19.6 = 24.5 m

9. B

× (1) Displacement increases in : 1 cm, 3 cm, 6 cm, 10 cm, 15 cm, 21 cm ; not uniformly

✓ (2) Length of each section of tape represents the velocity
∴ Velocity increases in unit of : 1, 2, 3, 4, 5, 6 ; i.e. increases uniformly

× (3) Since velocity increases uniformly, the acceleration is constant and not increasing

10. C

$s = ut + \frac{1}{2}at^2 = (0)t + \frac{1}{2}at^2$

$\therefore$ slope of the graph $= \frac{1}{2}a$

$\therefore\ \frac{4-0}{4-0} = \frac{1}{2}a$ $\therefore\ a = 2$ m s^{-2}

OR

At $t^2 = 4$ s^2, displacement $s = 4$ m.

By $s = ut + \frac{1}{2}at^2$ $\therefore\ (4) = (0) + \frac{1}{2}a(4)$ $\therefore\ a = 2$ m s^{-2}

11. B

Time interval for each flash = $\frac{1}{2}$ = 0.5 s

At MN, average speed : $v = \frac{36-16}{0.5}$ = 40 cm s^{-1}

12. B

× (1) It falls with the acceleration due to gravity, thus the speed is increasing.

× (2) After 1 s, $s = ut + \frac{1}{2}at^2 = (0) + \frac{1}{2}(9.8)(1)^2 = 4.9$ m.
Moreover, as it falls with acceleration, the distance travelled in every second should be increasing.

✓ (3) Acceleration of 9.8 m s^{-2} means in each second, there is a change in velocity of 9.8 m s^{-1}.
After 2 s, speed = 9.8 × 2 = 19.6 m s^{-1}.

13. D

At the maximum height, velocity is zero

but the acceleration of the particle is still equal to the acceleration due to gravity which is pointing downwards.

14. B

As air has been evacuated, the tube is vacuum, thus there is no air resistance acting on the falling object.

Coin : falls with uniform acceleration (as it falls under gravity)

Feather : falls with same uniform acceleration (as it experiences the same acceleration due to gravity if no air resistance)

15. B

By $v^2 = u^2 + 2as$ $\therefore\ v^2 = 2as$

$\therefore$ slope of the graph = $2a$ $\therefore\ \frac{4-0}{2-0} = 2a$ $\therefore\ a = 1$ m s^{-2}

OR

At the point when $s = 3$ m, $v^2 = 6$ m^2 s^{-2}

By $v^2 = u^2 + 2as$ $\therefore\ (6) = (0) + 2a(3)$ $\therefore\ a = 1$ m s^{-2}

16. D

Time interval between 2 flashes $= \frac{1}{5} = 0.2$ s

$u = \frac{0.04}{0.2} = 0.2\ \text{m s}^{-1}$ (occur at the instant of the mid point of 4 cm)

$v = \frac{0.12}{0.2} = 0.6\ \text{m s}^{-1}$ (occur at the instant of the mid point of 12 cm)

From the instant of u to the instant of v, there are only 2 time intervals, that is, 2 × 0.2 s.

$\therefore\ a = \frac{v-u}{t} = \frac{0.6-0.2}{2\times0.2} = 1\ \text{m s}^{-2}$

17. A

✓ (1) a = slope of the graph $= \frac{20-10}{10-0} = 2\ \text{m s}^{-2}$

× (2) s = area of the graph $= \frac{1}{2}(10+25)\times20 = 350$ m

× (3) At 25 s, the displacement s is 350 m, which is not 0 m, thus it is not the starting point.

18. C

Slope of $s \sim t$ graph represents velocity.

For a particle moving with deceleration, its velocity is decreasing.

The $s \sim t$ graph with decreasing slope represents uniform deceleration.

19. A

$v = \frac{\text{resultant displacement}}{\text{total time taken}} = \frac{3}{2+3} = 0.6\ \text{m s}^{-1}$

20. B

Displacement s = net area of v-t graph

$= \frac{1}{2}(6)(60) - \frac{1}{2}(18-6)(120)$

$= -540$ m

$\therefore$ The displacement is 540 m in downward direction

$\therefore$ Height of the cliff is 540 m

21. C

✓ (1) Falling back to A means returning to the original position $\therefore\ s = 0$

✓ (2) When moving in air, the acceleration is equal to the acceleration due to gravity g which is constant.

× (3) Same acceleration in upward and downward motion if there is no air resistance
$\therefore$ time for upward motion = time for downward motion

22. D

Time interval between 2 dots : 1 tick $= \frac{1}{50} = 0.02$ s

$u = \frac{0.015}{5\times0.02} = 0.15\ \text{m s}^{-1}$ (occur at the instant of the mid point of 1.5 cm)

$v = \frac{0.036}{5\times0.02} = 0.36\ \text{m s}^{-1}$ (occur at the instant of the mid point of 3.6 cm)

From the instant of u to the instant of v, there are 10 ticks, that is, 10 × 0.02 s.

$\therefore\ a = \frac{v-u}{t} = \frac{0.36-0.15}{10\times0.02} = 1.05\ \text{m s}^{-2}$

23. B

Slope of the $v \sim t$ graph = acceleration

Before $t = t_o$, acceleration is positive and constant, $v \sim t$ graph is a straight line that v increases from 0 to v

After $t = t_o$, acceleration is zero, thus $v \sim t$ graph a horizontal line and velocity continues from v and remains constant

24. B

× (1) Displacement $s = \sqrt{80^2 + 60^2} = 100$ m

× (2) speed $= \frac{80+60}{30+10} = 3.5\ \text{m s}^{-1}$

✓ (3) $v = \frac{100}{30+10} = 2.5\ \text{m s}^{-1}$

25. C

Distance travelled = total area of the graph between the line and the x-axis

As distance is a scalar, the direction is not relevant.

Thus, the absolute value of the area represents the distance travelled.

$\therefore\ d = \frac{1}{2}(20)(2) + \frac{1}{2}(3-2)(10) = 25$ m

26. D

✓ (1) $v = u + at = 0 + at$ $\therefore\ v \propto t$

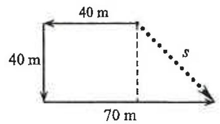
✓ (2) $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}at^2$ $\therefore\ s \propto t^2$

✓ (3) $v^2 = u^2 + 2as = 0 + 2as$ $\therefore\ v^2 \propto s$

27. C

The resultant displacement s is pointing from the starting position to the final position.

$s = \sqrt{(40)^2 + (30)^2} = 50$ m



28. D

× (1) Slope of $s \sim t$ graph = velocity.
Decreasing slope ⇒ decreasing velocity.
∴ The $s \sim t$ graph with decreasing slope represents uniform deceleration, not acceleration.

✓ (2) Slope of $v \sim t$ graph = acceleration.
Slope of $v \sim t$ graph is positive and is a straight line ⇒ a uniform acceleration.

✓ (3) Constant positive acceleration ⇒ uniform acceleration

29. B

Average velocity = $\dfrac{\text{resultant displacement}}{\text{total time taken}}$

$\therefore\ v = \dfrac{3\times 2+4\times 2}{2+5} = 2\text{ m s}^{-1}$

30. C

By $s = \frac{1}{2}gt^2 = \frac{1}{2}(10)t^2 = 5t^2$ (Take g to be 10 m s^{-2} for simplicity.)

Displacement in 1 s : $s_1 = 5\times(1)^2 = 5$ m

Displacement in 2 s : $s_2 = 5\times(2)^2 = 20$ m

Distance travelled in the 1st second = 5 m

Distance travelled in the 2nd second = 20 − 5 = 15 m

Ratio = 5 : 15 = 1 : 3

31. B

By $v^2 = u^2 + 2as$ for the first journey

$\therefore\ (20)^2 = (30)^2 + 2a(100)$ $\therefore\ a = -2.5\text{ m s}^{-2}$

By $v^2 = u^2 + 2as$ for the second journey

$\therefore\ (0)^2 = (20)^2 + 2(-2.5)s$ $\therefore\ s = 80$ m

32. B

slope of $v \sim t$ graph = a

For $t = 0$ s to $t = 10$ s, slope of $v \sim t$ graph is (+) ⇒ a is (+)

For $t = 10$ s to $t = 30$ s, slope of $v \sim t$ graph is 0 ⇒ $a = 0$

For $t = 30$ s to $t = 40$ s, slope of $v \sim t$ graph is (–) ⇒ a is (–)

33. C

$v = \dfrac{s}{t} = \dfrac{120+100}{30+20}$

$\therefore\ v = 4.4\text{ m s}^{-1}$

34. D

As slope of $v \sim t$ graph = acceleration,

When $t = 0$ s to $t = 10$ s, a : (+) ⇒ slope of $v \sim t$ graph : (+)

When $t = 10$ s to $t = 20$ s, a : (+) ⇒ slope of $v \sim t$ graph : 0 (a horizontal line)

When $t = 20$ s to $t = 30$ s, a : (+) with larger value ⇒ slope of $v \sim t$ graph : (+) with larger slope

35. B

× (1) At T_o, the two cars do not have same displacement, therefore, they do not meet each other.

× (2) At T_o, the two cars have the same positive velocity, thus they must move in the same direction.

✓ (3) Car A travels with increasing velocity while car B travels with decreasing velocity

36. B

$v = \dfrac{100\times 1000}{3600} = 27.78\text{ m s}^{-1}$

By $v = u + at$ $\therefore\ (27.78) = (0) + a(3.2)$ $\therefore\ a = 8.68\text{ m s}^{-2}$

37. C

Assume an arbitrary value (任意數值) for the distance between A and B, say 10 m.

Time taken from A to B = $\dfrac{10}{1}$ = 10 s

Time taken from B to A = $\dfrac{10}{2}$ = 5 s

Average speed = $\dfrac{\text{Total distance travelled}}{\text{Total time taken}} = \dfrac{10+10}{10+5} = 1.33\text{ m s}^{-1}$

38. B

× A. Since the slope represents the speed, a straight line indicates a constant speed without change.

✓ B. Since distance from P is decreasing, it is moving towards P.

× C. Since the speed is constant, acceleration is zero and thus no unbalanced (net) force acting on the car.

× D. Area under a distance-time graph has no physical meaning.

39. A

✓ (1) From the graph, when $s = 20$ m, car P has a smaller value of t.
Thus, P reaches the mark with a shorter time t.

✓ (2) From the graph, before $t = 5$ s, car Q has a larger value of s, car P is behind car Q.
At $t = 5$ s, car P and Q meet and car P is overtaking car Q.

× (3) Average speed = distance / time
In the first 5 s, car P and car Q travel the same distance, so they have the same average speed.

40. C

When the string is broken, the stone has the same initial velocity as the balloon, thus it moves upward at $t = 0$.

So the stone first moves upward (v is positive), at the highest point, it is momentarily at rest ($v = 0$ m s^{-1}), and then falls down (v is negative).

During the whole motion of falling, the stone experiences the same acceleration due to gravity g, thus the slope of the graph is constant and equal to $-g$.

41. D

Area of a velocity-time graph represents the displacement of the car.

42. A

✓ (1) At $t = t_1$, $v = 0$, the car reaches the extreme point and is momentarily at rest, it then reverses its direction of travel.

✓ (2) After $t = t_1$, the car reverses its direction and travels backwards. Thus the car is farthest away at t_1.

× (3) The area from $t = 0$ to $t = t_1$ represents the distance travelled in forward direction while the area from $t = t_1$ to $t = t_2$ represents the distance travelled in backward direction. As the two areas are not equal, the car does not return to its starting point at t_2.

43. D

Distance travelled : $d = 2\pi \times (30) = 188.5$ m

Average speed $= \dfrac{d}{t} = \dfrac{188.5}{15} = 12.6$ m s^{-1}

44. B

By $v^2 = u^2 + 2as$

$\therefore (60)^2 = (0) + 2(2)s$

$\therefore s = 900$ m

45. A

✓ (1) Area under a v-t graph represents the displacement. At time t_1, area of P is greater, thus P travels a greater distance, therefore, P has a greater average speed.

× (2) At time t_1, P and Q have different areas, thus they have different displacements, therefore, they must be at different points.

× (3) At time t_2, the area under the graph of P is greater, thus P should have travelled a greater distance, therefore, P should be ahead of Q.

46. B

Reaction time is the time taken before Patrick takes action to brake the car, thus it is the time interval of the horizontal line.

47. B

Distance travelled = area under the graph from 0 to 5 s

$= \frac{1}{2}(5.0 + 0.8) \times 14$

$= 40.6$ m

48. B

× (1) Average velocity $= \dfrac{\text{resultant displacement}}{\text{total time}}$

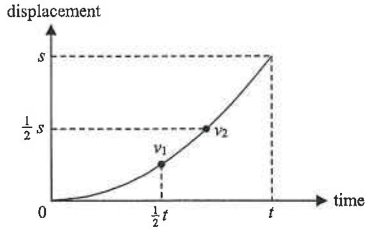
Since the area under the v-t graph represents the displacement, as the areas under the graph for A and B are different, they have different displacement from 0 to T, thus their average velocity must not be the same.

✓ (2) Average acceleration $= \dfrac{v-u}{t}$

As both cars have the same initial velocity u and final velocity v in time T, they must have the same average acceleration.

× (3) Since the areas under the two graphs A and B are different, their displacement must not be the same.

49. A



The displacement-time graph of a car undergoing acceleration is a quadratic curve shown as above.
At half of the time of the journey, the velocity is v_1 that is represented by the slope at that point.
At half of the displacement of the journey, the velocity is v_2 that is represented by the slope at that point.
Consider the slope, v_1 must be smaller than v_2.

OR

As the car is accelerating, the speed is increasing, thus v_2 is greater than v_1.

50. C

Slope of the v-t graph is the acceleration due to gravity g.
Since the acceleration due to gravity on the Moon is smaller, the slope should also be smaller, thus option C is the answer.

51. B

By $s = ut + \frac{1}{2}at^2$ $\quad \therefore (100) = (0) + \frac{1}{2}a(9.77)^2$ $\quad \therefore a = 2.10$ m s^{-2}

52. D

Slope of the velocity-time graph = acceleration

Straight line indicates constant slope, and thus constant acceleration.

The first part is a constant acceleration.

The second part is zero acceleration.

The third part is a constant acceleration with values less than the first part, as the slope is smaller.

53. A

By $v^2 = u^2 + 2as$

When $s = 0, u^2 = 1$ and when $s = 1, v^2 = 2$

$\therefore\ (2) = (1) + 2a(1) \quad \therefore\ a = 0.5 \text{ m s}^{-2}$

54. A

By $v^2 = u^2 + 2as \quad \therefore\ (0) = u^2 + 2(-9.81)(0.5) \quad \therefore\ u = 3.13 \text{ m s}^{-1}$

55. A

By $s = ut + \frac{1}{2}at^2 \quad \therefore\ s = \frac{1}{2}gt^2$

✓ A. As the positions of the stones are closer, i.e. s is smaller, thus a smaller time interval t should be used.

× B. If a longer time interval is used, the positions of the stone should be more separated.

× C. If a lighter stone is used, the positions should be unchanged since g is independent of the mass of stone.

× D. If a heavier stone is used, the positions should be unchanged since g is independent of the mass of stone.

56. D

Area under a $v - t$ graph = displacement

At $t = 10$ s :

displacement of the car $= \frac{1}{2}(10)(10) = 50$ m

displacement of the truck $= (10)(10) = 100$ m

$\therefore$ the car is 50 m behind the truck.

At $t = 20$ s :

displacement of the car $= \frac{1}{2}(20)(20) = 200$ m

displacement of the truck $= (10)(20) = 200$ m

$\therefore$ the car catches up the truck.

57. A

× (1) From the graph, the initial speed of P is about two times of that of Q.

✓ (2) The time interval of the horizontal line is the reaction time, which are the same.

× (3) The total stopping distance is represented by the area under the graph,
thus the total stopping distance of P is greater than that of Q.

58. C

The speed of 50 km h^{-1} should be changed into the SI unit of $50 \times \frac{1000}{3600}$ m s^{-1}.

By $s = ut \quad \therefore\ (500) = (50 \times \frac{1000}{3600})t \quad \therefore\ t = 36$ s

59. A

✓ (1) Displacement is the distance between the starting point and the ending point.
They have same displacement.

× (2) Distance travelled depends on the path, thus the three students have different distance travelled.

× (3) Average speed is the distance travelled per time taken.
Although they take the same time, they have different distance, thus they have different average speed.

60. C

Total distance travelled from P to Q = total area under the graph from 0 s to 2 s

$= \frac{1}{2}(0.3) \times (3) + \frac{1}{2}(2 - 0.3) \times (13) = 11.5$ m

Displacement from P to the water surface = net area under the graph from 0 s to 1.6 s

$= \frac{1}{2}(0.3) \times (3) - \frac{1}{2}(1.6 - 0.3) \times (13) = -8$ m

Thus, height of the platform above water surface = 8 m

61. C

Slope of the distance-time graph represents the speed.

The speed through XY and ZX are the same since they take the same time.

The speed through YZ is smaller as it takes longer time, thus the slope through YZ is lower.

62. C

Since the acceleration due to gravity g is independent of mass,

thus the heavier body of mass 2 m falls with the same g to reach the ground, therefore, the time taken is the same, t.

63. A

Since the slope of the $v - t$ graph is equal to the acceleration due to gravity g,

and g is not affected by the initial velocity, thus the slope should be the same,

that is, the dotted line should be parallel to the original line.

64. B

As slope of $s \sim t$ graph = velocity,

At the 1st ¼ cycle, $v\uparrow$ and v is (+) $\Rightarrow$ slope of s-t graph $\uparrow$ and the slope is (+)

At the 2nd ¼ cycle, $v\downarrow$ and v is (+) $\Rightarrow$ slope of s-t graph $\downarrow$ and the slope is (+)

At the 3rd ¼ cycle, $v\uparrow$ and v is (–) $\Rightarrow$ slope of s-t graph $\uparrow$ and the slope is (–)

At the 4th ¼ cycle, $v\downarrow$ and v is (–) $\Rightarrow$ slope of s-t graph $\downarrow$ and the slope is (–)

65. A

By $v^2 = u^2 + 2as$

Let the speed of the object when it passes Y be v and let the distance between XY be d. Distance between YZ is also d.

$X \to Y$: $v^2 = (10)^2 + 2a(d)$

$Y \to Z$: $(20)^2 = v^2 + 2a(d)$

Combining the above two equations : $v^2 - (10)^2 = (20)^2 - v^2$

$\therefore\ 2v^2 = (10)^2 + (20)^2$ $\qquad \therefore\ v = 15.8\ \text{m s}^{-1}$

66. C

For simplicity, take g to be 10 m s^{-2}.

As both balls are released from rest, $u = 0$.

Displacement of A at time t after A is released : $s_A = ut + \frac{1}{2}at^2 = \frac{1}{2}(10)t^2 = 5t^2$

Displacement of B at time t after A is released : $s_B = 5(t-2)^2$ (Ball B falls at 2 s later)

Maximum separation occurs when A just reaches the ground, that is, A falls for 180 m.

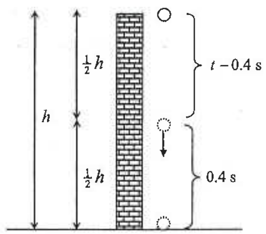
$\therefore\ (180) = 5t^2$ $\qquad \therefore\ t = 6$ s

When A just reaches the ground : $s_B = 5(6-2)^2 = 80$ m

Maximum separation $= 180 - 80 = 100$ m

67. D

Let the height of the building be h and the time taken to reach the ground be t.



By $s = \frac{1}{2}gt^2$ if the motion starts from rest at the top

Motion from top to the mid point : $(\frac{1}{2}h) = \frac{1}{2}g(t-0.4)^2$ .... (1)

Motion from top to the bottom : $(h) = \frac{1}{2}gt^2$ .... (2)

$\frac{(1)}{(2)}$: $\frac{1}{2} = \frac{(t-0.4)^2}{t^2}$ $\qquad \therefore\ t^2 = 2(t-0.4)^2$

Both sides take square root :

$\therefore\ t = 1.414(t-0.4)$ $\qquad \therefore\ 1.414t - t = 1.414 \times 0.4$ $\qquad \therefore\ t = 1.37$ s

68. C

Take $g = 10$ m s^{-2}.

By $s = ut + \frac{1}{2}at^2 = \frac{1}{2}(10)^2 = 5t^2$

After 1 s, $s = 5 \times (1)^2 = 5$ m

After 2 s, $s = 5 \times (2)^2 = 20$ m

After 3 s, $s = 5 \times (3)^2 = 45$ m

Distance travelled in the second sec $= 20 - 5 = 15$ m

Distance travelled in the third sec $= 45 - 20 = 25$ m

Ratio $= 15 : 25 = 3 : 5$

69. C

Distance travelled by the car in 0.5 s $= 18 \times 0.5 = 9$ m

Distance of the girl from the car when the brake is applied $= 36 - 9 = 27$ m

By $v^2 = u^2 + 2as$ $\qquad \therefore\ (0) = (18)^2 + 2a(27)$ $\qquad \therefore\ a = -6$ m s^{-2}

$\therefore$ Minimum deceleration $= 6$ m s^{-2}

70. C

Maximum distance from P = area from 0 to 30 s

$= \frac{1}{2} \times (10 + 30) \times 10 = 200$ m

71. D

× (1) Since car A is moving towards S but car B is moving away from S, they move in opposite directions. As their directions are not the same, their velocities must not be the same.

✓ (2) At t_0, since they are at the same position, they meet each other.

✓ (3) Since they have the same speed, they must have travelled the same distance in the same time.

72. A

✓ (1) As Peter returns to the original position, the resultant displacement is zero.

✓ (2) Average velocity is defined as the total displacement per total time taken. As the total displacement is zero, the average velocity must be zero.

× (3) Assume the distance between P and Q is D.

Time taken to travel from P to Q $= \frac{D}{2}$

Time taken to travel from Q to P $= \frac{D}{4}$

Average speed in whole journey $= \frac{D + D}{D/2 + D/4} = 2.67$ m s^{-1}

73. B

All bodies fall down with the same acceleration g in air where g is the acceleration due to gravity, if air resistance is neglected.

74. A

✓ (1) By $s = \frac{1}{2}gt^2 = \frac{1}{2}(10)(2)^2$ $\qquad \therefore\ s = 20$ m

$\therefore$ mid height $= 20$ m

$\therefore$ height of the building $= 2 \times 20 = 40$ m

× (2) By $s = \frac{1}{2}gt^2$ $\qquad \therefore\ (40) = \frac{1}{2}(10)t^2$ $\qquad \therefore\ t = 2.83$ s

× (3) By $v = gt = (10)(2.83) = 28.3$ m s^{-1}

75. B

Displacement during the first 3 seconds = area under the graph = $\frac{1}{2} \times 3 \times 12 = 18$ m

Average velocity $= \frac{s}{t} = \frac{18}{3} = 6 \text{ m s}^{-1}$

76. C

Average speed $= \frac{d}{t} = \frac{80+70}{20+10} = 5.0 \text{ m s}^{-1}$

77. C

Since the ball falls down with acceleration, $a = +g$.

By $s = ut + \frac{1}{2}at^2$

$\therefore\ s = (5) \times (3) + \frac{1}{2}(9.81) \times (3)^2 = 59.145 \approx 59$ m

78. B

There is no air on Moon, thus there is no air resistance on the feather.

By $v^2 = u^2 + 2as$

$\therefore\ v^2 = (2)^2 + 2\,(9.81 \times 16\%) \times (15)$

$\therefore\ v = 7.15 \text{ m s}^{-2}$

79. C

$\Delta s = s_1 - s_2 = \frac{1}{2}gt^2 - \frac{1}{2}g(t - t_o)^2 = g \cdot t \cdot t_o - \frac{1}{2}g \cdot t_o^2$

As t increases, Δs increases.

Thus the separation Δs increases with time.

80. A

Since the two balls are released at the same time, their displacements are always the same, thus, their separation remains unchanged throughout the flight.

81. C

From the instant of leaving the water surface to that reaching the maximum height :

By $v^2 = u^2 + 2as$

$\therefore\ (0) = u^2 + 2(-10)(0.8)$

$\therefore\ u = 4 \text{ m s}^{-1}$

From the instant of leaving water surface to that of returning back to water surface :

By $s = ut + \frac{1}{2}at^2$

$\therefore\ (0) = (4)t + \frac{1}{2}(-10)t^2$

$\therefore\ t = 0.8$ s

82. A

For ball P : $s_1 = 25t + \frac{1}{2}(-10)t^2$

For ball Q : $s_2 = 15t + \frac{1}{2}(+10)t^2$

By $s_1 + s_2 = 80$

$\therefore\ 25t + 15t = 80 \quad \therefore\ t = 2$ s

Height above the ground $= s_1 = 25 \times (2) + \frac{1}{2}(-10)(2)^2 = 30$ m

83. B

By $s = \frac{1}{2}at^2 \quad (u = 0)$

① $x = \frac{1}{2}a(3^2 - 2^2)$

② $y = \frac{1}{2}a(5^2 - 4^2)$

$\therefore\ x : y = (3^2 - 2^2) : (5^2 - 4^2) = 5 : 9$

84. D

During this time interval, the car travels a total distance d where $d = vt$.

If the car travels in straight line, then the resultant displacement s is equal to d, and the average velocity is 50 km h^{-1}

If the car does not travel in straight line, the resultant displacement s must be less than d, average velocity may be 25 km h^{-1}.

If the car returns to the starting point finally, then $s = 0$, and the average velocity is 0 km h^{-1}.

The resultant displacement s can never be greater than d, thus the average velocity cannot be 75 km h^{-1}.

85. C

By $s = ut + \frac{1}{2}at^2$

$\therefore\ (-30) = (15)t + \frac{1}{2}(-9.81)t^2$

$\therefore\ t = 4.44$ s

86. A

By $s = ut + \frac{1}{2}at^2$

$\therefore\ \Delta s = u(t_2 - t_1) + \frac{1}{2}a(t_2^2 - t_1^2) = (5)(4 - 3) + \frac{1}{2}(2)(4^2 - 3^2) = 12$ m

87. C

Maximum height reached by the ball :

By $v^2 = u^2 + 2as$

$\therefore\ (0) = (16)^2 + 2(-9.81)s$

$\therefore\ s = 13.0$ m

Total distance travelled $= 13.0 \times 2 = 26$ m

88. B

Distance travelled = area under the graph from 0 to 5 s = $\frac{1}{2}(5.0 + 0.8) \times 14 = 40.6$ m

89. C

For simplicity, take g to be 10 m s^{-2}.

For P, $s_P = ut + \frac{1}{2}at^2 = \frac{1}{2}(10)t^2 = 5t^2$

For Q, $s_Q = 5(t-1)^2$

$\Delta s = 5t^2 - 5(t-1)^2 = 10t - 5$

Maximum separation occurs when P just reaches the ground.

$\therefore$ $(80) = 5t^2$ $\therefore$ $t = 4$ s

$\therefore$ $\Delta s_{max} = 10 \times 4 - 5 = 35$ m

90. C

By $s = \frac{1}{2}gt^2 = \frac{1}{2}(10)t^2 = 5t^2$ (Take g to be 10 m s^{-2} for simplicity.)

Displacement in 1 s : $s_1 = 5 \times (1)^2 = 5$ m

Displacement in 2 s : $s_2 = 5 \times (2)^2 = 20$ m

Distance travelled in the 1st second = 5 m

Distance travelled in the 2nd second = 20 – 5 = 15 m

Ratio = 5 : 15 = 1 : 3

91. C

Average speed $= \frac{d}{t} = \frac{10+5}{5+1} = 2.5$ m s^{-1}

92. D

From X to Y: $XY = \frac{1}{2}gt_1^2$

From X to Z: $XY + YZ = \frac{1}{2}g(t_1+t_2)^2$

$\frac{XY}{XY+YZ} = \frac{t_1^2}{(t_1+t_2)^2}$ $\therefore$ $\frac{9}{9+16} = \left(\frac{t_1}{t_1+t_2}\right)^2$

Take root of both sides :

$\therefore$ $\frac{3}{5} = \frac{t_1}{t_1+t_2}$ $\therefore$ $\frac{t_1}{t_2} = \frac{3}{2}$

93. B

× (1) At $t = 1$ s, the velocity of P still remains negative, thus it is still moving in backward direction.

✓ (2) At $t = 2$ s, displacement of P is – 2 m and displacement of Q is + 2 m, thus their separation is 4 m.

× (3) At $t = 4$ s, since the area under the two graphs are not the same, their displacements are not the same, thus, they cannot meet each other.

94. B

Let the initial velocity of the particle be u and the acceleration be a.

By $s = ut + \frac{1}{2}at^2$

Consider the first 4 s :

$\therefore$ $(36) = u(4) + \frac{1}{2}a(4)^2$

$\therefore$ $36 = 4u + 8a$

Consider the whole journey of 6 s :

$\therefore$ $(36 + 36) = u(6) + \frac{1}{2}a(6)^2$

$\therefore$ $72 = 6u + 18a$

Combine the two equations : $a = 3$ m s^{-2}

95. B

Since the particle falls down with acceleration, $a = +g$

By $v^2 = u^2 + 2as$

$\therefore$ $(11)^2 = (2)^2 + 2(9.81)s$

$\therefore$ $s = 6.0$ m

96. D

✓ (1) As the signs of the velocity v of car P and car Q are always positive, both car P and car Q are always travelling in forward direction.

✓ (2) From $t = 0$ to t_1, speed of P is greater than that of Q. Thus, their separation is increasing. From $t = t_1$ to t_2, speed of P is smaller than that of Q. Thus, their separation is decreasing. Therefore, at t_2, the separation between two cars is at a maximum.

✓ (3) The area under v–t graph represents the displacement of the moving body. From $t = 0$ to t_2, the total area under the graph P is greater than that of Q. Therefore, the displacement of car P is greater than that of Q. Thus, car Q lags behind car P at time t_2.

97. A

Displacement of the whole journey : $s = \sqrt{(2.0\times1.5)^2 + (4.0\times1.0)^2} = 5$ m

Average velocity $= \frac{s}{t} = \frac{(5)}{(1.5+1.0)} = 2.0$ m s^{-1}

98. A

Speedometer shows the speed of the car at an instant since speed is a scalar that has magnitude only.

Speedometer can also show the magnitude of the velocity at an instant.

Since velocity is a vector that has both magnitude and direction,

a speedometer cannot show the velocity of the car since it does not indicate the direction of the car.

99. A

✓ A. By average speed = total distance travelled / time taken
For the same path with same distance travelled, shorter time gives greater average speed.

× B. Average velocity = resultant displacement / time taken
An object may have greater distance travelled but smaller resultant displacement
if it has direction changed.

× C. The object with greater velocity may not have greater acceleration, it may have even zero acceleration.

× D. For the same acceleration in forward direction,
an object have travel forward with acceleration,
but another object may travel backward with deceleration.

The following list of formulae may be found useful :

For uniformly accelerated motion $v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

Equation of a straight line $y = mx + c$

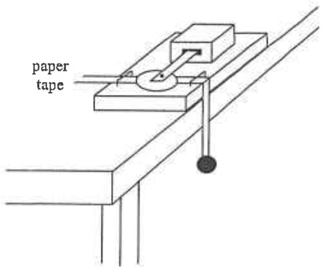
Use the following data wherever necessary :

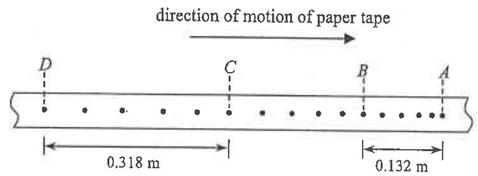
Acceleration due to gravity $g = 9.81\ \text{m s}^{-2}$ (close to the Earth)

Part A : HKCE examination questions

1. **< HKCE 1987 Paper I - 1 >**

The figure below shows an experimental set-up to find the acceleration due to gravity g. The ticker-tape timer produces 50 dots per second. A heavy ball attached to a paper tape is released from rest.





(a) The paper tape obtained from the experiment is shown above. Find the average speed of the heavy ball in the interval AB and CD. Hence calculate the value of the acceleration due to gravity g obtained in this experiment. (4 marks)

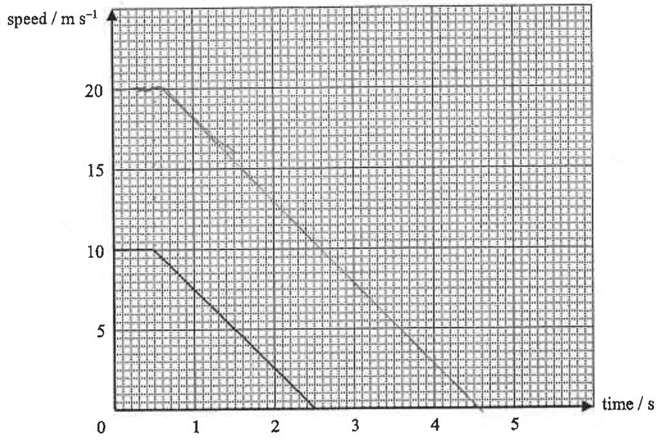
The interval between the every two dots = $\frac{1}{50}$ s
Average speed of AB = $\frac{0.132}{\frac{1}{50}}$ = 1.32 m s^{-1}
Average speed of CD = $\frac{0.318}{\frac{1}{50}}$ = 3.18 m s^{-1}
Acceleration = $\frac{3.18 - 1.32}{0.02 \times 10}$ = 9.3 m s^{-2}

(b) State TWO precautions that should be taken in this experiment. (2 marks)

(c) How would the result of g obtained from the experiment be affected if the metal ball was replaced by a ping-pong ball ? Explain briefly. (2 marks)

2. < HKCE 1992 Paper I - 1 >

A car is travelling at a uniform speed of 10 m s^{-1}. The driver sees a warning signal and applied the brakes to bring the car to rest with uniform deceleration. The figure below shows the speed-time graph of the car, starting from the instant the driver first sees the signal.



(a) Write down the reaction time of the driver, i.e. the time lapse between seeing the signal and starting to apply the brakes. (1 mark)

(b) Find the area under the graph in the above figure. State its physical meaning. (4 marks)

(c) If there is an obstacle 20 m ahead when the driver first sees the signal, would the car hit the obstacle ? Explain your answer. (2 marks)

(d) Assume that the reaction time of the driver and the deceleration of the car remain unchanged.

(i) In the figure above, draw a speed-time graph for the car if it is initially travelling at 20 m s^{-1}. (3 marks)

(ii) A student says 'If the initial speed of the car is doubled, the stopping distance of the car would also be doubled.' State whether his statement is true or false and explain briefly. (3 marks)

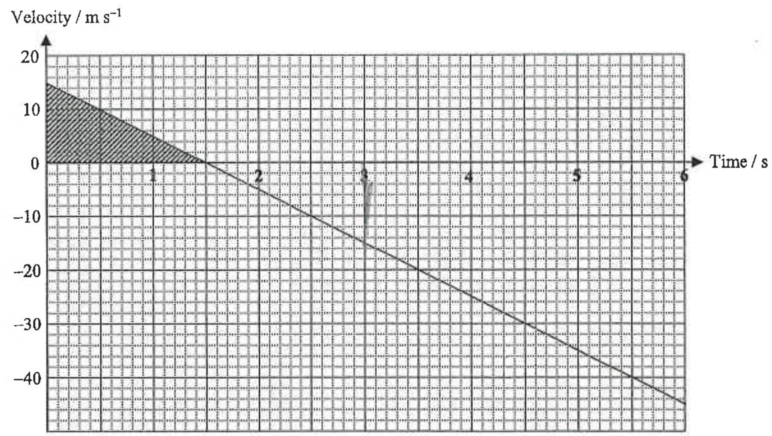
(e) Suggest TWO factors that would affect the deceleration of a car. (2 marks)

3. < HKCE 1993 Paper I - 1 >

A helicopter is initially at rest at a certain level above the ground. It accelerates uniformly and vertically upwards for 75 m and reaches a speed of 15 m s^{-1}. Assume the air resistance is negligible.

(a) Calculate the acceleration of the helicopter. (2 marks)

(b) At this moment, an object is released from the helicopter. The object reaches the ground after 6 s. The figure below shows the velocity-time graph of the object, starting from the instant the object is released. (g is taken to be 10 m s^{-2}.)



(i) Write down the velocity of the object when it reaches the ground. (1 mark)

(ii) State the physical meaning of the area of the shaded region in the figure above. (2 marks)

(iii) Using the above figure, find the height of the object above the ground when it is released. (3 marks)

(iv) Comment on the following two statements : (4 marks)

Statement 1 : At time t = 1.5 s, the acceleration of the object is zero.

Statement 2 : If the object is replaced by a heavier one, it would take the same time to reach the ground.

4. **< HKCE 1996 Paper I - 2 >**

Susan takes part in a 100 m race at an athletic meet. She starts at time $t = 0$ s and accelerate at a uniform rate of 1.6 m s^{-2} for 5 s. She then maintains a uniform speed afterwards and reaches the finishing line at $t = 15$ s.

(a) (i) Find the speed of Susan at $t = 5$ s. (2 marks)

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(ii) Find Susan's average speed for the whole journey. (2 marks)

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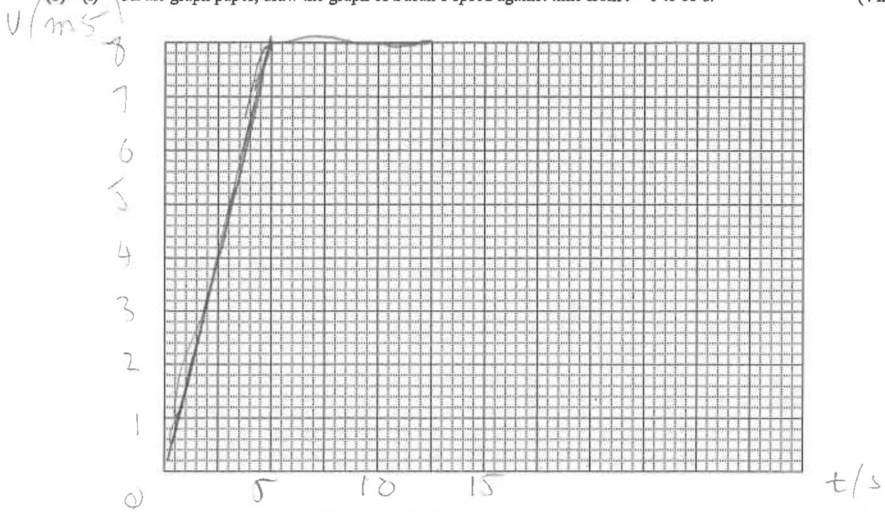
(b) (i) On the graph paper, draw the graph of Susan's speed against time from $t = 0$ to 15 s. (4 marks)



(ii) State the physical meaning of the area under the graph. (1 mark)

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(c) Mary also takes part in the same race. She first accelerates at a uniform rate of 1.5 m s^{-2} for 6 s and then maintains a uniform speed afterwards.

Explain whether Susan or Mary will reach the finishing line first. (4 marks)

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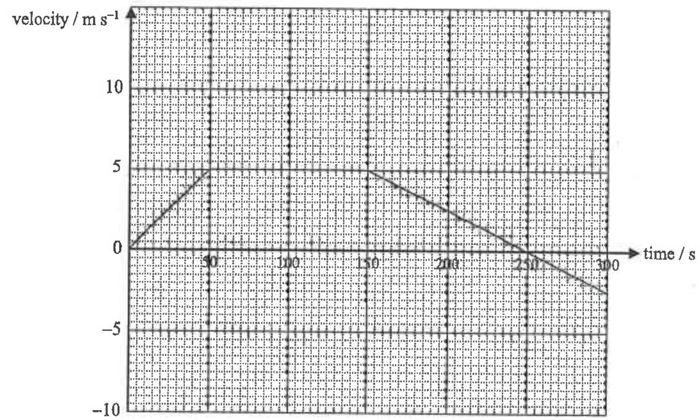
5. **< HKCE 1997 Paper I - 1 >**



A boat starts from rest at time $t = 0$ s and travels along straight line. The Figure above shows the velocity-time graph of the boat from $t = 0$ to 300 s.

(a) Describe the motion of the boat from $t = 0$ to 300 s. (4 marks)

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(b) Find the acceleration of the boat in the first 50 s. (2 marks)

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(c) Draw the acceleration-time graph of the boat from $t = 0$ to 300 s. (3 marks)

(d) Find the distance travelled by the boat in the first 50 s. (2 marks)

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(e) A buoy is located 900 m ahead of the starting point of the boat. Explain whether the boat will pass the buoy during its motion as shown in the Figure above. (3 marks)

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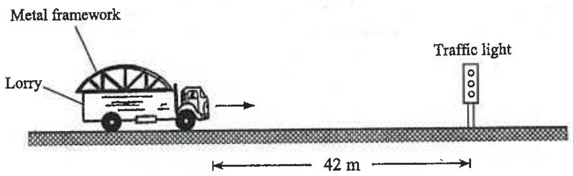
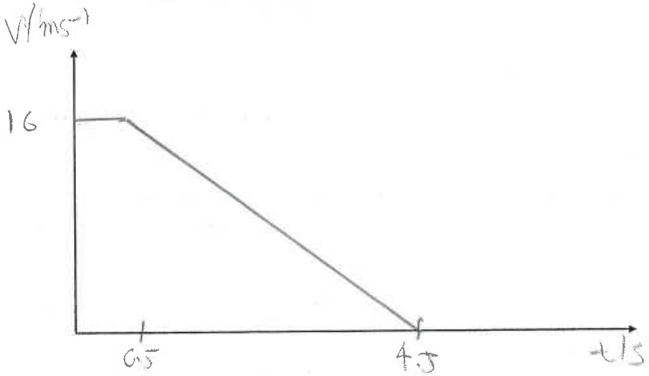
6. **< HKCE 1999 Paper I - 7 >**



A lorry is travelling at a uniform speed of 16 m s^{-1} along a straight road. At time t = 0, the driver observes that a traffic light, which is at a distance of 42 m from the lorry, is turning red. The driver applies the brake at t = 0.5 s. The lorry then decelerates uniformly and comes to a rest at t = 4.5 s.

(a) Sketch the speed-time graph of the lorry from t = 0 to 4.5 s. (3 marks)



(b) Find the deceleration of the lorry from t = 0.5 to 4.5 s. (1 mark)

(c) Explain whether the lorry will stop in front of the traffic light. (3 marks)

7. **< HKCE 2000 Paper I - 7 >**

Susan uses the following method to examine John's reaction time :

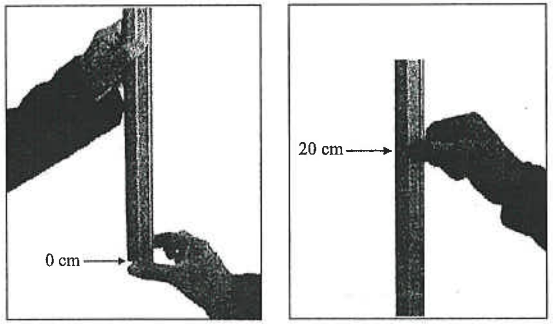


Figure 1 **Figure 2**

She holds a graduated ruler upright with the zero mark starting at the bottom. John lines up his fingers near the bottom of the ruler. (See Figure 1.) Without any warning, Susan releases the ruler and John grips the ruler with his finger as fast as possible. It is found that John grips at the 20 cm mark of the ruler. (See Figure 2.) Take the acceleration due to gravity g to be 10 m s^{-2}.

(a) Show that John's reaction time is 0.2 s. (2 marks)

(b) If a heavier ruler is used, how would the result of the above test be affected ? Explain your answer. (2 marks)

(c) Susan marks the other side of the ruler as shown in Figure 3 so that the reaction time can be read directly.

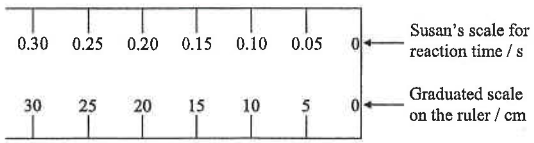


Figure 3

Explain whether Susan's scale for the reaction time is correct or not. (3 marks)

8. **< HKCE 2002 Paper I - 8 >**

A car is travelling with a speed u on a road. The stopping distance of the car includes two parts :

① the thinking distance ℓ

(i.e. the distance travelled after the driver has seen a danger and before the brakes are on).

② the braking distance s

(i.e. the distance travelled after the brakes have been put on).

Figure 1 shows the variations between ℓ and s with u.

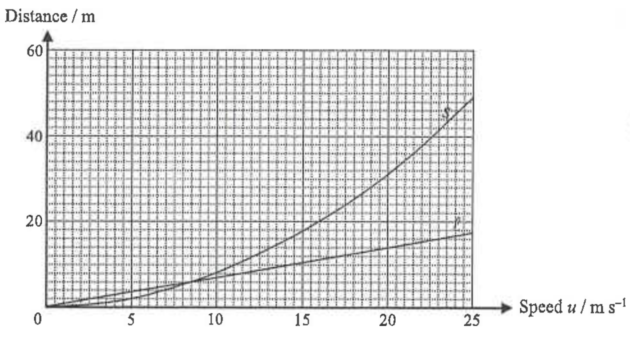


Figure 1

(a) Find the slope of the straight line in Figure 1 and state its physical meaning. (3 marks)

(b) Assume that the deceleration a of the car remains unchanged at different speeds. Write down an equation relating u, s and a. Using Figure 1, find the value of a. (3 marks)

8. (c) A boy was hit by the car when he was crossing a zebra-crossing. Figure 2 below shows a sketch of the accident drawn by the police. Let d be the distance between the car and the boy at the moment the driver first observed the boy. The driver applied the brakes and a skid mark 36.0 m long was left on the road. After hitting the boy, the car travelled a distance of 19.7 m before coming to rest. You may neglect the change in speed of the car during the impact.

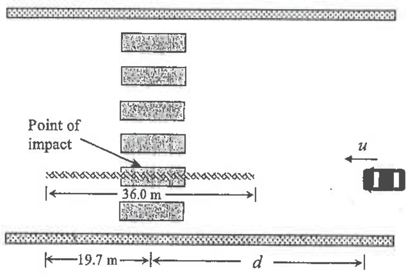


Figure 2

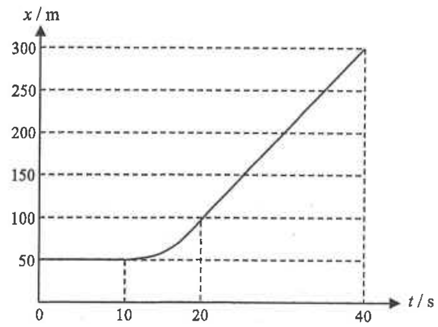
(i) Write down the braking distance of the car. (1 mark)

(ii) Using Figure 1, estimate the value of u. (1 mark)

(iii) Estimate the thinking distance and the value of d. (3 marks)

(iv) The speed limit of the road is 50 km h^{-1} (i.e. 13.9 m s^{-1}). If the car is travelling at this speed, explain whether it would hit the boy. (3 marks)

9. **< HKCE 2005 Paper I - 1 >**



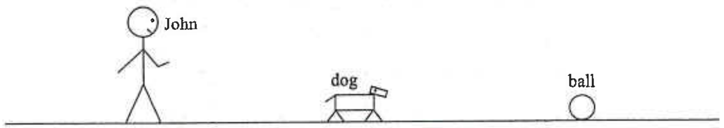
9. A car moves along a straight road. The Figure above shows the variation of the displacement x of the car from a certain point on the road with time t.

(a) Describe the motion of the car from $t = 0$ to 40 s. (3 marks)

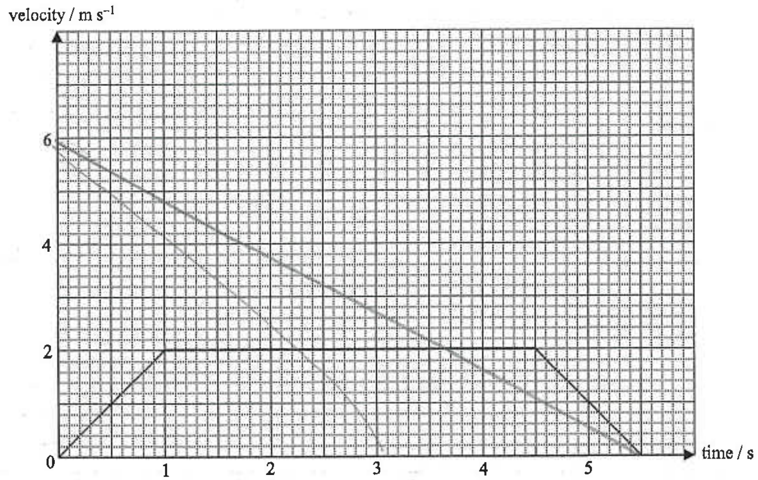
(b) Find the average velocity of the car from $t = 0$ to 40 s. (2 marks)

10. **< HKCE 2011 Paper I - 2 >**

On a horizontal grassland, John rolls a ball for his dog to catch. At time $t = 0$, John stands side by side with the dog and rolls the ball forward in a straight line. The dog immediately starts to run towards the ball. The figure below shows an instant at which the dog is running towards the ball.



The ball stops after a while, and the dog reaches the ball some time later. The velocity-time graph of the dog is shown in the figure below.



10. (a) Describe the motion of the dog between $t = 0$ and 5.5 s. (3 marks)

(b) The dog reaches the ball at $t = 5.5$ s. How far did the ball roll ? (2 marks)

(c) John rolls the ball with an initial velocity of 6 m s^{-1} and it decelerates uniformly afterwards. Draw the velocity-time graph of the ball in the above figure. (2 marks)

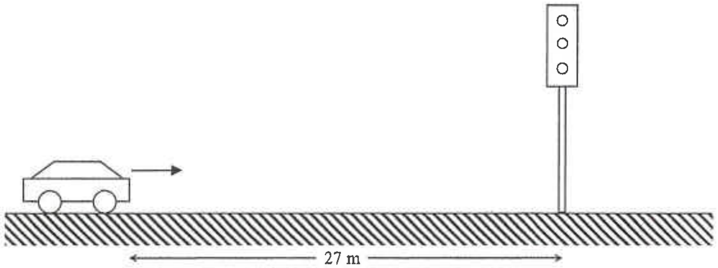
Part B : Supplemental exercise

11. (a) If you are given a stopwatch and an iron ball, describe how you and your partner can find the height of a building, assuming that the value of g is already known. (2 marks)

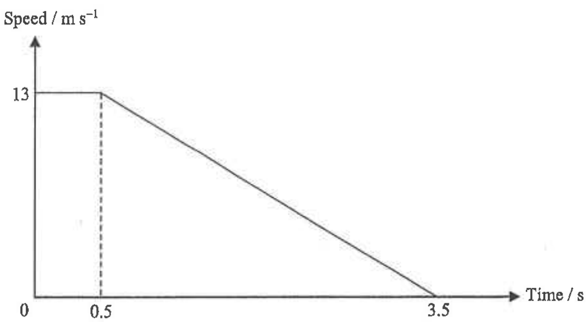
(b) If the ball is released from the top of the building and the time for it to reach the ground is 2 s, estimate the height of the building. (2 marks)

(c) If there is air resistance, what would be the effect on the time taken to reach the ground when the ball is released from the top of the building ? Explain briefly. (2 marks)

12.



A car is travelling at a speed of 13 m s^{-1} along a straight road. At time $t = 0$, the car is 27 m from a traffic light and the light turns from green to yellow at this moment. The driver applies the brakes to stop the car. It is known that the red light will be on 3 s after the yellow light is on. The figure below shows the speed-time graph of the car.

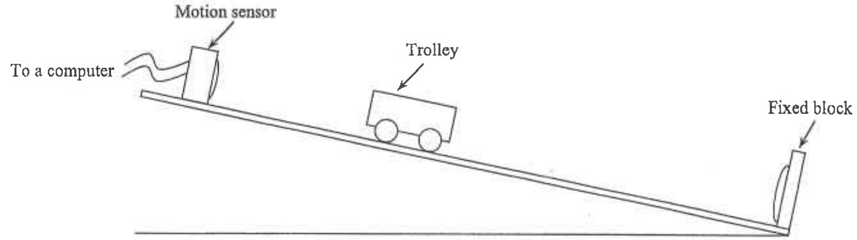


(a) What is the reaction time of the driver ? (1 mark)

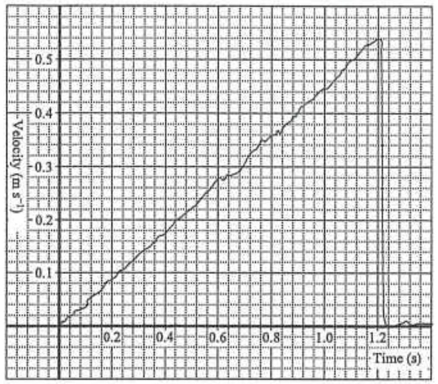
(b) Find the deceleration of the car from $t = 0.5$ to $t = 3.5$ s. (2 marks)

(c) Will the driver be charged for running a red light ? Explain your answer. (3 marks)

13. The figure below shows a data-logging experimental set-up to investigate the motion of a trolley. A trolley is held on an inclined runway and a motion sensor is mounted on the top of the runway to record the velocity of the trolley.



The trolley is released from rest so that it runs downwards along the runway. At the end of the runway, there is a fixed block used to stop the trolley. The velocity-time graph captured by the motion sensor is shown in the figure below.



(a) What is the time taken for the trolley to move from the starting point to reach the end of the runway ? (1 mark)

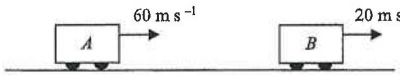
(b) What is the distance travelled by the trolley before it reaches the end of the runway ? (2 marks)

(c) Find the acceleration of the trolley. (2 marks)

Part C : HKDSE examination questions

14. **< HKDSE 2012 Paper IB - 4 >**

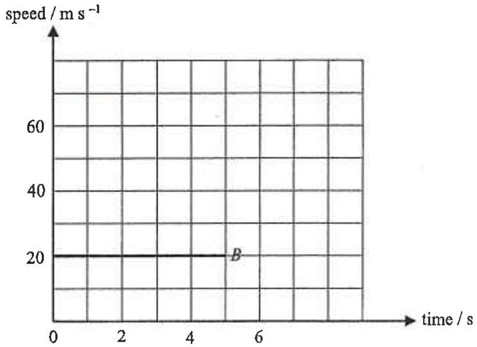
Train A initially travels at a speed of 60 m s^{-1} along a straight horizontal railway. Another identical train B travels ahead of A in the same direction on the same railway. Due to mechanical failure, B is only travelling at 20 m s^{-1}.



At time t = 0, A and B are x m apart, the captain of A receives a stopping signal and immediately A decelerates at 4 m s^{-2} while B continues to travel at 20 m s^{-1}. A eventually collides with B after 5 s. Neglect air resistance.

(a) Find the speed of A just before collision. (2 marks)

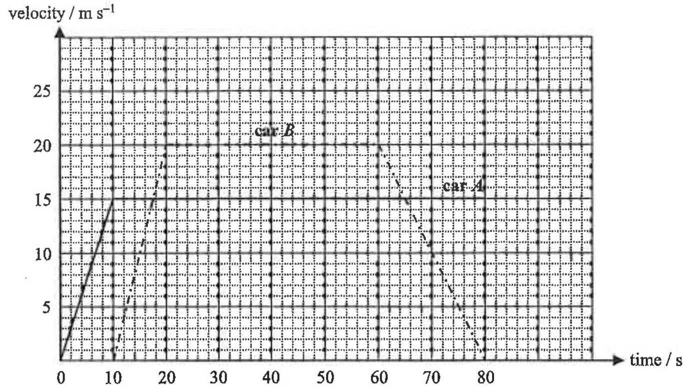
(b) The graph below shows how the speed of B varies with time within this 5 s. Sketch on the same graph the variation of the speed of A within the same period. (1 mark)



(c) Based on the above information, determine the separation x of the two trains at t = 0. (3 marks)

15. **< HKDSE 2014 Paper IB - 3 >**

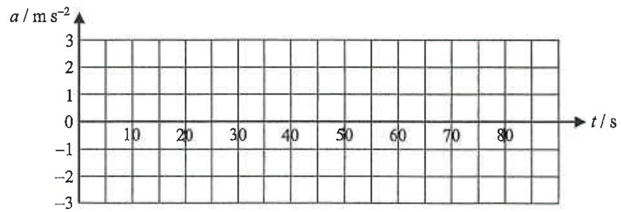
Two cars A and B initially at the same position, start to travel along the same straight horizontal road. The graph below shows how their velocities vary with time.



(a) Describe the motion of car A along the whole journey from t = 0 to t = 80 s. (2 marks)

(b) (i) Which car attained the greatest acceleration throughout the journey ? Find this acceleration. (2 marks)

(ii) Sketch the acceleration-time (a - t) graph of car B from t = 0 to t = 80 s. (2 marks)



(c) (i) At t = 20 s, what is the separation between cars A and B ? (2 marks)

(ii) Deduce the time at which car B catches up with car A. (2 marks)

Question Solution

1. (a) $u = \dfrac{0.132}{0.02 \times 5} = 1.32\ \text{m s}^{-1}$ [1]

$v = \dfrac{0.318}{0.02 \times 5} = 3.18\ \text{m s}^{-1}$ [1]

$g = \dfrac{v-u}{t} = \dfrac{3.18 - 1.32}{0.02 \times 10}$ [1]

$= 9.3\ \text{m s}^{-2}$ [1]

(b) ① The ball should be heavy enough so that air resistance is negligible. [1]

② Place polystyrene tile on the ground under the ball so that the ball would not hit the floor directly. [1]

(c) The result of g would be smaller. [1]

Since the air resistance will become significant. [1]

2. (a) Reaction time = 0.5 s [1]

(b) Area $= \frac{1}{2}(0.5 + 2.5) \times 10$ [1]

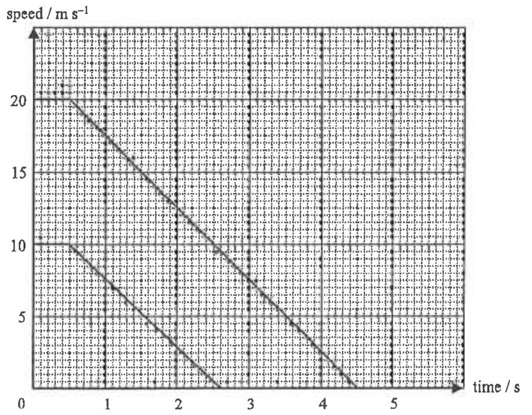
$= 15$ m [1]

Area under the graph is the **stopping distance** of the car. [2]

(c) The car would not hit the obstacle, [1]

since the total stopping distance travelled is 15 m which is less than 20 m. [1]

(d) (i)



< For same reaction time = 0.5 s > [1]

< For same slope > [1]

< For stopping time at $t = 4.5$ s > [1]

2. (d) (ii) False [1]

If initial speed is doubled, the area under the graph is not doubled. [2]

< **OR** >

False [1]

Area under the graph = stopping distance of the car $= \frac{1}{2}(0.5 + 4.5) \times 20 = 50$ m [1]

50 m is not doubled of the original 15 m. [1]

(e) Any **TWO** of the following : [2]

* Braking force of the car
* Number of passengers in the car **OR** Mass of the car
* Nature of the road surface **OR** Tyre condition
* Gradient of the road **OR** Angle of inclination of the road

3. (a) By $v^2 = u^2 + 2as$ [1]

$\therefore$ $(15)^2 = 0 + 2a(75)$

$\therefore$ $a = 1.5\ \text{m s}^{-2}$ [1]

(b) (i) $v = -45\ \text{m s}^{-1}$ [1]

(ii) The area represents the displacement (**OR** distance travelled) of the object [1]

in its upward motion. [1]

< **OR** >

The area represents the upward displacement of the object. [2]

(iii) Height = Area of graph below t-axis – area of shaded region [1]

$= \frac{1}{2} \times 45 \times 4.5 - \frac{1}{2} \times 15 \times 1.5$ [1]

$= 90$ m [1]

< **OR** >

Displacement $= \frac{1}{2} \times 15 \times 1.5 - \frac{1}{2} \times 45 \times 4.5$ [1]

$= -90$ m [1]

Height = 90 m [1]

(iv) Statement 1 : Incorrect (**OR** false) [1]

The acceleration of the object at $t = 1.5$ s is equal to the acceleration due to gravity. [1]

< **OR** >

The acceleration of the object at $t = 1.5$ s is equal to $-10\ \text{m s}^{-2}$ from the graph, which is not zero. [1]

Statement 2 : Correct (**OR** true) [1]

Acceleration due to gravity is independent of the mass of the object. [1]

4. (a) (i) Speed of Susan at 5 s $= a\,t$

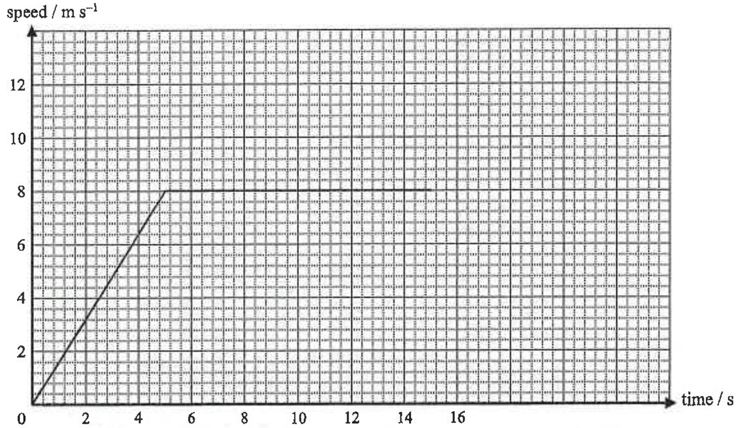
$= 1.6 \times 5$ [1]

$= 8 \text{ m s}^{-1}$ [1]

(ii) Average speed of Susan for the whole journey $= \dfrac{100}{15}$ [1]

$= 6.67 \text{ m s}^{-1}$ [1]

(b) (i)



< Two axes labelled with unit correctly > [1]

< From 0 s to 5 s, straight line with positive slope > [1]

< From 5 s, horizontal line > [1]

< Whole graph is correct > [1]

(ii) The area under the graph represents the distance travelled by Susan. [1]

OR

The area under the graph represents the displacement of Susan. [1]

(c) Distance travelled by Mary in the first 6 s $= \frac{1}{2} a\,t^2$

$= \frac{1}{2} \times (1.5) \times (6)^2$

$= 27 \text{ m}$ [1]

Speed of Mary at 6th second $= 1.5 \times 6 = 9 \text{ m s}^{-1}$

Time to cover the remaining journey $= \dfrac{100-27}{9} = 8.11 \text{ s}$ [1]

Total time taken by Mary $= 6 + 8.11 = 14.1 \text{ s}$ [1]

$\therefore$ Mary will win in the race. [1]

5. (a) From $t = 0$ to 50 s, the boat accelerates uniformly. [1]

From $t = 50$ to 150 s, the boat travels with a uniform velocity. [1]

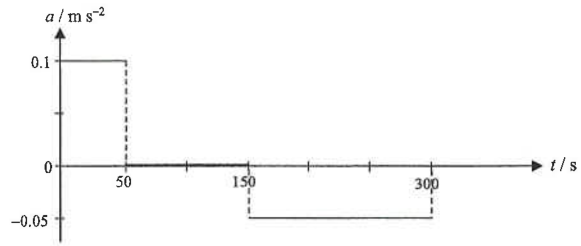
From $t = 150$ to 250 s, the boat decelerates uniformly. [1]

From $t = 250$ to 300 s, the boat travels backwards. [1]

(b) Acceleration = slope of the graph [1]

$= \dfrac{5}{50} = 0.1 \text{ m s}^{-2}$ [1]

(c)



< For $a = 0.1$ from $t = 0$ to 50 s > [1]

< For $a = 0$ from $t = 50$ s to 150 s > [1]

< For $a = -0.05$ from $t = 150$ to 300 s > [1]

(d) Distance travelled in the first 50 s = Area under the v-t graph [1]

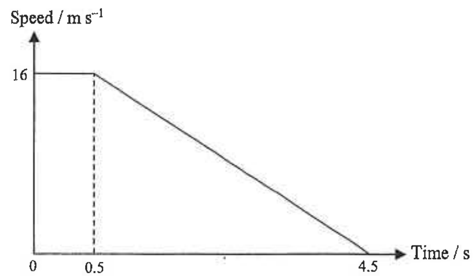
$= \frac{1}{2} \times 50 \times 5 = 125 \text{ m}$ [1]

(e) The boat is farthest away from the starting point at $t = 250$ s. [1]

At $t = 250$ s, distance travelled $= \frac{1}{2} \times (250 + 100) \times 5 = 875 \text{ m}$ [1]

As the farthest distance is smaller than 900 m, the boat will not pass the buoy. [1]

6. (a)



< Two axes labelled with correct unit > [1]

< From 0 to 0.5 s, a horizontal line > [1]

< From 0.5 to 4.5 s, a straight line of deceleration to rest > [1]

6. (b) deceleration = $\frac{16}{4}$ = 4 m s^{-2} [1]

(**OR** acceleration = – 4 m s^{-2}) [1]

(c) Stopping distance = area under the graph [1]

$= 16 \times 0.5 + \frac{1}{2} \times 16 \times 4 = 40$ m [1]

As the stopping distance < 42 m, the lorry will stop in front of the traffic light. [1]

7. (a) $s = ut + \frac{1}{2}at^2$ [1]

$(0.2) = \frac{1}{2}(10)t^2$ ∴ $t = 0.2$ s [1]

(b) The result would not be affected [1]

because the acceleration due to gravity is independent of the mass. [1]

(c) Susan's scale is not correct [1]

Since $s = \frac{1}{2}at^2$ [1]

thus s should be proportional to t^2. [1]

8. (a) Slope of the line = $\frac{14}{20}$ [1]

= 0.7 s [1]

The slope represents the reaction time of the driver. [1]

(b) By $v^2 = u^2 + 2as$

∴ $0 = (u)^2 + 2(-a)s$ ∴ $u^2 = 2as$ [1]

From Figure 1, when s = 20 m, u = 16 m s^{-1} ∴ $(16)^2 = 2a(20)$ [1]

∴ a = 6.4 m s^{-2} [1]

(c) (i) Braking distance = 36 m [1]

(ii) From Figure 1, when s = 36 m, u = 21.5 m s^{-1} [1]

(iii) From Figure 1, when u = 21.5 m s^{-1}, the thinking distance ℓ = 15 m [1]

From Figure 2, d = 15 + 36 – 19.7 [1]

= 31.3 m [1]

(iv) If u is equal to 13.9 m s^{-1}, then the thinking distance ℓ is equal to 10 m

and the braking distance s is equal to 15 m from Figure 1. [1]

Thus the stopping distance is equal to 25 m. [1]

As the stopping distance is smaller than d, the car will not hit the boy. [1]

9. (a) From t = 0 to 10 s, the car remains at rest. [1]

From t = 10 to 20 s, the car moves with acceleration. [1]

From t = 20 to 40 s, the car travels with a uniform velocity. [1]

(b) Average velocity = $\frac{s}{t} = \frac{300-50}{40}$ [1]

= 6.25 m s^{-1} [1]

10. (a) The dog accelerates from rest between t = 0 to t = 1 s. [1]

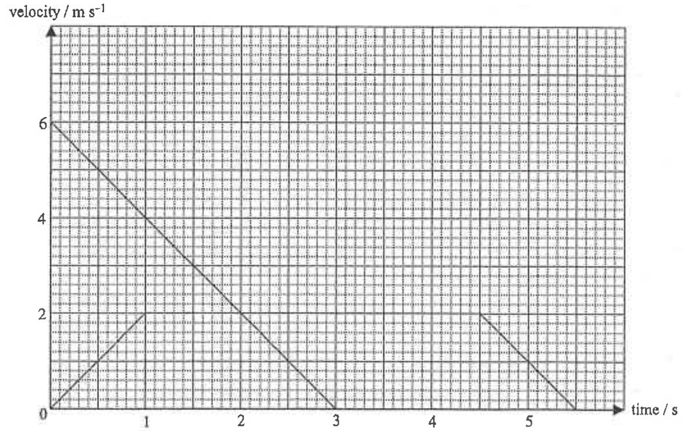
It then maintains a constant velocity between t = 1 to t = 4.5 s. [1]

It then decelerates and stops at t = 5.5 s. [1]

(b) Distance = area under the graph [1]

$= \frac{1}{2}(3.5 + 5.5) \times (2) = 9$ m [1]

(c) [2]



11. (a) The partner should release the iron ball at the top of the building and

I should record the time, t, taken for the ball to fall to the ground. [1]

Then the height of the building can be calculated by $s = \frac{1}{2}gt^2$ [1]

(b) Height of building = $\frac{1}{2}gt^2 = \frac{1}{2}(9.81)(2)^2$ [1]

= 19.6 m [1]

(c) The time taken would be longer [1]

since the acceleration would become smaller due to air resistance. [1]

12. (a) Reaction time = 0.5 s [1]

(b) Deceleration = slope of the graph

$= \frac{13}{3.5 - 0.5}$ [1]

$= 4.33 \text{ m s}^{-2}$ [1]

(c) Stopping distance = Total area under the graph

$= (13) \times (0.5) + \frac{1}{2}(13) \times (3.5 - 0.5)$ [1]

$= 26 \text{ m}$ [1]

Since the stopping distance is less than 27 m, the driver will not be charged. [1]

13. (a) Time taken = 1.2 s [1]

(b) Distance travelled = area from 0 to 1.2 s

$= \frac{1}{2}(0.54) \times (1.2)$ [1]

$= 0.324 \text{ m}$ [1]

(c) Acceleration = slope of the line

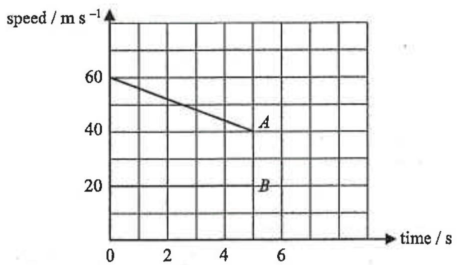
$= \frac{0.54}{1.2}$ [1]

$= 0.45 \text{ m s}^{-2}$ [1]

14. (a) $v = u + at = (60) + (-4)(5)$ [1]

$= 40 \text{ m s}^{-1}$ [1]

(b)



< Straight line from 60 m s^{-1} to 40 m s^{-1} during the 5 s > [1]

(c) Distance travelled by A during the 5 s = area under the graph $= \frac{1}{2}(40 + 60)(5) = 250 \text{ m}$ [1]

Distance travelled by B during the 5 s $= 20 \times 5 = 100 \text{ m}$ [1]

Separation $x = 250 - 100 = 150 \text{ m}$ [1]

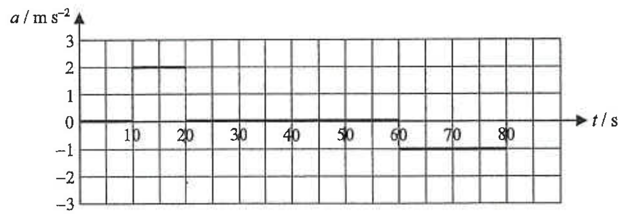
15. (a) From $t = 0$ to 10 s, car A accelerates uniformly. [1]

From $t = 10$ to 80 s, car A travels with the uniform velocity. [1]

(b) (i) Car B attained the greater acceleration. [1]

$a = \text{slope} = \frac{20 - 0}{20 - 10} = 2 \text{ m s}^{-2}$ [1]

(ii)



< Acceleration from 10 s to 20 s and deceleration from 60 s to 80 s correct > [1]

< All correct > [1]

(c) (i) Displacement of car A at 20 s $= \frac{1}{2}(10 + 20) \times (15) = 225 \text{ m}$ [1]

Displacement of car B at 20 s $= \frac{1}{2}(10) \times (20) = 100 \text{ m}$

Separation $= 225 - 100 = 125 \text{ m}$ [1]

(ii) Car B travels faster than car A by 5 m s^{-1}.

$\therefore \Delta s = \Delta v \times \Delta t$ $\therefore (125) = (5) \times \Delta t$ $\therefore \Delta t = 25 \text{ s}$ [1]

The time that car B catches up with car A is at 45 s. [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

FM2 : Newton's Laws

The following list of formulae may be found useful :

For uniformly accelerated motion

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81 \text{ m s}^{-2}$ (close to the Earth)

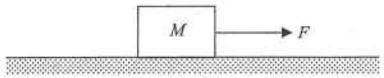
Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 10 >**

A spring balance suspended from the ceiling of a lift registers the weight of a 20 kg body as 150 N. The lift is probably

A. ascending with uniform velocity.
B. ascending with uniform acceleration.
C. descending with uniform velocity.
D. descending with uniform acceleration.

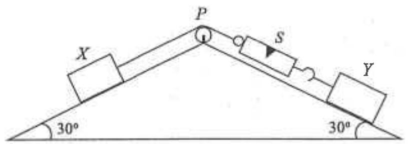
2. **< HKCE 1980 Paper II - 7 >**



A horizontal force F is applied to a block of mass M on a rough horizontal surface. The acceleration of the block is a. If the force is changed to $2F$ and the frictional force remains unchanged, then the acceleration of the block will be

A. greater than $2a$.
B. equal to $2a$.
C. between a and $2a$.
D. less than a.

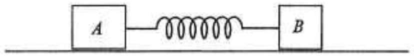
3. **< HKCE 1980 Paper II - 8 >**



In the figure shown, X and Y are blocks of mass 1 kg and 2 kg respectively. S is a spring balance of negligible mass and P is a smooth pulley fixed at the top of two smooth inclined planes. What is the reading of S when X is held stationary by an external force ?

A. 4.9 N
B. 9.8 N
C. 14.7 N
D. 19.6 N

4. **< HKCE 1980 Paper II - 3 >**



Two blocks A and B of masses m_1 and m_2 respectively are connected by a light spring on a horizontal frictionless table. The spring is stretched by moving the blocks apart. What is the ratio of the acceleration of A to that of B at the moment when they are released ?

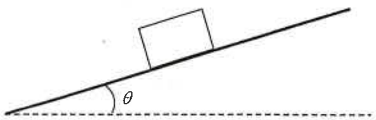
A. $m_1 : m_2$

B. $m_2 : m_1$

C. $m_1^2 : m_2^2$

D. $m_2^2 : m_1^2$

5. **< HKCE 1980 Paper II - 4 >**



An object is resting on a rough plane inclined at an angle θ to the horizontal. As θ gradually increases, the frictional force acting on the object before sliding occurs is directly proportional to

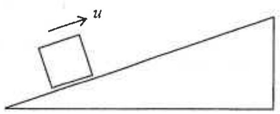
A. 1

B. θ

C. $\sin\theta$

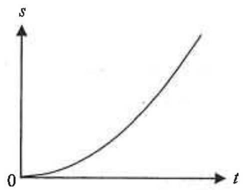
D. $\cos\theta$

6. **< HKCE 1981 Paper II - 9 >**

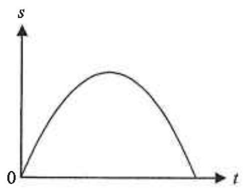


An object is projected up a smooth inclined plane with an initial velocity u. Which of the following graphs best represents the variation of the displacement s of the object along the plane with time t ?

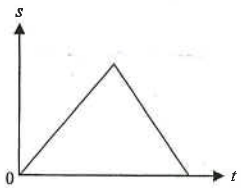
A.



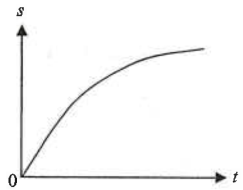
B.



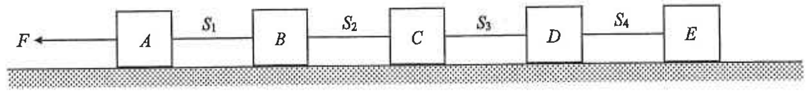
C.



D.



7. **< HKCE 1981 Paper II - 6 >**



Five blocks of equal mass A, B, C, D and E are connected by four identical strings, S_1, S_2, S_3 and S_4 as shown in the figure above. They are made to slide on a smooth horizontal surface by a steadily increasing force F applied to block A. Which of the strings is most likely to break first ?

A. S_1

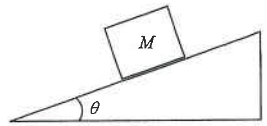
B. S_2

C. S_3

D. S_4

8. **< HKCE 1981 Paper II - 3 >**

A body of mass M rests in equilibrium on a plane inclined at an angle θ to the horizontal. What is the frictional force acting on the body ?



A. zero

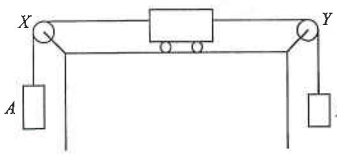
B. Mg

C. $Mg\sin\theta$

D. $Mg\cos\theta$

9. **< HKCE 1981 Paper II - 4 >**

A trolley of mass 1 kg placed on a smooth horizontal table is connected by two light strings to blocks A and B of masses 0.75 kg and 0.25 kg respectively, as shown in the figure. X and Y are frictionless pulleys. When the system is released, what will be its acceleration ?



A. $0\ \text{m s}^{-2}$

B. $1.0\ \text{m s}^{-2}$

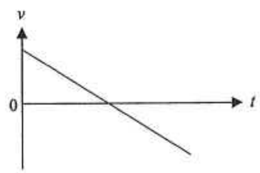
C. $2.5\ \text{m s}^{-2}$

D. $5.0\ \text{m s}^{-2}$

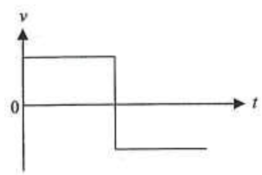
10. **< HKCE 1982 Paper II - 5 >**

A constant force directed to the left is acting on a body which is initially travelling to the right. Which of the graphs below best represents the velocity-time graph of the body ?

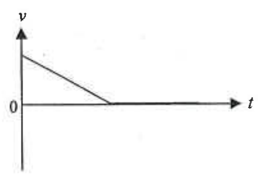
A.



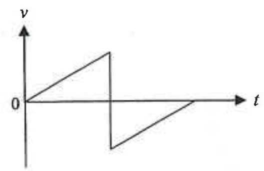
B.



C.

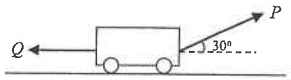


D.



11. **< HKCE 1982 Paper II - 7 >**

A trolley on a smooth horizontal surface is pulled by two forces P and Q in the direction as shown in the figure. The magnitude of P and Q are 2 N and 1 N respectively. If the mass of the trolley is 1 kg, the acceleration of the trolley is



A. 0.15 m s^{-2} towards the left
B. 2.24 m s^{-2} towards the left
C. 0.73 m s^{-2} towards the right
D. 0.15 m s^{-2} towards the right

12. **< HKCE 1983 Paper II - 8 >**

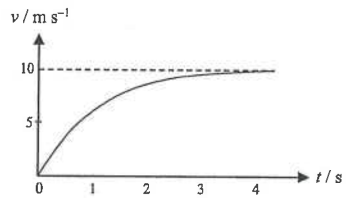
The net force acting on a particle is zero. Which of the statements below concerning the motion of the particle may be true ?
A. The particle is swinging to and fro.
B. The particle is decelerating in a straight line.
C. The particle is moving in a circle with constant speed.
D. The particle is moving with constant velocity.

13. **< HKCE 1983 Paper II - 1 >**

A person in a lift, which is ascending at a velocity of 10 m s^{-1}, releases a ball. What is the velocity of the ball with respect to the earth at the moment when the ball is released ?
A. 10 m s^{-1} upwards
B. 10 m s^{-1} downwards
C. 20 m s^{-1} upwards
D. 20 m s^{-1} downwards

14. **< HKCE 1983 Paper II - 9 >**

The graph shows the variation of velocity v with time t when a metal ball is released from rest and allowed to fall vertically under gravity through oil. Which of the following statements concerning the motion of the ball is/are correct ?



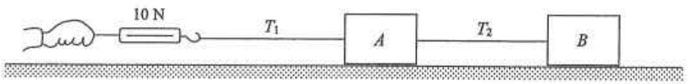
(1) The velocity of the ball decreases with time.
(2) The acceleration of the ball decreases with time.
(3) The ball stops falling after 4 s.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

15. **< HKCE 1984 Paper II - 1 >**

If the engine of a rocket travelling in space is turned off, the rocket will
A. stop moving.
B. continue to move with uniform velocity.
C. continue to move with decreasing velocity.
D. continue to move with uniform acceleration.

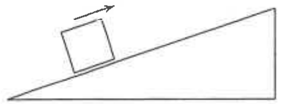
16. **< HKCE 1985 Paper II - 7 >**



Two blocks A and B of masses 1 kg and 1.5 kg respectively are resting on a smooth horizontal surface and are linked by a string. They are pulled by a force of 10 N as shown in the diagram. What are the tensions T_1 and T_2 ?

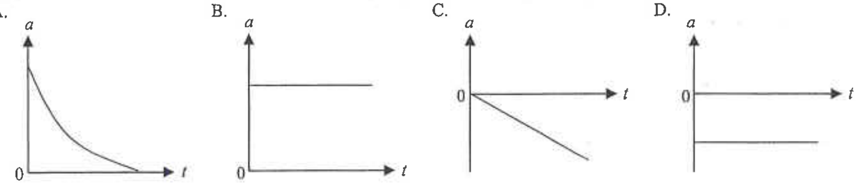
	Tension T_1	Tension T_2
A.	10 N	10 N
B.	10 N	6 N
C.	10 N	4 N
D.	6 N	4 N

17. **< HKCE 1985 Paper II - 10 >**

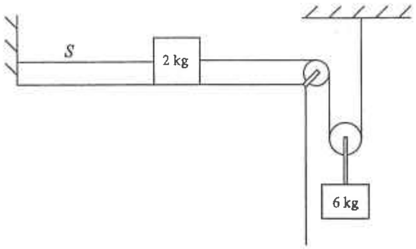


A block is given an initial velocity up a smooth inclined plane. Which graph below shows the acceleration of the block against time ? (The upward direction of motion along the plane is taken as positive.)

A. B. C. D.



18. **< HKCE 1986 Paper II - 5 >**

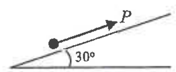


The system of pulleys and blocks is at rest. What is the tension in string S ? (Neglect all friction and the masses of the strings and pulleys.)
A. 9.8 N
B. 19.6 N
C. 29.4 N
D. 39.2 N

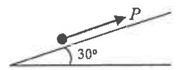
19. **< HKCE 1986 Paper II - 3 >**

Which of the following motions of a given mass requires the greatest force P ? (Assume that the surface is smooth.)

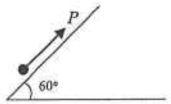
A. upward acceleration = 0 m s^{-2}



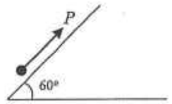
B. upward acceleration = 1 m s^{-2}



C. upward acceleration = 0 m s^{-2}



D. upward acceleration = 1 m s^{-2}



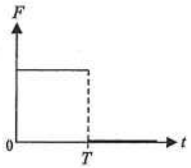
20. **< HKCE 1987 Paper II - 3 >**

Which of the following statements is/are true ? A man in a lift feels heavier when the lift is moving

(1) upwards with acceleration.
(2) upwards with retardation.
(3) downwards with retardation.

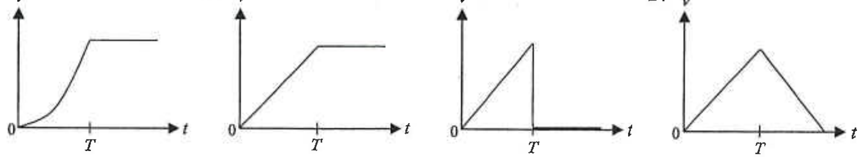
A. (1) only
B. (2) only
C. (1) & (2) only
D. (1) & (3) only

21. **< HKCE 1987 Paper II - 8 >**

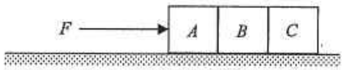


An object is subject to a resultant force (F) which varies with time (t) as shown in the diagram above. Which of the following graphs correctly shows the variation of its speed (v) with time (t) ?

A. B. C. D.



22. **< HKCE 1989 Paper II - 1 >**

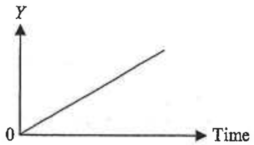


Three blocks of equal mass are placed on a smooth horizontal surface as shown above. A constant force F is applied to block A so that the three blocks move towards the right with the same acceleration. The resultant force acting on block B is

A. 0
B. $\frac{1}{3}F$
C. $\frac{1}{2}F$
D. $\frac{2}{3}F$

23. **< HKCE 1990 Paper II - 4 >**

Y has a linear relationship with time as shown. Y may represent

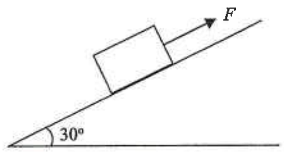


(1) the speed of a body starting from rest under a constant force.
(2) the distance travelled by a body at constant speed.
(3) the acceleration of a body falling from rest.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

24. **< HKCE 1991 Paper II - 9 >**

A force F is applied to a block of mass 1 kg as shown below. The **greatest** value of F for the block to remain at rest is 11 N. What would be the motion of the block if F is not applied ?
(Take the acceleration due to gravity to be 10 m s^{-2}.)



A. remaining at rest
B. sliding down with constant velocity
C. sliding down with an acceleration of 1 m s^{-2}
D. sliding down with an acceleration of 5 m s^{-2}

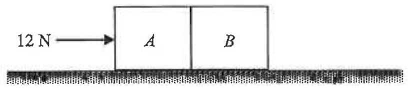
25. **< HKCE 1991 Paper II - 10 >**

A man of weight W stands inside a lift which is moving upwards with a constant speed. If the force exerted by the floor on the man is R, which of the below statements is/are correct ?

(1) R is greater than W in magnitude.
(2) R and W are in opposite directions.
(3) R and W form an action and reaction pair according to Newton's third law.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

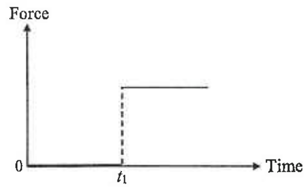
26. **< HKCE 1991 Paper II - 2 >**



Two blocks of equal mass are placed on a smooth horizontal surface as shown above. A constant force of 12 N is applied to block A so that the two blocks move towards the right together. The force acting on A by B is

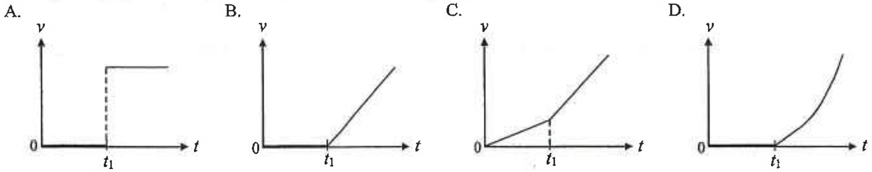
A. 6 N to the left.
B. 6 N to the right.
C. 12 N to the left.
D. 12 N to the right.

27. **< HKCE 1991 Paper II - 7 >**

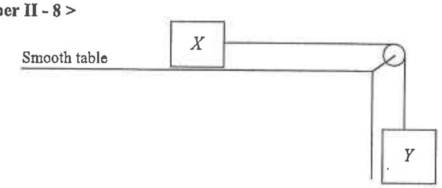


The diagram above shows the variation of the net force acting on an object which is initially at rest. Which of the following velocity-time graphs correctly describes the motion of the object ?

A. B. C. D.



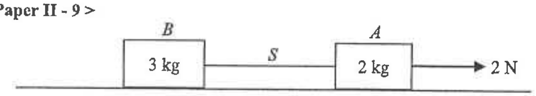
28. **< HKCE 1992 Paper II - 8 >**



Two identical blocks X and Y are connected by a light string passing over a smooth pulley as shown above. The two blocks are released from rest. After a while, the string breaks. Which of the following correctly describes the motion of the blocks immediately after the string breaks ? (Take the acceleration due to gravity to be 10 m s^{-2}.)

	X	Y
A.	stops moving	accelerates at 5 m s^{-2}
B.	moves with constant velocity	accelerates at 5 m s^{-2}
C.	moves with constant velocity	accelerates at 10 m s^{-2}
D.	decelerates at 5 m s^{-2}	accelerates at 10 m s^{-2}

29. **< HKCE 1992 Paper II - 9 >**



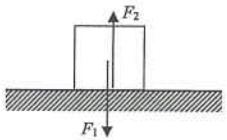
In the diagram above, blocks A and B are connected by a light inextensible string and rest on a smooth horizontal table. The masses of A and B are 2 kg and 3 kg respectively. Block A is pulled by a force of 2 N. Find the tension in the string S.

A. 0.4 N
B. 0.8 N
C. 1.0 N
D. 1.2 N

30. **< HKCE 1992 Paper II - 10 >**

Which of the following pairs of forces F_1 and F_2 is/are action and reaction pair(s) according to the Newton's third law of motion ?

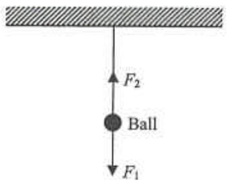
(1)



F_1 = Weight of the block

F_2 = Reaction from the floor

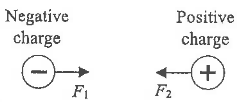
(2)



F_1 = Weight of the ball

F_2 = Tension of the string

(3)



F_1 = Electric force acting on the negative charge

F_2 = Electric force acting on the positive charge

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

31. **< HKCE 1994 Paper II - 6 >**

A man of mass 50 kg is standing in a lift. If the lift is falling freely, which of the following statements is/are true ?

(1) The weight of the man is 0 N.
(2) The force acting on the floor of the lift by the man is 491 N.
(3) The force acting on the man by the floor of the lift is 0 N.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

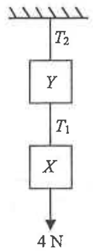
32. **< HKCE 1994 Paper II - 2 >**

A trolley is given a push and runs down a friction-compensated runway. The motion of the trolley is recorded on the paper tape as shown above. Which of the following changes can enable the trolley to produce a paper tape as shown below :

(1) Giving the trolley a harder initial push.
(2) Increasing the angle of inclination of the runway.
(3) Increasing the frequency of the ticker-tape timer.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

33. **< HKCE 1994 Paper II - 4 >**



Two blocks X and Y of weights 2 N and 8 N respectively are suspended by two light strings as shown in the diagram. A downward force of 4 N is applied to X. Find the tension T_1 and T_2 in the two strings.

	T_1	T_2
A.	4 N	10 N
B.	4 N	14 N
C.	6 N	12 N
D.	6 N	14 N

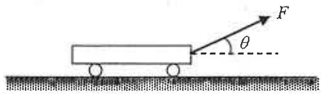
34. **< HKCE 1995 Paper II - 7 >**

A car moves with a speed 30 km h^{-1}. The driver applies the brake and the car is stopped in a distance of 12 m. If the car is moving at 60 km h^{-1}, what is the stopping distance ? Assume that the same constant braking force is applied in both cases.

A. 12 m
B. 24 m
C. 48 m
D. 72 m

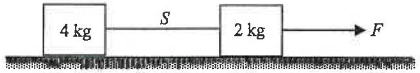
35. **< HKCE 1995 Paper II - 6 >**

A trolley is placed on a horizontal ground. A force F inclined at an angle θ to the horizontal acts on the trolley. What is the horizontal component of F that pulls the trolley towards the right ?



A. $F\theta$
B. $F \sin \theta$
C. $F \cos \theta$
D. $F / \sin \theta$

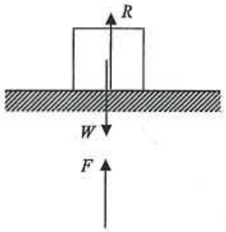
36. **< HKCE 1995 Paper II - 2 >**



Two blocks are connected together by a light string S placed on a smooth horizontal surface. They move with uniform acceleration of 2 m s^{-2} under the action of force F. What will the accelerations of the blocks become if S suddenly breaks ?

	2 kg block	4 kg block
A.	6 m s^{-2}	0 m s^{-2}
B.	6 m s^{-2}	2 m s^{-2}
C.	2 m s^{-2}	0 m s^{-2}
D.	0 m s^{-2}	3 m s^{-2}

37. **< HKCE 1995 Paper II - 11 >**



W : the weight of the block

F : the gravitational force acting on the earth by the block

R : the force acting on the block by the ground

The above diagram shows a block resting on the ground. Which of the following pairs of forces is/are action and reaction pair(s) according to Newton's third law of motion ?

(1) R and W
(2) W and F
(3) F and R

A. (1) only
B. (2) only
C. (3) only
D. (1) & (2) only

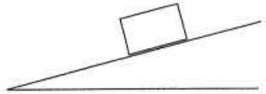
38. **< HKCE 1995 Paper II - 5 >**

Two objects of difference masses are released from rest at the same height. Assume air resistance is negligible. Which of the following statements is/are correct ?

(1) A greater gravitational force is acting on the object with greater mass.
(2) They take the same time to reach the ground.
(3) They have equal velocities when they reach the ground.

A. (1) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

39. **< HKCE 1996 Paper II - 8 >**

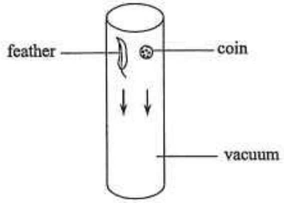


A block remains at rest on an inclined plane as shown above. Which of the following statements is/are true ?

(1) The frictional force acting by the plane on the block is zero.
(2) The normal reaction acting by the plane on the block is zero.
(3) The resultant force acting on the block is zero.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

40. **< HKCE 1996 Paper II - 6 >**



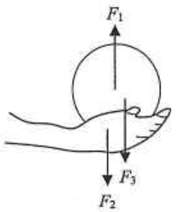
A coin and a feather are released from rest in a cylinder which is vacuum as shown. Which of the following is/are correct deductions from this experiment ?

(1) The masses of the coin and the feather are identical in vacuum.
(2) The coin and the feather fall with the same acceleration in vacuum.
(3) The forces acting on the coin and the feather in vacuum are identical.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

41. **< HKCE 1996 Paper II - 10 >**

The below diagram shows a man lifting a ball vertically upwards with uniform acceleration.



Let F_1 be the force acting on the ball by the man,
F_2 be the force acting on the man by the ball,
F_3 be the gravitational force acting on the ball.

Which of the following correctly describes the relation between the magnitudes of the forces ?

A. $F_1 = F_2 > F_3$
B. $F_1 = F_3 > F_2$
C. $F_1 > F_2 = F_3$
D. $F_1 > F_2 > F_3$

42. **< HKCE 1996 Paper II - 5 >**

Which of the following statements concerning the motion of an object is/are correct ?

(1) A constant unbalanced force is needed to keep an object moving with uniform velocity.
(2) An increasing unbalanced force is needed to keep an object moving with uniform acceleration.
(3) An object may remain at rest if there is no unbalanced force acting on it.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

43. **< HKCE 1996 Paper II - 3 >**

Which of the following statements about mass and weight is **incorrect** ?

A. Mass is measured in kilograms and weight in newtons.
B. Mass is a measure of the inertia of an object and weight is a measure of the gravitational pull on it.
C. The weight of an object at a particular place is proportional to its mass.
D. Both the mass and weight of an object vary slightly at different places on the earth.

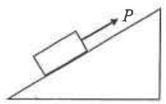
44. **< HKCE 1997 Paper II - 9 >**

Which of the following pairs of forces is/are action and reaction pair(s) according to Newton's third law of motion ?

(1)	The weight of a man standing on a chair.	**and**	The force acting on the man by the chair.
(2)	The gravitational force acting on the earth by the moon.	**and**	The gravitational force acting on the moon by the earth.
(3)	The force exerted by a swimmer on the water to push the water backward.	**and**	The force exerted by the water to push the swimmer forward.

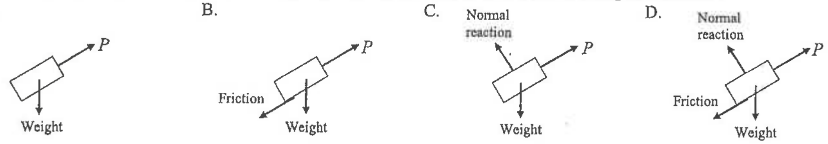
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

45. **< HKCE 1997 Paper II - 4 >**



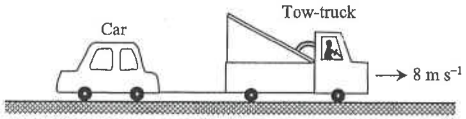
A block is placed on a <u>smooth</u> inclined plane. A force P parallel to the inclined plane is applied to the block so that the block moves up the plane. Which of the following diagrams correctly shows all the forces acting on the block ?

A. B. C. D.



46. **< HKCE 1998 Paper II - 6 >**

A broken-down car of mass 1000 kg is pulled by a tow-truck and moves at a constant velocity 8 m s^{-1} along a horizontal road. It is known that the frictional force acting on the car is 500 N. Find the tension in the cable connecting the truck and the car.



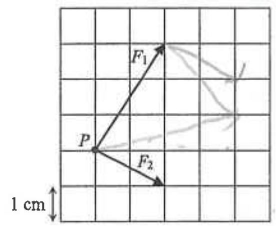
A. 0 N
B. 500 N
C. 8000 N
D. 8500 N

47. **< HKCE 1998 Paper II - 8 >**

A girl in a lift uses a spring balance to measure the weight of an object. The reading of the spring balance is 10 N when the lift is at rest. When the lift is moving, the reading of the spring balance becomes 8 N. Which of the following describes the motion of the lift ?

A. moving downwards with a uniform velocity
B. moving upwards with an acceleration
C. moving downwards with an acceleration
D. moving downwards with a deceleration

48. **< HKCE 1998 Paper II - 7 >**



Scale : 1 cm represents 1 N

Two forces F_1 and F_2 act on a particle P as shown. If a third force F_3 acts on P to keep it in equilibrium, what should be the magnitude of F_3 ?

A. 1.4 N
B. 4.0 N
C. 4.2 N
D. 4.5 N

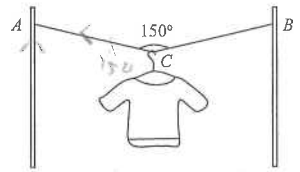
49. **< HKCE 1998 Paper II - 9 >**

Which of the following phenomena can be explained by Newton's first law of motion ?

(1) A passenger in a car tends to move forward when the car suddenly stops.
(2) A coin and a feather fall with the same acceleration in a vacuum.
(3) The maximum mass an astronaut can lift on the moon is greater than on earth.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

50. **< HKCE 1999 Paper II - 5 >**



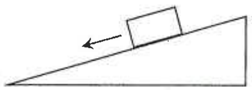
A light rope is fixed at two poles with the ends A and B at the same level. A T-shirt of weight 2 N is hung at the midpoint C of the rope. The rope depresses such that $\angle ACB = 150°$. Find the tension in the rope.

A. 1.0 N
B. 2.0 N
C. 3.9 N
D. 7.7 N

51. < HKCE 1999 Paper II - 4 >

A block is sliding down a friction compensated runway as shown. Which of the following statements is/are correct ?

(1) The speed of the block is increasing.
(2) The normal reaction acting by the runway on the block is increasing.
(3) The net force acting on the block is zero.



A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

52. < HKCE 1999 Paper II - 2 >

A 2 kg steel sphere and a 1 kg wooden sphere are initially held at the same level above the ground and then released from rest simultaneously. Assume air resistance is negligible. Which of the following statements about the two spheres at any instant before they reach the ground is/are correct ?

(1) The speeds of the two spheres are equal.
(2) The accelerations of the two spheres are equal.
(3) The gravitational forces acting on the two spheres are equal.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

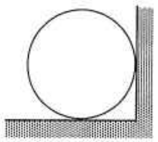
53. < HKCE 2000 Paper II - 2 >

It is said that Galileo Galilei (1564 - 1642), an Italian scientist, dropped a small iron ball and a large cannon ball from the top of the Leaning Tower of Pisa. He found that the two balls reached the ground at almost the same time.
Which of the following is/are correct deduction(s) from this experiment ?

(1) The two balls fell with the same acceleration.
(2) A body will maintain uniform motion if there is no external force acting on it.
(3) The gravitational forces acting on the two balls were identical.

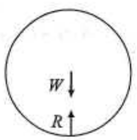
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

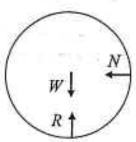
54. < HKCE 2000 Paper II - 8 >

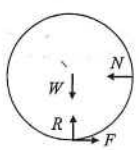


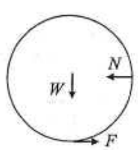
A uniform steel ball lies at rest on a horizontal ground and just touches a vertical wall as shown in the diagram. Which of the following diagrams shows all the forces acting on the ball ?

(Note : W = gravitational force acting on the ball, R = normal reaction from the ground,
F = friction acting by the ground on the ball, N = normal reaction from the wall.)

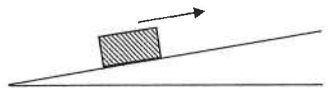
A.


B.


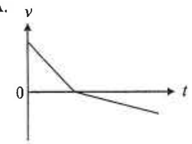
C.


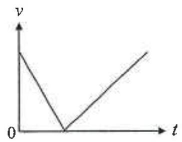
D.


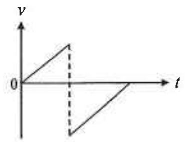
55. < HKCE 2000 Paper II - 7 >

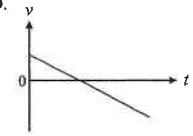


A block is placed on a rough inclined plane and then projected upwards along the plane. After reaching the highest point, the block slides down along the plane. Which of the following graphs shows the time variation of the velocity v of the block ?

A.


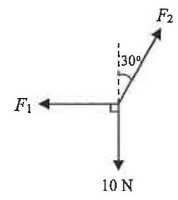
B.


C.


D.


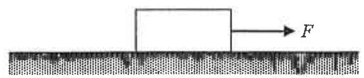
56. < HKCE 2000 Paper II - 6 >

Three forces of magnitudes F_1 , F_2 and 10 N act on an object as shown.
If the object is in equilibrium, find the force F_2.

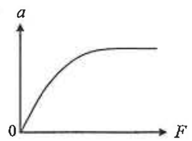


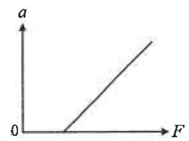
A. 5.0 N
B. 8.7 N
C. 11.5 N
D. 17.3 N

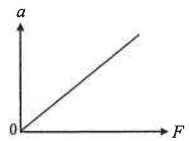
57. < HKCE 2000 Paper II - 9 >

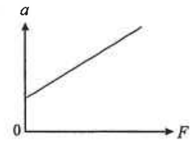


A block is placed on a rough horizontal ground and a horizontal force acts on the block. If the magnitude of the force, F, is increased gradually, which of the following graphs shows the relation between F and the acceleration a of the block ?

A.


B.


C.


D.


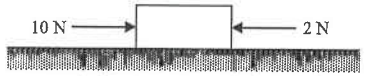
58. < HKCE 2000 Paper II - 5 >

An astronaut lands on the moon and finds that his weight is about one-sixth of that on the earth. Which of the following deductions is/are correct ?

(1) If he throws an object upwards on the moon, it will reach a higher level than throwing the object with the same speed on earth.
(2) If he releases an object on the moon, it will take a shorter time to reach the ground than releasing the object from the same height on earth.
(3) The maximum weight he can lift on the moon is greater than on earth.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

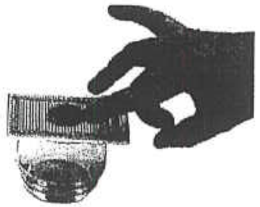
59. **< HKCE 2001 Paper II - 5 >**



A block on a rough horizontal table is acted on by two horizontal forces of magnitudes 10 N and 2 N as shown. It remains at rest on the table. If the force of magnitude 10 N is removed, find the resultant force acting on the block.

A. zero
B. 2 N
C. 6 N
D. 8 N

60. **< HKCE 2001 Paper II - 4 >**

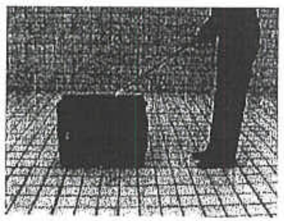


A coin is placed on a piece of cardboard resting on a glass as shown above. If the cardboard is flickered with a finger, the coin will drop into the glass. What does this experiment demonstrate ?

A. The coin will fall with uniform acceleration under the action of gravity.
B. The acceleration of the coin is proportionally to the applied force.
C. Action and reaction always occur in pairs.
D. The coin has a tendency to maintain its state of rest.

61. **< HKCE 2001 Paper II - 9 >**

A man is pulling a suitcase along the horizontal ground as shown below.

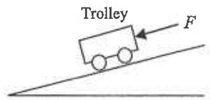


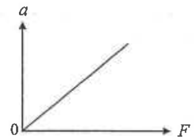
Which of the following pairs of forces is/are action and reaction pair(s) according to Newton's third law of motion ?

(1)	The gravitational force exerted by the earth on the man	**and**	The gravitational force exerted by the man on the earth
(2)	The pulling force exerted by the man on the suitcase	**and**	The friction exerted by the ground on the suitcase
(3)	The gravitational force exerted by the earth on the suitcase	**and**	The normal reaction exerted by the ground on the suitcase

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

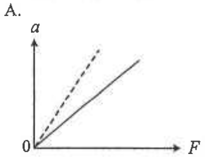
62. **< HKCE 2001 Paper II - 7 >**



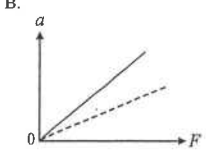


A student uses a friction-compensated runway to study Newton's second law of motion. The variation of the acceleration a of the trolley with the force F applied parallel to the runway is shown above. If the experiment is repeated with the runway making a larger angle of inclination with the horizontal, which of the graphs (in dotted lines) represents the expected result ?

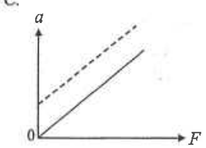
A.



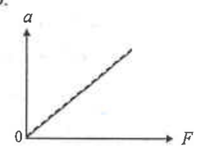
B.



C.



D.



63. **< HKCE 2002 Paper II - 7 >**

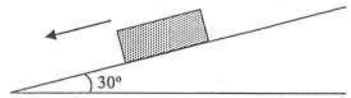
John, of mass 80 kg, is standing on a weighing scale in a lift. At a certain instant, the reading of the weighing scale is 600 N. Which of the following statements about John at this instant is/are correct ?
(Take the acceleration due to gravity to be 10 m s^{-2}.)

(1) The gravitational force acting on John is 600 N.
(2) The force exerted by the weighing scale on John is 200 N.
(3) John is accelerating downward at a rate of 2.5 m s^{-2}.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

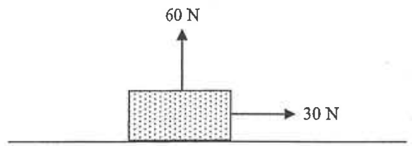
64. **< HKCE 2002 Paper II - 6 >**

A block of mass 0.5 kg slides down a rough inclined plane with an acceleration of 3 m s^{-2}. If the plane is inclined at 30° to the horizontal, find the friction between the block and the plane.



A. 0.95 N
B. 1.47 N
C. 2.75 N
D. 3.92 N

65. **< HKCE 2002 Paper II - 9 >**



A block of weight 100 N is placed on a smooth horizontal table. A vertical force of 60 N and a horizontal force of 30 N are applied to the block as shown. Find the magnitude of the resultant force acting on the block.

A. 30 N
B. 40 N
C. 50 N
D. 67 N

66. < HKCE 2002 Paper II - 4 >

The following are statements written by three students about Newton's first law of motion.

(1) A stationary object will remain in a state of rest unless acted on by an unbalanced force.
(2) An object undergoing uniform motion will maintain its motion unless acted on by an unbalanced force.
(3) An unbalanced force is required to maintain the motion of an object at uniform velocity.

Which of the above statements is/are correct ?

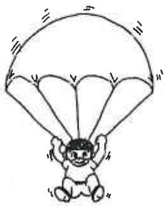
A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

67. < HKCE 2002 Paper II - 5 >

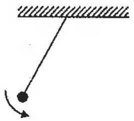
Which of the following objects are under the action of an unbalanced force at the instant shown in the diagrams ?

(1) a **football** being kicked by a player

(2) a **parachutist** falling with uniform velocity

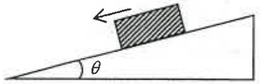


(3) a swinging pendulum **bob**



A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

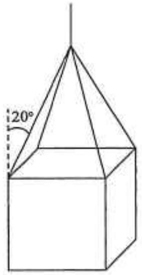
68. < HKCE 2003 Paper II - 5 >



A block of mass m slides down an inclined plane with uniform velocity. What is the net force acting on the block ?

A. mg
B. $mg \sin \theta$
C. $mg \cos \theta$
D. zero

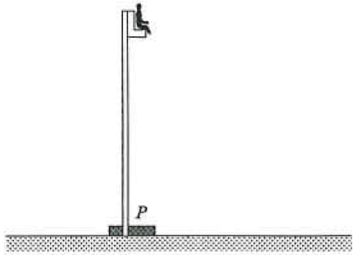
69. < HKCE 2003 Paper II - 7 >



A uniform cube of weight 600 N is held in equilibrium in the air by four identical cables as shown above. If each cable makes an equal angle of 20° with the vertical, find the tension in each cable.

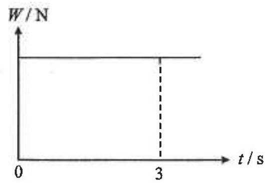
A. 150 N
B. 160 N
C. 412 N
D. 439 N

70. < HKCE 2003 Paper II - 6 >

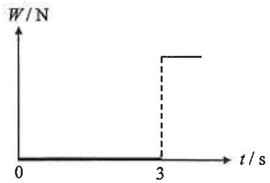


The figure shows a ride in an amusement park. A passenger is fastened to a seat which is then raised to the top of a vertical pole. At time $t = 0$, the seat is released from rest and falls freely. After 3 s, the seat is brought to rest at a point P near the ground. Which of the below graphs best shows the relation between the gravitational force acting on the passenger W and t ?

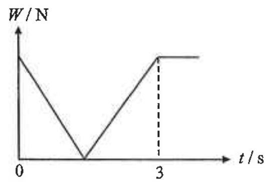
A.



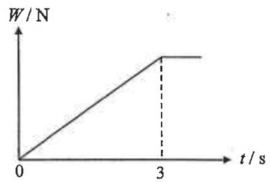
B.



C.



D.



71. < HKCE 2003 Paper II - 8 >

A car accelerates at 3 m s^{-2} along a straight horizontal road. A child of mass 10 kg is sitting on a safety seat inside a car. Find the magnitude of the resultant force exerted by the safety seat on the child.
(Take the acceleration due to gravity to be 10 m s^{-2}.)

A. 30 N
B. 100 N
C. 104 N
D. 130 N

72. < HKCE 2003 Paper II - 12 >

A child is sitting on a chair as shown above. Which of the following pairs of forces is/are (an) action and reaction pair(s) ?

(1)	The gravitational force exerted by the earth on the child.	**and**	The normal reaction exerted by the chair on the child.
(2)	The force exerted by the child on the chair.	**and**	The normal reaction exerted by the chair on the child.
(3)	The force exerted by the chair on the ground.	**and**	The gravitational force exerted by the earth on the chair.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

73. < HKCE 2004 Paper II - 2 >

An object weighs 60 N on the Earth and 10 N on the moon. Which of the following statements are correct ?
(Take the acceleration due to gravity to be 10 m s^{-2}.)

(1) The mass of the object on the Earth is 6 kg.
(2) The mass of the object on the moon is 1 kg.
(3) The acceleration due to gravity on the moon is one-sixth that on the Earth.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

74. < HKCE 2004 Paper II - 5 >

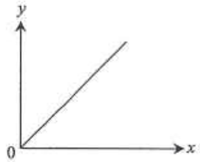
Figure (a) Figure (b)

Two blocks, of masses m_1 and m_2 ($m_1 > m_2$), are connected by a light inextensible string and placed on a smooth horizontal surface. Let T_1 and T_2 be the tensions in the string when a horizontal force of magnitude F is applied to the blocks as shown in Figures (a) and (b) respectively. Which of the following relationships are correct ?

(1) $T_1 > T_2$
(2) $\frac{T_1}{m_1} = \frac{T_2}{m_2}$
(3) $T_1 + T_2 = F$

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

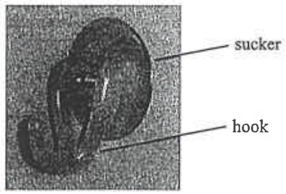
75. < HKCE 2004 Paper II - 7 >



A block is initially at rest on a smooth horizontal table and is pulled by a constant horizontal force. The figure shows the relationship between the physical quantities y and x. Which of the following combinations of y and x is **impossible** ?

	y	x
A.	displacement of the block	square of time
B.	velocity of the block	time
C.	square of velocity of the block	displacement of the block
D.	acceleration of the block	time

76. < HKCE 2004 Paper II - 8 >



The photograph shows a sucker sticking a hook to a vertical wall. Which of the following forces balances the gravitational force acting on the sucker and hook by the Earth ?

A. the friction between the sucker and the wall
B. the force exerted by the air molecules on the sucker
C. the normal reaction exerted by the wall on the sucker
D. the gravitational force acting on the Earth by the sucker and hook

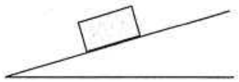
77. **< HKCE 2004 Paper II - 4 >**

An object is acted on by three forces F_1, F_2 and F_3 in suitable directions such that it remains at rest. Which of the following combinations of the magnitude of the forces is/are possible ?

	F_1	F_2	F_3
(1)	3 N	4 N	5 N
(2)	3 N	4 N	7 N
(3)	3 N	5 N	9 N

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

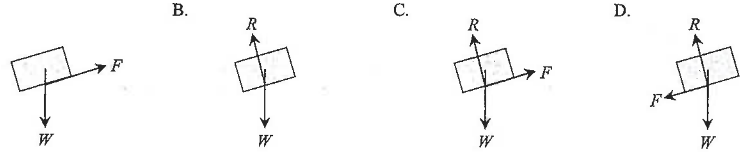
78. **< HKCE 2005 Paper II - 3 >**



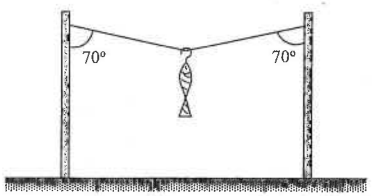
A block remains at rest on a rough inclined plane. Which of the following diagrams shows all the forces acting on the block ?

Note : W = gravitational force acting on the block,
R = normal reaction exerted by the inclined plane on the block, and
F = friction acting on the block.

A. B. C. D.



79. **< HKCE 2005 Paper II - 32 >**



A fish is hung on a light string as shown above. If the tension in the string is 10 N, find the total weight of the fish and the hook.

A. 10 sin 70° N
B. 10 cos 70° N
C. 20 sin 70° N
D. 20 cos 70° N

80. **< HKCE 2005 Paper II - 4 >**

A 1 kg block is pulled by a horizontal force of 5 N and moves with an acceleration of 2 m s^{-2} on a rough horizontal plane. Find the frictional force acting on the block.

A. zero
B. 2 N
C. 3 N
D. 7 N

81. **< HKCE 2005 Paper II - 30 >**

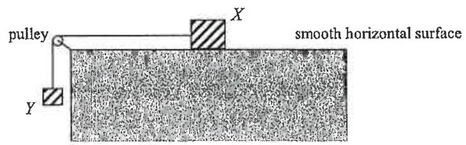
Kelvin is standing on a balance inside a lift. The table shows the readings of the balance in three situations.

Motion of the lift	Reading of the balance
moving upwards with a uniform speed	R_1
moving downwards with a uniform speed	R_2
moving upwards with an acceleration	R_3

Which of the following relationships is correct ?

A. $R_1 = R_2 > R_3$
B. $R_3 > R_1 = R_2$
C. $R_1 > R_2 > R_3$
D. $R_3 > R_1 > R_2$

Questions 82 and 83 :
Two blocks X and Y are connected by a light string passing over a smooth pulley as shown below. The mass of X is greater than that of Y. The blocks are released from rest.



82. **< HKCE 2005 Paper II - 28 >**

Which of the following pairs of physical quantities are **not** equal while the blocks are in motion ?

A. the speeds of the blocks
B. the magnitude of the accelerations of the blocks
C. the magnitude of the resultant forces acting on the blocks
D. the magnitude of the forces exerted by the string on the blocks

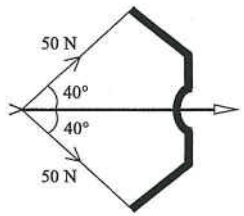
83. **< HKCE 2005 Paper II - 29 >**

Which of the following pairs of forces is an action and reaction pair ?

A. The force exerted by the string on X **and** The force exerted by the string on Y
B. The force exerted by the string on Y **and** The force exerted by Y on the string
C. The gravitational force exerted on X **and** The force exerted by X on the horizontal surface
D. The gravitational force exerted on Y **and** The force exerted by the string on Y

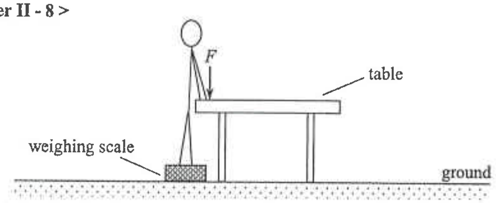
84. **< HKCE 2006 Paper II - 30 >**

A bow is pulled horizontally to create a tension of 50 N on its string as shown in the figure. What is the net horizontal force acting on the arrow when it is released ?



A. 32.1 N
B. 38.3 N
C. 64.3 N
D. 76.6 N

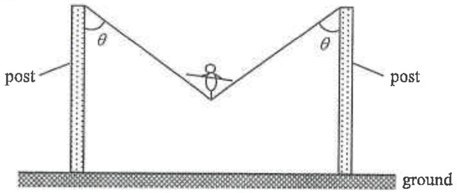
85. < HKCE 2006 Paper II - 8 >



If Peter stands with his feet on a weighing scale placed on level ground, his weight measured by the scale is W. What would be the reading on the scale if he exerts a downward force F on a table top with his hands while he is still standing on the same scale as shown above ?

A. W
B. $W+F$
C. $W-F$
D. F

86. < HKCE 2006 Paper II - 29 >



An acrobat is standing in the middle of a cable as shown. The angle θ is less than 60°. Which of the following relations between the tension T of the cable and the weight W of the acrobat is correct ? (Neglect the weight of the cable.)

A. $T > W$
B. $W > T > \frac{W}{2}$
C. $T = \frac{W}{2}$
D. $T < \frac{W}{2}$

87. < HKCE 2006 Paper II - 31 >

A student performed an experiment to investigate the factors affecting the acceleration of a trolley carrying different loads. The table below shows the data recorded :

Trial	Net Force / N	Total mass of the loaded trolley / kg	Acceleration / m s^{-2}
(i)	2	2	1
(ii)	2	1	2
(iii)	2	0.5	4
(iv)	4	2	2
(v)	4	4	1
(vi)	8	2	4

Which trials can the student use to deduce the relationship between the acceleration and the net force acting on the trolley ?

A. (i), (ii) and (iii)
B. (i), (iv) and (vi)
C. (ii), (iv) and (v)
D. (iii), (v) and (vi)

88. < HKCE 2006 Paper II - 2 >

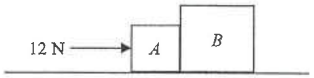
Many traffic accidents on highways are associated with inertia. Which of the following traffic regulations can reduce the risk of traffic accidents due to inertia ?

(1) Passengers should wear seat belts.
(2) Vehicles should not be overloaded.
(3) People should not drive over the speed limit.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

89. < HKCE 2007 Paper II - 3 >

Two blocks, A and B, of masses 1 kg and 3 kg respectively, are placed on a horizontal smooth surface as shown. A horizontal constant force of 12 N is applied to block A so that the two blocks move to the right with uniform acceleration. What is the magnitude of the contact force between A and B ?



A. 3 N
B. 4 N
C. 8 N
D. 9 N

90. < HKCE 2007 Paper II - 5 >

A horse pulls a block along a rough horizontal road and moves with a uniform velocity. Which of the following correctly describes the directions of the friction from the ground acting on the horse and the block ?

	Horse	Block
A.	backward	forward
B.	backward	backward
C.	forward	forward
D.	forward	backward

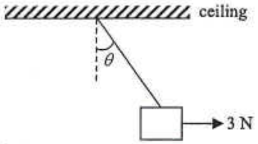
91. < HKCE 2007 Paper II - 6 >

A child is standing on a weighing scale as shown above. Which of the following pairs of forces is/are (an) action and reaction pair(s) ?

(1)	The force exerted by the child on the scale	**and**	The force exerted by the scale on the child
(2)	The gravitational force exerted by the Earth on the child	**and**	The force exerted by the scale on the child
(3)	The gravitational force exerted by the Earth on the scale	**and**	The gravitational force exerted by Earth on the child

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

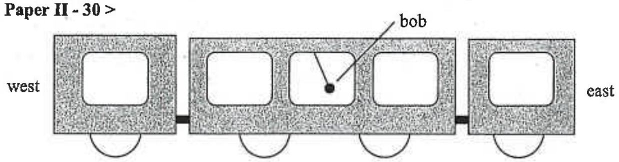
92. **< HKCE 2007 Paper II - 30 >**



In the above figure, a 1 kg block is suspended by a string under the ceiling. The block is pulled by a 3 N horizontal force such that it makes angle θ to the vertical. Which of the following descriptions is correct ? (Note: The tension of the string is denoted as T.)

	θ	T
A.	$\theta < 30°$	$13\text{ N} > T > 10\text{ N}$
B.	$\theta < 30°$	$T > 13\text{ N}$
C.	$\theta > 30°$	$13\text{ N} > T > 10\text{ N}$
D.	$\theta > 30°$	$T > 13\text{ N}$

93. **< HKCE 2008 Paper II - 30 >**



A bob is hung by a string from the ceiling of a train. At a certain instant, the bob is inclined to the east as shown in the figure. Which of the following descriptions about the motion of the train at this instant is/are possible ?

(1) It is moving to the east and decelerating.
(2) It is moving to the west and accelerating.
(3) It starts to move to the east from rest.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

94. **< HKCE 2008 Paper II - 7 >**

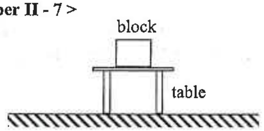


Figure (a)

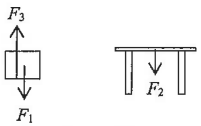


Figure (b)

A block is placed on a table resting on the ground as shown in Figure (a) above. Figure (b) shows the forces acting on the block and the table respectively.

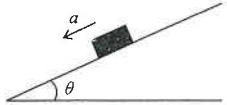
Let F_1 = weight of the block
F_2 = force exerted by the block on the table
F_3 = force exerted by the table on the block

Which of the following statements are correct ?

(1) F_1 and F_2 represent the same force.
(2) F_1 and F_3 balance each other.
(3) F_2 and F_3 form an action-reaction pair.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

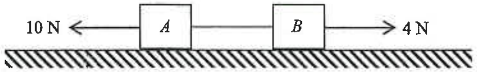
95. **< HKCE 2008 Paper II - 33 >**



A block of mass m slides down along a rough inclined plane with constant acceleration a as shown above. What are the friction and the normal reaction acting on the block ?

	Friction	**Normal Reaction**
A.	$m\,g\sin\theta + m\,a$	$m\,g\sin\theta$
B.	$m\,g\sin\theta - m\,a$	$m\,g\cos\theta$
C.	$m\,g\cos\theta + m\,a$	$m\,g\sin\theta$
D.	$m\,g\cos\theta - m\,a$	$m\,g\cos\theta$

96. **< HKCE 2008 Paper II - 5 >**



Two blocks A and B of the same mass on a horizontal surface are connected by a string as shown above. Two horizontal forces of 10 N and 4 N are acting on A and B respectively. Assume all contact surfaces are smooth. What is the magnitude of the tension in the string ?

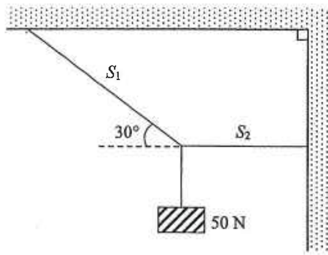
A. 3 N
B. 6 N
C. 7 N
D. 14 N

97. **< HKCE 2009 Paper II - 4 >**

A block of mass 1 kg rests on a rough horizontal plane. When it is pulled by a horizontal force of 5 N, it moves with an acceleration of 2 m s^{-2}. Now, the block is at rest and is pulled by a horizontal force of 2 N, what is the resultant force acting on the block ?

A. zero
B. 1 N
C. 2 N
D. 3 N

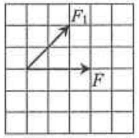
98. **< HKCE 2009 Paper II - 29 >**



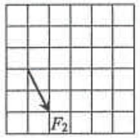
A 50 N block is suspended by two threads as shown in the figure above. Thread S_1 makes an angle 30° with the horizontal and thread S_2 is horizontal. What is the tension in S_2 ?

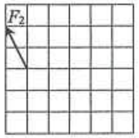
A. 28.9 N
B. 57.7 N
C. 86.6 N
D. 100 N

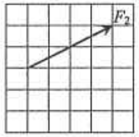
99. **< HKCE 2009 Paper II - 7 >**

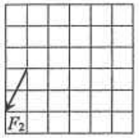


Force F is the resultant of two forces F_1 and F_2 on a horizontal plane. Which of the following diagrams best represents the missing force F_2 ?

A.


B.


C.


D.


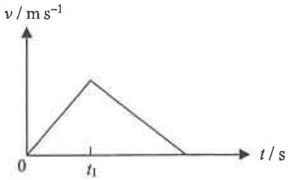
100. **< HKCE 2009 Paper II - 8 >**

An object of weight 120 N on the Earth's surface is taken to the Moon's surface where the acceleration due to gravity is $\frac{1}{6}$ of that at the Earth's surface. What are the mass and the weight of the object at the Moon's surface ?

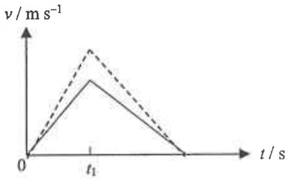
(Take the acceleration due to gravity on the Earth's surface to be 10 m s^{-2}.)

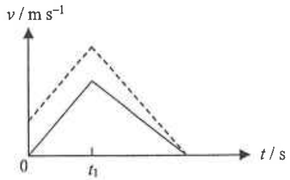
	mass	weight
A.	2 kg	20 N
B.	2 kg	120 N
C.	12 kg	20 N
D.	12 kg	120 N

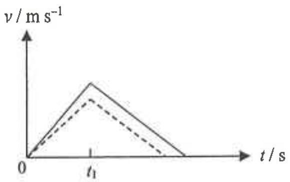
101. **< HKCE 2010 Paper II - 2 >**

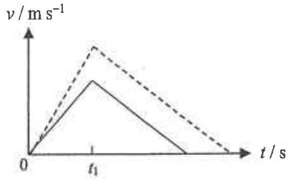


A man pushes a supermarket trolley with a constant horizontal force for t_1 seconds, and then releases the trolley. The velocity-time graph of the trolley is shown above. Assume that the friction between the trolley and the ground is constant, which of the following graphs (in dotted lines) best represents the variation of the velocity of the trolley with time if the man repeats the action with a stronger force ?

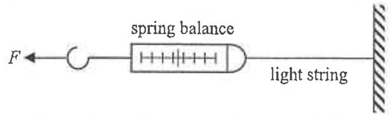
A.


B.


C.


D.


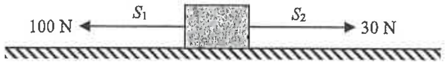
102. **< HKCE 2010 Paper II - 3 >**



A spring balance is connected to the wall by alight string. A horizontal force F is acting on the spring balance as shown below. The spring balance shows a reading of 5 N. Assume that the mass of the balance can be neglected, what is the magnitude of the tension in the string ?

A. zero
B. 2.5 N
C. 5 N
D. 10 N

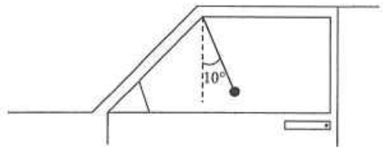
103. **< HKCE 2010 Paper II - 28 >**



A block of mass 4 kg remains at rest on a horizontal rough surface when strings S_1 and S_2 of tensions 100 N and 30 N respectively are pulling it. If S_1 is broken, what is the magnitude of the net force acting on the block ?

A. zero
B. 30 N
C. 50 N
D. 70 N

104. **< HKCE 2010 Paper II - 31 >**



In the figure above, a ball is hanging inside a car by a string. When the car accelerates on a horizontal road, the string makes an angle of 10° with the vertical. Find the magnitude of the acceleration of the car. (Take g to be 10 m s^{-2}.)

A. 1.74 m s^{-2}
B. 1.76 m s^{-2}
C. 5.67 m s^{-2}
D. 9.85 m s^{-2}

105. **< HKCE 2010 Paper II - 30 >**

An object is projected vertically upwards. F denotes the magnitude of the net force acting on the object and W denotes the magnitude of the weight of the object. If air resistance is **not** negligible, which of the following descriptions are correct ?

(1) When the object is moving up, F is greater than W.

(2) When the object is at the highest point, F is equal to W.

(3) When the object is moving down, F is smaller than W.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

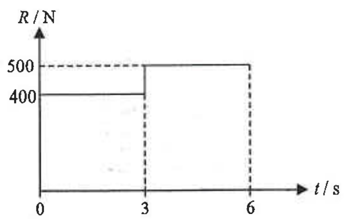
106. **< HKCE 2010 Paper II - 4 >**

A man is standing in a lift. The lift is initially at rest. When the lift starts to move upward, the man feels heavier. Which of the following statements is/are correct ?

(1) The gravitational force acting on the man increases.
(2) The gravitational force acting on the lift increases.
(3) The force acting on the man by the floor of the lift increases.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Questions 107 and 108 :
A man of mass 50 kg stands still on a balance in a lift which is initially moving downwards. Between $t = 0$ and 6 s, the reading R of the balance varies with time as shown in the graph below. Take g to be 10 m s^{-2}.



107. **< HKCE 2011 Paper II - 3 >**

Which of the following statements is/are correct ?
(1) Between $t = 0$ and 3 s, the net force acting on the man is 400 N.
(2) At $t = 3$ s, the lift starts to move upwards.
(3) Between $t = 3$ s and 6 s, the lift is moving at a constant velocity.

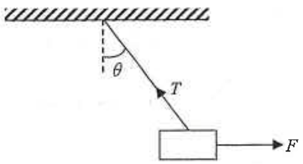
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

108. **< HKCE 2011 Paper II - 4 >**

What is the acceleration of the lift between $t = 0$ and 3 s ?
A. 2 m s^{-2}
B. 6 m s^{-2}
C. 8 m s^{-2}
D. 10 m s^{-2}

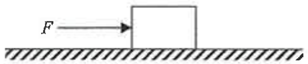
109. **< HKCE 2011 Paper II - 30 >**

In the figure shown, horizontal force F is applied to a block which is hung by a string under the ceiling. At equilibrium, the string makes an angle θ with the vertical and the tension in the string is T. The weight of the block is



A. $F \sin \theta$
B. $F \cos \theta$
C. $T \sin \theta$
D. $T \cos \theta$

110. **< HKCE 2011 Paper II - 5 >**



On a horizontal surface, horizontal force F is exerted on a block as shown in the figure above. When $F = 25$ N, the block remains at rest. Which of the following statements must be correct ?
A. If $F > 25$ N, the block will start to move.
B. If $F = 25$ N, the friction acting on the block will be greater than 25 N.
C. If $F = 20$ N, the friction acting on the block will be 20 N.
D. If $F = 0$, the friction acting on the block will be 25 N.

111. **< HKCE 2011 Paper II - 6 >**

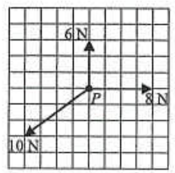
The photo above shows an ant hanging upside down from the ceiling. The ant is holding a 500 mg block using its jaws. The ceiling, the ant and the block are at rest. Which of the following statements is/are correct ?
(1) The force acting on the ant by the ceiling points upwards.
(2) The force acting on the block by the ant and the weight of the block are an action and reaction pair .
(3) The net force acting on the ant is zero.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

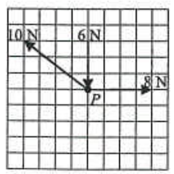
112. **< HKCE 2011 Paper II - 29 >**

Three forces are acting on particle P. In which of the following diagrams is the net force on P **not** zero ?

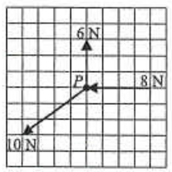
A.



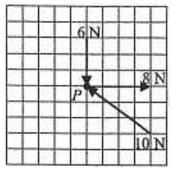
B.



C.



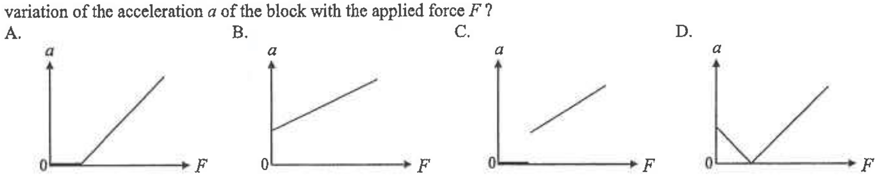
D.



Part B : HKAL examination questions

113. < HKAL 1980 Paper I - 1 >

A block on a rough horizontal plane is subjected to an applied force F. Which one of the graphs below best represents the variation of the acceleration a of the block with the applied force F ?

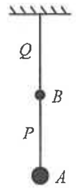


114. < HKAL 1985 Paper I - 2 >

A lift of mass M carries a passenger of mass m. When the lift rises with a uniform acceleration a, the normal reaction between the passenger and the floor of the lift is

A. $m g$.
B. $m(g - a)$.
C. $m(g + a)$.
D. $m(g + a) - Ma$.

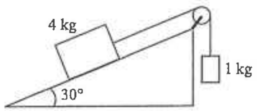
115. < HKAL 1985 Paper I - 1 >



Two bodies A and B are connected by a light string P as shown in the figure. The weights of A and B are 10 N and 4 N respectively. B is connected to the roof by another light string Q. If string Q is cut and the two bodies allowed to fall, the net force acting on B during free fall is

A. 0 N.
B. 4 N.
C. 6 N.
D. 10 N.

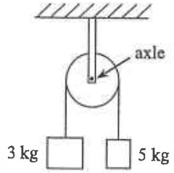
116. < HKAL 1986 Paper I - 1 >



An object of mass 4 kg is placed on a smooth plane inclined at 30° to the horizontal. It is connected by a light string passing over a frictionless pulley to another object of mass 1 kg, as shown above. Take g to be 10 m s^{-2}. If the system is released, the tension in the string will be

A. 12 N.
B. 15 N.
C. 18 N.
D. 25 N.

117. < HKAL 1987 Paper I - 4 >



A block of mass 3 kg is tied to another block of mass 5 kg with a string passing over a fixed smooth pulley. The weight of the pulley is negligible. Take g to be 10 m s^{-2}. When the two blocks are released to move under the action of gravity, the vertical upward force acting on the axle of the pulley is

A. 60 N.
B. 72 N.
C. 75 N.
D. 80 N.

118. < HKAL 1989 Paper I - 7 >

David weighs a load with a spring balance inside a lift. Before the lift moves, the scale reads 50 N. The lift goes down and then stops. The reading on the scale is

A. more than 50 N when the lift starts, and remains steady until it comes to rest.
B. less than 50 N when the lift starts, and remains steady until it comes to rest.
C. more than 50 N as the lift starts, and less than 50 N as it comes to rest.
D. less than 50 N as the lift starts, and more than 50 N as it comes to rest.

119. < HKAL 1991 Paper I - 2 >

A block of mass m moves with constant acceleration a down an inclined plane making an angle θ with the horizontal. The friction acting on the block is

A. $mg - ma$.
B. $mg - ma \sin\theta$.
C. $mg \sin\theta - ma$.
D. $(mg - ma) \sin\theta$.

120. < HKAL 1992 Paper I - 2 >

Peter has a mass of 40 kg. When he measures his weight with a compression balance inside a lift, he discovers that his weight indicated by the balance is 360 N. Take g to be 10 m s^{-2}, the lift is probably

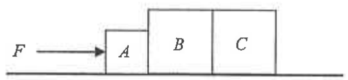
(1) moving upwards and accelerating at 1 m s^{-2}.
(2) moving upwards and decelerating at 1 m s^{-2}.
(3) moving downwards and accelerating at 1 m s^{-2}.
(4) moving downwards and decelerating at 1 m s^{-2}.

A. (1) & (3) only
B. (1) & (4) only
C. (2) & (3) only
D. (2) & (4) only

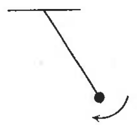
121. < HKAL 1992 Paper I - 1 >

Three blocks A, B and C of masses m, $2m$ and $2m$ respectively are placed on a smooth horizontal ground as shown in the figure. A constant horizontal force F of 20 N is applied to block A so that the three blocks move with the same acceleration towards the right. What is the resultant force acting on block B ?

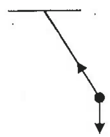
A. 4 N
B. 6 N
C. 8 N
D. 12 N

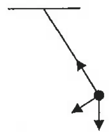


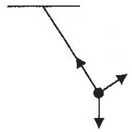
122. < HKAL 1992 Paper I - 3 >

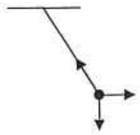


A bob is connected to a light string attached to the ceiling. The string then swings in a vertical plane. When it is at the position shown, which of the following diagrams best represents the forces acting on the bob ? Neglect air resistance.

A. 

B. 

C. 

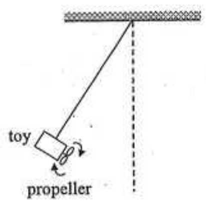
D. 

123. < HKAL 1993 Paper I - 1 >

The resultant of two forces F_1 and F_2 acting at a point has a minimum value of 7 N and a maximum value of 17 N. When the two forces act at right angles to each other, the magnitude of their resultant is

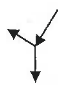
A. 10 N
B. 13 N
C. 18 N
D. 22 N

124. < HKAL 1994 Paper IIA - 1 >



The above figure shows a toy with a propeller driven by a motor inside the toy connected by a light string to a fixed point on the ceiling. The toy remains stationary when the motor is on. Which of the following diagrams correctly represents the forces acting on the toy ?

A. 

B. 

C. 

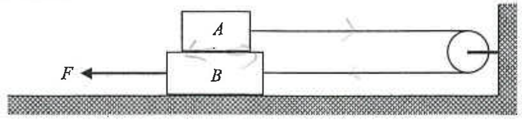
D. 

125. < HKAL 1995 Paper IIA - 1 >

When given a slight push, a block moves freely with constant velocity down a plane inclined at 20° to the horizontal. If the mass of the block is 0.5 kg, find the force parallel to the inclined plane to pull the block up the plane with constant velocity.

A. 1.7 N
B. 3.4 N
C. 4.7 N
D. 6.7 N

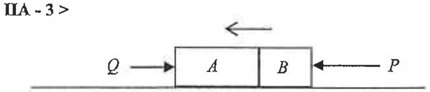
126. < HKAL 1997 Paper IIA - 1 >



Two blocks A and B are connected by a light string which passes over a smooth, fixed pulley as shown in the above figure. The maximum friction between any two surfaces is 1.5 N. If a horizontal force F is applied to block B, find the minimum value of this applied force for moving B.

A. 1.5 N
B. 3.0 N
C. 4.5 N
D. 6.0 N

127. < HKAL 1998 Paper IIA - 3 >



Two blocks A and B of mass ratio 2 : 1 are placed on a horizontal frictionless surface as shown above. P and Q are horizontal forces acting on A and B respectively (with $P > Q$) so that the blocks move to the left with constant acceleration. Find the force acting on B by A.

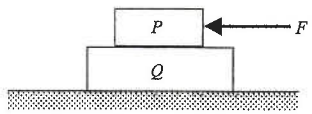
A. $\frac{P-Q}{3}$ B. $\frac{P+Q}{3}$ C. $\frac{2(P-Q)}{3}$ D. $\frac{2P+Q}{3}$

128. < HKAL 2000 Paper IIA - 4 >

Amy holds one end of a string to which a block of mass 8 kg is tied at the other end. She raises the block with a constant acceleration by pulling the string in an upward direction. If the maximum tension that the string can withstand is 100 N, find the maximum acceleration of the block before the string breaks.

A. 2.7 m s^{-2}
B. 3.8 m s^{-2}
C. 4.6 m s^{-2}
D. 7.2 m s^{-2}

129. < HKAL 2000 Paper IIA - 1 >



Two books P and Q are placed on a horizontal table surface as shown. A horizontal force F is applied to P but the system remains stationary. Which of the following statements is/are correct ?

(1) The frictional force acting on Q by the table surface is greater than F.
(2) The frictional force acting on P by Q is towards the right.
(3) The system would remain stationary if F is applied to Q instead.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

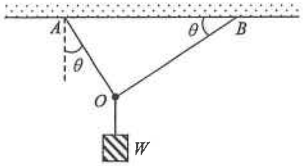
130. < HKAL 2000 Paper IIA - 5 >

A trolley of mass 0.4 kg moves with a certain acceleration down a runway which is inclined to the horizontal at 12°. If the angle of inclination is increased to 18°, the acceleration of the trolley would be doubled. Find the average frictional force, assuming the same in both cases, acting on the trolley.

A. 0.35 N
B. 0.39 N
C. 0.42 N
D. 0.47 N

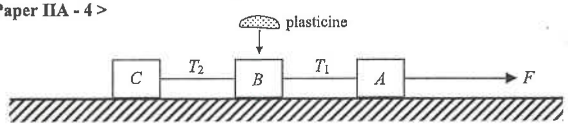
131. < HKAL 2006 Paper IIA - 1 >

A weight W is suspended from the ceiling by inextensible strings as shown. String OA makes an angle θ with the vertical while string OB makes the same angle θ with the ceiling. Find the tension in OB.



A. $W \sin \theta$
B. $W / \sin \theta$
C. $W \cos \theta$
D. $W / \cos \theta$

132. < HKAL 2008 Paper IIA - 4 >

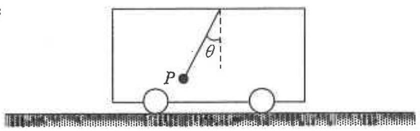


Three blocks A, B and C, connected by light strings, are placed on a smooth horizontal surface as shown. A constant force F is applied to block A so that the whole system travels to the right with acceleration. If a lump of plasticine is placed on B and it moves together with B while the applied force F remains unchanged, how would the tensions T_1 and T_2 in the two strings change ?

	Tension T_1	Tension T_2
A.	decrease	increase
B.	decrease	decrease
C.	increase	increase
D.	increase	decrease

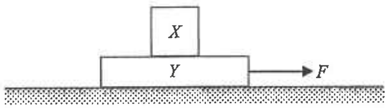
133. < HKAL 2009 Paper IIA - 4 >

A small bob P is suspended by an inextensible string from the ceiling of a vehicle. The vehicle is moving on a straight horizontal road and the string makes an angle θ with the vehicle as shown in the figure. Which of the following description of the acceleration of the vehicle is correct ?



A. $g \sin \theta$ to the left
B. $g \sin \theta$ to the right
C. $g \tan \theta$ to the left
D. $g \tan \theta$ to the right

134. < HKAL 2009 Paper IIA - 3 >

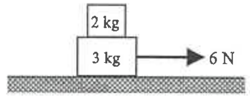


A block X is placed on top of another block Y, which rests on a horizontal surface. The blocks have the same mass m. The block Y is pulled by a horizontal force F as shown. Assume that all contact surfaces are smooth. What is the acceleration of each block ?

	acceleration of X	acceleration of Y
A.	zero	$\frac{F}{m}$
B.	zero	$\frac{F}{2m}$
C.	$\frac{F}{2m}$	$\frac{F}{m}$
D.	$\frac{F}{2m}$	$\frac{F}{2m}$

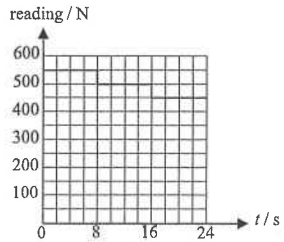
135. < HKAL 2012 Paper IIA - 5 >

A 2 kg block is placed on top of a 3 kg block on a smooth horizontal surface as shown. A horizontal force of 6 N is applied to the 3 kg block such that the two blocks move together. The friction acting between the two blocks is



A. 0 N.
B. 1.2 N.
C. 2.4 N.
D. 3.6 N.

136. < HKAL 2012 Paper IIA - 6 >

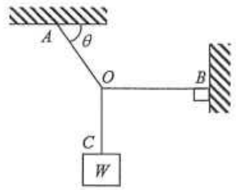


Billy of mass 50 kg stands still on a weighing scale in a lift. The lift starts to ascend at $t = 0$ and comes to rest at $t = 24$ s. The graph shows how the reading of the weighing scale varies within this time interval. What is the corresponding height ascended by the lift ? (Take the acceleration due to gravity to be 10 m s^{-2}.)

A. 192 m
B. 144 m
C. 128 m
D. 96 m

137. < HKAL 2013 Paper IIA - 3 >

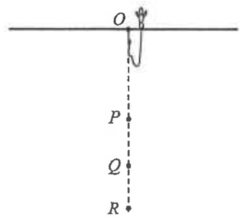
A body of weight W is suspended by three inextensible light strings OA, OB and OC as shown in the figure. OA makes an angle θ with the horizontal while OB is horizontal. The maximum tension that each string can bear is the same. If the weight W gradually increases, which string will break first ?



A. string OA
B. string OB
C. string OC
D. It depends on the value of θ.

138. < HKAL 2013 Paper IIA - 7 >

A boy performs a 'bungee jump' from the top of a bridge. He is connected with a light elastic cord to the bridge at O as shown in the figure. When he falls down from rest at O, the cord starts to stretch at point P. He then passes Q where the tension in the cord is just equal to his weight. Finally, the boy reaches point R where he is momentarily at rest. If air resistance is neglected, which of the following descriptions are correct ?

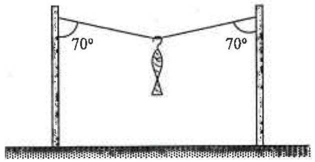


(1) From P to Q, the speed of the boy increases throughout.
(2) At Q, the speed of the boy is the maximum in the falling motion.
(3) At R, the net force acting on the boy is zero.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Part C : HKDSE examination questions

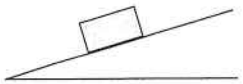
139. **< HKDSE Sample Paper IA - 5 >**



A fish is hung on a light string as shown. If the tension in the string is 10 N, find the total weight of the fish and the hook.

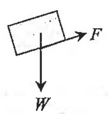
A. 20 sin 70° N
B. 20 cos 70° N
C. 10 sin 70° N
D. 10 cos 70° N

140. **< HKDSE Sample Paper IA - 8 >**

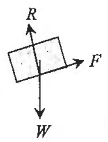


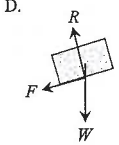
A block remains at rest on a rough inclined plane. Which of the following diagrams shows all the forces acting on the block ?

Note : W = gravitational force acting on the block,
R = normal reaction exerted by the inclined plane on the block, and
F = friction acting on the block.

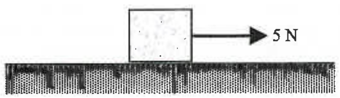
A.


B.


C.


D.


141. **< HKDSE Sample Paper IA - 6 >**



A 1 kg block is pulled by a horizontal force of 5 N and moves with an acceleration of 2 m s^{-2} on a rough horizontal plane. Find the frictional force acting on the block.

A. zero
B. 2 N
C. 3 N
D. 7 N

142. **< HKDSE Sample Paper IA - 9 >**

Kelvin is standing on a balance inside a lift. The table shows the readings of the balance in three situations.

Motion of the lift	Reading of the balance
moving upwards with a uniform speed	R_1
moving downwards with a uniform speed	R_2
moving upwards with an acceleration	R_3

Which of the following relationships is correct ?

A. $R_1 = R_2 > R_3$
B. $R_3 > R_1 = R_2$
C. $R_1 > R_2 > R_3$
D. $R_3 > R_1 > R_2$

143. **< HKDSE Practice Paper IA - 10 >**

As shown in Figure (a), a block slides down along a smooth inclined plane from rest. The corresponding speed-time graph of its motion is shown in Figure (b).

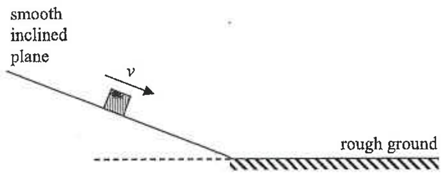


Figure (a)

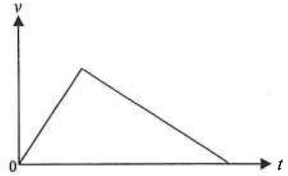
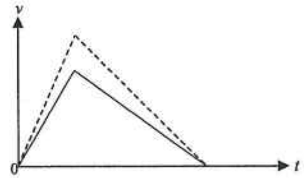
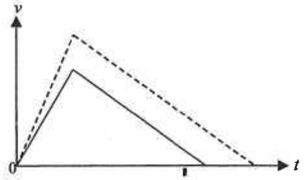
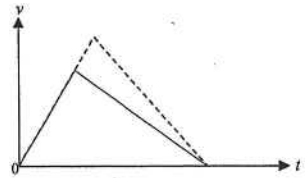


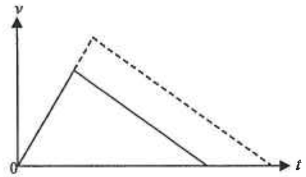
Figure (b)

Which of the following speed-time graphs (in dotted line) best represents the motion of the block if it is released at a higher position on the plane instead ? Assume that the friction between the ground and the block remains unchanged.

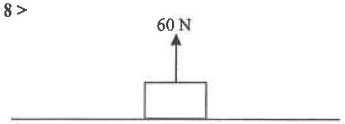
A.


B.


C.


D.


144. < HKDSE Practice Paper IA - 8 >



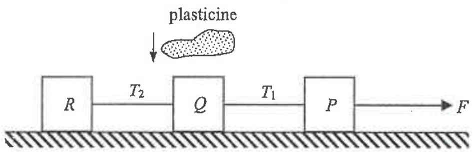
A block of weight 100 N is placed on a horizontal table and a vertical force of 60 N is exerted on the block as shown in the figure above. Which of the following statements is/are correct ?

(1) The weight of the block is balanced by the force exerted on the block by the table.
(2) The weight of the block and the force exerted on the table by the block are equal in magnitude.
(3) The force exerted on the table by the block and the force exerted on the block by the table are an action-reaction pair.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

145. < HKDSE Practice Paper IA - 9 >

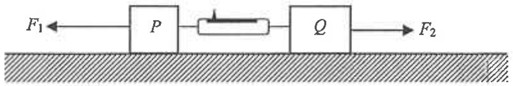
Blocks, P, Q and R, connected by light inextensible threads, are placed on a smooth horizontal surface as shown. A constant force F is applied to P so that the whole system travels to the right with acceleration.



A lump of plasticine is placed on Q and it moves together with Q. If the applied force F remains unchanged, how would the tensions T_1 and T_2 in the two threads change ?

	Tension T_1	Tension T_2
A.	increase	decrease
B.	increase	increase
C.	decrease	decrease
D.	decrease	increase

146. < HKDSE 2012 Paper IA - 8 >



Blocks P and Q of mass m and $2m$ respectively are connected by a light spring balance and placed on a smooth horizontal surface as shown. If horizontal forces F_1 and F_2 (with $F_1 > F_2$) act on P and Q respectively and the whole system moves to the left with constant acceleration, what is the reading of the spring balance ?

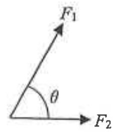
A. $\dfrac{2F_1 - F_2}{3}$

B. $\dfrac{2(F_1 - F_2)}{3}$

C. $\dfrac{2F_1 + F_2}{3}$

D. $\dfrac{F_1 + 2F_2}{3}$

147. < HKDSE 2012 Paper IA - 5 >

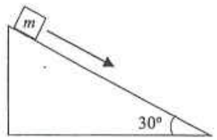


Two forces F_1 and F_2 of constant magnitude act at the same point as shown. When the angle θ between F_1 and F_2 increases from 0° to 180°, the magnitude of the resultant force

A. decreases throughout.
B. increases throughout.
C. decreases and then increases.
D. increases and then decreases.

148. < HKDSE 2012 Paper IA - 10 >

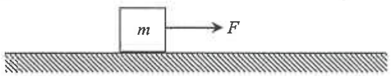
A block of mass m resting on a 30° incline is given a slight push and slides down the incline with a uniform speed. Which of the following statements about the block's motion on the incline is/are correct ?



(1) There is no net force acting on the block.
(2) The frictional force acting on the block is 0.5 mg.
(3) If the block is given a greater initial speed, it will slide down the incline with acceleration.

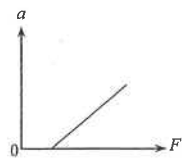
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

149. < HKDSE 2012 Paper IA - 11 >

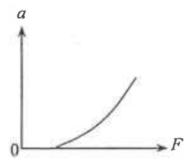


A block of mass m initially resting on a rough horizontal surface is pulled along the surface by a horizontal force F increasing from zero. If the frictional force is constant, which graph shows the relation between the acceleration of the block a and force F ?

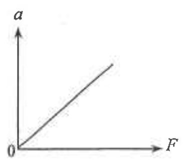
A.



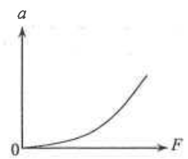
B.



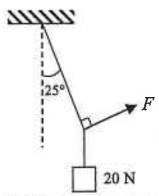
C.



D.



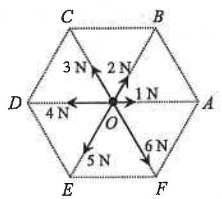
150. < HKDSE 2013 Paper IA - 5 >



A block of weight 20 N is suspended by a light string from the ceiling. A force F is applied such that the block is displaced to one side with the string making an angle of 25° with the vertical as shown. Find the magnitude of F.

A. 8.5 N
B. 9.3 N
C. 18.1 N
D. 47.3 N

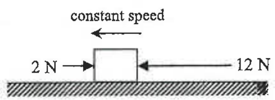
151. < HKDSE 2013 Paper IA - 6 >



In the figure, O is the centre of a regular hexagon. A particle at O is subject to six forces with magnitudes indicated as shown. The resultant force acting on the particle is

A. 9 N along direction OE.
B. 8 N along direction OE.
C. 8 N along direction OF.
D. 6 N along direction OE.

152. < HKDSE 2013 Paper IA - 7 >

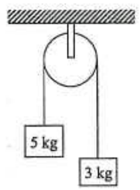


A block on a rough horizontal surface is moving to the left with constant speed under two horizontal forces 2 N and 12 N indicated as shown. If the force of 12 N is suddenly removed, what is the net force acting on the block at that instant ?

A. 12 N
B. 10 N
C. 8 N
D. 2 N

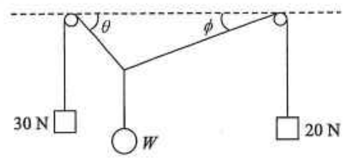
153. < HKDSE 2014 Paper IA - 8 >

Two blocks of masses 5 kg and 3 kg respectively are connected by a light string passing through a frictionless fixed light pulley. Find the magnitude of the acceleration of the blocks in terms of the acceleration due to gravity g when they are released. Neglect air resistance.



A. g
B. $\frac{1}{2}g$
C. $\frac{1}{4}g$
D. $\frac{1}{8}g$

154. < HKDSE 2014 Paper IA - 4 >



The figure shows a weight W attached to two light strings which pass over two smooth pegs at the same height and with weights 30 N and 20 N attached to the respective ends of each string. The system is at equilibrium. Which deduction about W is correct ?

A. W is less than 50 N.
B. W is equal to 50 N.
C. W is greater than 50 N.
D. No information about W can be obtained as angles θ and ϕ are not known.

155. < HKDSE 2015 Paper IA - 5 >

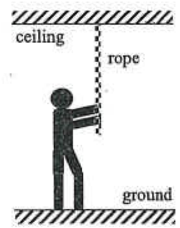
A constant net force acting on an object of mass m_1 produces an acceleration a_1 while the same force acting on another object of mass m_2 produces an acceleration a_2. If this net force acts on an object of mass ($m_1 + m_2$), what would be the acceleration produced ?

A. $a_1 + a_2$
B. $\frac{a_1 + a_2}{2}$
C. $\frac{a_1 a_2}{a_1 + a_2}$
D. $\frac{2a_1 a_2}{a_1 + a_2}$

156. < HKDSE 2016 Paper IA - 6 >

A boy of weight W exerts a downward pulling force F on a rope of weight G hung vertically from the ceiling. He stands still on the ground as shown. Which of the following gives the magnitude of the force exerted by

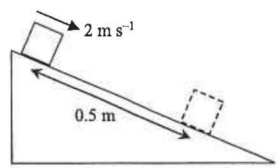
(1) the boy on the ground ;
(2) the rope on the ceiling ?



	(1)	(2)
A.	W	$G - F$
B.	W	$G + F$
C.	$W - F$	$G - F$
D.	$W - F$	$G + F$

157. < HKDSE 2016 Paper IA - 7 >

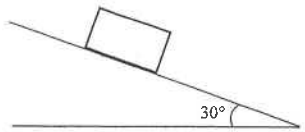
A block with initial speed 2 m s^{-1} slides down a rough inclined plane and stops after travelling a distance of 0.5 m. What is the deceleration of the block ?



A. 1 m s^{-2}
B. 2 m s^{-2}
C. 4 m s^{-2}
D. Answer cannot be found as the angle of inclination of the plane is not given.

158. < HKDSE 2017 Paper IA - 6 >

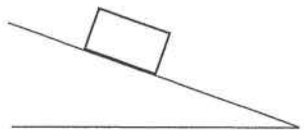
A block is released from rest on an inclined plane as shown. The inclined plane makes an angle of 30° to the horizontal. The block moves with uniform acceleration, and travels a distance of 1 m in the first 3 s. Determine the acceleration of the block.



A. 0.22 m s^{-2}
B. 0.33 m s^{-2}
C. 4.91 m s^{-2}
D. Cannot be determined as the frictional force acting on the block is unknown.

159. < HKDSE 2017 Paper IA - 7 >

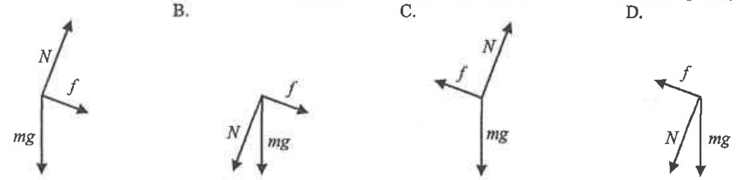
A block of mass *m* stays at rest on a rough inclined plane as shown.



Which of the following diagrams correctly shows the forces acting on the block ?

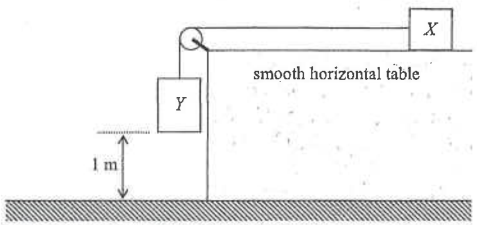
(*N* is the normal reaction from the inclined plane, and *f* is the frictional force between the block and the plane.)

A. B. C. D.



160. < HKDSE 2017 Paper IA - 10 >

Blocks *X* and *Y* are connected by a light inextensible string passing over a fixed frictionless light pulley as shown. The mass of *X* and *Y* are 0.5 kg and 1 kg respectively. Initially, *Y* is 1 m above the ground and the string is taut. The system is then released from rest.



What is the speed of *Y* just before it reaches the ground ?
A. 3.62 m s^{-1}
B. 4.43 m s^{-1}
C. 6.26 m s^{-1}
D. 9.81 m s^{-1}

There is question in next page

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. D	11. C	21. B	31. B	41. A	51. B
2. A	12. D	22. B	32. A	42. B	52. C
3. B	13. A	23. C	33. D	43. D	53. A
4. B	14. B	24. A	34. C	44. D	54. A
5. C	15. B	25. B	35. C	45. C	55. A
6. B	16. B	26. A	36. A	46. B	56. C
7. A	17. D	27. B	37. B	47. C	57. B
8. C	18. C	28. C	38. D	48. D	58. A
9. C	19. D	29. D	39. B	49. A	59. A
10. A	20. D	30. B	40. B	50. C	60. D
61. A	71. C	81. B	91. A	101. D	111. D
62. C	72. B	82. C	92. A	102. C	112. C
63. B	73. B	83. B	93. C	103. A	113. A
64. A	74. D	84. D	94. C	104. B	114. C
65. A	75. D	85. C	95. B	105. D	115. B
66. C	76. A	86. B	96. C	106. B	116. A
67. B	77. C	87. B	97. A	107. B	117. C
68. D	78. C	88. D	98. C	108. A	118. D
69. B	79. D	89. D	99. A	109. D	119. C
70. A	80. C	90. D	100. C	110. C	120. C
121. C	131. A	141. C	151. D	161. A	
122. A	132. D	142. B	152. A	162. A	
123. B	133. D	143. D	153. C	163. C	
124. D	134. A	144. B	154. A	164. B	
125. B	135. C	145. A	155. C		
126. C	136. C	146. C	156. D		
127. D	137. A	147. A	157. C		
128. A	138. A	148. C	158. A		
129. D	139. B	149. A	159. C		
130. C	140. C	150. A	160. A		

161. <HKDSE 2019 Paper IA-5>

162. <HKDSE 2019 Paper IA-12>

163. <HKDSE 2020 Paper IA-5>

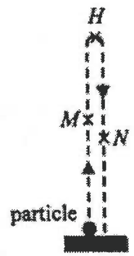
For a car travelling on a highway, which of the following statements about the safety design of the headrest is/are correct ?

(1) As the headrest is soft, it can reduce the force exerted on the passenger's head during impact.
(2) It can minimise injury of the passenger when the car is struck by another one from behind.
(3) It can minimise injury of the passenger when the car brakes suddenly.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

164. <HKDSE 2020 Paper IA-6>

A particle is thrown vertically upward and its path is shown below. H is the highest point that the particle reached. Which of the following statements about the particle is/are correct ? Neglect air resistance.



(1) Its acceleration at M is upward.
(2) Its acceleration at H is zero.
(3) Its acceleration at N is downward.

A. (1) only
B. (3) only
C. (2) and (3) only
D. (1), (2) and (3)

M.C. Solution

1. D

Actual weight = $m g$ = (20) × (9.81) = 196 N

The reading of the balance 150 N is indeed the normal reaction R, represents the apparent weight.

$\therefore R < mg$ $\therefore$ direction of acceleration is downwards

$\therefore$ The lift is descending with uniform acceleration.

2. A

① $F - f = Ma$ $\therefore 2F - 2f = 2Ma$ $\therefore 2F = 2f + 2Ma$

② $2F - f = Ma'$

$\therefore 2f + 2Ma - f = Ma'$

$\therefore f = Ma' - 2Ma$ $\therefore a' = 2a + \dfrac{f}{M}$

3. B

As X is held stationary, there is a unknown applied force acting on X.

Consider Y that is also stationary : $T = mg \sin\theta$ = (2) (9.81) sin 30° = 9.81 N

Reading of S = tension of the string = 9.81 N ≈ 9.8 N

4. B

After the system is released, A and B move towards each other because of the elastic force of the spring.

The force acting on A and the force acting on B form an action-reaction pair. Thus they are equal and opposite.

$\therefore F = ma$ = constant

$\therefore m \propto \dfrac{1}{a}$ $\therefore \dfrac{a_A}{a_B} = \dfrac{m_2}{m_1}$

5. C

As the object is at rest along a rough inclined plane, forces along the inclined plane are balanced.

$\therefore f = mg \sin\theta$ $\therefore f \propto \sin\theta$.

6. B

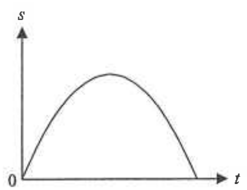
Slope of s-t graph = velocity

When the object is moving upwards, it is decelerating,
thus the slope of the graph representing the velocity should be decreasing.

At the highest point, the object is momentarily at rest.

After reaching the highest point, the object moves downwards with acceleration.

The curve should then bend downwards with magnitude of slope increasing.



7. A

Consider block E : $T_4 = (1m)\, a$

Consider block D, E : $T_3 = (2m)\, a$.

Consider block C, D, E : $T_2 = (3m)\, a$

Consider block B, C, D, E : $T_1 = (4m)\, a$

The string S_1 with tension T_1 has the greatest tension.

As four strings are identical, S_1 is likely to be broken first.

8. C

As the object is at rest along a rough inclined plane, forces along the inclined plane must be balanced.

$\therefore f = mg \sin\theta$.

9. C

Consider the whole system of the two blocks and the trolley.

By Newton's second law : $F_{net} = ma$

(0.75 × 9.81) – (0.25 × 9.81) = (0.75 + 1 + 0.25) a $\therefore a$ = 2.45 m s^{-2} ≈ 2.5 m s^{-2}

10. A

As the force is acting to the left, the acceleration is also towards the left.

As the body is moving to the right, leftward acceleration means that it is under deceleration, thus the velocity should drop.

When the body comes to rest, the force continues to apply to give leftward acceleration,

thus the velocity increases as the body moves leftwards.

Note that as the force is constant, the acceleration is constant, thus the slope of the graph should be constant.

11. C

$P \cos\theta - Q = ma$

(2) cos 30° – (1) = (1) a $\therefore a$ = 0.73 m s^{-2}

12. D

As the resultant force is zero, the acceleration must be zero.

The particle may then be at rest or moving with constant velocity.

13. A

As the ball and the lift move together upwards before the ball is released, due to inertia,

velocity of the ball at the moment of release = velocity of the lift = 10 m s^{-1} upwards

14. B

× (1) Velocity of the ball increases with time up to 10 m s^{-1}.

✓ (2) Acceleration = slope of $v \sim t$ graph, which decreases with time.

× (3) After 4 s, the ball should move with a terminal velocity which is not zero.

15. B

Engine turned off

⇒ no net force acting on the rocket

⇒ the rocket has no acceleration

⇒ the rocket continues to move with uniform velocity due to inertia

16. B

The spring balance reads the tension T_1 ∴ $T_1 = 10$ N

Consider A and B as a whole system :

$(10) = (1 + 1.5)\,a$ ∴ $a = 4$ m s^{-2}

Consider block B : $T_2 = m_B\,a = (1.5)(4) = 6$ N

17. D

The resultant force acting on the block is $m\,g \sin\theta$, thus the acceleration of the block is $g \sin\theta$

and it is constant and always pointing downwards, no matter whether the block is moving upwards or downwards.

18. C

Consider the pulley connecting to the 6 kg body. There are two strings giving two upwards tensions T to hold the pulley.

∴ $2T = mg$ ∴ $2T = (6)(9.81)$ ∴ $T = 29.4$ N

As the 2 kg block is at rest, tension of S = tension of the string connecting 2 kg block and 6 kg block = 29.4 N

19. D

$P - mg\sin\theta = ma$

∴ $P = mg\sin\theta + ma$

The one with maximum θ and maximum a would give the maximum P,

Thus, the case in D has the maximum P.

20. D

The man feels heavier if the normal reaction : $R > mg$

i.e., the direction of acceleration is upwards.

Moving upwards with acceleration and moving downwards with retardation both mean an upward acceleration.

21. B

∵ $F = ma \propto a$

∴ The shape of the $F \sim t$ graph is the same as that of $a \sim t$ graph.

As slope of $v \sim t$ graph = $a \propto F$,

Before $t = t_o$, force is positive ⇒ slope of $v \sim t$ graph is positive

After $t = t_o$, force is zero ⇒ slope of $v \sim t$ graph is zero (horizontal line)

Option C is not correct as the velocity cannot be suddenly dropped to zero.

22. B

Since the three blocks are of equal mass, they should experience the same net force.

∴ Net force on block B : $F_B = \frac{F}{3}$

23. C

✓ (1) Constant force ⇒ constant acceleration ⇒ constant slope in $v \sim t$ graph

✓ (2) Slope of $s \sim t$ graph = velocity, which is a constant

× (3) Falling from rest ⇒ constant acceleration ⇒ a horizontal line

24. A

When the force F is applied,

$F = f + mg\sin\theta$ ∴ $(11) = f + (1)(10)\sin 30°$

∴ $f = 6$ N ∴ Maximum friction is 6 N.

If F is not applied,

downward force = $mg \sin\theta = (1)(10)\sin 30° = 5$ N.

Thus, $f = 5$ N ∴ The block remains at rest.

25. B

× (1) If the lift is moving upwards with constant speed, $R = W$.

✓ (2) The normal reaction acting on the man by the floor R is upward while weight W is downward.

× (3) R and W are both acting on the same body, the man, thus they cannot be action-reaction pair.

26. A

Assume the two blocks A and B, each block has a mass of M.

Consider the whole system : $F = ma$ ∴ $(12) = (2M)\,a$ ∴ $a = \frac{6}{M}$

The force between A and B is the normal reaction.

Consider A : $(12) - R = (M)(\frac{6}{M})$ ∴ $R = 6$ N

OR

Consider B : $R = ma = (M)(\frac{6}{M}) = 6$ N

27. B

By $F = ma$ ∴ $F \propto a$

∴ The shape of the $F \sim t$ graph is the same as that of $a \sim t$ graph.

As slope of $v \sim t$ graph = a ∴ slope of $v \sim t$ graph $\propto F$

Before $t = t_1$, force is zero ⇒ slope of $v \sim t$ graph is zero (horizontal line)

After $t = t_1$, force is positive ⇒ slope of $v \sim t$ graph is positive.

28. C

X: No net force acting on the $X \Rightarrow X$ moves with constant velocity due to inertia

Y: Y is under free fall with the acceleration due to gravity, where $g = 10$ m s^{-2} $\Rightarrow Y$ accelerates at 10 m s^{-2}

29. D

Consider A and B as a whole system :

$F = m a$ $\therefore$ $(2) = (3+2)\,a$ $\therefore$ $a = 0.4$ m s^{-2}

Consider block A : $F - T = m_A a$ $\therefore$ $(2) - T = (2)(0.4)$ $\therefore$ $T = 1.2$ N

OR

Consider block B : $T = m_B a = (3)(0.4) = 1.2$ N

30. B

× (1) Both F_1 and F_2 are acting on the same block. (F_2 is the normal reaction acting on the block by the floor.)

× (2) Both F_1 and F_2 are acting on the ball. (F_2 is the tension acting on the ball by the string.)

✓ (3) F_1 acts on negative charge while F_2 acts on positive charge, they act on two different bodies.

31. B

× (1) $W = m g = 50 \times 9.81 = 490.5$ N which is a constant all the time.

× (2) As the lift falls freely under gravity, the man loses contact with the floor, thus normal reaction $R = 0$

✓ (3) As the man loses contact with the floor, the force acting on the man by the floor $R = 0$.

32. A

✓ (1) A harder initial push would give a greater initial velocity, thus the dots is more separated as shown.

× (2) If the angle of inclination is increased, $mg \sin\theta$ would be greater than the friction f, thus the trolley would move down with acceleration, and the dots would not be equally spaced

× (3) If the frequency is increased, more dots are produced in 1 s, thus the dots should be less separated.

33. D

$T_1 = F + W_X = 4 + 2 = 6$ N

$T_2 = T_1 + W_Y = 6 + 8 = 14$ N

34. C

Constant braking force means constant deceleration.

By $v^2 = u^2 + 2as$ $\therefore$ $(0) = u^2 + 2(-a)s$ $\therefore$ $s = \dfrac{u^2}{2a}$ $\therefore$ $s \propto u^2$

$\therefore$ $\dfrac{s_1}{s_2} = (\dfrac{u_1}{u_2})^2$ $\therefore$ $\dfrac{(12)}{s_2} = (\dfrac{30}{60})^2$ $\therefore$ $s_2 = 48$ m

35. C

Horizontal component the applied force $= F\cos\theta$

as θ is the angle between the direction of motion and applied force.

36. A

Before the string S breaks, $F = m a = (4+2)(2) = 12$ N

After the string S breaks,

consider the 4-kg block : no horizontal force acts on it $\therefore$ $a = 0$ m s^{-2}

consider the 2-kg block : the net force acting on the 2-kg block is F, i.e. 12 N.

$\therefore$ $F = m a$ $\therefore$ $(12) = (2)\,a$ $\therefore$ $a = 6$ m s^{-2}

37. B

× (1) R and W are both acting on the same block, they cannot be action-reaction pair.

✓ (2) W and F are equal and opposite, and they act on 2 different bodies.

× (3) F and R are in same direction.

38. D

✓ (1) As $W = m g$, thus greater mass experiences a greater gravitational attraction force.

✓ (2) Both of them have the same acceleration due to gravity g, as g is independent of mass, thus they reach the ground at the same time.

✓ (3) Both of them have the same acceleration due to gravity g, thus they reach the ground with the same velocity.

39. B

× (1) As the block is at rest, there must be frictional force acting on it to prevent the tendency of sliding.

× (2) As the block is in contact with the inclined plane, there must be normal reaction acting on the block.

✓ (3) As the block is at rest, there must be no net force (no resultant force) acting on it.

40. B

× (1) The mass of the coin should be much greater than that of the feather.

✓ (2) In vacuum, there is no air resistance, thus both of them fall down with the same acceleration due to gravity g.

× (3) As the coin and the feather have different mass, by $W = m g$, they should have different weight, i.e., different gravitational attraction force acting on each other them.

41. A

Since both F_1 and F_3 are acting on the ball, and the ball has upward acceleration,

thus the net force acting on the ball must be upwards $\therefore$ $F_1 > F_3$

Since F_1 and F_2 are action-reaction pair, $\therefore$ $F_1 = F_2$

Thus, $F_1 = F_2 > F_3$

42. B

× (1) To keep an object moving with uniform velocity, i.e. zero acceleration, the net force should be zero. Thus no unbalanced force is needed.

× (2) To keep an object moving with uniform acceleration, i.e. constant acceleration, the net force (unbalance force) should be constant, not increasing.

✓ (3) If there is no unbalanced force, the acceleration is zero. The object may remain at rest OR may move with uniform velocity.

43. D

✓ A. Mass : in kg ; Weight : in N.

✓ B. Mass indicates how large is its inertia ; weight represents how large the gravitational force acting on it.

✓ C. $W = m\,g$, for a particular place, g is constant, thus $W \propto m$.

× D. Mass is always a constant but weight would vary at different places.

44. D

× (1) Both these two forces are acting on the man, but action-reaction pair must act on 2 different bodies

✓ (2) If the action force is on A by B, then the reaction force is on B by A, thus forces between the earth and the moon are action and reaction pair.

✓ (3) The force exerted by a swimmer on the water is the action force, and the force exerted by the water to push the swimmer forward is the reaction force.

45. C

The block must have weight pointing vertically downwards.

Since the object is in contact with the inclined plane, normal reaction must act on the block.

Since the inclined plane is smooth, there is no friction.

46. B

As the car moves with constant velocity, it has zero acceleration, thus the horizontal forces acting on it are balanced.

$\therefore\ T = f = 500\text{ N}$

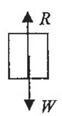
47. C

As $W = 10$ N, $R = 8$ N, $\therefore\ R < W$

since the downward force W is greater, the net force is downwards

thus, the acceleration is downwards

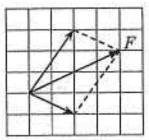
$\therefore$ the lift should have a downward acceleration OR upward deceleration.



48. D

To keep P in equilibrium,

$F_3 = F = \sqrt{2^2 + 4^2} = 4.5\text{ N}$



49. A

✓ (1) The passenger in a moving car should move together with the car with the same velocity. As the car suddenly stops, due to the inertial of the passenger, he would keep on moving forwards. This is explained by the First law of motion, which is also called the Law of Inertia.

× (2) By Newton's second law, $m\,g = m\,a \quad \therefore\ a = g$

× (3) The maximum mass an astronaut can lift is greater on the moon is due to the smaller gravity of the moon.

50. C

At equilibrium, both ropes AC and CB exert an upward component $T\cos\theta$ on the shirt.

$2\,T\cos\left(\dfrac{150°}{2}\right) = 2$

$\therefore\ T = 3.9\text{ N}$

51. B

× (1) On a friction-compensated runway, a block should move with constant velocity.

× (2) The normal reaction force : $R = mg\cos\theta$, which is a constant throughout the motion.

✓ (3) As friction is compensated by the component of weight along the inclined plane, i.e. $f = m\,g\sin\theta$, there is no net force acting the block.

52. C

✓ (1) As the two balls are falling under the same acceleration due to gravity, they must reach the ground at the same time with the same speed.

✓ (2) They have the same acceleration as the acceleration due to gravity is independent of the mass of a body.

× (3) By $W = mg$, different masses should have different gravitational forces W.

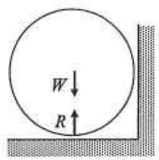
53. A

✓ (1) As the two balls reach the ground at the same time, they must have the same acceleration due to gravity.

× (2) This is Newton's first law, but it cannot be deduced from the result of the two falling balls.

× (3) Two balls of different mass should have different gravitational forces.

54. A



W: gravitational force by the earth must exist for a body placed on the earth's surface

R : normal reaction must exist and this force is used to support or balance the weight W

F : friction does not exist as the ball has to tendency to slide

N: normal reaction from the wall does not exist as the ball just touches the wall, it does not really press the wall

55. A

When the block is moving upward, the friction is pointing downwards.

$\therefore$ $mg\sin\theta + f = ma_1$ and a_1 causes the deceleration of the block.

When the block is moving downward, the friction is pointing upwards.

$\therefore$ $mg\sin\theta - f = ma_2$ and a_2 causes the acceleration of the block.

Comparing the two equations : $a_1 > a_2$

As absolute value of the slope of $v \sim t$ graph = magnitude of acceleration

$\therefore$ slope of the line representing the upward motion should be steeper.

56. C

Balance of forces in vertical direction : $F_2 \cos 30° = 10$ $\therefore$ $F_2 = 11.5$ N

57. B

On a rough surface, there must be friction.

$\therefore$ $F - f = ma$

$\therefore$ $a = \frac{1}{m}F - \frac{f}{m}$

This is a linear equation with a positive x-intercept, thus option B is correct.

58. A

By $W = mg$, as the weight W is one-sixth on the moon, the acceleration due to gravity g is also one-sixth on the moon.

✓ (1) By $v^2 = u^2 + 2as$ $\therefore$ $(0) = u^2 + 2(-g)s$ $\therefore$ $g\downarrow \Rightarrow s\uparrow$ for the same u

× (2) By $s = ut + \frac{1}{2}gt^2$ $\therefore$ $s = \frac{1}{2}gt^2$ $\therefore$ $g\downarrow \Rightarrow t\uparrow$ for the same s

× (3) To lift an object, the maximum force that can be applied by the astronaut = weight of the object
Since the maximum force of the astronaut is the same on the moon, he can only lift the same weight.
However, he can lift a greater mass on the moon.

59. A

Since the block is at rest, the friction acting on the block = 10 – 2 = 8 N

When the force 10 N is removed, the only applied force is 2 N, thus the friction would also reduce to 2 N.

$\therefore$ The resultant force is zero.

60. D

This experiment is used to demonstrate the Newton's 1st law.

When the cardboard is flickered away, the coin has the tendency to remain at rest, and the tendency is the inertia.

61. A

✓ (1) This is the action and reaction pair between the earth and the moon.

× (2) These two forces both act on the same body : the suitcase.

× (3) These two forces both act on the same body : the suitcase.

62. C

Slope of the a - F graph represents $\frac{1}{\text{mass}}$ $\therefore$ slopes of the two graphs are the same since the mass is unchanged.

If the angle is increased, the runway would not be friction compensated

and the trolley would have an acceleration even when the applied force F is zero.

$\therefore$ The new graph should have a positive y-intercept.

63. B

× (1) The gravitational force (weight) acting on John by the earth = mg = (80)(10) = 800 N

× (2) The force exerted by the weighing scale on John is the normal reaction,
and this is equal to the normal reaction acting on the weighing scale, which is 600 N.

✓ (3) As reading of the weighing scale is smaller than the weight of John, direction of a is downwards,
the lift must either be accelerating downward or decelerating upward.
By Newton's second law,
$mg - R = ma$ $\therefore$ $(800) - (600) = (80)a$ $\therefore$ $a = 2.5$ m s^{-2}

64. A

Net force acting on the block = $mg\sin\theta - f = ma$

$\therefore$ $(0.5)(9.81)\sin 30° - f = (0.5) \times (3)$

$\therefore$ $f = 0.9525$ N ≈ 0.95 N

65. A

Since the vertical force 60 N would be balanced by the normal reaction acting on the block and its weight,

i.e. downward force of weight 100 N = upward vertical force 60 N + upward normal reaction 40 N

Thus, the only force unbalanced is the horizontal force of 30 N, and this is the resultant force.

66. C

✓ (1) The object has the inertia to remain its initial state (at rest) when there is no unbalanced force.

✓ (2) The object has the inertia to remain its initial state (uniform motion) when there is no unbalanced force.

× (3) If there is unbalanced force, the object would have acceleration, and cannot be at uniform velocity.

67. B

✓ (1) The football first is at rest and then moves after being kicked by the player.
The football is under acceleration, so an unbalanced force exists.

× (2) For uniform velocity, the acceleration is zero, there is no unbalanced force acting in the parachutist.

✓ (3) The velocity of the bob is continuously changing as the direction of velocity is changing.
As velocity changes, acceleration must occur, an unbalanced force is required for the acceleration.

68. D

Since the block moves with uniform velocity, $a = 0$

Thus net force = 0

69. B

Balance of forces in vertical direction :

$4\,T\cos 20° = 600$

$\therefore\ T = 160$ N

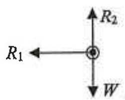
70. A

The gravitational force W is the weight of a body which is acting on the body by the Earth.

Thus the weight is always a constant value, thus the graph should be a horizontal line.

71. C

Consider the forces acting on the child :



The force R_1 is the normal reaction acting on the child from the back of the seat.

R_1 causes the acceleration of the child, thus $R_1 = m\,a = (10) \times (3) = 30$ N

The force R_2 is the normal reaction acting on the child from the bottom of the seat.

R_2 is balanced by the weight, thus $R_2 = m\,g = (10) \times (10) = 100$ N

Both R_1 and R_2 are the forces exerted by the safety seat on the child, thus, their resultant is $\sqrt{(30)^2 + (100)^2} = 104$ N

72. B

× (1) These two forces act on the same body, the child, thus they must not be an action and reaction pair.

✓ (2) The force exerted on the chair by the child and the force exerted on the child by the chair are action and reaction pair since they act on two different bodies.

× (3) The force exerted by the chair on the ground is pointing downwards.
The gravitational force exerted by the earth on the chair is also pointing downwards.
Both of these two forces have the same direction, they must not be action and reaction pair.

73. B

✓ (1) By $W = m\,g$, since g on the Earth is 10 m s^{-2}, mass of the object on the Earth is 6 kg.

× (2) Mass is independent of the gravity, thus mass of the object on the moon should also be 6 kg.

✓ (3) By $W = m\,g$, since the same mass gives one-sixth of the weight on the moon, g on the moon must then be one-sixth that on the Earth.

74. D

✓ (1) In Figure (a), $F = (m_1 + m_2)\,a$. In Figure (b), $F = (m_1 + m_2)\,a$.
Thus, the acceleration must be the same in both figures.
In Figure (a), $T_1 = m_1\,a$. In Figure (b), $T_2 = m_2\,a$.
As $m_1 > m_2$, therefore, $T_1 > T_2$

✓ (2) In Figure (a), $T_1 = m_1\,a\ \therefore\ a = \frac{T_1}{m_1}$. In Figure (b), $T_2 = m_2\,a\ \therefore\ a = \frac{T_2}{m_2}$.
Since the acceleration a are the same, thus $\frac{T_1}{m_1} = \frac{T_2}{m_2}$

✓ (3) $F = (m_1 + m_2)\,a = m_1\,a + m_2\,a = T_1 + T_2$

75. D

✓ A. By $s = \frac{1}{2}\,a\,t^2$, a graph of s against t^2 gives a straight line through the origin.

✓ B. By $v = a\,t$, a graph of v against t gives a straight line through the origin.

✓ C. By $v^2 = 2\,a\,s$, a graph of v^2 against s gives a straight line through the origin.

× D. Since the acceleration is constant due to the constant horizontal force, a graph of a against t should give a horizontal line.

76. A

To balance the weight of the sucker, there must be an upwards force acting on the sucker.

The only force that can act along the wall is the friction.

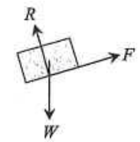
77. C

✓ (1) If F_1 and F_2 are in perpendicular direction, then their resultant force is $\sqrt{3^2 + 4^2} = 5$ N.
If F_3 is in the opposite direction to the resultant of F_1 and F_2, then the object is in equilibrium.

✓ (2) If F_1 and F_2 are in the same direction, then their resultant force is $3 + 4 = 7$ N.
If F_3 is in the opposite direction to the resultant of F_1 and F_2, then the object is in equilibrium.

× (3) If F_1 and F_2 are in the same direction, then their resultant force is $3 + 5 = 8$ N.
However, F_3 has a magnitude of 9 N which is too great for the object to be in equilibrium.

78. C



Since the inclined plane is rough, there must be friction acting on the block.

As friction tends to prevent the block from sliding down, the direction of the friction is upwards along the plane.

Normal reaction exists when two surfaces are in contact.

79. D

Resolve the tension in each side into vertical and horizontal components.

The two vertical components $T\cos 70°$ are balanced by the weight of the fish and hook.

$\therefore\ W = 2\,T\cos 70° = 20\cos 70°$ N

80. C

By $F - f = m\,a$

$\therefore\ (5) - f = (1)(2)$ $\therefore\ f = 3$ N

81. B

① When the lift is moving upwards with a uniform speed, there is no acceleration, thus $R_1 = mg$.

② When the lift is moving downwards with a uniform speed, there is no acceleration, thus $R_2 = mg$.

③ When the lift is moving upwards with an acceleration, there is an upward net force, thus $R_3 > mg$.

$\therefore\ R_3 > R_1 = R_2$

82. C

× A. Since the two blocks are connected together, they must move together with the same speed.

× B. Since the two blocks are connected together, they must move together with the same magnitude of acceleration.

✓ C. As the two blocks have the same magnitude of acceleration, but their masses are different, they have different magnitude of resultant force.

× D. Since the two blocks are connected together by the same string, the tension exerted by the same string must be the same.

83. B

To be an action and reaction pair, the two forces must be equal in magnitude and opposite in direction, and act on two different bodies such that : force exerted by A on B and force exerted by B on A.

Option B is correct as these are the action-reaction pair between the string and Y.

84. D

Net horizontal force $= 2 \times 50 \cos 40°$

$= 76.6$ N

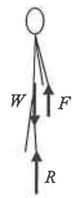
85. C

Consider the forces acting on Peter :

① weight of Peter W

② reaction force by the table F

③ normal reaction force R by the weighing scale, i.e. the reading of the scale



Since Peter is in equilibrium,

$\therefore\ F + R = W$

$\therefore\ R = W - F$

86. B

Resolve the tension in each side into vertical and horizontal components.

The two vertical components $T \cos \theta$ are balanced by the weight of the acrobat.

$\therefore\ W = 2\,T \cos \theta \qquad \therefore\ \cos \theta = \dfrac{W}{2T}$

As $0° < \theta < 60°$

$\therefore\ \cos 0° > \cos \theta > \cos 60°$ ($\cos \theta$ is a decreasing function, that is, greater θ gives smaller cos θ)

$\therefore\ 1 > \dfrac{W}{2T} > 0.5 \qquad \therefore\ T > \dfrac{W}{2}$ and $W > T$

87. B

In order to deduce the relationship between the acceleration and the net force, the mass should be kept constant. Since trials (i), (iv) and (vi) have the same mass of 2 kg, these 3 trials should be chosen.

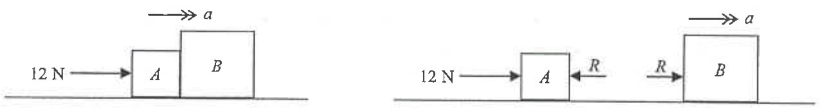
88. D

✓ (1) Seat belts can prevent passengers from throwing forwards due to inertia when accident occurs.

✓ (2) When a vehicle is overloaded, its mass increases, thus its tendency to keep on motion is increased, therefore, it is harder to brake the vehicle within a safety distance.

✓ (3) If a vehicle exceeds the speed limit, it is harder to brake the vehicle to rest due to its inertia.

89. D



Consider the two blocks together,

F_{net} = total mass × acceleration $\quad \therefore\ (12) = (1 + 3)\,a \quad \therefore\ a = 3\ \text{m s}^{-2}$

Consider the block B, contact force = mass of B × acceleration = (3) × (3) = 9 N

90. D

Since the horse gives a pulling force in forward direction to the block, the friction acts on the block is in backward direction.

Since the block gives a pulling force in backward direction to the horse, the friction acts on the horse should be in forward direction.

91. A

For an action and reaction pair, one should be acting on A by B and the other should be acting on B by A.

✓ (1) These are action and reaction pair between the child and the scale.

× (2) The reaction of the force by the Earth on the child should be the force by the child on the Earth.

× (3) The reaction of the force by the Earth on the scale should be the force by the scale on the Earth.

92. A

Resolve the tension T into a horizontal component $T \sin \theta$ and a vertical component $T \cos \theta$.

Since the block is in equilibrium under 3 forces : the tension T, the weight of 10 N, the force of 3 N,

balance the force horizontally, $T \sin \theta = 3$

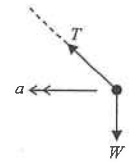
balance the force vertically, $T \cos \theta = 10$

$\therefore\ \tan \theta = 0.3 \quad \therefore\ \theta = 16.7° \quad \therefore\ \theta < 30°$

$\therefore\ T \sin 16.7° = 3 \quad \therefore\ T = 10.4\ \text{N} \quad \therefore\ 13\ \text{N} > T > 10\ \text{N}$

93. C

Since the vertical component of the tension T balances the weight W, the horizontal component of the tension T is the net force, thus, the acceleration is towards the west.



✓ (1) Moving to the east and decelerating means that the acceleration is towards the west.

✓ (2) Moving to the west and accelerating means that the acceleration is towards the west.

× (3) Starting to move to east means that the acceleration is towards the east.

94. C

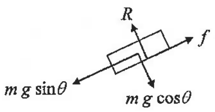
× (1) F_1 is the weight of the block acting by the Earth,
F_2 is the normal reaction acting on the table by the block.
They are two different types of forces.

✓ (2) Since F_1 and F_3 are the only two forces acting on the block, and the block is at rest, thus these two forces balance each other.

✓ (3) F_2 is the normal action acting on the table by the block,
F_3 is the normal action acting on the block by the table.
These two forces act on two different bodies and they are action and reaction pair.

95. B

Along the inclined plane, there are two forces acting on the block.



The $m g \sin\theta$ is downwards and the friction f is upwards.

By net force = $m a$ $\therefore$ $m g \sin\theta - f = m a$

$\therefore$ $f = m g \sin\theta - m a$

In the direction perpendicular to the inclined plane, there are two forces acting on the block.

The $m g \cos\theta$ is downwards and the normal reaction R is upwards.

Since there is no net force in this direction, these two forces are balanced.

$\therefore$ $R = m g \cos\theta$

96. C

By Newton's second law, net force = mass × acceleration

Consider A : $10 - T = m a$

Consider B : $T - 4 = m a$

$\therefore$ $10 - T = T - 4$ $\therefore$ $T = 7$ N

97. A

Under the pulling force of 5 N :

$F_{net} = m a$ $\therefore$ $(5) - f = (1)(2)$ $\therefore$ maximum friction $f = 3$ N

Under the pulling force of 2 N :

friction = 2 N to oppose the tendency of motion, thus the resultant force is zero.

98. C

Resolve the tension T_1 in S_1 into two components :

vertical component = $T_1 \sin 30°$ horizontal component = $T_1 \cos 30°$

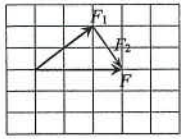
Balance the forces in vertical direction :

$T_1 \sin 30° = 50$ $\therefore$ $T_1 = 100$ N

Balance the forces in horizontal direction :

$T_1 \cos 30° = T_2$ $\therefore$ $T_2 = (100) \cos 30° = 86.6$ N

99. A



The two forces F_1 and F_2 should give a vector sum of F.

100. C

On the Earth's surface : weight = 120 N mass = 12 kg

On the Moon's surface : weight = $120 \times \frac{1}{6}$ = 20 N mass = 12 kg

101. D

From $t = 0$ to $t = t_1$, since the applied force is stronger, the acceleration is greater, thus the slope of the graph is greater.

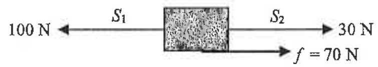
Beyond t_1, the only force acting on the trolley is friction.
Since the friction remains the same, the deceleration is the same, thus the slope should be the same.

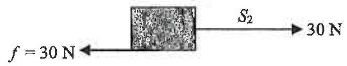
102. C

Spring balance reads the tension in the string,

thus tension = reading = 5 N

103. A

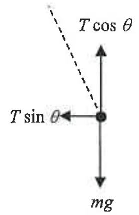




Initially, in order to prevent sliding of the block, friction of 70 N acts on the block towards the right to keep it at rest.
After S_1 is broken, friction would change direction and reduce to 30 N towards the left to prevent sliding of the block.
Thus, the net force acting on the block is zero.

104. B

The tension should be resolved into two components.



The horizontal component of tension is the net force.

$\therefore$ $T \sin\theta = m a$

The vertical forces are balanced.

$\therefore$ $T \cos\theta = m g$

Combining the two equations :

$\therefore$ $\tan\theta = \frac{a}{g}$

$\therefore$ $a = g \tan\theta = (10) \tan 10° = 1.76$ m s^{-2}

105. D

✓ (1) When the object is moving up, air resistance R is downwards, thus the net force : $F = W + R$
$\therefore F > W$

✓ (2) When the object is at the highest point, it is momentarily at rest, thus air resistance is zero.
$\therefore F = W$

✓ (3) When the object is moving down, air resistance R is upwards, thus the net force : $F = W - R$
$\therefore F < W$

106. B

× (1) The gravitational force acting on the man is the weight of the man, which is unchanged.

× (2) The gravitational force acting on the lift is the weight of the lift, which is unchanged.

✓ (3) The force acting on the man by the floor is the normal reaction force R.
When the lift accelerates upwards, $R - m g = m a$, thus R increases.
As R becomes greater than $m g$, the man feels heavier.

107. B

× (1) At $t = 0$ to 3 s, $R = 400$ N, and $W = m g = 500$ N $\therefore$ Net force $= W - R = 100$ N.

× (2) At $t = 3$ s, $R = 500$ N, thus there is no net force, and the lift should move down with constant velocity.

✓ (3) At $t = 3$ to 6 s, since there is no net force, thus no acceleration, the lift is moving at constant velocity.

108. A

By Newton's second law, net force $= m a$

$\therefore m g - R = m a$

$\therefore (50 \times 10) - (400) = (50) a$

$\therefore a = 2 \text{ m s}^{-2}$

109. D

Resolve the tension T into vertical component $T \cos\theta$ and horizontal component $T \sin\theta$

Since the forces are balanced, thus

$T \sin\theta = F$

$T \cos\theta = W$

Thus the weight is equal to $T \cos\theta$.

110. C

× A. The maximum friction may not be equal to 25 N.
If the maximum friction is greater than 25 N, then the block can still be at rest even when $F > 25$ N.

× B. When $F = 25$ N, the block is at rest, thus the friction $f = 25$ N, so that the net force is zero.

✓ C. If $F = 20$ N, $f = 20$ N to oppose the start of motion.

× D. If $F = 0$ N, $f = 0$ N.

111. D

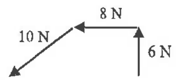
✓ (1) The force acting on the ant by the ceiling must be upwards to balance the weight of the ant and the block.

× (2) These two forces are both acting on the block, they cannot be an action and reaction pair.

✓ (3) As the ant is at rest, the net force acting on it must be zero.

112. C

If the net force is zero, the three forces adding head-to-tail should form a closed triangle.



The three forces in diagram C cannot form a closed triangle, thus they cannot give zero net force.

113. A

By Newton's 2nd law, $F - f = m a$ $\therefore$ $a = \frac{1}{m}F - \frac{f}{m}$

It is a straight line with positive slope ($1 / m$) and negative y-intercept ($- f / m$)

114. C

$R - mg = ma$ $\therefore R = mg + ma = m(g + a)$

115. B

When the system is in free fall, the strings become slack and no tension acts on every body.

The only force acting on each body is its own weight. Thus, net force on B is 4 N.

116. A

Consider the 4 kg body : $(4 \times 10 \times \sin 30°) - T = (4) a$

Consider the 1 kg body : $T - (1 \times 10) = (1) a$

$\therefore a = 2 \text{ m s}^{-2}$ and $T = 12$ N

117. C

Consider the 5 kg body : $(50) - T = (5) a$

Consider the 3 kg body : $T - (30) = (3) a$

$\therefore a = 2.5 \text{ m s}^{-2}$ and $T = 37.5$ N

$\therefore$ Vertical upward force on the axle $= 2T = 2 \times 37.5 = 75$ N

118. D

Reading on the spring balance scale is the tension T.

When the lift starts to go down, it undergoes downward acceleration.

$\therefore m g - T = m a$ $\therefore T < m g$ $\therefore$ reading is less than 50 N

When the lift is going to stop, it undergoes downward deceleration (i.e. acceleration in upward direction)

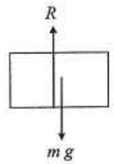
$\therefore T - m g = m a$ $\therefore T > m g$ $\therefore$ reading is more than 50 N

119. C

$m\,g \sin\theta - f = m\,a$ $\therefore\ f = m\,g\sin\theta - m\,a$

120. C

The weight indicated by the balance is in fact the normal reaction R.



When $R < mg$, the direction of the acceleration is downwards,

that is, moving downward with acceleration **OR** moving upward with deceleration.

By $m\,g - R = m\,a$

$\therefore$ $(400) - (360) = (40)\,a$ $\therefore\ a = 1\text{ m s}^{-2}$

121. C

$F = (m + 2m + 2m)\,a$ $\therefore\ a = \dfrac{F}{m+2m+2m} = \dfrac{20}{5m}$

Net force on B = $m_B \times a$ = $(2m)\left(\dfrac{20}{5m}\right)$ = 8 N

122. A

Tension exists along the string and weight exists to act on the bob.

Only two forces act on the bob when it is swinging in air.

123. B

Minimum resultant $\Rightarrow$ two forces are in opposite direction $\therefore\ F_1 - F_2 = 7$ ... (1)

Maximum resultant $\Rightarrow$ two forces are in same direction $\therefore\ F_1 + F_2 = 17$ ... (2)

Solving (1) and (2),

$F_1 = 12$ N and $F_2 = 5$ N

When 2 forces are at right angle,

$F = \sqrt{F_1^2 + F_2^2} = \sqrt{12^2 + 5^2} = 13\text{ N}$

124. D

Weight of the body is vertically downwards.

Tension of the string acting on the toy is upward along the string.

The propeller gives a propelling force in upward left direction to make the toy in equilibrium.

125. B

For the block moves downward with constant velocity without acceleration, friction is balanced by $mg\sin\theta$.

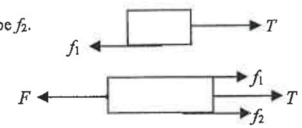
$\therefore\ f = m\,g\sin\theta = (0.5)(9.81)\sin 20° = 1.68$ N

To move the block upward with constant velocity, applied force F must overcome $mg\sin\theta$ and the downward friction.

$\therefore\ F = m\,g\sin\theta + f = (0.5)(9.81)\sin 20° + 1.68 = 3.4$ N

126. C

Let the friction between A and B be f_1 and the friction between B and the ground be f_2.



Consider block A : $T = f_1$ $\therefore\ T = 1.5$ N

Consider block B : $F = f_1 + T + f_2$

$= (1.5) + (1.5) + (1.5) = 4.5$ N

127. D

$P - Q = (2m + m)\,a$ $\therefore\ a = \dfrac{P-Q}{3m}$

The force acting on B by A is the normal reaction R.

Consider body B,

$P - R = m_B\,a$

$\therefore\ R = P - (m)\cdot\left(\dfrac{P-Q}{3m}\right) = \dfrac{2P+Q}{3}$

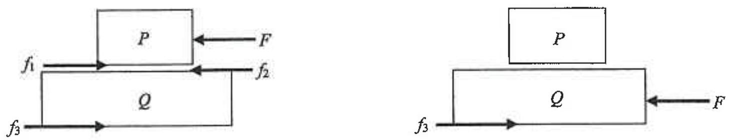
128. A

$T_{max} - m\,g = m\,a$

$(100) - (8)(9.81) = (8)\,a$

$\therefore\ a = 2.69\text{ m s}^{-2} \approx 2.7\text{ m s}^{-2}$

129. D



× (1) At rest $\Rightarrow$ no net force $\Rightarrow$ $f_1 = F$ and $f_1 = f_2$ (action-reaction) and $f_2 = f_3$ (balance of forces)
$\therefore\ F = f_3$

✓ (2) Direction of f_1 is opposite to F $\Rightarrow$ f_1 is towards the right

✓ (3) If F is applied to Q, then the friction acting on Q by the floor is still f_3 and $f_3 = F$, thus Q is still at rest.
As Q is at rest, P is also at rest and there is no friction between P and Q.

130. C

When inclined angle is 15° :

$(0.4 \times 9.81)\sin 12° - f = (0.4)\,a$ ... ①

When inclined angle is 20° :

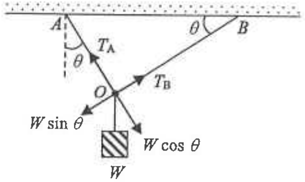
$(0.4 \times 9.81)\sin 18° - f = (0.4)\,(2a)$ ... ②

① × 2 − ② :

$\therefore\ 2 \times (0.4 \times 9.81)\sin 12° - (0.4 \times 9.81)\sin 18° = f$

$\therefore\ f = 0.42$ N

131. A



Since $\angle AOB = 90°$, the weight W should be resolved into two perpendicular components along OA and OB.

Balance of forces along OB : $T_B = W \sin \theta$

132. D

After the plasticine is placed, the total mass M of the system increases.

By $F = Ma$, the acceleration of the system decreases.

Consider the block A : $F - T_1 = m_A a$ As acceleration a decreases, tension T_1 increases.

Consider the block C : $T_2 = m_C a$ As acceleration a decreases, tension T_2 decreases.

133. D

The tension is resolved into a vertical component $T \cos \theta$ and a horizontal component $T \sin \theta$ towards the right.

① $T \sin \theta = m a$

② $T \cos \theta = m g$

$\therefore \tan \theta = \dfrac{a}{g}$

$\therefore a = g \tan \theta$

As the net force $T \sin \theta$ is towards the right, the acceleration of the vehicle is towards the right.

134. A

Consider the block X, there is no friction acting on it, thus there is no horizontal force acting on it.

The acceleration of X is zero.

Consider the block Y, as there is no friction, the only horizontal force acting on it is F.

By $F = m a$, the acceleration of Y is F / m.

135. C

Since the two blocks move together, they have the same acceleration.

Consider the two blocks as a whole system :

$F = (m_1 + m_2) a$ $\therefore (6) = (2 + 3) a$ $\therefore a = 1.2 \text{ m s}^{-2}$

Consider the 2 kg block :

$f = m_1 a = (2)(1.2) = 2.4 \text{ N}$

OR

Consider the 3 kg block :

$F - f = m_2 a$ $\therefore (6) - f = (3)(1.2)$ $\therefore f = 2.4 \text{ N}$

136. C

Reading of the scale is equal to the normal reaction R acting on the man.

At t = 0 to 8 s, R = 550 N.

By $R - mg = ma$ $\therefore (550) - (500) = (50) a$ $\therefore a = 1 \text{ m s}^{-2}$. The lift is accelerating upwards.

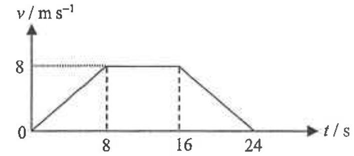
At t = 8 to 16 s, R = 500 N.

As $R = W$, the net force is zero, thus the lift is moving upwards with uniform velocity.

At t = 16 to 24 s, R = 450 N.

By $mg - R = ma$ $\therefore (500) - (450) = (50) a$ $\therefore a = 1 \text{ m s}^{-2}$. The lift is decelerating upwards.

Draw a velocity - time graph.



Maximum velocity : $v = u + at = (0) + (1)(8) = 8 \text{ m s}^{-1}$

Height = total distance travelled = area under the graph

$= \frac{1}{2}(8 + 24)(8) = 128 \text{ m}$

137. A

$T_A \sin \theta = T_C$ $\therefore T_A > T_C$

$T_A \cos \theta = T_B$ $\therefore T_A > T_B$

String OA would break first as its tension is the greatest among the three strings.

138. A

✓ (1) Tension of the elastic cord depends on the extension.
From P to Q, the extension of the cord is smaller than that at Q,
thus the weight of the boy is greater than the tension of the cord ($mg > T$).
As the net force is downwards, the acceleration is downwards,
therefore, the boy is under acceleration and his speed increases throughout.

✓ (2) From O to Q, the boy's speed increases throughout as $mg > T$.
At Q, the forces are balanced as $mg = T$.
From Q to R, the boy's speed decreases as $T > mg$.
Thus, the speed is the maximum at Q.

× (3) At R, the boy is momentarily at rest but the acceleration is upwards as $T > mg$.
Thus, net force is not zero.

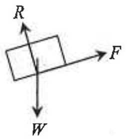
139. B

Resolve the tension in each side into vertical and horizontal components.

The two vertical components $T \cos 70°$ are balanced by the weight of the fish and hook.

$\therefore W = 2T \cos 70° = 20 \cos 70° \text{ N}$

140. C



Since the inclined plane is rough, there must be friction acting on the block.

As friction tends to prevent the block from sliding down,
the direction of the friction is upwards along the plane.

Normal reaction exists when two surfaces are in contact.

141. C

By $F - f = ma$ $\quad\therefore\ (5) - f = (1)(2)$ $\quad\therefore\ f = 3$ N

142. B

① When the lift is moving upwards with a uniform speed, there is no acceleration, thus $R_1 = mg$.

② When the lift is moving downwards with a uniform speed, there is no acceleration, thus $R_2 = mg$.

③ When the lift is moving upwards with an acceleration, there is an upward net force, thus $R_3 > mg$.

$\therefore\ R_3 > R_1 = R_2$

143. D

Motion of the block on the smooth inclined plane :

$mg\sin\theta = ma$

$\therefore\ a = g\sin\theta$

The acceleration depends on the angle of the incline. Slope of the *v-t* graph represents the acceleration *a*.

Release at higher position with the same angle results in the same slope with greater velocity at the bottom.

Motion of the block on the rough ground :

$f = ma$

The deceleration depends on the friction *f*. Slope of the second portion of the line represents the deceleration.

Same friction indicates the same deceleration and the same slope.

144. B

× (1) The weight of the block should be balanced by the force exerted by the table and the 60 N, that is, $W = R + 60$ and $R = 40$ N.

× (2) The force exerted on the table by the block is the normal reaction *R* which is equal to 40 N.

✓ (3) These two forces are equal and opposite, and act on each other.

145. A

After the loading of the plasticine, the total mass increases, thus the acceleration *a* decreases.

Consider block *R*, $T_2 = m_R a$, as *a* decreases, T_2 decreases.

Consider block *P*, $F - T_1 = m_P a$, as *a* decreases, T_1 increases.

146. C

Consider the whole system : $F_1 - F_2 = (m + 2m)\,a$ $\quad\therefore\ a = \dfrac{F_1 - F_2}{3m}$

Consider P : $F_1 - T = (m)\left(\dfrac{F_1 - F_2}{3m}\right)$

$\therefore\ T = \dfrac{2F_1 + F_2}{3}$

147. A

At 0°, the resultant force is $F_1 + F_2$, and this resultant force is the greatest.

At 180°, the resultant force is $F_1 - F_2$, and this resultant force is the smallest.

Thus, the resultant force decreases throughout.

148. C

✓ (1) Since the slides down with uniform speed, the acceleration is zero, thus the net force is also zero.

✓ (2) Since net force is zero $\therefore\ f = mg\sin 30° = 0.5\,mg$

× (3) The acceleration depends on the friction and the angle of the incline, but not affected by the initial speed.

149. A

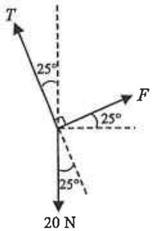
By Newton's second law, net force = mass × acceleration

$\therefore\ F - f = ma$

$\therefore\ a = \dfrac{1}{m}F - \dfrac{f}{m}$

The graph is a straight line with a negative *y*-intercept.

150. A



Balance of forces in *x*-direction : $T\sin 25° = F\cos 25°$ $\quad\therefore\ T = F\dfrac{\cos 25°}{\sin 25°}$

Balance of forces in *y*-direction : $T\cos 25° + F\sin 25° = 20$

$\therefore\ F\dfrac{\cos 25°}{\sin 25°} \times \cos 25° + F\sin 25° = 20$

$\therefore\ F\dfrac{\cos^2 25° + \sin^2 25°}{\sin 25°} = 20$

$\therefore\ F = 20\sin 25° = 8.5$ N

OR

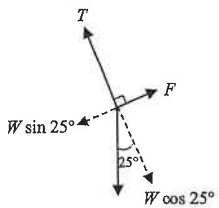
Resolve the weight *W* into 2 components : $W\sin\theta$ and $W\cos\theta$

Balances of forces :

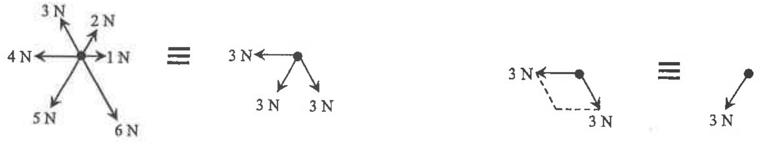
① $F = W\sin\theta$

② $T = W\cos\theta$

$\therefore\ F = 20\sin 25° = 8.5$ N

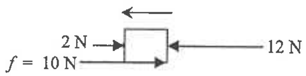


151. D

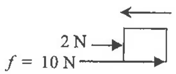


The resultant force is 3 N + 3 N = 6 N along *OE* direction.

152. A



Friction along sliding surface must always be opposite to the motion and keep constant.



When the 12 N is removed, as the block still keeps moving, the direction and magnitude of the friction f is unchanged, thus, the net force acting on the block = 2 + 10 = 12 N

153. C

Let the tension be T and the acceleration be a.

As block of 3 kg has smaller mass, acceleration of 3 kg block is upwards and acceleration of 5 kg block is downwards.

Consider the 3 kg block : $T - (3\,g) = (3)\,a$

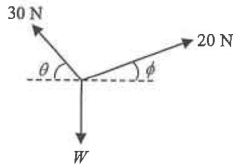
Consider the 5 kg block : $(5\,g) - T = (5)\,a$

Combine the two equations :

$(5\,g) - (3\,g) = (3+5)\,a$

$\therefore\ a = \frac{1}{4}g$

154. A



As the system is in equilibrium, forces in the vertical direction are balanced.

$\therefore\ 30\sin\theta + 20\sin\phi = W$

As $\sin\theta$ and $\sin\phi$ must be less than 1,

$\therefore\ 30\sin\theta < 30$ and $20\sin\phi < 20$

$\therefore\ W < 50$ N

$\therefore$ W must be less than 50 N

155. C

$F = m_1 a_1$ and $F = m_2 a_2$

$F = (m_1 + m_2)\,a$

$\therefore\ F = (\frac{F}{a_1} + \frac{F}{a_2})\,a$ $\therefore\ \frac{1}{a} = \frac{1}{a_1} + \frac{1}{a_2}$

$\therefore\ a = \frac{a_1 a_2}{a_1 + a_2}$

156. D

The boy experiences 3 forces :

① weight W acting on the boy by the Earth (downwards)

② normal reaction R acting on the boy by the ground (upwards)

③ pulling force F by the rope on the boy (upwards)

$\therefore\ F + R = W$ $\therefore\ R = W - F$

By Newton's third law, force acting on the ground by the boy is also R, which is $W - F$.

Force acting on the ceiling by the rope = weight of the rope + pulling force by the boy

= $G + F$

157. C

By $v^2 = u^2 + 2as$

$\therefore\ (0) = (2)^2 + 2\,a\,(0.5)$ $\therefore\ a = -4$ m s^{-2}

Deceleration of the block is 4 m s^{-2}.

158. A

By $s = ut + \frac{1}{2}at^2$

$\therefore\ (1) = (0) + \frac{1}{2}a\,(3)^2$ $\therefore\ a = 0.22$ m s^{-2}

159. C

Weight mg is pointing vertically downwards.

Normal reaction N is pointing upwards and perpendicular to the inclined plane.

Friction f is pointing upwards along the inclined plane to oppose the sliding of the block.

160. A

Since X and Y move together, they have the same magnitude of acceleration a.

The net force pushing them to move together is the weight of Y.

$\therefore\ (1)(9.81) = (0.5 + 1)\,a$ $\therefore\ a = 6.54$ m s^{-2}

Consider the falling motion of Y.

By $v^2 = u^2 + 2as$

$\therefore\ v^2 = (0) + 2\,(6.54)\,(1)$ $\therefore\ v = 3.62$ m s^{-1}

The following list of formulae may be found useful :

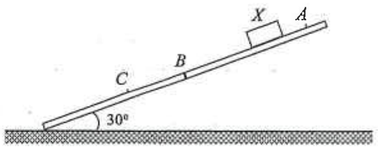
For uniformly accelerated motion
$v = u + at$
$s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

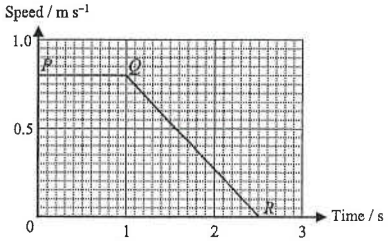
Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81 \text{ m s}^{-2}$ (close to the Earth)

Part A : HKCE examination questions

1. **< HKCE 1985 Paper I - 1 >**





The figure above shows a block X of mass 0.5 kg sliding down a plane inclined at an angle of 30° with the horizontal. The plane is composed of two portions made of different materials. They join at B. The speed-time graph of the block is shown . PQ denotes the motion of the block in portion AB while QR denotes the motion in portion BC.

(a) Find

(i) the resultant force, and

(ii) the frictional force

acting on the block X in the portion AB of the inclined plane. (4 marks)

(b) From the graphs shown above, find

(i) the acceleration of, and

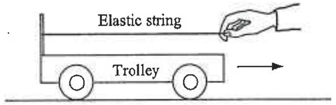
(ii) the distance travelled by

the block X in the portion BC of the inclined plane. (4 marks)

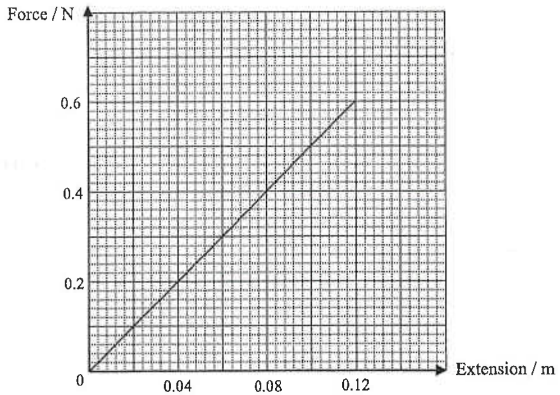
1. (c) If the block X is projected upwards from point C along the inclined plane with a certain initial speed, sketch the speed-time graph of the upward motion. (Assume the block passes through point B.) (4 marks)

2. **< HKCE 1990 Paper I - 1 >**

The figure below shows a trolley of length 0.25 m resting on a horizontal runway. An elastic string of unstretched length 0.15 m is tied to the trolley. The trolley is pulled along the runway by stretching the elastic string. By keeping the length of the stretched string equal to the length of the trolley, a constant force F_1 N is applied to pull the trolley.



(a) The force-extension characteristic of the elastic string is shown below.



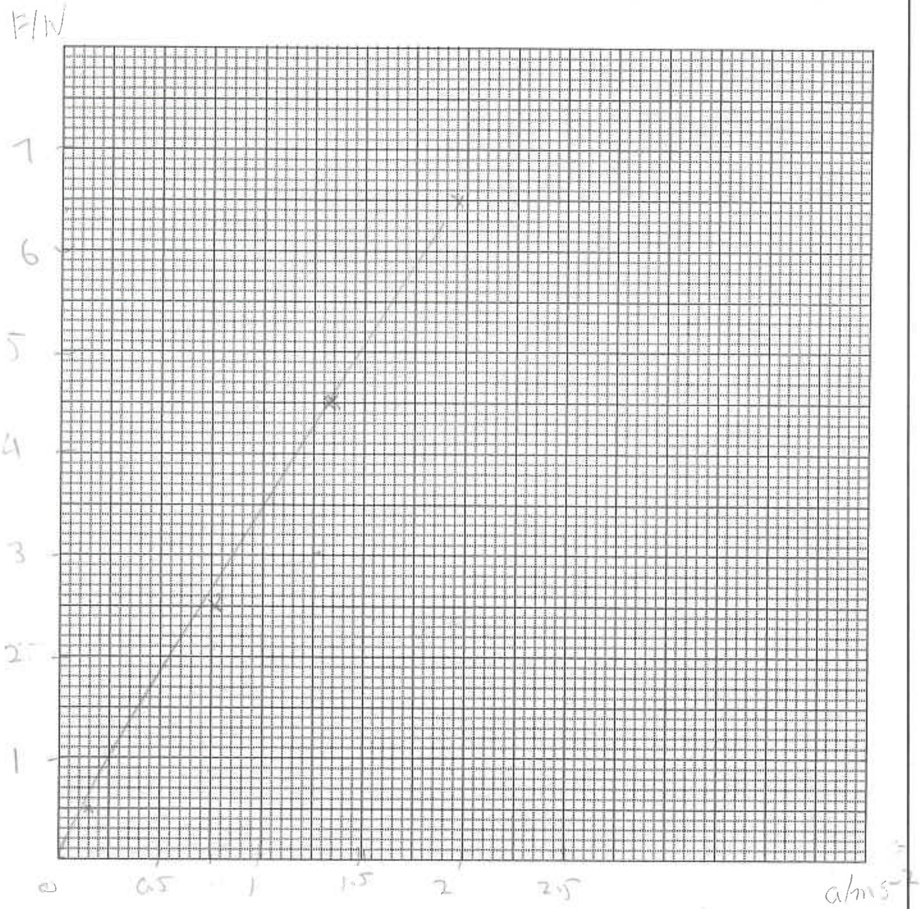
What is the value of F_1 ? (1 mark)

(b) The experiment is repeated with two, three and four identical strings in parallel. The following results are obtained :

Number of elastic strings	1	2	3	4
Force on trolley by strings F / N	F_1	F_2	F_3	F_4
Acceleration a / m s^{-2}	0.15	0.75	1.35	1.95

(i) Find the values of F_2, F_3 and F_4. (1 mark)

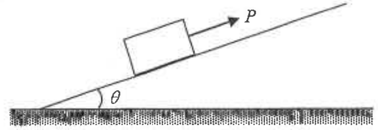
2. (b) (ii) Using a scale that 4 cm represents 0.5 N and 4 cm represents 0.5 m s^{-2}, plot a graph of F against a. (4 marks)



(iii) Find the equation relating F and a from the graph in (ii). (3 marks)

(iv) Comment on the physical meaning of F_o, the intercept on the F axis, when a equals zero. (2 marks)

3. **< HKCE 1994 Paper I - 1 >**

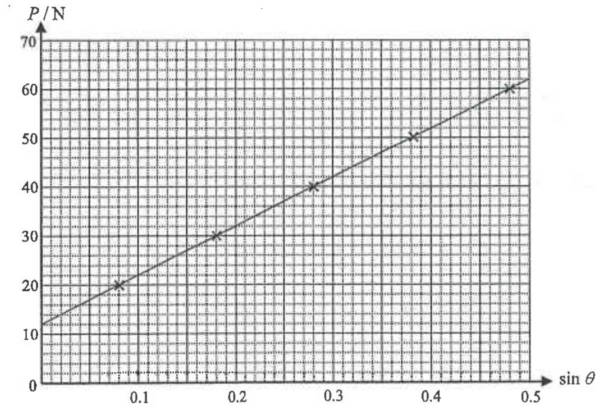


A block is placed on a rough plane inclined at an angle θ to the horizontal. A force P parallel to the inclined plane is applied to the block so that it moves up the plane at a constant speed. See the figure above.

(a) Draw a diagram to show all the forces acting on the block. Name the forces. (3 marks)

(b) Describe briefly a method to check whether the speed of the block remains constant. (2 marks)

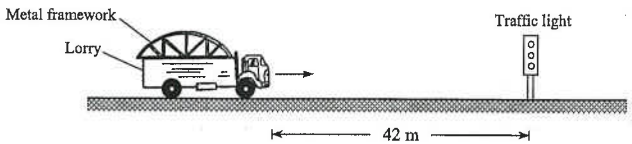
(c) A student performs an experiment to find the relationship between P and θ. Different values of θ are used and the corresponding values of P are measured. The results are plotted in a graph of P against sin θ as shown below.



(i) Find the intercept of the graph on the P-axis and the slope of the graph. Hence write down the equation relating P and sin θ. (4 marks)

(ii) State the physical meanings of the intercept and the slope found in (i). (2 marks)

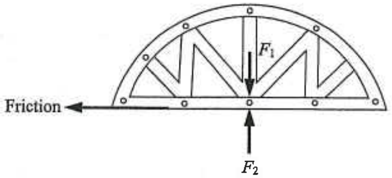
4. **< HKCE 1999 Paper I - 7 >**



A lorry, with a heavy metal framework placed on top, is travelling at a uniform speed of 16 m s^{-1} along a straight road. (See the above figure.) At time t = 0, the driver observes that a traffic light, which is at a distance of 42 m from the lorry, is turning red. The driver applies the brake at t = 0.5 s. The lorry then decelerates uniformly and comes to a rest at t = 4.5 s.

(a) Find the deceleration of the lorry from t = 0.5 to 4.5 s. (1 mark)

(b)



The above figure shows the forces acting on the framework when the lorry is decelerating. The mass of the framework is 1000 kg.

(i) Name the forces F_1 and F_2. (2 marks)

(ii) Explain whether F_1 and F_2 are a pair of action and reaction according to Newton's third law of motion. (2 marks)

(iii) Find the magnitude of the friction if the framework decelerates at the same rate as the lorry. (2 marks)

(iv) The driver is charged by a policeman for not fastening the framework on the lorry. State **two** daily situations in which the framework will slip from the moving lorry. (2 marks)

5. **< HKCE 2001 Paper I - 8 >**

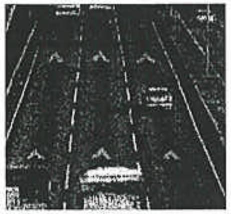


Figure 1

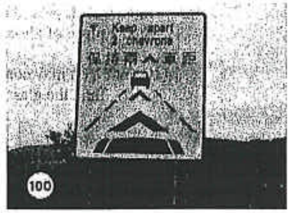


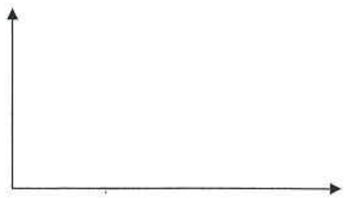
Figure 2

Figure 1 shows a horizontal straight highway with a speed limit of 100 km h^{-1} (i.e. 27.8 m s^{-1}). For safety reasons, drivers are advised to maintain a safety distance of 80 m from the cars ahead. Large arrows (chevrons) are painted on the highway (each at 80 m apart) and road signs are set up to remind drivers of this safety distance (see Figure 1 and 2).

(a) Find the time taken by a car to drive from one arrow to another when it is travelling at 100 km h^{-1}. (1 mark)

(b) A car is travelling at 100 km h^{-1} on the highway. At time t = 0, the driver observes that an accident has happened and a lorry stops 80 m ahead. He applies the brakes to stop the car with uniform deceleration. The reaction time of the driver is 0.8 s and the decelerating time of the car is 4 s.

(i) Sketch the speed-time graph of the car. (3 marks)

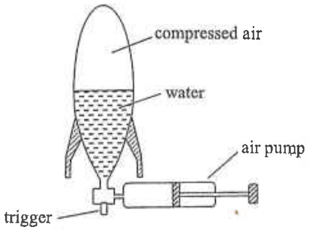


(ii) Explain whether the car will hit the lorry. (3 marks)

(iii) The total mass of the car and the driver is 1200 kg. Find the average braking force on the car. (3 marks)

(c) Suppose the highway in Figure 1 is on a slope with traffic running downhill. Do you think that the distance between two arrows should be greater than, equal to or less than 80 m ? Explain your answer by considering the forces acting on a car. Assume that the speed limit of the highway and the braking force acting on the car remain unchanged. (4 marks)

6. **< HKCE 2004 Paper I - 2 >**



The Figure above shows a water rocket. The rocket is filled with water and compressed air. Explain why the rocket rises when the trigger is pulled and name the law or principle involved. (3 marks)

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7. **< HKCE 2005 Paper I - 13 >**

Read the following descriptions about ejection seats and answer the questions that follow.

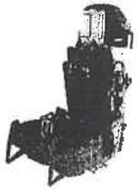


Figure 1

Figure 2

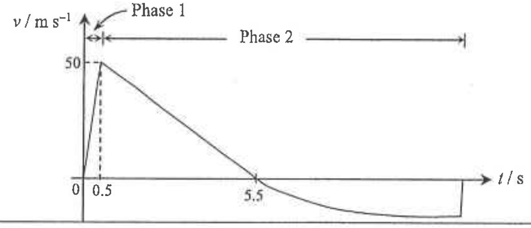
Ejection seats (see Figure 1) are important safety devices in military planes. The pilot, together with the seat, are ejected out of the plane in an emergency. Figure 2 shows a test of the ejection process. A dummy pilot sitting on the ejection seat is initially placed on the ground. The ejection process can be divided into two phases.

Phase 1 : At time $t = 0$, a rocket installed under the seat is ignited. From $t = 0$ to 0.5 s, the seat accelerates upwards.

Phase 2 : At $t = 0.5$ s, the rocket exhausts its fuel. After a while, the seat reaches its maximum height. The seat is then detached from the dummy and a parachute carried by the dummy is opened. The dummy eventually reaches the ground.

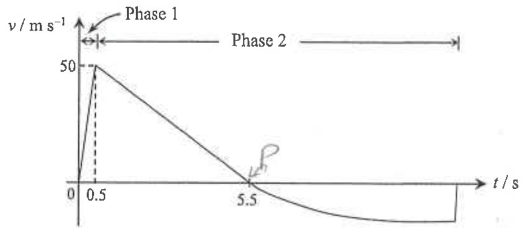
Figure 3 shows the velocity-time graph of the dummy during the ejection process. Assume that the motion of the dummy is vertical throughout the process, and the effect of air resistance is negligible before the parachute is opened. (The acceleration due to gravity is taken to be 10 m s^{-2}.)

Figure 3



Source for Figures 1 and 2 : http://www.science.howstuffworks.com/ejection-seat2.htm

7. (a) In the Figure below, label the point which corresponds to the instant when the dummy reaches the maximum height. (Note : Use P to denote the point.) (1 mark)



(b) Find the maximum height above the ground reached by the dummy. (2 marks)

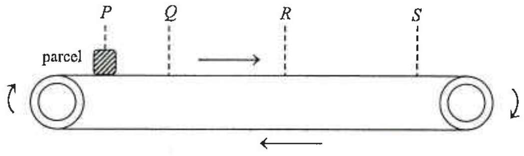
(c) The mass of the dummy is 80 kg. Find the force exerted by the ejection seat on the dummy in Phase I. (3 marks)

(d) By considering the forces acting on the dummy, explain the following motion of the dummy in Phase 2 :

After the parachute has been opened, the dummy accelerates downwards at first and then falls with a uniform velocity (see Figure 3).

It is known that the force exerted by the parachute on the dummy increases with its speed. (3 marks)

8. **< HKCE 2006 Paper I - 4 >**



The above Figure shows a conveyor belt in a factory. A parcel of mass 10 kg is placed at position P when the belt remains at rest. The workman controls the belt such that the parcel undergoes a motion described in the below Table. The parcel and the conveyor belt move together without slipping during the entire motion.

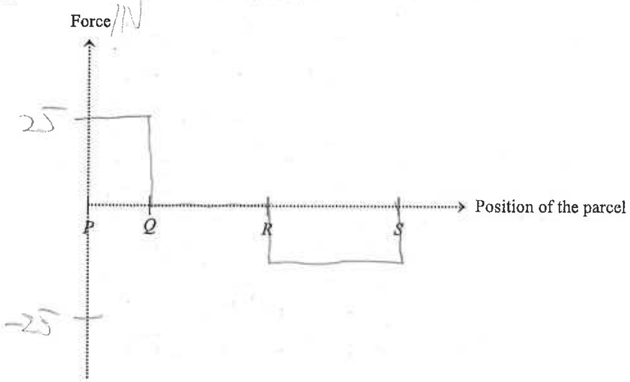
Position of the parcel	Motion	Data given
$P \to Q$	Uniform acceleration	PQ = 5 m and time required = 2 s
$Q \to R$	Uniform velocity	-----
$R \to S$	Uniform deceleration to rest	-----

(a) Consider the motion when the parcel travels from P to Q.

(i) Draw a free-body diagram to show all forces acting on the parcel in the space provided below. Name the forces. (2 marks)

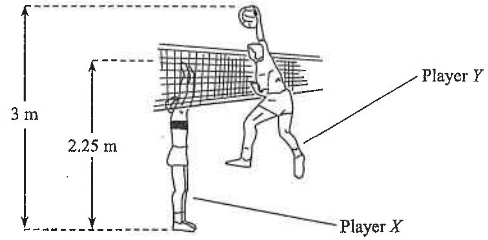
(ii) Find the net force acting on the parcel. (3 marks)

(b) In the Figure below, sketch a graph to show the variation of the frictional force exerted by the conveyor belt on the parcel. (3 marks)



9. **< HKCE 2007 Paper I - 2 >**

The Figure below shows Player X trying to block the ball from Player Y in a volleyball game. Standing on the ground with his arms fully stretched upwards, Player X's hands are 2.25 m above the ground. In order to block the ball, Player X has to jump up such that his hands reach a height of 3 m.

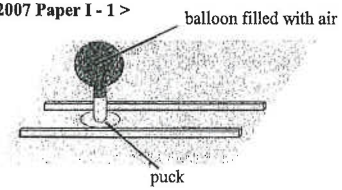


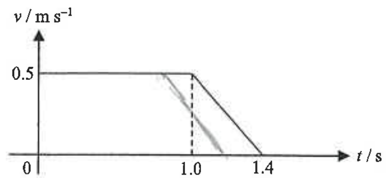
(a) Using Newton's laws of motion, explain why Player X can gain an initial speed to leave the ground vertically. (3 marks)

(b) Player X jumps up vertically and his hands can just reach a height of 3 m. Estimate the initial speed of Player X at the instant he leaves the ground. Assume that air resistance is negligible. (2 marks)

(c) Player Z is a teammate of Player X. His hands can also reach a height of 2.25 m when his arms are fully stretched upwards, but he is heavier than Player X. If he jumps up such that his hands just reach a height of 3 m, explain whether the initial vertical speed of Player Z will be the same as Player X. (2 marks)

10. **< HKCE 2007 Paper I - 1 >**





A balloon is filled with air and is attached to a puck. It releases air through a hole at the bottom of the puck. The balloon puck then moves on a horizontal straight track as shown in the above figure and its velocity-time graph is also shown.

(a) (i) Describe the motion of the balloon puck from time t = 0 to 1.4 s. (2 marks)

(ii) Explain why the motion of the balloon puck changes at t = 1.0 s. (2 marks)

(b) If the balloon is filled with less air and its initial velocity is still 0.5 m s^{-1}, sketch the corresponding velocity-time graph of the balloon puck in the above velocity-time graph. (2 marks)

11. < HKCE 2008 Paper I - 3 >

Read the following passage about Mega Drop and answer the questions that follow.

Figure 1 shows a "Mega Drop" in an amusement park. The vehicle carrying the passengers is lifted by an electric motor-winch and steel ropes. Once it reaches the top of the tower, the vehicle remains at rest for a while. It is then released and falls under gravity. When the vehicle gets very close to the ground, it decelerates downward and finally stops.

Figure 1

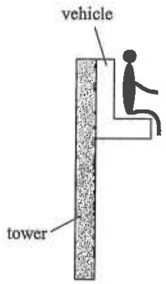


Figure 2

Let's consider why the passengers experience weights when the vehicle is at rest at the top of the tower (Figure 2). The earth attracts our bodies while the seat also gives a supporting force on us. These two forces are equal in magnitude but opposite in direction. Our bodies experience the supporting force and thus we can experience our weight.

When we are falling in a "Mage Drop", we are nearly free falling and experience weightlessness. This feeling gives an excitement to the passengers.

(a) Consider when the passenger is at rest at the top of the tower :

(i) Explain in terms of force acting on the passenger why the passenger is at rest. (2 marks)

(ii) Explain whether the forces acting on the passenger mentioned in the passage are action-reaction pair. (2 marks)

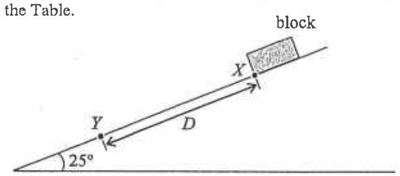
(b) Consider when the "Mega Drop" falls with acceleration :

(i) Compare the magnitude of the vertical forces action on the passenger with those mentioned in (a)(ii). (2 marks)

(ii) Hence, explain why the passenger experiences "weightlessness". (1 mark)

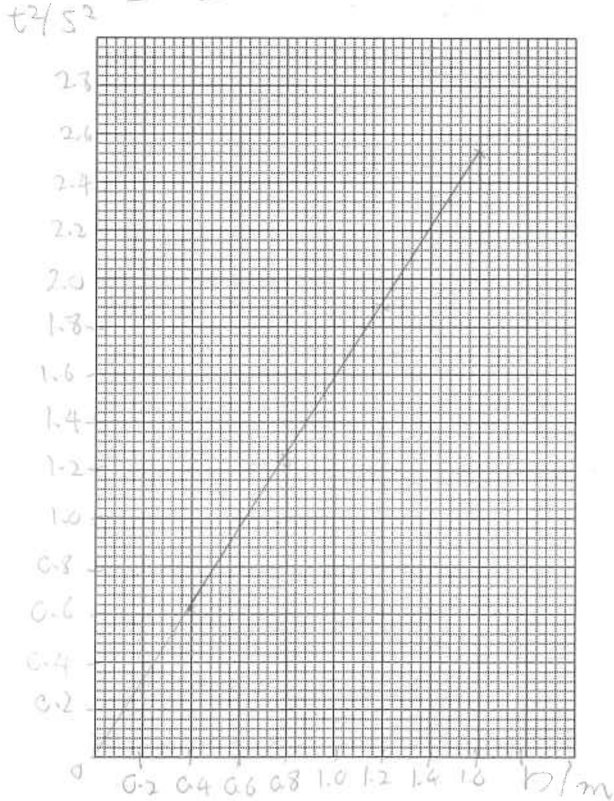
12. < HKCE 2009 Paper I - 9 >

An experiment is set up to measure the average friction acting on a plastic block sliding on a wooden plane with an inclination 25°C to the horizontal as shown in the figure below. When the block is released from rest at *X*, the timer starts. When the block reaches *Y*, the timer stops. The experiment is repeated by varying the positions of *Y* along the plane. The results obtained are shown in the Table.



Distance between *X* and *Y* (D / m)	Time taken (t / s)
0.4	0.79
0.8	1.12
1.2	1.37
1.6	1.59

(a) (i) Plot a graph of t^2 against D in the below Figure. A scale of 1 cm representing 0.2 s^2 and 0.2 m is used. (4 marks)



12. (a) (ii) Find the slope of the graph plotted in (a)(i). (1 mark)

(iii) Hence, find the average acceleration of the block. (2 marks)

(b) Draw a free-body diagram to show all the forces acting on the sliding block in the space provided below. Name the forces. (2 marks)

(c) The mass of the block is 0.178 kg. Find the average friction acting on the sliding block. (2 marks)

13. **< HKCE 2010 Paper I - 1 >**

Figure 1 shows a 15 kg parcel resting on the floor of a train which travels along a straight horizontal path. The parcel and the train move together without slipping during the entire motion. Take the direction of the motion of the train as positive.

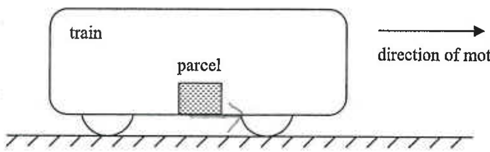


Figure 1

The velocity-time graph of the train is shown in Figure 2.

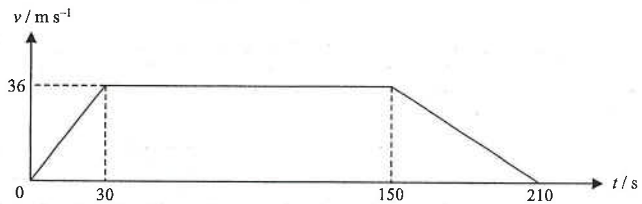


Figure 2

(a) In Figure 1, use an arrow to show the direction of the frictional force acting on the parcel by the train floor between $t = 0$ and 30 s. (1 mark)

13. (b) In Figure 3, sketch the force-time graph showing the net force acting on the parcel between $t = 30$ s and 210 s. (The part between $t = 0$ and 30 s has been shown in the graph.) (2 marks)

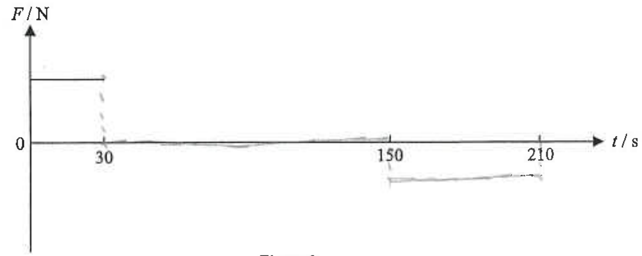


Figure 3

(c) Find the magnitude of the net force acting on the parcel between $t = 0$ and 30 s. (2 marks)

(d) Find the distance travelled by the train from $t = 0$ to 210 s. (2 marks)

Part B : Supplemental exercise

14. Susan takes part in a 100 m race at an athletic meet. She starts at time $t = 0$ s and accelerate at a uniform rate of 1.6 m s^{-2} for 5 s. She then maintains a uniform speed afterwards and reaches the finishing line at $t = 15$ s. Susan's mass is 45 kg.

(a) Find the resultant force acting on Susan in the race during the first 5 s. (2 marks)

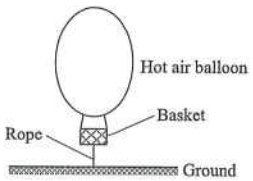
(b) Find the resultant force acting on Susan in the race after $t = 5$ s. (1 mark)

15. A helicopter of mass 1500 kg is initially at rest at a certain level above the ground. It accelerates uniformly and vertically upwards for 75 m and reaches a speed of 15 m s^{-1}. Assume the air resistance is negligible.

(a) Calculate the acceleration of the helicopter. (2 marks)

(b) Calculate the uplifting force acting on the helicopter. (3 marks)

16.



A hot-air balloon is tied to the ground by a rope to stop it from rising as shown in the above figure. The total mass of the balloon and the basket is 750 kg. There also exists an upward force of 8000 N acting on the balloon.

(a) What is the tension of the rope ? (3 marks)

(b) The rope is then cut and the balloon starts to rise up.

(i) What is the acceleration of the balloon after the rope is cut ? (3 marks)

(ii) What is the height that the balloon has risen after 1 minute ? (2 marks)

(iii) If the balloonist throws some sandbags out of the basket during the rise, what is the effect on the acceleration of the balloon ? Explain briefly. (3 marks)

17. John is riding a bicycle along a straight road with uniform speed 10 m s^{-1}. At time $t = 0$, he sees a warning signal. John applies the brake for 2.0 s to bring the bicycle to rest with uniform deceleration. Assume John's reaction time (i.e. the time lapse between seeing the signal and starting to apply the brake) is 0.2 s.

(a) Find the distance travelled by the bicycle from $t = 0$ to $t = 0.2$ s. (2 marks)

(b) Find the distance travelled by the bicycle when it is decelerating. (2 marks)

(c) By using Newton's laws of motion, explain why it is dangerous for John to carry an excessive amount of goods on the bicycle when he is riding in the street. (3 marks)

Part C : HKDSE examination questions

18. **< HKDSE 2014 Paper IB - 4 >**

Read the following description about **accelerometers** and answer the questions that follow.

An accelerometer is a device for measuring acceleration. The following example illustrates the principle of a simple accelerometer. An object of mass M is suspended by a spring balance inside a box. If the box is at rest without acceleration, the object is h above the bottom of the box (Figure 1). When the box accelerates upward, h decreases (Figure 2). Likewise, when the box accelerates downwards, h increases (Figure 3). Since it is known that the tension of the spring balance is directly proportional to its extension, we can therefore determine the magnitude and direction of the box's acceleration by measuring h.

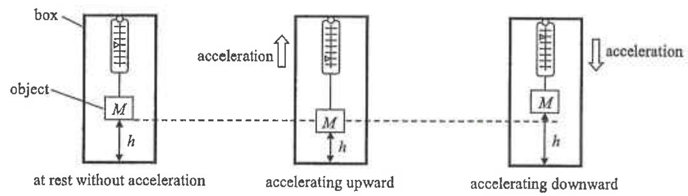
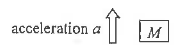


Figure 1 **Figure 2** **Figure 3**

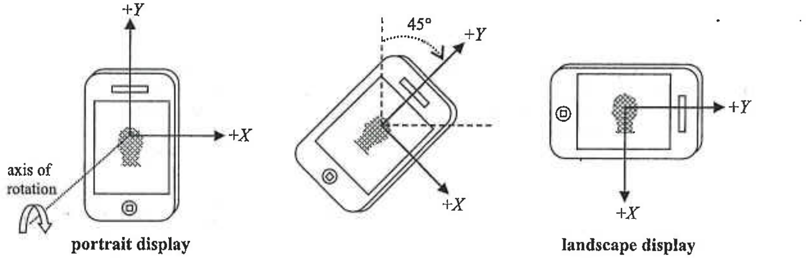
(a) Draw a labelled free-body diagram in the space provided below showing the forces acting on the object when the box accelerates upward with acceleration a. Explain why h decreases in this case. (4 marks)



(b) The scale of the spring balance is calibrated such that the pointer moves 1 cm for a change of 2 N of force. The weight of the object is 5 N. If h decreases by 0.5 cm compared to the situation in Figure 1, what is the reading of the balance ? Hence find the magnitude of the corresponding acceleration of the box.
(Acceleration due to gravity $g = 9.81$ m s^{-2}) (3 marks)

18. Electronic accelerometers employing similar principles are widely used in smart phones. The phone's orientation is detected by a set of built-in accelerometers each detecting the acceleration due to gravity along mutually perpendicular axes of the phone. A phone in vertical orientation is shown on the left of Figure 4, its accelerometer along the Y axis would be sensing the acceleration due to gravity, denoted by $a_Y = -g$. When the phone is rotated about a horizontal axis perpendicular to both X and Y axes by more than 45°, 'portrait display' would change to 'landscape display' as shown on the right of Figure 4.

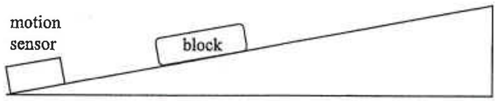
Figure 4



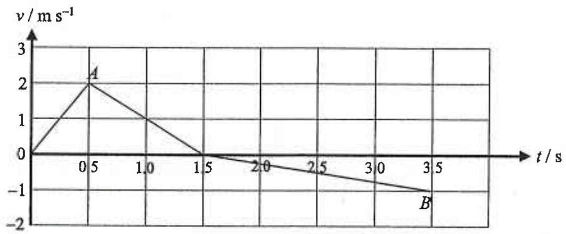
(c) What would the kind of display be if the phone is rotated clockwise until the acceleration a_Y sensed by the accelerometer along the Y axis is $-0.5\ g$? Explain. (2 marks)

19. **< HKDSE 2015 Paper IB - 4 >**

The motion of a block on an inclined plane can be investigated using a motion sensor connected to a computer (not shown in the figure.)



A block is given a push up a rough inclined plane and then released. The velocity-time (v-t) graph recorded by the sensor is shown below. Assume that the frictional force acting on the block is constant in magnitude throughout the motion. Neglect air resistance. ($g = 9.81\ \text{m s}^{-2}$)

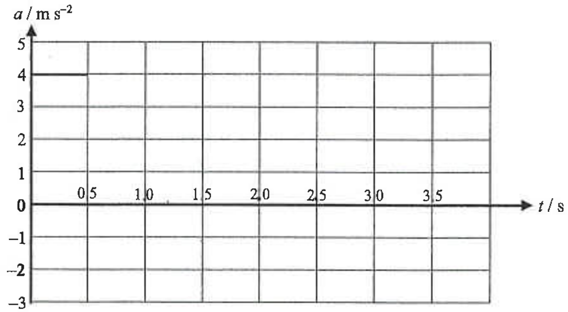


Point A on the graph corresponds to the instant at which the push is removed.

(a) Describe the block's motion from A to B. (2 marks)

19. (b) (i) Find the magnitude of the block's acceleration from $t = 1.5$ s to $t = 3.5$ s. (2 marks)

(ii) Draw the corresponding acceleration-time (a-t) graph of the block. With the direction up the inclined plane taken to be positive, the part during which the block is being pushed has been drawn for you. (2 marks)

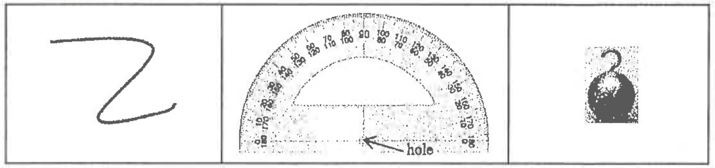


(c) Draw a free-body diagram to show the force(s) (with labels) acting on the block as it moves up the inclined plane after the push is removed. (2 marks)

(d) If the mass of the block is 1.0 kg, find the magnitude of the frictional force. (3 marks)

20. < HKDSE 2015 Paper IB - 5 >

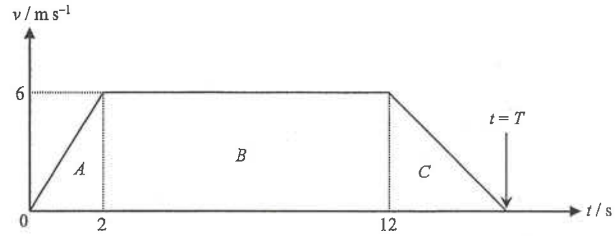
You are given a long light string, a protractor and a metal ball with a hook.



Suppose you are inside a train which is at rest initially and later it travels along a straight horizontal track with constant acceleration. With the aid of a diagram, describe how to measure the acceleration of the train. Show your working including mathematical derivation. (6 marks)

21. < HKDSE 2016 Paper IB - 3 >

A person of mass m stands on a balance inside a lift. The lift goes down from the top of a building at time $t = 0$ and it reaches the ground at $t = T$. The velocity-time (v - t) graph of the lift is shown in the Figure below. ($g = 9.81$ m s^{-2})



(a) Calculate the acceleration of the lift from $t = 0$ to $t = 2$ s. (2 marks)

The reading of the balance changes during the person's ride on the lift and the readings registered are 685 N, 569 N and 395 N.

(b) Match these readings with the three stages, A, B and C, of the ride shown in the above Figure. Hence deduce the mass of the person. (3 marks)

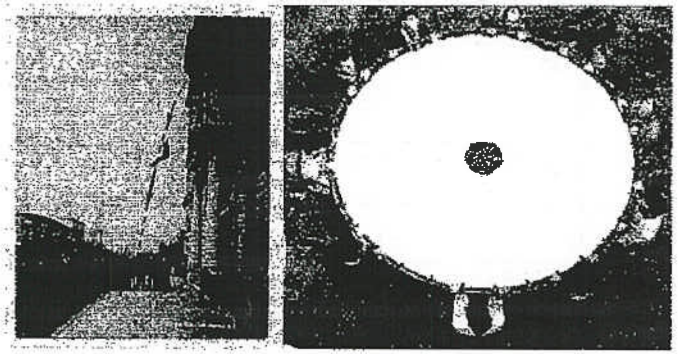
A : ________ B : ________ C : ________

(c) (i) Show that $T = 15$ s. (2 marks)

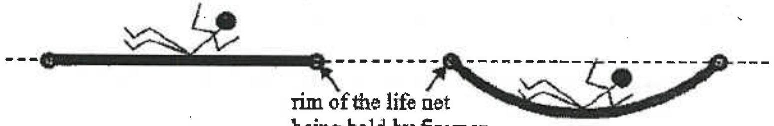
(ii) Hence estimate the height of the building. (2 marks)

22. <HKDSE 2019 Paper-IB-3>

A life net is a rescue equipment formerly used by firefighters. It gives people on the upper floors of a burning building an opportunity to jump to safety, usually to ground level. It became obsolete due to advances in firefighting technology.



The practical height limit for successful use of life nets is about six storeys, although a few people once have survived jumps from an eight-storey building into a life net with various degree of injuries. The diagrams below explain its working principle.



When a person hits the net, it deforms and puts the person to a stop in a longer time as compared to hitting the solid ground.

(a) A person falls from a height of 12 m above a life net with negligible initial speed. Neglect air resistance and the size of the person. ($g = 9.81$ m s^{-2})

(i) Estimate (1) the vertical speed v and (2) the time of fall t of the person just before hitting the life net. (4 marks)

(ii) If this falling person of mass 70 kg is stopped in 0.3 s by the life net, estimate the average force acting on the person by the net within this time interval. (3 marks)

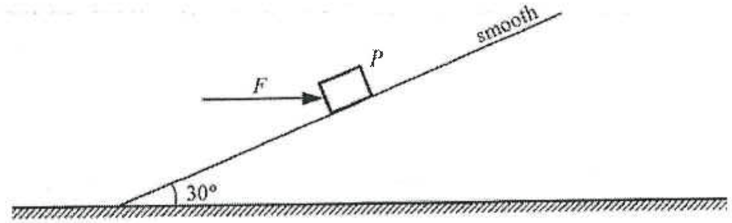
(iii) What form of energy is stored by the life net during the deceleration of the falling person ? (1 mark)

(b) (i) Give a reason why there exists a height limit of using life nets. (1 mark)

*(ii) The falling person might hit the rim of the net, thus the person or the firemen holding the rim would be injured. Explain why it is not easy for a person jumping from a height to reach the life net's central part. (2 marks)

23. < HKDSE 2020 Paper 1B -5>

gure 5.1



(a) A block P of mass 10 kg is kept stationary on a smooth incline by a horizontal force F as shown in Figure 5.1. The incline makes an angle of 30° with the horizontal. ($g = 9.81$ m s^{-2})

(i) On Figure 5.1, indicate and label all other forces acting on P. (2 marks)

(ii) Find the magnitudes of the force F and the force exerted by the block on the incline respectively. (3 marks)

(b) Now F is removed and neglect air resistance.

(i) What is the magnitude of the acceleration of the block ? (1 mark)

(ii) Explain whether the force exerted by the block on the incline would increase, decrease or remain unchanged when compared with that in (a)(ii). (2 marks)

Question Solution

1. (a) (i) Acceleration = slope = 0 [1]

Resultant force = 0 [1]

(ii) Frictional force = $m g \sin\theta$ [1]

$= (0.5) \times (9.81) \times \sin 30^\circ$

$= 2.45$ N [1]

(b) (i) acceleration = slope

$= \dfrac{(0 - 0.8)}{(2.5 - 1)}$ [1]

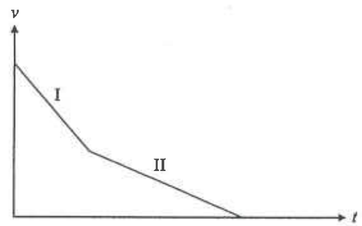
$= -0.53$ m s^{-2} [1]

(ii) distance travelled = area

$= \frac{1}{2} \times (0.8) \times (1.5)$ [1]

$= 0.6$ m [1]

(c)



< Negative slope drawn at I > [1]

< Turning point drawn when the block passes *B* > [1]

< Negative slope drawn at II > [1]

< Slope of I is steeper than that of II > [1]

(since the friction at *BC* is greater, the deceleration of the block at I is greater than that at II)

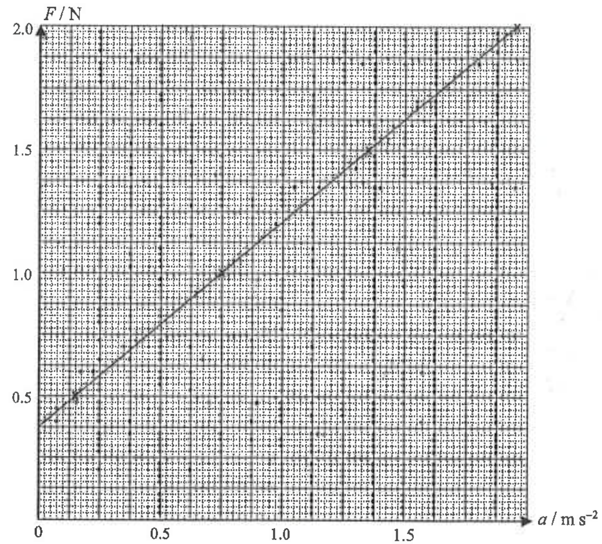
2. (a) $F_1 = 0.5$ N [1]

(observed from the graph when the extension is 0.10 m)

(b) (i) $F_2 = 1.0$ N $F_3 = 1.5$ N $F_4 = 2.0$ N

< all the three forces are correct > [1]

2. (a) (ii)



< Correct labelled axes > [1]

< Correct scale > [1]

< Correct points > [1]

< Straight line > [1]

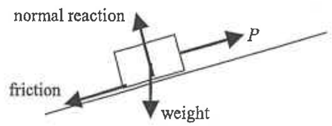
(iii) Slope = 0.83 [1]

Intercept on *F* axis = 0.375 [1]

Equation : $F = 0.83\,a + 0.375$ [1]

(iv) F_o is the friction acting on the trolley by the runway [2]

3. (a)



< normal reaction force > [1]

< friction > [1]

< weight > [1]

(b) Attach a paper tape which is connected to a ticker tape timer to the block. [1]

The dots on the tape should be evenly spaced. [1]

3. (c) (i) Intercept = 12 [1]

Slope = $\frac{62-12}{0.5-0}$ = 100 [2]

The equation is $P = 100 \sin\theta + 12$ [1]

(ii) The intercept represents the frictional force between the block and the plane. [1]

The slope represents the weight of the block. [1]

4. (a) By $v = u + at$

$\therefore (0) = (16) + a(4.5 - 0.5)$ $\therefore a = -4 \text{ m s}^{-2}$ [1]

(b) (i) F_1 is the weight of the framework. [1]

F_2 is the normal reaction force acting on the framework by the lorry. [1]

(ii) F_1 and F_2 are not action and reaction pair [1]

since they act on the same body. [1]

(iii) Friction = $m\,a$ [1]

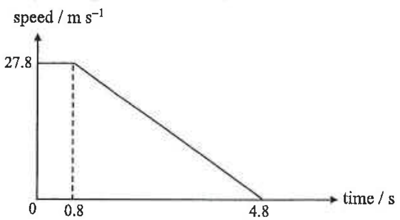
= 1000 × 4 = 4000 N [1]

(iv) Any **TWO** of the following : [2]

* The lorry accelerates hardly.
* The lorry is travelling up along an inclined road.
* The lorry is turning round a corner.

5. (a) $t = \frac{80}{27.8}$ = 2.88 s [1]

(b) (i)



< Two axes correctly labelled with units > [1]
< From 0 s to 0.8 s correct > [1]
< From 0.8 s to 4.8 s correct > [1]

(ii) Stopping distance = area under the v - t graph [1]

= $\frac{1}{2}(0.8 + 4.8) \times 27.8$

= 77.8 m [1]

As the stopping distance is less than 80 m, the car will not hit the lorry. [1]

5. (b) (iii) Deceleration of the car = slope = $\frac{27.8}{4}$

= 6.95 m s^{-2} [1]

Average braking force = $m\,a$ [1]

= 1200 × 6.95

= 8340 N [1]

(c) When the car is running downhill on the slope, there is a component of weight acting on it down the slope. [1]

Part of the braking force is used to overcome this component, [1]

thus the net braking force is reduced and the deceleration is decreased. [1]

As a result, the stopping distance becomes larger and distance between 2 arrows should be larger than 80 m. [1]

6. The compressed air exerts a force on the water to push the water out. [1]

By Newton's third law, [1]

the water exerts an opposite reaction force on the rocket to lift it up. [1]

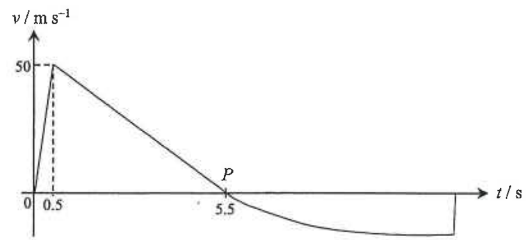
OR

When the water is pushed down, the water acquires a downward momentum. [1]

By the principle of conservation of momentum, [1]

the rocket acquires an upward momentum and rises. [1]

7. (a)



[1]

(b) Maximum height = area from 0 to 5.5 s

= $\frac{50 \times 5.5}{2}$ [1]

= 137.5 m < accept 138 m > [1]

(c) acceleration a = slope in phase 1 = $\frac{50}{0.5}$ = 100 m s^{-2} [1]

$R - mg = m\,a$ [1]

R − (80)(10) = (80)(100)

$\therefore R$ = 8800 N [1]

7. (d) Initially, the air resistance exerted by the parachute R is smaller than the weight mg of the dummy. [1]

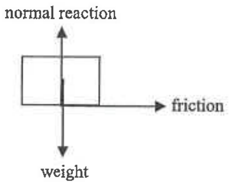
Since a net downward force acts on the dummy, thus the dummy accelerates downwards. [1]

As the speed of dummy increases, the air resistance R increases.

Finally, when the air resistance just equals the weight of the dummy, i.e. $R = mg$ [1]

the resultant force is zero and the dummy fall with a uniform velocity.

8. (a) (i)



< Any one force with label correct > [1]

< The other forces with label correct > [1]

(ii) By $s = ut + \frac{1}{2}at^2$

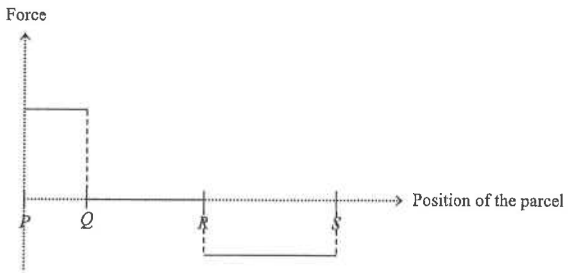
$\therefore$ $(5) = (0) + \frac{1}{2}a(2)^2$

$\therefore$ $a = 2.5 \text{ m s}^{-2}$ [1]

$F = ma$ [1]

$= 10 \times 2.5 = 25 \text{ N}$ [1]

(b)



< P to Q : a horizontal line above or below the x-axis > [1]

< Q to R : a horizontal line at the x-axis > [1]

< R to S : a horizontal line at the opposite side of the line PQ > [1]

9. (a) Player X exerts an action force on the ground when he jumps. [1]

By Newton's third law, the ground exerts an equal reaction force on him. [1]

If the normal reaction is greater than his weight, he can jump up with an initial acceleration. [1]

9. (b) $v^2 = u^2 + 2as$ < OR > $\frac{1}{2}mu^2 = mgh$ [1]

$(0) = u^2 + 2(-9.81)(3 - 2.25)$ $\frac{1}{2}mu^2 = m(9.81)(3 - 2.25)$

$u = 3.84 \text{ m s}^{-1}$ $u = 3.84 \text{ m s}^{-1}$ [1]

(c) The initial vertical speed of Player Z should be the same as Player X [1]

since the acceleration due to gravity is independent of the mass. [1]

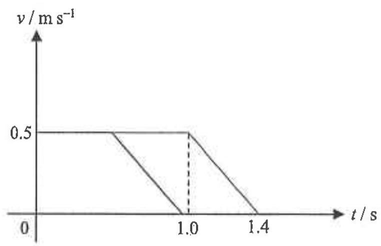
10. (a) (i) From $t = 0$ to 1.0 s, the balloon puck moves with uniform velocity. [1]

From $t = 1$ to 1.4 s, the balloon puck decelerates uniformly from 0.5 m s^{-1} to zero. [1]

(ii) After $t = 1.0$ s, the balloon puck does not release air. [1]

Friction acts on the puck to oppose the motion. [1]

(b)



< shorter time to come to rest > [1]

< same slope of deceleration > [1]

11. (a) (i) Weight of the passenger and the supporting force exerted by the seat are acting on the passenger. [1]

These two forces balance each other. [1]

(ii) They are not action-reaction pair [1]

since they act on the same body. [1]

OR

since they are different types of forces. [1]

(b) (i) The weight is the same as the one at the top. [1]

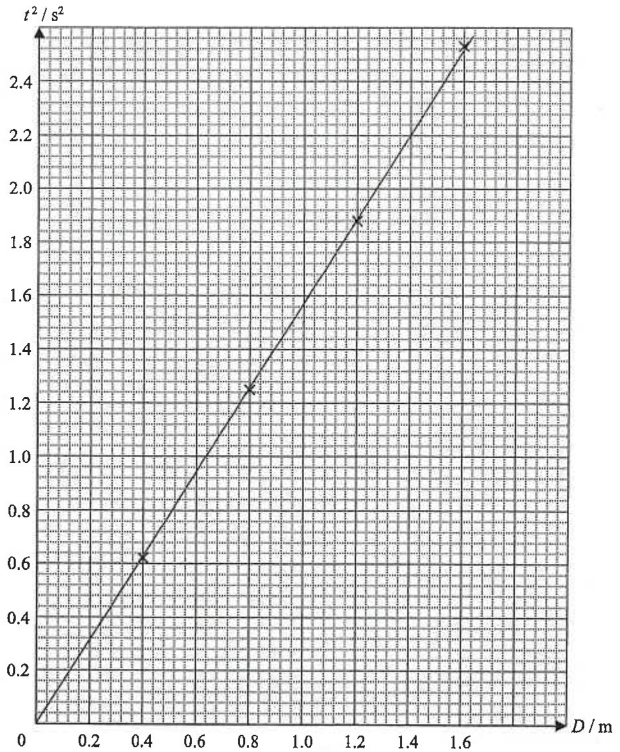
The supporting force by the seat is zero (**OR** smaller). [1]

(ii) There is no supporting force by the seat to the passenger. [1]

OR

There is no normal reaction acting on the passenger. [1]

12. (a) (i)



D	t^2
0.4	0.62
0.8	1.25
1.2	1.88
1.6	2.53

< Correct labelled axes with units > [1]
< Correct scale > [1]
< Correct points plotted > [1]
< Straight line drawn > [1]

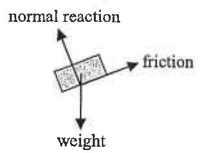
(ii) slope = 1.57 $s^2\ m^{-1}$ [1]

< accept 1.5 – 1.6 ; accept 2 sig. fig. ; accept no unit >

(iii) By $s = \frac{1}{2} a t^2$ $\therefore$ slope of the graph $= \dfrac{2}{a}$ [1]

$a = \dfrac{2}{\text{slope}} = 1.27\ m\ s^{-2}$ < accept 1.25 – 1.33 ; accept 2 sig. fig. > [1]

(b)



< 3 forces drawn correctly > [1]

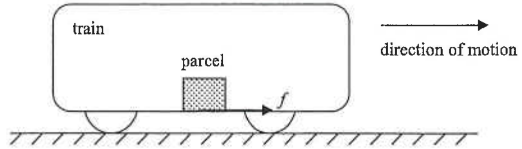
< names of 3 forces correct with correct spelling > [1]

12. (c) $m g \sin\theta - f = m a$ [1]

$(0.178)(9.81)\sin 25° - f = (0.178)(1.27)$

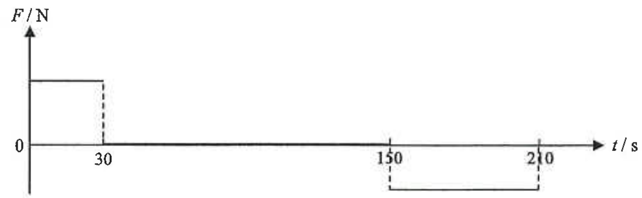
$f = 0.512$ N < accept 0.506 N – 0.530 N > [1]

13. (a)



< Friction towards the right > [1]

(b)



< From t = 30 to 150 s, F is zero > [1]

< From t = 150 to 210 s, F is negative and its magnitude is smaller than that in the first 30 s > [1]

(c) a = slope $= \dfrac{36}{30} = 1.2\ m\ s^{-2}$ [1]

$F = m a = 15 \times 1.2 = 18$ N [1]

(d) d = area [1]

$= \frac{1}{2}(120 + 210) \times 36 = 5940$ m [1]

14. (a) Resultant force acting on Susan during the first 5 s $= m a = 45 \times 1.6$ [1]

$= 72$ N [1]

(b) Resultant force acting on Susan after 5 s = 0 N [1]

15. (a) $v^2 = u^2 + 2 a s$ [1]

$(15)^2 = 0 + 2 a (75)$ $\therefore a = 1.5\ m\ s^{-2}$ [1]

(b) $F - m g = m a$ [1]

$F - (1500)(9.81) = (1500)(1.5)$ [1]

$\therefore F = 16965$ N < accept 17000 N > [1]

16. (a) Weight of the balloon = 750 × 9.81 = 7360 N [1]

$\therefore$ (8000) = (7360) + T [1]

$\therefore$ T = 640 N < accept 643 N > [1]

(b) (i) Upward force − weight = $m\,a$ [1]

$\therefore$ (8000) − (7360) = (750) a [1]

$\therefore$ a = 0.853 m s^{-2} < accept 0.840 − 0.865 > [1]

(ii) $s = ut + \frac{1}{2}at^2$ [1]

$= (0) + \frac{1}{2}(0.853)(60)^2 = 1540$ m < accept 1500 − 1580 > [1]

(iii) Since the weight of the balloon is reduced, [1]

the upward net force is increased, [1]

thus the upward acceleration is increased. [1]

17. (a) $d = ut = (10) \times (0.2)$ [1]

$= 2$ m [1]

(b) $s = \frac{1}{2}(u+v)\,t = \frac{1}{2}(10+0) \times (2)$ [1]

$= 10$ m [1]

< OR >

$v = u + at$ $\therefore$ (0) = (10) + a (2) $\therefore$ $a = -5$ m s^{-2} [1]

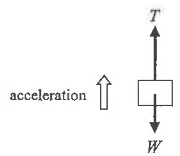
$s = ut + \frac{1}{2}at^2 = (10) \times (2) + \frac{1}{2}(-5) \times (2)^2 = 10$ m [1]

(c) As the mass of the bicycle increases, by Newton's second law, [1]

the deceleration of the bicycle would become smaller for the same braking force. [1]

As a result, the stopping distance would increase, and the chance of having an accident is larger. [1]

18. (a)



< Upward force labelled with T or tension > [1]

(labelled with F not accepted)

< Downward force labelled with W or mg or weight > [1]

As the acceleration is upwards, the net force is upwards, thus tension T is greater than mg. [1]

As the tension increases, the extension of the spring increases, thus h decreases. [1]

(b) Reading of the balance = 5 + 2 × 0.5 = 6 N [1]

By $T - Mg = Ma$

$\therefore$ (6) − (5) = $(\frac{5}{9.81})a$ < do not accept g = 10 m s^{-2} > [1]

$\therefore$ a = 1.96 m s^{-2} < accept 1.962 m s^{-2} > < do not accept 2 m s^{-2} > [1]

18. (c) If $a_y = -0.5\,g$

$\therefore$ $a_y = -g\cos\theta = -0.5\,g$ [1]

$\therefore$ $\theta = 60°$

Since the angle is greater than 45°, the display is landscape. [1]

OR

At 45°, magnitude of $a_y = g\cos 45° = 0.707g$ [1]

When magnitude of $a_y = 0.5\,g$, it is less than that of 45°, thus the display is landscape. [1]

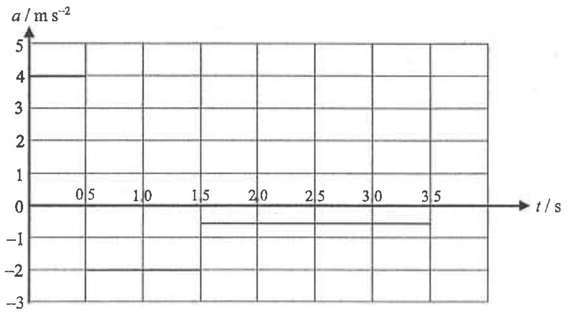
19. (a) From t = 0.5 s to 1.5 s, the block moves up the inclined plane with uniform deceleration. [1]

From t = 1.5 s to 3.5 s, the block moves down the inclined plane with uniform acceleration. [1]

(b) (i) $a = |\text{slope}| = \left|\frac{-1-0}{3.5-1.5}\right|$ [1]

$= 0.5$ m s^{-2} < no mark for − 0.5 m s^{-2} > [1]

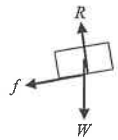
(ii)



< a horizontal line at $a = -2$ m s^{-2} > [1]

< a horizontal line at $a = -0.5$ m s^{-2} > [1]

(c)



< Weight W and normal reaction R correctly drawn and labelled > [1]

< Friction f correctly drawn and labelled > [1]

[Weight can be labelled with mg] [Names of forces instead of symbols are accepted]

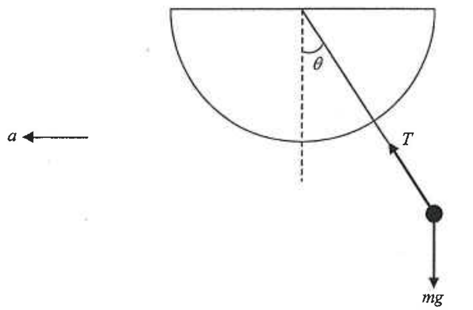
(d) Upward motion : $mg\sin\theta + f = m\,a_1 = (1) \times (2) = 2$ [1]

Downward motion : $mg\sin\theta - f = m\,a_2 = (1) \times (0.5) = 0.5$ [1]

Combine the two equations : $2f = 2 - 0.5$

$\therefore$ f = 0.75 N [1]

20.



< set-up of apparatus with force diagram : tension T and weight mg drawn > [1]

Tie one end of the string to the metal ball and the other end through the hole of the protractor. [1]

When the train is at rest,
held fixed the protractor in the plane along the direction of motion such that the string is on the 90° mark. [1]

When the train is accelerating with acceleration a,
the string will make an angle θ with the vertical. Measure the angle θ. [1]

Resolve the tension T into vertical component and horizontal component.

The horizontal component of the tension provides the net force for acceleration a.

$\therefore \quad T \sin\theta = m a$

The vertical component of the tension balances the weight of the metal ball.

$\therefore \quad T \cos\theta = m g$ [1]

Combine the two equations : $\tan\theta = \dfrac{a}{g}$ $\quad \therefore \; a = g \tan\theta$ [1]

21. (a) $a = \text{slope} = \dfrac{6}{2}$ [1]

$= 3 \text{ m s}^{-2}$ [1]

(b) A : 395 N $\quad B$: 569 N $\quad C$: 685 N [1]

In stage B, balance reading = weight

$\therefore \; 569 = m g = m \times 9.81$ [1]

$\therefore \; m = 58.0 \text{ kg}$ [1]

(c) (i) At C : $R - m g = m a$

$\therefore \; 685 - 569 = 58\,a \quad \therefore \; a = 2 \text{ m s}^{-2}$ (upwards) [1]

By $v = u + a t$

$\therefore \; (0) = (6) + (-2)(T - 12)$ [since a is upwards, it undergoes deceleration] [1]

$\therefore \; T = 15 \text{ s}$

(ii) Height = area under graph

$= \frac{1}{2}(15 + 10) \times (6)$ [1]

$= 75 \text{ m}$ [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普通氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

22.

			Marks	
(a) (i) (1)	$\frac{1}{2}mv^2 = mgh$	1M	
	$v^2 = 2(9.81)(12)$		
	$v = 15.344054\ \text{m s}^{-1} \approx 15.3\ \text{m s}^{-1}$	1A	
	($v = 15.491933\ \text{m s}^{-1} \approx 15.5\ \text{m s}^{-1}$ for $g = 10\ \text{m s}^{-2}$)		
			2
(2)	$s = \frac{1}{2}gt^2$	1M	
	$12 = \frac{1}{2}(9.81)t^2$		
	$t = 1.564124\ \text{s} \approx 1.56\ \text{s}$	1A	
	($t = 1.5491933\ \text{s} \approx 1.55\ \text{s}$ for $g = 10\ \text{m s}^{-2}$)		
			2
(ii)	$F - mg = \frac{mv - mu}{t}$		
	$F = \frac{70 \times (0 - (-15.3))}{0.3} + 70 \times 9.81$	1M+1M	
	$= 4266.9793\ \text{N} \approx 4270\ \text{N}$	1A	
	($F = 4314.7845\ \text{N} \approx 4310\ \text{N}$ for $g = 10\ \text{m s}^{-2}$)		
			3
(iii)	Elastic potential energy	1A	
			1
(b) (i)	(Velocity is too high, hence the force for deceleration is very large.) - The life net may be torn. - The falling person may be injured. - The firemen may not be able to hold the life net tight. } Any ONE	1A	
			1
(ii)	There exists a horizontal velocity when a person jumps and the horizontal displacement is very difficult to estimate as it depends on the time of fall, which is relatively long.	1A 1A	
			2

DSE Physics - Section B : M.C. **PB - FM3 - M / 01**

FM3 : Moment of Force

The following list of formulae may be found useful :

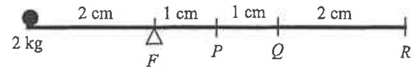
Moment of a force — moment $= F \times d$

Use the following data wherever necessary :

Acceleration due to gravity — $g = 9.81\ \text{m s}^{-2}$ (close to the Earth)

Part A : HKCE examination questions

1. **< HKCE 1987 Paper II - 9 >**

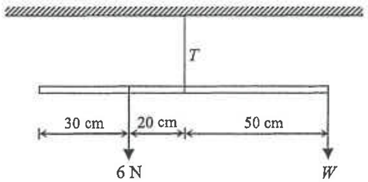


If a mass of 2 kg is placed at a distance of 2 cm from the fulcrum F as shown in the diagram, which of the following cases could keep the light rod in equilibrium ?

(1) a mass of 4 kg placed at P
(2) a mass of 2 kg placed at Q
(3) a mass of 1 kg placed at R

A. (1) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

2. **< HKCE 1990 Paper II - 9 >**

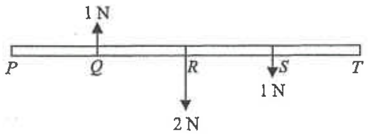


In the figure shown, the uniform metre rule of weight 1 N is balanced horizontally. Find the tension T in the string.

A. 2.4 N
B. 3.4 N
C. 8.4 N
D. 9.4 N

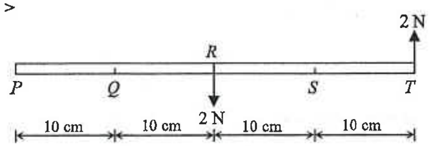
3. **< HKCE 1992 Paper II - 11 >**

The diagram shows a light rod under the action of three vertical forces. The points P, Q, R, S and T are equally spaced along the rod. At which point must an upward vertical force of 2 N be applied to hold the rod in equilibrium ?



A. P
B. Q
C. R
D. S

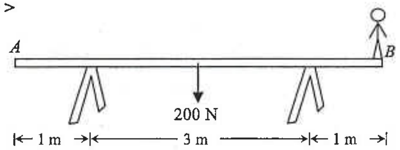
4. **< HKCE 1994 Paper II - 7 >**



The above diagram shows a light rod under the action of two vertical forces. Under which of the following conditions will the rod be in equilibrium ?

A. Applying an upward force of 2 N at P.
B. Applying a downward force of 2 N at P.
C. Applying an upward force of 4 N at R and a downward force of 4 N at Q.
D. Applying an upward force of 4 N at Q and a downward force of 4 N at R.

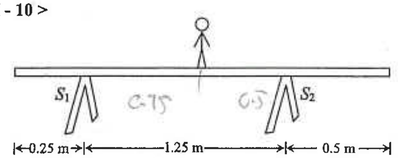
5. **< HKCE 1996 Paper II - 9 >**



A uniform plank AB of weight 200 N rests on two trestles as shown above. A boy stands at the end B of the plank. What can the maximum weight of the boy be without tilting the plank ? (Assume the weight of the plank acts through its centre.)

A. 75 N
B. 100 N
C. 200 N
D. 300 N

6. **< HKCE 1997 Paper II - 10 >**



A light plank of length 2 m rests on two trestles S_1 and S_2 as shown in the figure. A boy of weight 500 N stands at the mid-point of the plank. Find the forces acting on the two trestles by the plank.

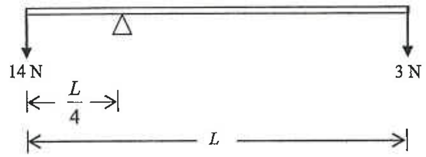
	Force acting on S_1	Force acting on S_2
A.	$166\frac{2}{3}$ N	$333\frac{1}{3}$ N
B.	200 N	300 N
C.	250 N	250 N
D.	300 N	200 N

7. **< HKCE 1998 Paper II - 11 >**

A uniform beam of length 3 m and weight 300 N lies on a horizontal ground. What minimum vertical force must be applied to one end of the beam to just lift that end off the ground ? (Assume the weight of the beam acts through its mid-point.)

A. 100 N
B. 150 N
C. 300 N
D. 450 N

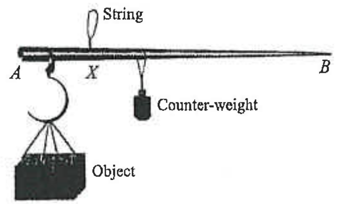
8. **< HKCE 1999 Paper II - 9 >**



A uniform rod of length L is pivoted at a point $\frac{1}{4}L$ from one of its ends. Two forces 14 N and 3 N act on its two ends as shown above. If the rod is in equilibrium, find the weight of the rod.
(Assume the weight of the rod acts through its midpoint.)

A. 2.5 N
B. 5 N
C. 8 N
D. 11 N

9. **< HKCE 2000 Paper II - 12 >**

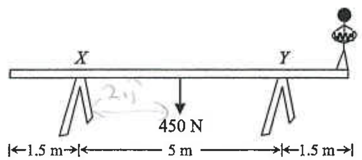


A company intends to produce a kind of weighing device as shown. The device is held at point X. The position of the counter-weight is adjusted until the rod AB becomes horizontal. The weight of the object can be read from the scale calibrated on AB. Which of the following changes can increase the maximum weight that can be measured by the device ?

(1) moving the string at X towards A
(2) increasing the mass of the counter-weight
(3) increasing the length of the string from which the counter-weight hangs

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

10. **< HKCE 2001 Paper II - 6 >**

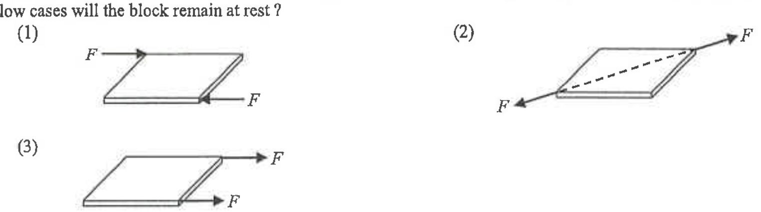


A uniform plane of weight 450 N rests on two trestles X and Y and a worker of weight 675 N stands at one end of the plank as shown above. The worker holds a light basket which contains several packets of goods each of weight 6 N. What is the maximum number of packets he can hold without tilting the plank ?

A. 11
B. 12
C. 13
D. 18

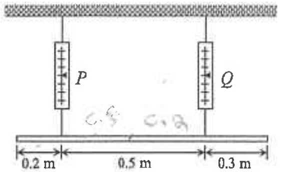
11. < HKCE 2002 Paper II - 11 >

A block is initially at rest on smooth horizontal ground. Two forces of equal magnitude F act on the block. In which of the below cases will the block remain at rest ?



A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

12. < HKCE 2003 Paper II - 10 >



A uniform rod of weight 50 N is supported by two spring balances P and Q and remains at rest as shown above. Assume the weight of the rod acts through its mid-point. Find the readings of P and Q.

	Reading of P	Reading of Q
A.	17 N	33 N
B.	20 N	30 N
C.	30 N	20 N
D.	33 N	17 N

13. < HKCE 2004 Paper II - 11 >

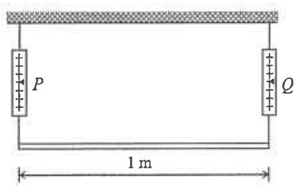


Figure (a)

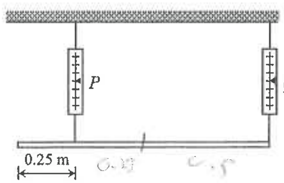


Figure (b)

Figure (a) shows a uniform plank supported by two spring balances P and Q. The readings of the two balances are both 150 N. P is now moved 0.25 m towards Q (see Figure (b)). Find the new readings of P and Q.

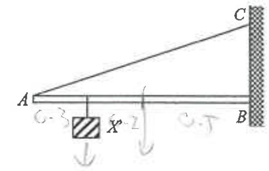
	Reading of P / N	Reading of Q / N
A.	100 N	200 N
B.	150 N	150 N
C.	200 N	100 N
D.	200 N	150 N

DSE Physics - Section B : M.C. PB - FM3 - M / 05
FM3 : Moment of Force

Part B : HKAL examination questions

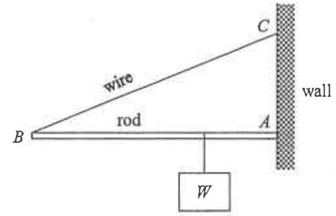
14. < HKAL 1994 Paper IIA - 3 >

A uniform metre rule AB of mass 0.15 kg is hinged to a wall at B and the other end A is connected by a wire attached to the wall at C as shown in the figure. A block X of mass 0.1 kg is hung from the metre rule at 30 cm from A. The metre rule is horizontal. Find the moment of the tension in the wire about B.



A. 1.42 N m
B. 1.05 N m
C. 0.75 N m
D. 0.70 N m

15. < HKAL 1995 Paper IIA - 8 >

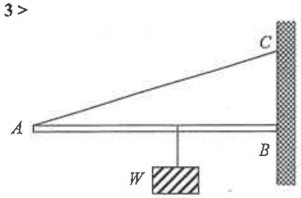


The figure shows a uniform rod AB being held in horizontal position by a wire attached to a wall at point C with the other end pivoted at A. The rod carries a load W. If W is shifted gradually from A towards B, which of the following quantities will increase ?

(1) moment of the weight of the rod about A
(2) moment of the load W about A
(3) tension of the wire

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

16. < HKAL 2000 Paper IIA - 3 >



A light rigid rod AB is hinged to the wall at one end while the other end is connected by an inextensible string to a point C vertically above B. A weight W is suspended from a point on the rod. If the rod remains horizontal, which of the following change(s) would increase the tension in the string ?

(1) Shifting the weight towards A.
(2) Replacing the string with a shorter one and connecting it to the mid-points of AB and BC.
(3) Replacing the string with a longer one and connecting it to a point higher than C.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Part C : HKDSE examination questions

17. **< HKDSE Sample Paper IA - 10 >**

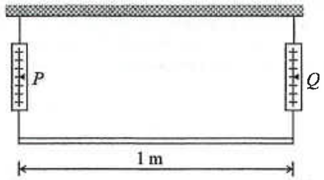


Figure (a)

Figure (a) shows a uniform plank supported by two spring balances P and Q. The readings of the two balances are both 150 N.

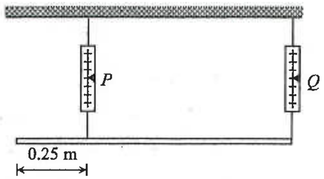


Figure (b)

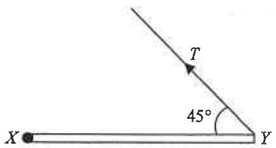
P is now moved 0.25 m towards Q as shown in Figure (b). Find the new readings of P and Q.

	Reading of P / N	Reading of Q / N
A.	100 N	200 N
B.	150 N	150 N
C.	200 N	100 N
D.	200 N	150 N

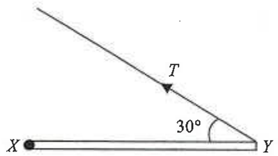
18. **< HKDSE Practice Paper IA - 12 >**

A rod XY hinged at X is kept horizontal by a light string. M is the midpoint of XY. In which of the following arrangements will the tension T in the string be the smallest ?

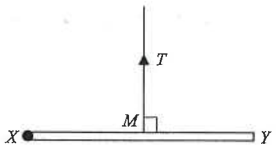
A.



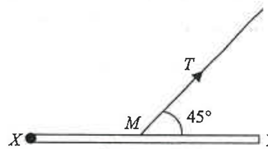
B.



C.

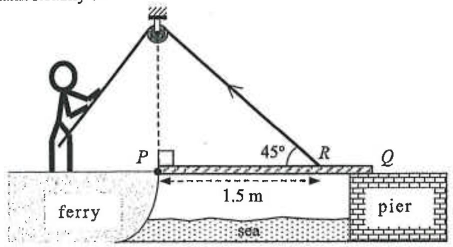


D.



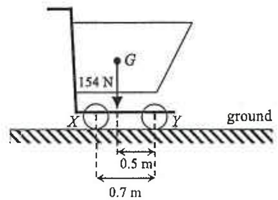
19. **< HKDSE 2012 Paper IA - 6 >**

A uniform gangplank PQ of a ferry smoothly hinged at end P initially rests horizontally on the pier. The gangplank has mass M and length 2 m. It is raised by a man on the ferry using a light rope passing a smooth fixed light pulley and connecting to R on the gangplank as shown. R is 1.5 m from end P. Which of the following correctly describes the force required to raise the gangplank steadily ?



	initial force required to raise the gangplank when it is horizontal	*subsequent* force required to raise the gangplank
A.	0.67 Mg	greater than 0.67 Mg
B.	0.67 Mg	smaller than 0.67 Mg
C.	0.94 Mg	greater than 0.94 Mg
D.	0.94 Mg	smaller than 0.94 Mg

20. **< HKDSE 2013 Paper IA - 9 >**

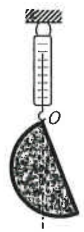


The figure shows a supermarket trolley resting on the ground. The separation between cylindrical wheels X and Y is 0.7 m. When the trolley is loaded to a total weight of 154 N, its centre of gravity G is at a horizontal distance of 0.5 m from the wheel Y. What is the reaction acting on the wheel X from the ground ?

A. 44 N
B. 62 N
C. 92 N
D. 110 N

21. **< HKDSE 2013 Paper IA - 14 >**

A semi-circular cardboard hangs from a spring balance from point O as shown. The reading of the spring balance is 5 N. Which statements are correct ?



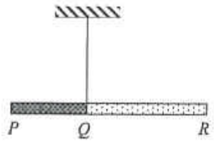
(1) The weight of the cardboard is 5 N.

(2) The centre of gravity of the cardboard is directly under O.

(3) The reading of the balance becomes zero if the set-up is brought to the Moon's surface.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

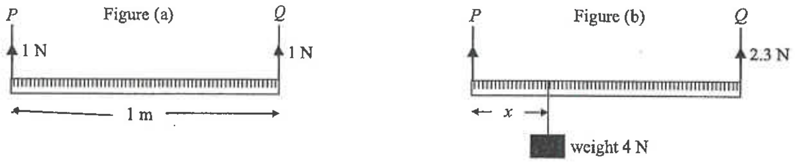
22. < HKDSE 2014 Paper IA - 3 >



PQR is a composite rod having a uniform cross-section but with portions PQ and QR made of different materials, each of uniform density. The ratio of the length of PQ to that of QR is 2 : 3. When the rod is suspended at Q, it remains horizontal as shown. What is the ratio of the mass of PQ to that of QR ?

A. 2 : 3
B. 1 : 1
C. 3 : 2
D. Answer cannot be found as the ratio of their densities is not given.

23. < HKDSE 2016 Paper IA - 11 >

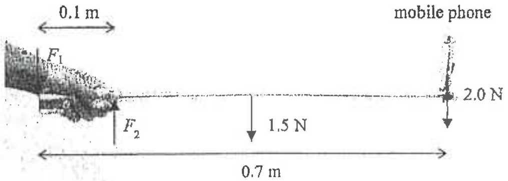


A uniform metre rule is supported by vertical wires P and Q and remains at rest horizontally as shown in Figure (a). The tension in each wire is 1 N. When a weight of 4 N is hung from the metre rule at a certain position as shown in Figure (b), the tension in Q becomes 2.3 N while the metre rule remains horizontal. Find the distance x shown.

A. 32.5 cm
B. 57.5 cm
C. 67.5 cm
D. Answer cannot be found as the tension in P is not known.

24. < HKDSE 2017 Paper IA - 8 >

Selfie sticks are popular nowadays. A uniform selfie stick of length 0.7 m is held horizontally as shown. Assume that the forces required to hold the selfie stick by the hand are represented by F_1 and F_2, and F_1 and F_2 are perpendicular to the stick.



It is given that the weight of the selfie stick and the mobile phone are 1.5 N and 2.0 N respectively. Taking the mobile phone as a point mass, estimate the magnitude of F_2 .

A. 3.5 N
B. 19.3 N
C. 35 N
D. Cannot be determined as F_1 is unknown.

1.5 × 0.35 + 2 × 0.7 = F_2 · 0.1

There is question in next page

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. D	6. B	11. A	16. C	21. A	26. D
2. D	7. B	12. B	17. C	22. C	
3. D	8. B	13. C	18. A	23. A	
4. D	9. C	14. A	19. D	24. B	
5. D	10. B	15. D	20. D	25. B	

M.C. Solution

1. D

Moment of 2 kg mass about $F = 2 \times 2 = 4$

✓ (1) Moment of 4 kg mass about F = 4 × 1 = 4 = Moment of given mass about F
✓ (2) Moment of 2 kg mass about F = 2 × 2 = 4 = Moment of given mass about F
✓ (3) Moment of 1 kg mass about F = 1 × 4 = 4 = Moment of given mass about F

2. D

Note that the weight of the metre rule 1 N is at the mid-point of the rule.

Take moment about right end, the force W does not have moment.

∴ (6) × (20 + 50) + (1) × (50) = T × (50)

∴ T = 9.4 N

3. D

Moment of the couple at Q and S = 1 × 2 = 2 (clockwise)

To balance this couple, another couple in anticlockwise direction is needed.

Moment of the other couple = (2) × d = 2 ∴ d = 1

An upward force of 2 N applied at point S can then give another couple to make the rod in equilibrium.

4. D

Moment of the given couple = 2 × 2 × 10 = 40 N cm

Moment of the required couple = Moment of the given couple

∴ 4 × d = 40 ∴ d = 10 cm

Given couple is in anti-clockwise direction ⇒ the required couple is clockwise

∴ The required points should have a separation of 10 cm, and in clockwise direction. Only D can satisfy this.

5. D

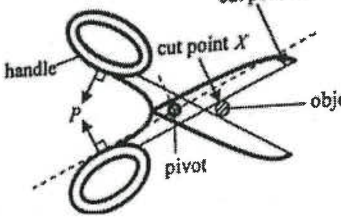
Take moment about right trestle,

(200) × (1.5) = W(1) ∴ W = 300 N

25.<HKDSE 2019 Paper IA-7>

26. <HKDSE 2020 Paper IA-7>

The figure shows that a pair of forces P of constant magnitude is applied at right angles to the handles of a pair of scissors in order to cut an object.



6. B

Take moment about S_2,

$F_1 \times (1.25) = (500) \times (1 - 0.5)$ $\therefore F_1 = 200$ N

Balance of forces,

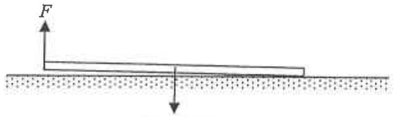
$(200) + F_2 = 500$ $\therefore F_2 = 300$ N

7. B

Take moment about the other end,

$F \times (3) = (300) \times (1.5)$

$\therefore F = 150$ N



8. B

Take moment about the pivot,

$14 \times \frac{L}{4} = W \times \frac{L}{4} + 3 \times \frac{3L}{4}$ $\therefore W = 5$ N

9. C

Take moment about X, $W_o d_o = W_w d_w$.

✓ (1) Moving the string towards $A \Rightarrow d_o \downarrow$ $\therefore d_w \uparrow$ $\therefore W_o \uparrow$

✓ (2) $W_w \uparrow \Rightarrow W_o \uparrow$

× (3) The length of the string hanging the counter-weight has no effect on W_w and d_w

10. B

Let the maximum number of packets he can hold be n.

When he holds the maximum packets, the plank will just tilt so that X will lose contact with the plank.

Take moment about Y,

$450 \times 2.5 = (675 + 6n) \times 1.5$ $\therefore n = 12.5$

$\therefore$ The maximum number of packets is 12 without tilting the plank.

11. A

× (1) The two forces form a couple and cause the block to rotate, thus the block will not remain at rest.

✓ (2) The two forces will balance each other, so there is no net force acting on the block, the block will remain at rest.

× (3) The two forces give a resultant force towards the right causing an acceleration towards the right, thus the block will not remain at rest.

12. B

Take moment at the point under balance P: $50 \times 0.3 = Q \times 0.5$ $\therefore Q = 30$ N

Balance of forces : $P + 30 = 50$ $\therefore P = 20$ N

13. C

Weight of the plank $= 150 + 150 = 300$ N

In Figure (b), take moment about the point under balance Q:

$P \times (1 - 0.25) = 300 \times 0.5$ $\therefore P = 200$ N

Balance of forces : $200 + Q = 300$ $\therefore Q = 100$ N

14. A

Take moment about B,

Moment of tension about B = moment of weight of X + moment of weight of metre rule

$= (0.1 \times 9.81)(1 - 0.3) + (0.15 \times 9.81)(0.5) = 1.42$ N m

15. D

× (1) As the position of the C.G. of the rod remains unchanged, the moment of the weight of rod is unchanged.

✓ (2) As the distance of load W from the pivot A increases, the moment of W increases.

✓ (3) As moment of load W increases, the moment of tension must increase for balancing. Thus, the tension of the wire increases.

16. C

Let the length of AB be L and length of WB be d, and θ be the angle between string and rod.

Take moment about B: $T \sin\theta \cdot L = W \cdot d$

✓ (1) Shifting W towards $A \Rightarrow d\uparrow \Rightarrow T\uparrow$

✓ (2) Replace the string $\Rightarrow \theta$: no change and $L\downarrow \Rightarrow T\uparrow$

× (3) Replace the string $\Rightarrow \theta\uparrow \Rightarrow T\downarrow$

17. C

Weight of the plank $= 150 + 150 = 300$ N

In Figure (b), take moment about the point under balance Q:

$P \times (1 - 0.25) = 300 \times 0.5$ $\therefore P = 200$ N

Balance of forces :

$200 + Q = 300$ $\therefore Q = 100$ N

18. A

Let the length of the rod be L.

A. Take moment about X: $T \sin 45° \times L = mg \times \frac{1}{2}L$ $\therefore T = 0.707\,mg$

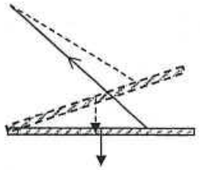
B. Take moment about X: $T \sin 30° \times L = mg \times \frac{1}{2}L$ $\therefore T = mg$

C. Take moment about X: $T \times \frac{1}{2}L = mg \times \frac{1}{2}L$ $\therefore T = mg$

D. Take moment about X: $T \sin 45° \times \frac{1}{2}L = mg \times \frac{1}{2}L$ $\therefore T = 1.41\,mg$

In figure A, the tension is the smallest.

19. D



Initially, take moment about P :

$T \sin\theta \times d = Mg \times \frac{1}{2}L$

$\therefore$ $T \sin 45° \times 1.5 = Mg \times 1$ $\therefore$ $T = 0.94\ Mg$

Subsequently, when the plank PQ is pulled up,

the C.G. of the plank would be closer to the end P, i.e., the C.G. would be closer than $\frac{1}{2}L$,

$\therefore$ the moment of the weight would decrease, therefore, the tension would decrease.

Note that the angle θ would increase subsequently.

20. D

Take moment about Y.

$R_X \times (0.7) = (154) \times (0.5)$

$\therefore$ $R_X = 110$ N

21. A

✓ (1) The reading of the spring balance represents the weight of the supporting body.

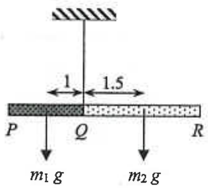
✓ (2) The centre of gravity must be along the line of support.

✗ (3) On the Moon's surface, the acceleration due to gravity is less than that of the Earth, thus the reading is smaller but not zero.

22. C

Since the cross-section of the rods are uniform,

the centre of weight must be at the middle point of each portion.



Take moment about Q :

$\therefore$ $m_1 g \times 1 = m_2 g \times 1.5$

$\therefore$ $m_1 : m_2 = 3 : 2$

23. A

In Figure (a), weight of the metre rule is balanced by the tension of P and Q, thus, weight of the metre rule is 2 N.

As the metre rule is uniform, the centre of gravity of the metre rule is at the mid-point, that is, at the 50 cm mark.

In Figure (b), take moment at P.

Moment of Q = moment of the 4 N weight + moment of the weight of the metre rule

$\therefore$ $(2.3) \times (100) = (4) \times (x) + (2) \times (50)$

$\therefore$ $x = 32.5$ cm

24. B

Take moment at the point of F_1.

$F_2 \times 0.1 = 1.5 \times 0.35 + 2.0 \times 0.7$

$\therefore$ $F_2 = 19.25 \approx 19.3$ N

The following list of formulae may be found useful :

Moment of a force moment = $F \times d$

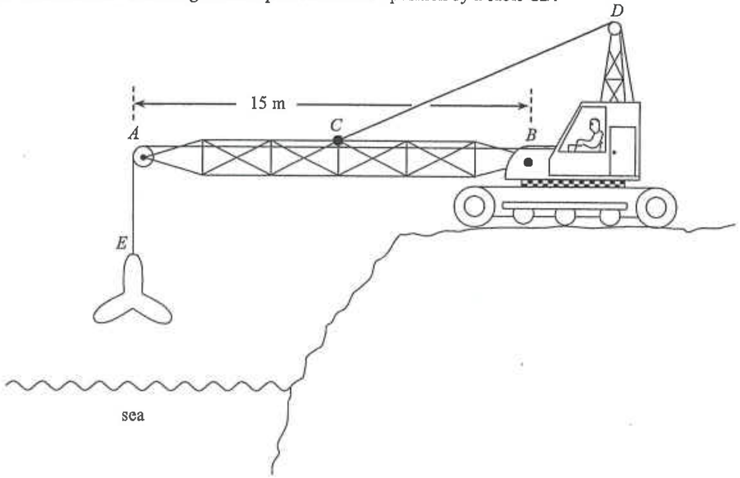
Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81\ m\ s^{-2}$ (close to the Earth)

Part A : HKCE examination questions

1. **< HKCE 1986 Paper I - 1 >**

A concrete block of total mass 4000 kg is slowly lowered into the sea by a machine as shown in the figure below. The heavy arm *AB* of the machine is 15 m long and is kept in a horizontal position by a cable *CD*.



(a) What is the moment of the weight of the concrete block acting about *B* ? (State whether the moment is clockwise or anticlockwise.) (3 marks)

(b) What other forces acting on the heavy arm *AB* can also produce moments about *B* ? (2 marks)

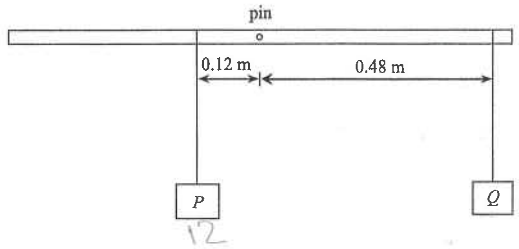
(c) Find the tension in the cable *AB* if the block is lowered with

(i) uniform velocity of 2 m s^{-1},

(ii) downward uniform acceleration of 2 m s^{-2}. (5 marks)

2. **< HKCE 1991 Paper I - 1 >**

A uniform metre rule with a small hole bored in the middle is pivoted by a pin inserted into the hole, as shown in the figure below. The weight of the metre rule is 1 N. An object *P* of weight 12 N is suspended on the left-hand side of the metre rule at a distance of 0.12 m from the pin. Another object *Q* is also suspended on the right-hand side at a distance of 0.48 m from the pin to balance the metre rule.



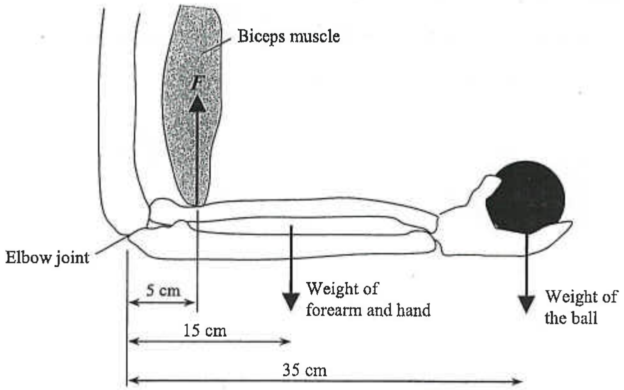
(a) (i) What is the moment of the weight of *P* about the pin ? (1 mark)

(ii) Find the weight of *Q*. (2 marks)

(iii) Find the force acting on the metre rule by the pin. (2 marks)

(b) If the metre rule fails to balance before the objects are suspended on it, suggest a simple method to make it balance. (2 marks)

3. **< HKCE 2002 Paper I - 3 >**



A man holds a ball of weight 60 N with his hand. The weight of the forearm and hand of the man is 20 N, and the biceps muscle in the upper arm exerts an upward force F on the forearm. The horizontal distances of these forces from the elbow joint are shown in the above figure.

(a) Find the moment of the weight of the ball about the elbow joint. (1 mark)

(b) Find the magnitude of F. (2 marks)

(c) Some weight-lifting champions are known to have their biceps muscles a few millimeters further sway from the elbow joint than usual. Explain how this feature can help such athletes in lifting heavy weights. (2 marks)

Part B : HKAL examination questions

4. **< HKAL 2009 Paper I - 2 >**

A skier bends his back to lift his pair of skis as shown in Figure 1.

Figure 1

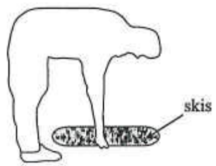


Figure 2 shows the skier's spine as represented by a horizontal light rigid rod OP of length 0.54 m pivoted at the base O. At equilibrium, there are four forces acting on the spine :

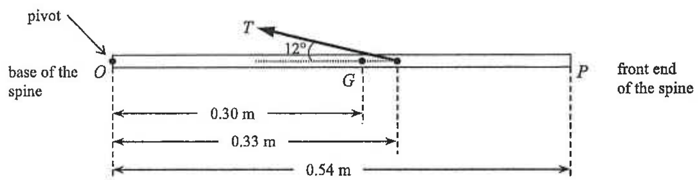
W : the weight of the skier's upper body, which equals 520 N, acting through point G of the spine

L : the load of the pair of skis, which equals 40 N, acting through the front end of the spine P

T : the tension of the back muscle exerting at a point 0.33 m from O, making a angle of 12° with spine

R : the reaction force in the spine acting through the base of the spine O

Figure 2



(a) Calculate the tension T. (2 marks)

(b) Hence explain why it is unhealthy to lift the load in the way shown in Figure 1. (1 mark)

Question Solution

1. (a) Moment = $(4000 \times 9.81) \times 15$ [1]
$= 588\,600$ N m [1]
The moment is anticlockwise [1]

(b) Tension in wire *CD* [1]
Weight of *AB* [1]

(c) (i) Tension $= m\,g = 4000 \times 9.81$ [1]
$= 39240$ N [1]

(ii) $m\,g - T = m\,a$ [1]
$\therefore\ (4000) \times (9.81) - T = (4000) \times (2)$ [1]
$\therefore\ T = 31240$ N [1]

2. (a) (i) Moment $= 12 \times 0.12$
$= 1.44$ N m [1]

(ii) Take moment about the mid point.
$\therefore\ (1.44) = Q \times (0.48)$ [1]
$\therefore\ Q = 3$ N [1]

(iii) Force acting on the pin is upward.
Since forces are balanced in vertical direction,
$\therefore\ F = 12 + 3 + 1$ [1]
$= 16$ N [1]

(b) Add some plasticine to the lighter side of the rule [1]
until it balances. [1]

3. (a) Moment $= 60 \times 0.35 = 21$ N m [1]

(b) Take moment about the elbow joint,
$\therefore\ 0.05\,F = 0.15 \times 20 + 21$ [1]
$\therefore\ F = 480$ N [1]

(c) If the bicep muscle is further away from the elbow joint, the moment produced by the force *F* is larger. [1]
So a heavier load can be lifted by the athlete. [1]

4. (a) Take moment about *O* :
$\therefore\ (520) \times (0.30) + (40) \times (0.54) = (T \sin 12°) \times (0.33)$ [1]
$\therefore\ T = 2589$ N < accept 2580 N to 2600 N > [1]

(b) The tension is very large, about 5 times the weight of the body, thus easy to cause injury to the muscle. [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恒星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

The following list of formulae may be found useful :

Gravitational potential energy	$E_P = mgh$
Kinetic energy	$E_K = \frac{1}{2}mv^2$
Mechanical power	$P = Fv = \frac{W}{t}$

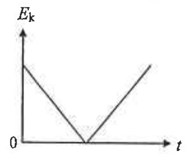
Use the following data wherever necessary :

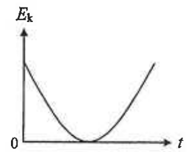
Acceleration due to gravity $g = 9.81 \text{ m s}^{-2}$ (close to the Earth)

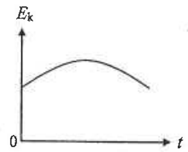
Part A : HKCE examination questions

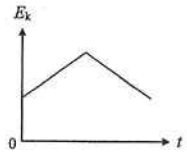
1. **< HKCE 1980 Paper II - 5 >**

An object is thrown vertically upwards with initial speed u. Which of the following graphs represents the variation of its kinetic energy E_k with time t ?

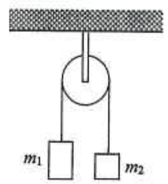
A.


B.


C.


D.


2. **< HKCE 1981 Paper II - 2 >**



Two masses m_1 and m_2 ($m_1 > m_2$) are hung over a smooth pulley as shown. If the system is released from rest, what is the kinetic energy of the system after the mass m_1 has descended through a distance h ?

A. $m_1 g h$
B. $m_2 g h$
C. $(m_1 - m_2) g h$
D. $(m_2 - m_1) g h$

3. **< HKCE 1981 Paper II - 7 >**

A vehicle moves up a road inclined at an angle θ to the horizontal with a constant velocity of 10 m s^{-1}. If the forces resisting the movement of the vehicle are uniform, the power developed by the vehicle engine is

A. constant.
B. increasing uniformly.
C. decreasing uniformly.
D. increasing, but not uniformly.

4. **< HKCE 1982 Paper II - 6 >**

Which of the following statements concerning the energy of a body falling freely under the action of gravity is/are correct ?

(1) It gains kinetic energy while falling.
(2) Its total energy at any point in the flight is equal to the work done in raising it from ground level to that point.
(3) Its kinetic energy at the end of the flight is all converted into potential energy.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

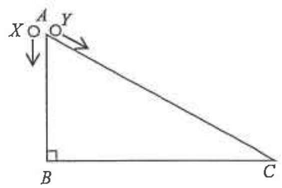
5. **< HKCE 1982 Paper II - 3 >**

A vehicle moving with uniform speed travels up a road of constant gradient. The power developed by the vehicle's engine is

A. uniformly increasing.
B. increasing, but not uniformly.
C. constant.
D. uniformly decreasing.

6. **< HKCE 1983 Paper II - 2 >**

Two balls X and Y, of the same mass, are released from rest simultaneously at A. X falls vertically downwards while Y runs downwards along the smooth plane AC as shown in the figure. Which of the following statements is/are correct ?



(1) X reaches B at the same time as Y reaches C.
(2) The velocity of X at B is the same as that of Y at C.
(3) The kinetic energy possessed by X at B is the same as that of Y at C.

A. (1) only
B. (2) only
C. (3) only
D. (1) & (3) only

7. **< HKCE 1983 Paper II - 14 >**

When 40 kg of water falls through a certain distance, its temperature is increased by 0.2°C. What is the height through which it has fallen ? Given : Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

A. 20 m
B. 22 m
C. 42 m
D. 86 m

8. **< HKCE 1983 Paper II - 6 >**

A student of weight 500 N runs up a flight of stairs 15 m high in 20 s. The average power developed by the student is

A. 37.5 W
B. 375 W
C. 750 W
D. 7500 W

9. **< HKCE 1983 Paper II - 3 >**

A bullet of mass 0.01 kg travelling horizontally at 100 m s^{-1} is stopped by 0.1 m of concrete. What retarding force is applied to the bullet by the concrete ?

A. 0.1 N
B. 10 N
C. 500 N
D. 1000 N

10. **< HKCE 1984 Paper II - 8 >**

A cannon ball is fired so that it hits the wall at the top of a 10 m tower. If the energy needed to destroy the wall is 49000 J and the mass of the cannon ball is 10 kg, the minimum initial velocity of the cannon ball required to break the tower wall is

A. 100 m s^{-1}
B. 200 m s^{-1}
C. 300 m s^{-1}
D. 400 m s^{-1}

11. **< HKCE 1984 Paper II - 9 >**

A bullet hits a target at a speed of 200 m s^{-1}. If 50% of the kinetic energy has been converted into the internal energy of the bullet, what is the rise in temperature of the bullet ? (Specific heat capacity of the bullet = 100 J kg^{-1} °C^{-1})

A. 10°C
B. 20 °C
C. 100 °C
D. 200 °C

12. **< HKCE 1985 Paper II - 8 >**

A block is moving with uniform velocity along a rough horizontal plane. Which of the following statements is/are true ?

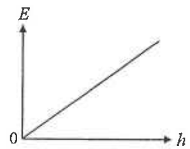
(1) The kinetic energy of the block is increasing.
(2) The potential energy of the block is increasing.
(3) The resultant force acting on the block is zero.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

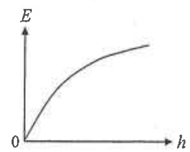
13. **< HKCE 1985 Paper II - 6 >**

An object is projected vertically upwards. Which of the graphs below correctly describes the variation of the kinetic energy E of the object with height h ?

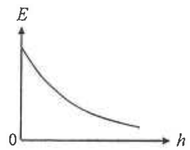
A.



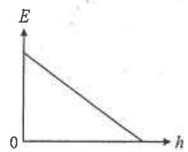
B.



C.



D.



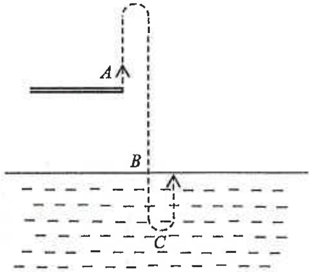
14. **< HKCE 1985 Paper II - 14 >**

The difference in water temperature between the top and the bottom of a waterfall is 0.15°C. Assuming no heat is lost from the water to the surroundings, what is the height of the waterfall ? (The specific heat capacity of water is 4200 J kg^{-1} $°C^{-1}$.)

A. 3.6 m
B. 28 m
C. 64 m
D. 360 m

15. **< HKCE 1985 Paper II - 9 >**

A diver jumps up at A from a high platform into water at the point B as shown. The diver descends to C and then floats up to the water surface. Assume that the potential energy at point B is taken to be zero. Which of the following statements is/are true concerning the diver at point C ?



(1) The kinetic energy of the diver is at a maximum.
(2) The kinetic energy of the diver is at a minimum.
(3) The sum of the kinetic energy and potential energy of the diver is zero.

A. (1) only
B. (2) only
C. (3) only
D. (1) & (3) only

16. **< HKCE 1987 Paper II - 4 >**

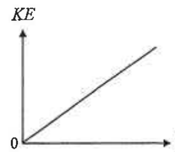
An escalator is said to be able to carry 120 passengers to a height of 10 m in one minute. Assuming each passenger has a weight of 500 N, the possible power output by the escalator must be at least

A. 1 000 W
B. 5 000 W
C. 10 000 W
D. 50 000 W

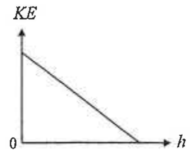
17. **< HKCE 1987 Paper II - 5 >**

An object is projected vertically upwards. Which of the graphs below correctly describes the variation of its kinetic energy (KE) with height (h) ?

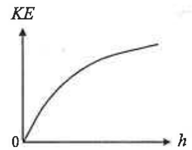
A.



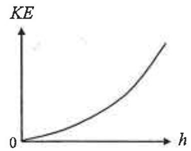
B.



C.

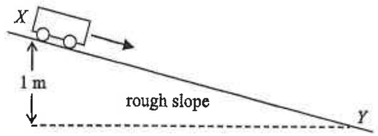


D.



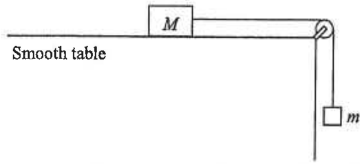
18. **< HKCE 1988 Paper II - 4 >**

The figure shows a trolley of mass 1 kg being released from rest from point X of a rough slope. Its speed at Y is 3 m s^{-1}. What is the loss in energy by the trolley when it is moving from X to Y ? (Take g = 10 m s^{-2}.)



A. 1.0 J
B. 4.5 J
C. 5.5 J
D. 9.0 J

19. **< HKCE 1988 Paper II - 5 >**



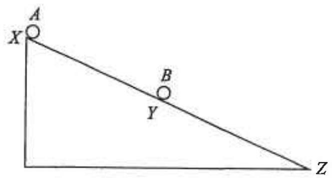
The figure above shows a mass m connected to another mass M by a string passing over a smooth pulley. The system is moving freely under gravity. Assuming that the table is smooth, which of the following statements is/are correct ?

(1) m and M move with the same acceleration in magnitude.
(2) The loss in potential energy of m is equal to the gain in kinetic energy of M.
(3) If the mass of M is doubled, its acceleration is halved.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

20. **< HKCE 1988 Paper II - 8 >**

The figure shows a smooth inclined plane with Y being midway between XZ. Two particles A and B of the same mass are released from rest at X and Y respectively. Which of the following statements about A and B is/are true ?



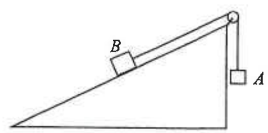
(1) The time required for A to reach Z is double that for B to reach Z.
(2) The potential energy for A at Z is double that for B at Z.
(3) The kinetic energy for A at Z is double that for B at Z.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

21. **< HKCE 1989 Paper II - 4 >**

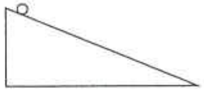
Two equal masses A and B are connected by a light string passing over a smooth pulley as shown in the below figure. The inclined plane is smooth. Which of the following is/are correct ?

(1) The potential energy lost by A is equal to the potential energy gained by B.
(2) The kinetic energy gained by A is equal to the kinetic energy gained by B.
(3) The potential energy lost by A is equal to the sum of kinetic energies gained by A and B.



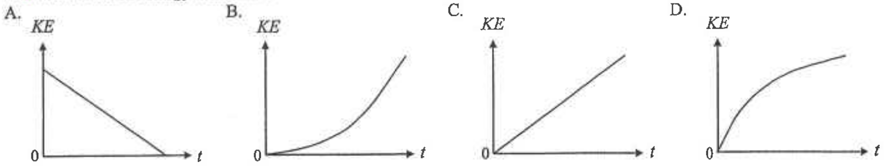
A. (1) only
B. (2) only
C. (3) only
D. (1) & (2) only

22. **< HKCE 1989 Paper II - 6 >**



An object slides down a smooth plane from rest as shown in the figure above. Which of the following graphs best shows the variation of kinetic energy with time ?

A. B. C. D.



23. **< HKCE 1990 Paper II - 6 >**

Two objects P and Q, of mass 0.1 kg and 0.5 kg respectively, are thrown vertically upwards with the same speed from the same level. Neglecting air resistance, which of the following is true ?

A. P will reach a point higher than that of Q.
B. Q will take a shorter time to reach its highest point.
C. Both will have the same kinetic energy on returning to the staring point.
D. Both rise with the same deceleration.

24. **< HKCE 1990 Paper II - 2 >**

A block of mass 5 kg is moving horizontally on a smooth surface along a straight line at 6 m s^{-1}. In order to change its speed to 10 m s^{-1}, the work done would need to be

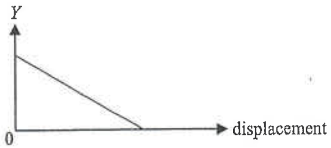
A. 40 J
B. 90 J
C. 160 J
D. 400 J

25. **< HKCE 1991 Paper II - 6 >**

A block is pulled along a horizontal bench at a constant velocity of 10 m s^{-1} by a force of 5 N. What is the work done against friction in 4 s ?

A. 200 J
B. 50 J
C. 20 J
D. 12.5 J

26. **< HKCE 1991 Paper II - 3 >**



For a body falling freely under gravity, Y has a linear relationship with the displacement of the body as shown in the above figure. Y may represent

A. the potential energy of the body.
B. the kinetic energy of the body.
C. the velocity of the body.
D. the speed of the body.

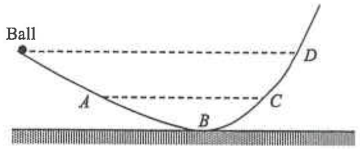
27. **< HKCE 1992 Paper II - 7 >**

Which of the following involve(s) an energy transfer of 100 J ?

(1) A mass of 10 kg is raised vertically by 10 m.
(2) A mass of 2 kg gains a speed of 10 m s^{-1} from rest.
(3) A 10 W heater is switched on for 10 s.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

28. **< HKCE 1992 Paper II - 6 >**

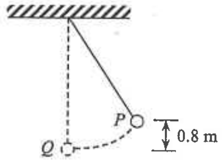


A ball is released from rest from one end of a smooth curved rail as shown in the above diagram. Neglecting air resistance and friction, which of the following statements about the motion of the ball is/are correct ?

(1) The ball has maximum kinetic energy at point B.
(2) The speed of the ball at point C is the same as that at point A.
(3) The ball would not rise to a level higher than point D.

A. (1) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

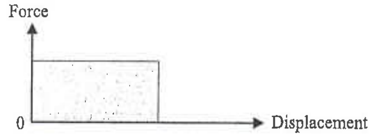
29. **< HKCE 1993 Paper II - 6 >**



A pendulum bob is released from rest from a point P 0.8 m above its lowest position Q, as shown in the diagram. Neglecting air resistance, find the speed of the bob when it reaches Q. (Take g = 10 m s^{-2}.)

A. 2.8 m s^{-1}
B. 4 m s^{-1}
C. 8 m s^{-1}
D. 16 m s^{-1}

30. **< HKCE 1993 Paper II - 4 >**

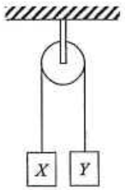


The figure shows the variation of the force acting on an object. What physical quantity does the area of the shaded portion represent ?

A. Velocity
B. Acceleration
C. Power
D. Work

31. < HKCE 1994 Paper II - 10 >

Two blocks X and Y are connected by a light string passing over a smooth pulley as shown. The mass of X is greater than that of Y. The two blocks are released from rest. Which of the following statements is/are correct ?

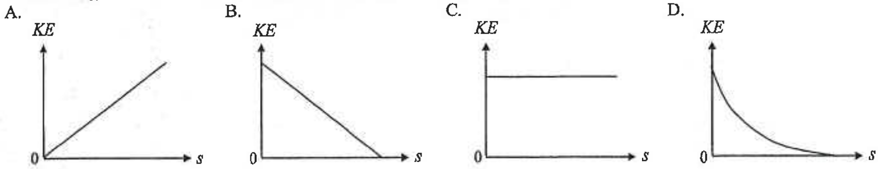


(1) The potential energy lost by X is equal to the potential energy gained by Y.
(2) The kinetic energy gained by X is greater than the kinetic energy gained by Y.
(3) The potential energy lost by X is equal to the sum of kinetic energies gained by X and Y.

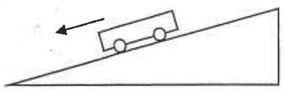
A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

32. < HKCE 1994 Paper II - 9 >

A stone is projected vertically upwards. Neglecting air resistance, which of the following graphs shows the variation of the kinetic energy KE of the stone with the distance travelled s during its upward motion ?



33. < HKCE 1995 Paper II - 10 >



A trolley runs down a friction-compensated runway as shown above. Which of the following statements is true ?

A. The kinetic energy of the trolley increases with time.
B. The sum of kinetic and potential energies of the trolley remains unchanged.
C. The frictional force acting on the trolley is zero.
D. The resultant force acting on the trolley is zero.

34. < HKCE 1995 Paper II - 9 >

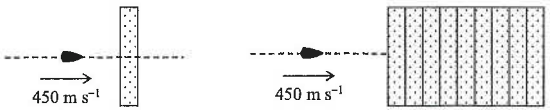


Figure (a) Figure (b)

A bullet of mass 0.02 kg traveling at 450 m s^{-1} enters a wooden block as shown in Figure (a) and leaves it with a speed 400 m s^{-1}. In figure (b), what is the maximum number of identical blocks that the same bullet can pass through ?

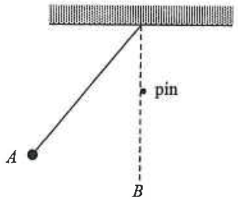
A. 3
B. 4
C. 5
D. 9

35. < HKCE 1996 Paper II - 7 >

A motor car of mass 2500 kg accelerates from rest to a speed of 20 m s^{-1} in 5 s on a level road. Find the average power of the car.

A. 10 kW
B. 50 kW
C. 100 kW
D. 200 kW

36. < HKCE 1997 Paper II - 7 >



A pendulum bob is suspended by a light inextensible string. The bob is released from rest at point A. When the bob reaches the lowest point B, the string hits a fixed pin. Neglect air resistance. Which of the following statements is/are correct ?

(1) The bob has maximum kinetic energy at B.
(2) The highest level that the bob can reach is the level of the pin.
(3) The work done by the tension of the string is zero throughout the motion.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

37. < HKCE 1997 Paper II - 8 >

A machine lifts up a load of 1200 N to a height of 1.5 m in 2 s. Find the average output power of the machine.

A. 400 W
B. 900 W
C. 1800 W
D. 3600 W

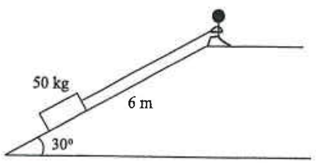
38. < HKCE 1998 Paper II - 1 >

Which of the following units does **not** represent energy ?

A. N m
B. W s
C. J
D. kg m s^{-2}

39. < HKCE 1998 Paper II - 10 >

A smooth inclined plane makes an angle 30° with the horizontal as shown. A man pulls a 50 kg block up the inclined plane with uniform velocity. The inclined plane is 6 m long and the block is pulled from the bottom of the inclined plane to the top in 30 s. Find the average power of the man. Take the acceleration due to gravity to be 10 m s^{-2}.



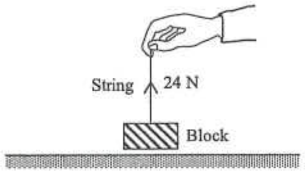
A. 5 W
B. 10 W
C. 50 W
D. 87 W

40. **< HKCE 1999 Paper II - 7 >**

A motor car of mass 2000 kg accelerates from rest at 3 m s^{-2} for 4 s on a straight road. Find the average useful output power of the engine of the car.

A. 24 kW
B. 36 kW
C. 72 kW
D. 144 kW

41. **< HKCE 2000 Paper II - 11 >**



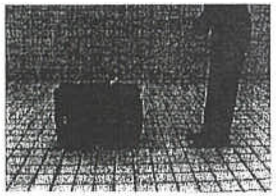
A 2 kg block is initially at rest on the ground. A man uses a force to pull up the block as shown above. If the tension in the string is kept at 24 N and the block reaches a height of 4 m in 2 s, which of the following statements is/are correct ?

(1) The potential energy of the block is increasing when the block is rising.
(2) The kinetic energy of the block is increasing when the block is rising.
(3) The average power developed by the man during the two seconds is 40 W.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

42. **< HKCE 2001 Paper II - 10 >**

A man is pulling a suitcase along the horizontal ground as shown below.



If the rope is inclined at an angle θ to the horizontal and the tension in the rope is 100 N, find the work done by the man in pulling the suitcase for a distance of 5 m along the ground.

A. 500 sin θ J
B. 500 cos θ J
C. 500 / sin θ J
D. 500 / cos θ J

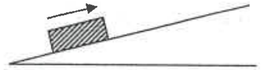
43. **< HKCE 2001 Paper II - 3 >**

A stone is thrown vertically upwards. Assuming air resistance is negligible, which of the following statements is/are correct ?

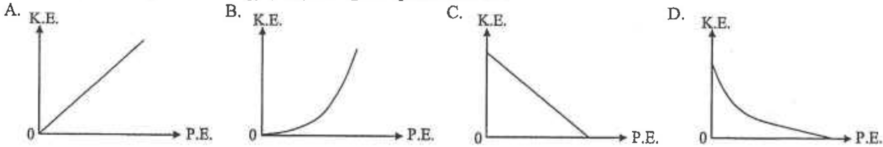
(1) The acceleration of the stone decreases throughout the upward motion.
(2) The net force acting on the stone becomes zero when the stone reaches the highest point.
(3) The total energy of the stone remains unchanged throughout the motion.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

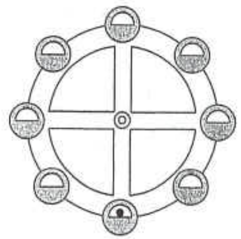
44. **< HKCE 2002 Paper II - 8 >**



A block is projected up a smooth inclined plane. Which of the graphs below shows the variation of the kinetic energy (K.E.) of the block with its potential energy (P.E.) during the upward motion ?



45. **< HKCE 2002 Paper II - 10 >**



The figure above shows a flying wheel in an amusement park. The wheel is of diameter 18 m and carries eight cages. There is only one passenger of mass 60 kg inside one of the cages. The wheel rotates with uniform speed and it takes 80 s for the passenger to travel from the bottom to the top of the wheel. Find the average useful power output of the motor of the wheel.

A. $(60 \times 9.81 \times 18)$ W
B. $(\frac{60 \times 9.81 \times 18}{80})$ W
C. $(\frac{60 \times 9.81 \times \pi \times 9}{80})$ W
D. $(60 \times 9.81 \times \pi \times 9 \times 80)$ W

46. **< HKCE 2004 Paper II - 12 >**

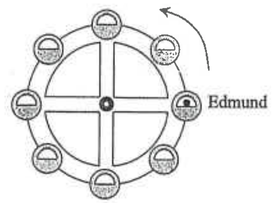
The photograph shows a baby sitting on a push-chair and her mother Amy is pushing the push-chair with a uniform velocity v along the horizontal ground.

Let F = horizontal force exerted by Amy on the push-chair, and
m = total mass of the baby and the push-chair.

Which of the following expressions denotes the average output power of Amy in pushing the push-chair ?

A. Fv
B. mgv
C. $(F - mg)v$
D. $(F + mg)v$

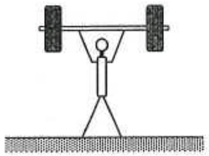
47. **< HKCE 2005 Paper II - 6 >**



The diagram shows Edmund riding the 'Ferris Wheel' in an amusement park. If the wheel is rotating at a uniform speed, which of the following physical quantities of Edmund would remain unchanged ?

A. velocity
B. kinetic energy
C. potential energy
D. total mechanical energy

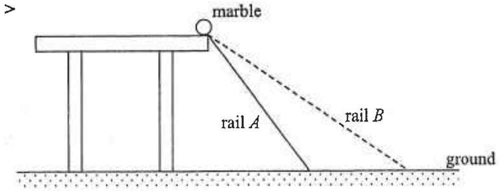
48. **< HKCE 2005 Paper II - 5 >**



The diagram shows a weight-lifter lifting a weight of mass 80 kg from the floor to a height of 2 m. Find the work done by the weight-lifter.

A. 160 J
B. 785 J
C. 1570 J
D. 3140 J

49. **< HKCE 2006 Paper II - 3 >**



John releases a marble from the top of a smooth rail *A* placed at the edge of a table as shown above. He repeats the same process by using another smooth rail *B*. Which of the following statements about the marble is/are correct ?

(1) The marble has the same velocity when it reaches the ends of both rails.
(2) The marble has the same kinetic energy when it reaches the ends of both rails.
(3) It takes the same time for the marble to travel through both rails.

A. (1) only
B. (2) only
C. (3) only
D. (1), (2) & (3)

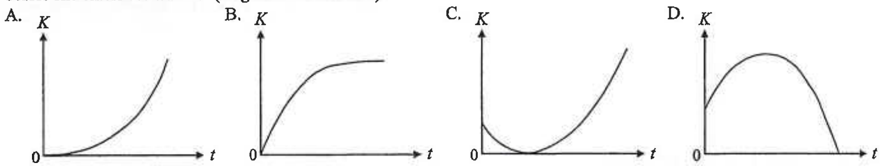
50. **< HKCE 2006 Paper II - 4 >**

A car stopped after emergency braking. The skid mark left by the car was 22.3 m long. Assume that the friction between the road and tyres was 0.65 times that of the weight of the car. Estimate the speed of the car when it began to skid.

A. 5.38 m s^{-1}
B. 11.8 m s^{-1}
C. 16.1 m s^{-1}
D. 16.9 m s^{-1}

51. **< HKCE 2006 Paper II - 5 >**

A high-diver jumps up into the air from a spring board and then falls into a swimming pool. Which of the following graphs best shows the variation of her kinetic energy *K* with time *t* from the time she just leaves the board up to the moment just before she enters the water ? (Neglect air resistance.)

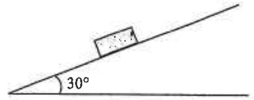


52. **< HKCE 2007 Paper II - 31 >**

An electrical toy car of mass *m* goes up an inclined plane of inclination 30° with constant speed *v*. The air resistance acting on the car is half of the weight of the car. What is the average power of the car ?

A. $\frac{1}{2}mgv$
B. mgv
C. $\frac{3}{2}mgv$
D. $2mgv$

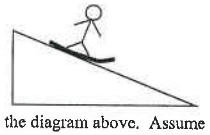
53. **< HKCE 2007 Paper II - 32 >**



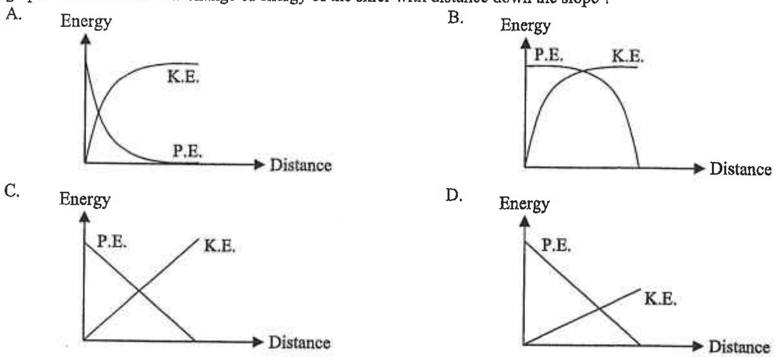
A block of mass 1 kg is sliding down with constant speed along an inclined plane of inclination 30° to the horizontal. What are the gain in kinetic energy and the work done against friction by the block after travelling a distance of 2 m along the plane ? (Take the acceleration due to gravity to be 10 m s^{-2}.)

	Gain in kinetic energy / J	Work done against friction / J
A.	0	10
B.	10	10
C.	0	20
D.	10	30

54. **< HKCE 2007 Paper II - 4 >**



A skier slides down a slope as shown in the diagram above. Assume constant friction along the slope, which of the following graphs best describes the change of energy of the skier with distance down the slope ?



55. **< HKCE 2008 Paper II - 3 >**

A car is travelling at a constant speed of 15 m s^{-1} along a horizontal straight road. The total resisting force acting on the car is 500 N. Which of the following statements are correct ?

(1) The car travels a distance 120 m in 8 s.
(2) The work done by the car in overcoming the resisting force in 8 s is 60 kJ.
(3) The output power of the car is 7.5 kW.

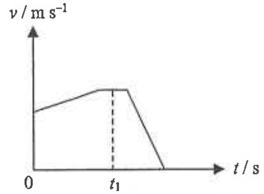
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

56. **< HKCE 2008 Paper II - 1 >**

A fish jumps up vertically to a maximum height of 0.5 m above the water surface. What is the speed when it just leaves the surface ?

A. 3.13 m s^{-1}
B. 4.47 m s^{-1}
C. 6.32 m s^{-1}
D. 9.81 m s^{-1}

57. **< HKCE 2008 Paper II - 4 >**



The figure above shows the velocity - time graph of a car travelling on a horizontal straight road. Which of the following statements is/are correct ?

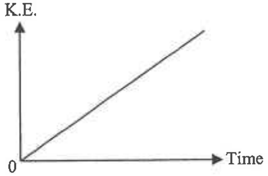
(1) Area under the graph is equal to the total displacement of the car.
(2) The acceleration of the car is maximum at time t_1.
(3) The kinetic energy of the car remains unchanged throughout the whole journey.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

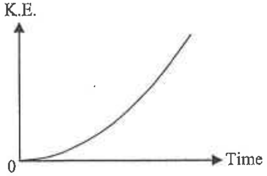
58. **< HKCE 2008 Paper II - 8 >**

An object is released from rest. Which of the following graphs best describes the variation of the kinetic energy of the object with time during falling ? (Neglect air resistance.)

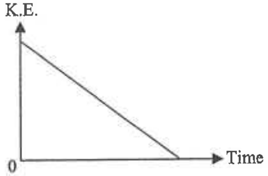
A.



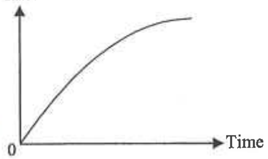
B.



C.



D.

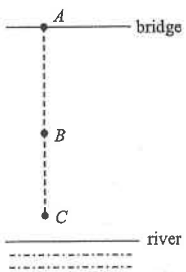


59. **< HKCE 2008 Paper II - 32 >**

John performs a bungee jump from a bridge above a river. He (assumed to be a particle) is tied to the bridge at A with an elastic cord. He falls from rest at A. When he reaches B, the elastic cord starts to stretch. John is momentarily at rest at C and then bounces up. Which of the following descriptions about the motion of John is/are correct ? (Neglect the air resistance.)

(1) From A to B, John is under free falling.
(2) From B to C, the gravitational potential energy of John increases.
(3) At C, there is no net force acting on John,

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only



60. **< HKCE 2008 Paper II - 28 >**

When a skydiver falls steadily in air under no net force, which of the following descriptions about his gravitational potential energy, kinetic energy and power in overcoming air resistance is correct ?

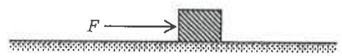
	Gravitational potential energy	Kinetic energy	Power in overcoming air resistance
A.	decreases	increases	increases
B.	decreases	increases	remains unchanged
C.	decreases	remains unchanged	remains unchanged
D.	remains unchanged	increases	increases

61. **< HKCE 2009 Paper II - 3 >**

A ball of mass 0.5 kg resting on a horizontal ground is kicked by a player. The ball travels along a straight path and come to rest after travelling a horizontal distance of 10 m. If the average resistive force acting on the ball during the motion is 3 N, what is its initial speed ?

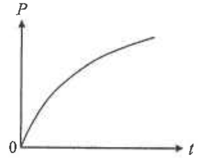
A. 3.2 m s⁻¹
B. 7.7 m s⁻¹
C. 11.0 m s⁻¹
D. 15.0 m s⁻¹

62. **< HKCE 2009 Paper II - 6 >**

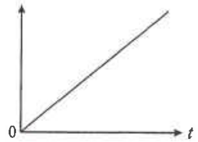


A constant force F is applied to an object which is initially at rest on a horizontal smooth surface. Which of the graphs below best represents the variation of the power P developed by the force F with time t ?

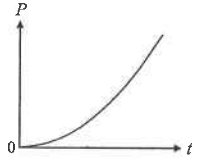
A.



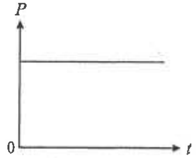
B.



C.



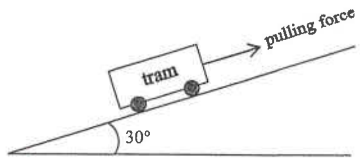
D.



63. **< HKCE 2009 Paper II - 31 >**

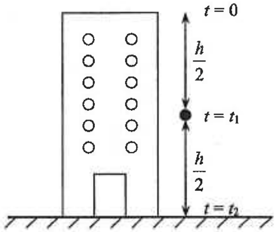
A tram of mass 1500 kg is being pulled by a steel cable. It goes up a 30° slope with a uniform speed. The average resistive force along the tram is 200 N. What is the energy required for the tram to move 100 m up along the slope ?

A. 20 kJ
B. 734 kJ
C. 756 kJ
D. 1500 kJ



64. **< HKCE 2009 Paper II - 32 >**

An object is released from rest at the top of a building of height h. At time t_1, the object is at the half of the height of the building as shown in the figure. At time t_2, the object just reaches the ground. Which of the following is/are correct ? (Neglect air resistance.)



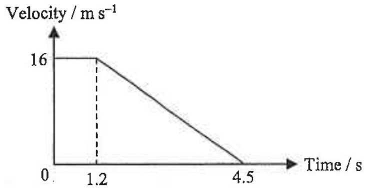
(1) velocity of the object at t_2 = 2 × velocity of the object at t_1

(2) $t_2 = 2 \times t_1$

(3) K.E. of the object at t_2 = 2 × K.E. of the object at t_1

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

Questions 65 and 66 : A car is travelling along a straight horizontal path at 16 m s^{-1} initially. The driver sees an obstacle and applies the brake. The velocity-time graph of his car is shown below.



65. **< HKCE 2010 Paper II - 6 >**

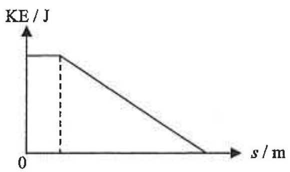
What is the magnitude of the deceleration of the car during braking ?

A. 3.56 m s^{-2}
B. 4.85 m s^{-2}
C. 13.3 m s^{-2}
D. 26.4 m s^{-2}

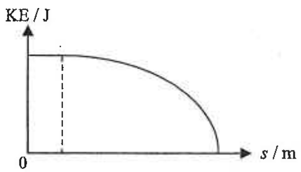
66. **< HKCE 2010 Paper II - 7 >**

Which of the following graphs best represents the variation of the kinetic energy (K.E.) of the car with distance s travelled ?

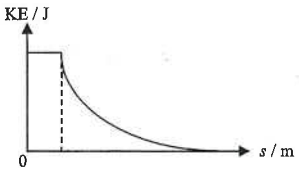
A.



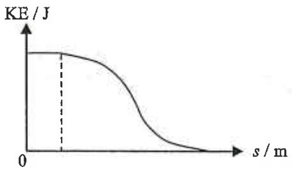
B.



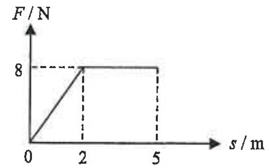
C.



D.



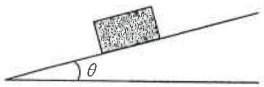
67. **< HKCE 2010 Paper II - 5 >**

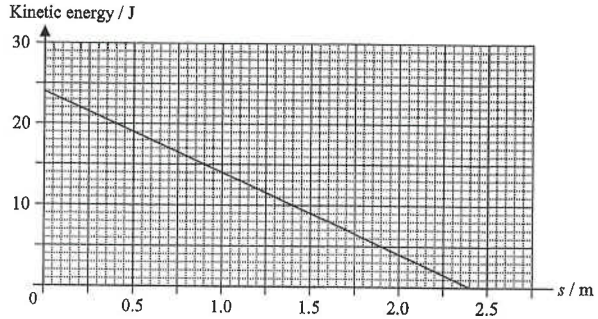


Horizontal force F is applied to a block of mass 4 kg which is initially at rest on a horizontal smooth surface. The variation of the magnitude of F with displacement s is shown in the graph. The direction of F remains unchanged throughout the motion. What is the work done on the block by F from s = 2 m to 5 m ?

A. 16 J
B. 24 J
C. 32 J
D. 40 J

68. **< HKCE 2010 Paper II - 29 >**

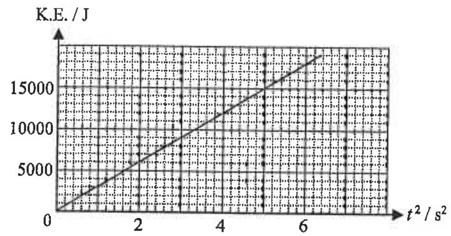




A block of mass 5 kg is projected up along a smooth inclined plane of inclination θ as shown in the figure above. The graph shows the variation of kinetic energy of the block with the distance travelled s up along the plane. Find the angle θ. Take g to be 10 m s^{-2}.

A. 5.7°
B. 11.5°
C. 23.6°
D. 26.7°

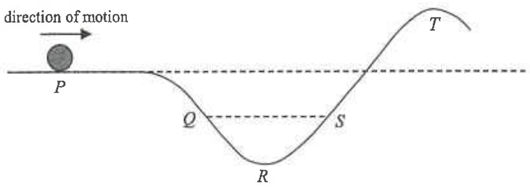
69. **< HKCE 2011 Paper II - 7 >**



A car of mass 1500 kg is accelerating from rest along a straight road. The above figure shows the variation of its kinetic energy (K.E.) with the square of time t. What is the acceleration of the car ?

A. 0.89 m s^{-2}
B. 1.41 m s^{-2}
C. 2.00 m s^{-2}
D. 4.00 m s^{-2}

70. < HKCE 2011 Paper II - 2 >

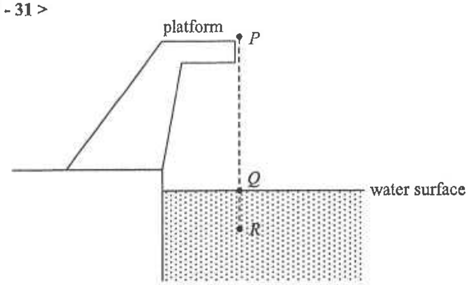


A ball moves along a smooth curved rail and passed P at a certain speed as shown in the figure above. Neglecting air resistance and friction, which of the following statements about the motion of the ball are correct ?

(1) The ball has maximum kinetic energy at R.
(2) The speed of the ball at S is the same as that at Q.
(3) The ball can never reach T.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

71. < HKCE 2011 Paper II - 31 >



In the above figure, a mass is released from rest at P from a high platform into a swimming pool. After a while, the mass reaches the water surface at Q and enters the water. Finally, it reaches a maximum depth at R. Which of the following descriptions about the motion of the mass is/are correct ?

(1) From P to Q, the acceleration of the mass is increasing.
(2) From Q to R, the net force acting on the mass is pointing upward.
(3) From P to R, the gravitational potential energy loss of the mass equals to its kinetic energy gain.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

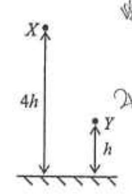
Part B : HKAL examination questions

72. < HKAL 1994 Paper IIA - 7 >

When a body falls freely in air with air resistance negligible, its total mechanical energy

A. increases during the fall.
B. decreases during the fall.
C. remains constant during the fall.
D. is zero at the beginning of the fall.

73. < HKAL 1995 Paper IIA - 2 >



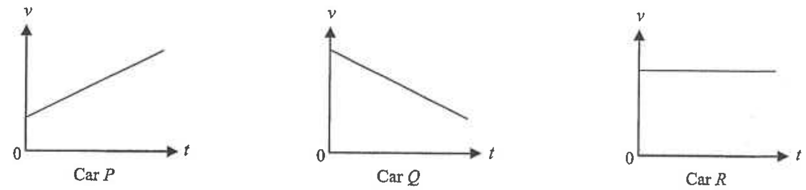
Two small balls X and Y of masses 1 kg and 2 kg respectively are released from rest at heights $4h$ and h above the ground as shown. If air resistance is negligible, which of the following statements is/are correct ?

(1) The acceleration of ball X doubles that of ball Y.
(2) The time taken for ball X to reach the ground is double that of ball Y.
(3) The kinetic energy of ball X when reaching the ground is double that of ball Y.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Part C : Supplemental exercise

Questions 74 and 75 : Three toy cars P, Q and R move along a straight line. The velocity-time (v - t) graphs of the three toy cars are shown below :



74. Which of the toy cars experience(s) an increase in kinetic energy during the motion ?

A. P only
B. R only
C. P & Q only
D. Q & R only

75. Which of the toy cars has/have an unbalanced force acting on it/them during the motion ?

A. P only
B. R only
C. P & Q only
D. Q & R only

76. An electric motor is used to lift a 10 N load through a vertical distance of 3 m. The total amount of electrical energy supplied to the motor is 54 J. What amount of energy is wasted by the motor ?

A. 18 J
B. 24 J
C. 30 J
D. 44 J

77. A windmill is used to raise water from a well. The depth of the well is 12 m. The windmill raises 270 kg of water every day. What is the useful power extracted from the wind ? (Take $g = 10 \text{ m s}^{-2}$.)

A. 0.375 W
B. 0.9375 W
C. 9.375 W
D. 135 W

78. David exerts a horizontal force of 500 N on a block placed on a rough horizontal surface. The friction between the block and the surface is 100 N. After the box has moved a horizontal distance of 3 m, what is the gain of kinetic energy of the block ?

A. 300 J
B. 1200 J
C. 1500 J
D. 1800 J

79. Peter pushes a cart along a level road and then lets it go. As the cart is slowing down, the main energy change of the cart is

A. from chemical energy to internal energy.
B. from chemical energy to kinetic energy.
C. from kinetic energy to internal energy.
D. from kinetic energy to potential energy.

80. When a wooden block is rubbed against sand-paper, which of the following statements is/are correct ?

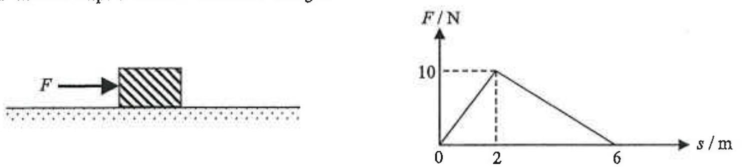
(1) Friction acts on the wooden block by the sand paper.
(2) Work done against friction is converted into internal energy.
(3) The temperature of the rubbed surface of the block rises.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

81. Which of the following physical quantities is **not** a vector ?

A. acceleration
B. displacement
C. weight
D. work

82. A student pushes a block of mass 0.25 kg which is initial at rest on a smooth horizontal surface. The variation of the applied force F with the displacement s is shown in the figure.



What is the speed of the block after it has been pushed for 6 m ?

A. 12.5 m s^{-1}
B. 15.5 m s^{-1}
C. 17.5 m s^{-1}
D. 25.5 m s^{-1}

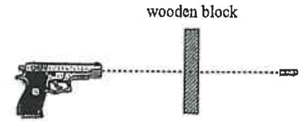
Part D : HKDSE examination questions

83. < HKDSE 2012 Paper IA - 9 >

An object of mass 0.5 kg is raised vertically from the ground by a motor. The object is raised 2.5 m in 1.5 s with uniform speed. Estimate the output power of the motor. Neglect air resistance.

A. 5.5 W
B. 8.2 W
C. 11.0 W
D. 16.4 W

84. < HKDSE 2013 Paper IA - 12 >



A bullet of mass 50 g is fired from a gun with a speed of 400 m s^{-1} and passes right through a fixed wooden block of 6 cm thickness as shown. Find the average resistive force acting on the bullet due to the block if it emerges with a speed of 250 m s^{-1}. Neglect air resistance and the effects of gravity.

A. 4.06×10^4 N
B. 1.02×10^4 N
C. 125 N
D. Answer cannot be found as the time of travel of the bullet within the block is not known.

85. < HKDSE 2014 Paper IA - 6 >

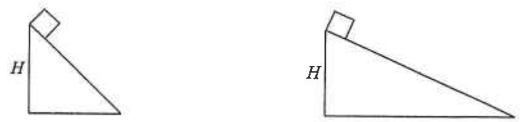


Figure (a) **Figure (b)**

Two small identical blocks slide down from rest on smooth incline planes from the same height H as shown in Figure (a) and Figure (b) above. Their respective speeds at the bottom of the incline planes are denoted by v_1 and v_2 and the respective times taken to reach the bottom are t_1 and t_2. Which of the following is correct ? Neglect air resistance.

A. $v_1 > v_2$ and $t_1 = t_2$
B. $v_1 > v_2$ and $t_1 < t_2$
C. $v_1 = v_2$ and $t_1 = t_2$
D. $v_1 = v_2$ and $t_1 < t_2$

86. < HKDSE 2015 Paper IA - 8 >

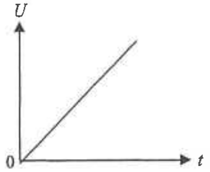
An object is released from rest and falls from P to Q as shown below. Throughout the motion, air resistance increases with the speed of the object. Which of the following description is/are correct ?

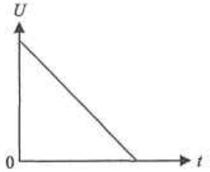
(1) The net force acting on the object is constant throughout the motion.
(2) The magnitude of the object's acceleration decreases from P to Q.
(3) The kinetic energy gained by the object from P to Q is equal to its loss in gravitational potential energy.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

87. **< HKDSE 2016 Paper IA - 8 >**

An object at a certain height falls freely from rest under gravity. Which of the below graphs correctly shows the variation of its gravitational potential energy U with time t ? Neglect air resistance and take $U = 0$ at the ground.

A.


B.


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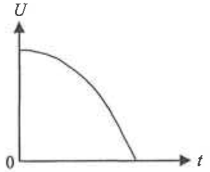

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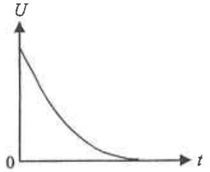
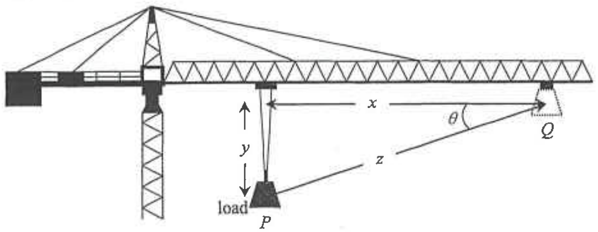


88. **< HKDSE 2016 Paper IA - 9 >**



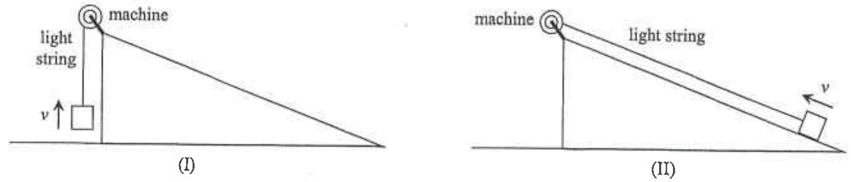
A crane moves a load of weight W steadily from point P to point Q as shown. The work done on the load by the crane is

A. Wy.
B. $W(x + y)$.
C. Wz.
D. $Wz \cos \theta$.

89. **< HKDSE 2017 Paper IA - 11 >**

A machine is fixed at the top of a smooth inclined plane. Two methods, (I) and (II), are used to lift a block from the ground to the top of the inclined plane by the machine.

(I) Pull the block vertically upward at a uniform speed v.
(II) Pull the block up along the inclined plane at the same uniform speed v.



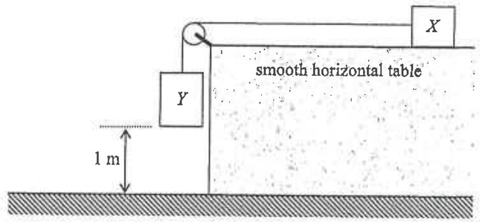
Which of the following statements correctly compare(s) the two methods ?

(1) The tension in the string is the same.
(2) The average output power of the machine is the same.
(3) The work done by the machine on the block is the same

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

90. **< HKDSE 2017 Paper IA - 10 >**

Blocks X and Y are connected by a light inextensible string passing over a fixed frictionless light pulley as shown. The mass of X and Y are 0.5 kg and 1 kg respectively. Initially, Y is 1 m above the ground and the string is taut. The system is then released from rest.



What is the speed of Y just before it reaches the ground ?

A. 3.62 m s^{-1}
B. 4.43 m s^{-1}
C. 6.26 m s^{-1}
D. 9.81 m s^{-1}

M.C. Answers

1. B	11. C	21. B	31. A	41. C
2. C	12. B	22. B	32. B	42. B
3. A	13. D	23. D	33. D	43. B
4. A	14. C	24. C	34. B	44. C
5. C	15. B	25. A	35. C	45. B
6. C	16. C	26. A	36. D	46. A
7. D	17. B	27. D	37. B	47. B
8. B	18. C	28. D	38. D	48. C
9. C	19. A	29. B	39. C	49. B
10. A	20. B	30. D	40. B	50. D
51. C	61. C	71. B	81. D	**91. B**
52. B	62. B	72. C	82. B	
53. A	63. C	73. D	83. B	
54. D	64. B	74. A	84. A	
55. D	65. B	75. C	85. D	
56. A	66. A	76. B	86. B	
57. A	67. B	77. A	87. C	
58. B	68. B	78. B	88. A	
59. A	69. C	79. C	89. B	
60. C	70. A	80. D	90. A	

M.C. Solution

1. B

At $t = 0$, the kinetic energy is the greatest.

At the topmost point, the object is instantaneously at rest, thus the kinetic energy = 0 at the highest point.

When the object moves down, the kinetic energy increases again.

Kinetic energy against time is a quadratic curve.

2. C

Loss of *PE* of m_1 = Gain of *PE* of m_2 + gain of *KE* of m_1 + gain of *KE* of m_2

$\therefore\ m_1 g h = m_2 g h + KE_1 + KE_2$

$\therefore\ KE_1 + KE_2 = (m_1 - m_2) g h$

3. A

By $P = F v$, as velocity is constant and resistive force acting on the car is constant, thus P is a constant.

Power developed by vehicle is equal to the power dissipated against the resistive force and is constant.

4. A

✓ (1) It loses gravitational *PE* during free fall and is converted into *KE*.

✗ (2) Work done in raising it from the ground level to that point is the *PE* at that height.
At any point in the flight, there exists *KE* in addition to *PE*.

✗ (3) Instead, its *PE* at the end of flight is all converted into *KE* before hitting the ground.

5. C

By $P = F v$, as velocity is constant and resistive force acting on the car is constant, thus P is a constant.

Power developed by vehicle is equal to the power dissipated against the resistive force and is constant.

6. C

✗ (1) X : moves down with acceleration equal to g and travels a smaller distance
Y : moves down with acceleration equal to $g \sin\theta$ which is less than g and travels a greater distance
Thus, Y should take a longer time to reach the bottom.

✗ (2) They have different direction, thus they should have different velocity as velocity is a vector.

✓ (3) As both of them have the loss of same *PE*, thus they gain the same *KE* when they reach the bottom.

7. D

Loss of *PE* = Gain in internal energy

$\therefore\ m g h = m c \Delta T$ $\quad \therefore\ (9.81)\, h = (4200)(0.2)$ $\quad \therefore\ h = 85.6 \approx 86\text{ m}$

8. B

$$P = \frac{W}{t} = \frac{m g h}{t} = \frac{(500)(15)}{20} = 375\text{ W}$$

9. C

Loss of *KE* = Work done against the retarding force of the concrete

$\therefore\ \frac{1}{2} m v^2 = F s$

$\therefore\ \frac{1}{2}(0.01)(100)^2 = F(0.1)$ $\quad \therefore\ F = 500\text{ N}$

10. A

Loss of *KE* = Gain of *PE* + Energy needed to destroy the wall

$\therefore\ \frac{1}{2} m u^2 = m g h + E$

$\therefore\ \frac{1}{2}(10)\, u^2 = (10)(9.81)(10) + (49000)$ $\quad \therefore\ v = 100\text{ m s}^{-1}$

11. C

Loss in kinetic energy = Gain in internal energy

$\therefore \frac{1}{2} m v^2 \times 50\% = m c \Delta T$

$\therefore \frac{1}{2} m (200)^2 \times 50\% = m (100) \Delta T$

$\therefore \Delta T = 100°C$

12. B

× (1) As the block moves with uniform velocity, kinetic energy should be constant.

× (2) As the plane is horizontal, potential energy should be constant.

✓ (3) As the block moves with uniform velocity, the acceleration is zero and the resultant force is also zero.

13. D

As the graph is a graph of the Energy against distance (height), the graph must be a straight line.

Initially, at $h = 0$, the object is projected upwards and should have maximum kinetic energy E.

When h increases, the potential energy increases and thus the kinetic energy E decreases.

Option D is thus the answer.

14. C

Loss of PE = Gain of internal energy

$m g h = m c \Delta T$

$\therefore (9.81) h = (4200)(0.15)$ $\therefore h = 64$ m

15. B

× (1) At point C, the diver is momentarily at rest, thus the KE is zero, not maximum.

✓ (2) As the KE is zero, it is a minimum.

× (3) PE at point B is defined as zero. C is a point below B, thus the PE at C is negative (less than zero), therefore, the sum of KE and PE should be less than zero.

16. C

$$P = \frac{E}{t} = \frac{n \cdot mg \cdot h}{t}$$

$$= \frac{(120)(500)(10)}{1 \times 60} = 10000 \text{ W}$$

17. B

As the graph is an Energy against distance (height) graph, the graph must be a straight line.

Initially, at $h = 0$, the object is projected upwards and should have maximum kinetic energy KE.

When h increases, the potential energy increases and thus the kinetic energy KE decreases. Option B is thus the answer.

18. C

Initial P.E. of the trolley = $m g h = (1)(10)(1) = 10$ J

Final K.E. of the trolley = $\frac{1}{2} m v^2 = \frac{1}{2}(1)(3)^2 = 4.5$ J

Loss of energy of the trolley = $10 - 4.5 = 5.5$ J

This loss of energy is due to work done against friction by the trolley.

19. A

✓ (1) As the two bodies are connected together, they must move with the same magnitude of acceleration.

× (2) Loss in PE of m = gain in KE of M + gain in KE of m

× (3) By $a = \frac{mg}{M+m}$, acceleration is not halved when M is doubled.

20. B

× (1) By $s = ut + \frac{1}{2} a t^2 = \frac{1}{2} a t^2$ $\therefore s \propto t^2$ $\therefore t \propto \sqrt{s}$
As distance travelled by A is 2 times of B, time required for A is $\sqrt{2}$ times of B.

× (2) As A and B are of same level when they reach Z, they should have the same PE at Z.

✓ (3) KE at the bottom = Loss of PE in moving down
As the height of A is double that of B, the loss of PE of A is double that of B, thus KE of A at Z is double.

21. B

× (1) Both A and B move the same distance, but B moves on an inclined plane, thus the rise of height for B is less than the drop of height for A, therefore, the PE gained by B is less than the PE lost by A.

✓ (2) Two connected bodies must have the same speed, as their masses are equal, they have the same KE.

× (3) Loss of PE by A = Gain in KE by A + Gain in PE by B + Gain in KE by B

22. B

As it is a graph of energy against time, it must be a curve.

At $t = 0$, the object starts from rest, thus $KE = 0$.

As time increases, the object moves down with loss of PE, thus KE increases.

As $KE \propto v^2$, the curve is a quadratic curve opening upwards.

23. D

× A. As both move under the same acceleration due to gravity, they should reach the same height.

× B. As both move under the same acceleration due to gravity, they take same time to reach the highest point.

× C. $KE = \frac{1}{2} m v^2$, although they have the same speed, they have different mass, thus they have different KE.

✓ D. When they rise up, they move with the same deceleration due to gravity.

24. C

$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{1}{2}(5)(10)^2 - \frac{1}{2}(5)(6)^2 = 160\ \text{J}$

25. A

$W_f = Fs = F(vt) = (5)\times(10)\times(4) = 200\ \text{J}$

26. A

✓ A. *PE* decreases as displacement increases when the body is falling.

× B. *KE* should increase as displacement increases when the body is falling.

× C. Velocity should increase as displacement increases when the body is falling.

× D. Speed should increase as displacement increases when the body is falling.

27. D

× (1) $E = mgh = (10)(9.81)(10) = 981\ \text{J}$

✓ (2) $E = \frac{1}{2}mv^2 = \frac{1}{2}(2)(10)^2 = 100\ \text{J}$

✓ (3) $E = Pt = (10)(10) = 100\ \text{J}$

28. D

✓ (1) At the lowest point, *PE* is minimum, thus *KE* is maximum.

✓ (2) *A* and *C* are at same level, thus they have the same *PE* and the same *KE*, as total energy is conserved.

✓ (3) The ball is at rest at initial position, thus when it rises to *D*, it comes to rest, thus it cannot rise higher than *D*.

29. B

Loss of *PE* = Gain of *KE*

$mgh = \frac{1}{2}mv^2$

$(10)(0.8) = \frac{1}{2}v^2 \qquad \therefore v = 4\ \text{m s}^{-1}$

30. D

Area = $F \cdot s$

Thus, the area represents the work done.

31. A

× (1) As the mass of *X* is greater, the loss of *PE* of *X* is greater than the gain of *PE* of *Y*.

✓ (2) They have the same speed but *X* has greater mass, thus *X* has greater *KE*.

× (3) Loss of *PE* by *X* = Gain in *KE* by *X* + Gain in *KE* by *Y* + Gain in *PE* by *Y*

32. B

As the graph is an Energy against distance graph, the graph must be a straight line.

Initially, at $s = 0$, the object is projected upwards and should have maximum kinetic energy *KE*.

When *s* increases, the potential energy increases and thus the kinetic energy *KE* decreases. Option B is thus the answer.

33. D

× A. On friction-compensated runway, the trolley should move with constant velocity and constant *KE*.

× B. Loss of *PE* = work done against friction but *KE* has no change ∴ sum of *KE* and *PE* decreases.

× C. Friction still exists in friction-compensated runway.

✓ D. As the trolley moves down with constant velocity, it has no acceleration, thus no resultant force.

34. B

Let the work done against the resistance of 1 concrete be *W*.

$\therefore W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{1}{2}(0.02)[(450)^2 - (400)^2] = 425\ \text{J}$

$\therefore \frac{1}{2}mv^2 = nW$

$\therefore \frac{1}{2}(0.02)(450)^2 = n(425) \qquad \therefore n = 4.76$

∴ The bullet can pass through 4 identical blocks.

35. C

$P = \frac{KE}{t} = \frac{\frac{1}{2}mv^2}{t} = \frac{\frac{1}{2}(2500)(20)^2}{(5)} = 100\,000\ \text{W} \qquad \therefore P = 100\ \text{kW}$

36. D

✓ (1) At the lowest position, the bob has minimum *PE*, thus it has maximum *KE*.

× (2) As the bob is released at *A*, it can only rise to the same level of *A* at the other side.

✓ (3) Tension is always perpendicular to the motion of the bob, thus the tension has no work done.

37. B

$P = \frac{E}{t} = \frac{F \cdot s}{t} = \frac{(1200)(1.5)}{2} = 900\ \text{W}$

38. D

✓ A. N m = Fs = Energy

✓ B. W s = Pt = Energy

✓ C. J = Energy

× D. kg m s^{-2} = ma = Force

39. C

Since the inclined plane is smooth and there is no gain of K.E.

$\therefore$ Work done by the applied force = gain of P.E.

$\therefore$ $W = mgh = mgs\sin\theta = (50)(10)(6 \times \sin 30°) = 1500$ J

$\therefore$ $P = \frac{W}{t} = \frac{1500}{30} = 50$ W

40. B

$v = u + at = (0) + (3)(4) = 12$ m s^{-1}

$P = \frac{\Delta KE}{t} = \frac{\frac{1}{2}mv^2 - \frac{1}{2}mu^2}{t} = \frac{\frac{1}{2}(2000)(12)^2 - 0}{4} = 36$ kW

41. C

✓ (1) As the block rises up, its *PE* increases.

✓ (2) As the tension *T* is greater than the weight *m g*, thus the block rises up with acceleration, *KE* increases.

× (3) $P = \frac{E}{t} = \frac{F \cdot s}{t} = \frac{(24)(4)}{2} = 48$ W

42. B

Work done = applied force × displacement in the direction of the force

= 100 cos θ × 5 = 500 cos θ

43. B

× (1) The acceleration should be constant throughout the motion as $a = g$.

× (2) At the highest point, the stone still has acceleration due to gravity, thus the net force is not zero. The net force is the weight of the stone acting by the earth.

✓ (3) As there is no work done on the stone, the total mechanical energy must be unchanged.

44. C

By conservation of energy, K.E. + P.E. = E = constant

$\therefore$ K.E. = − P.E. + E

The graph is a straight line with slope −1 and y-intercept E

45. B

$P = \frac{E}{t} = \frac{mgh}{t} = \frac{60 \times 9.81 \times 18}{80}$

46. A

Power = applied force × velocity in the same direction of the force

$\therefore$ $P = Fv$

47. B

× A. The direction of the velocity is always changing when Edmund moves in circular path.

✓ B. Kinetic energy is a scalar, and Edmund moves with constant speed, thus giving a constant kinetic energy.

× C. The height of Edmund is changing, thus giving a varying potential energy.

× D. Total mechanical energy = kinetic energy + potential energy
Since the potential energy is changing, the total mechanical energy is also changing.

48. C

Work done = gain of P.E. of the weight

= mgh = (80) (9.81) (2) = 1570 J

49. B

× (1) The marble has different velocity when it reaches the ends of the two rails since it has different directions and velocity is a vector.

✓ (2) Since the marble loses the same potential energy in both rails, it gains the same kinetic energy when it reaches the ends.

× (3) In rail *A*, the acceleration is greater and the displacement is smaller, thus the time taken to travel in rail *A* should be shorter.

50. D

Loss of kinetic energy = Work done against the friction

$\frac{1}{2}mu^2 = fs$

Friction = 0.65 times of the weight

$f = 0.65 \times mg$

$\therefore$ $\frac{1}{2}mu^2 = 0.65 \times mgs$

$\therefore$ $\frac{1}{2}u^2 = 0.65 \times gs$

$\therefore$ $\frac{1}{2}u^2 = 0.65 \times (9.81) \times (22.3)$

$\therefore$ $u = 16.9$ m s^{-1}

51. C

When the high-diver leaves the board, she has an initial kinetic energy.

At the highest point, the kinetic energy is zero.

During the downward motion, the kinetic energy increases.

52. B

The force exerted by the motor of the car is equal to the component of the weight along the plane and the air resistance.

$\therefore$ $F = mg\sin 30° + \frac{1}{2}mg = mg$

$\therefore$ $P = Fv = mgv$

53. A

Since the block moves down with constant speed, the kinetic energy is also constant, thus gain of *KE* is zero.

Work done against friction $= fs = mg\sin\theta \times s$
$= (1)(10)\sin 30° \times 2$
$= 10$ J

54. D

Energy against distance must be straight line, thus option *A* and *B* must not be correct.

As the skier moves down, P.E. → K.E. + Work done against friction

Thus the gain of K.E. should be less than the loss of P.E.

55. D

✓ (1) Since the car travels at constant speed, $s = vt = (15)(8) = 120$ m

✓ (2) Since acceleration = 0, there is no net force. ∴ Engine force of the car = 500 N
Work done by the engine force of the car $= Fs = (500)(120) = 60\,000$ J

✓ (3) Power of the car $= Fv = (500)(15) = 7500$ W

56. A

By $\frac{1}{2}mu^2 = mgh$

$\therefore \frac{1}{2}mu^2 = m(9.81)(0.5)$

$\therefore u = 3.13$ m s^{-1}

OR

By $v^2 = u^2 + 2as$

$\therefore (0) = u^2 + 2(-9.81)(0.5)$

$\therefore u = 3.13$ m s^{-1}

57. A

✓ (1) Area of velocity – time graph = total displacement

✗ (2) Slope of velocity – time graph = acceleration
At t_1, the slope is zero, thus the acceleration is zero, and should be the minimum.

✗ (3) Kinetic energy depends on the speed of the car; as the speed changes, kinetic energy changes.

58. B

By $v = u + at = (0) + gt$ $\therefore v \propto t$

By $KE = \frac{1}{2}mv^2$

$\therefore KE \propto v^2 \propto t^2$

The graph of $KE - t$ should be a quadratic curve opening upwards.

59. A

✓ (1) From *A* to *B*, as the cord does not start to stretch, John falls down freely under gravity.

✗ (2) From *B* to *C*, the gravitational potential energy of John should be decreasing as he falls down.

✗ (3) At *C*, John is momentarily at rest and then bounces up, thus his acceleration is upwards at *C*, there should be a net force acting on John at *C* to provide his acceleration at *C*.

60. C

① Gravitational potential energy gradually decreases as the skydiver falls down in air.

② Kinetic energy should remain unchanged as the skydiver falls down with no acceleration, its speed is constant.

③ Power remains unchanged by $P = Fv$, since both F and v are constant.

61. C

Loss of *KE* = Work done against friction

$\frac{1}{2}mu^2 = fs$

$\frac{1}{2}(0.5)u^2 = (3)(10)$ $\therefore u = 10.95 \approx 11.0$ m s^{-1}

62. B

By $P = Fv$ $\therefore P \propto v$ as F is constant

By $v = u + at$ $\therefore v \propto t$ as $u = 0$ and a is constant

$\therefore P \propto t$

$\therefore$ $P - t$ graph is a straight line passing through the origin.

63. C

Pulling force : $F = mg\sin\theta + f = (1500)(9.81)\sin 30° + (200) = 7557.5$ N

Energy required = work done by $F = Fs = 7557.5 \times 100 = 755750$ J ≈ 756 kJ

OR

Energy required = gain of *PE* + work done against air resistance
$= mgh + fs$
$= (1500)(9.81)(100\sin 30°) + (200)(100) = 755750$ J ≈ 756 kJ

64. B

✗ (1) By $v^2 = u^2 + 2as$, as $u = 0$ and a is constant, thus $v^2 \propto s$ or $v \propto \sqrt{s}$
At t_2, the distance travelled is h, which is two times that at t_1, thus the velocity should be $\sqrt{2}$ times of v_1.

✗ (2) By $s = ut + \frac{1}{2}at^2$, as $u = 0$ and a is constant, thus $s \propto t^2$ or $t \propto \sqrt{s}$
At t_2, the distance travelled is two time that at t_1, thus $t_2 = \sqrt{2}\,t_1$

✓ (3) As the loss of *PE* at t_2 is two times that of the loss of *PE* at t_1, the gain of *KE* is also two times.

65. B

Deceleration = slope = $\frac{16}{4.5-1.2}$ = 4.85 m s^{-2}

66. A

When the velocity is constant at the first 1.2 s, the kinetic energy is also constant.

When the velocity is decreasing after 1.2 s, the kinetic energy is also decreasing.

By consideration of energy : (Let the initial KE be KE_o)

$KE_o = KE + fs$ (where fs is the work done against the braking force f)

$\therefore KE = -fs + KE_o$ (compared with $y = mx + c$, this is a straight line with negative slope)

67. B

Work done = area under the F - s graph from 2 m to 5 m

= (5 – 2) × 8

= 24 J

68. B

The initial K.E. is 24 J, and after moving 2.4 m, it reaches the maximum height.

By conservation of energy, loss of K.E. = gain of P.E.

$\therefore KE_o = m g h = m g s \sin\theta$

$\therefore (24) = (5)(10)(2.4)\sin\theta$ $\therefore \theta = 11.5°$

< OR >

Magnitude of the slope of the graph = net force = $m g \sin\theta$

$\frac{24}{2.4} = (5)(10)\sin\theta$ $\therefore \theta = 11.5°$

69. C

K.E. = $\frac{1}{2} m v^2 = \frac{1}{2} m (a t)^2 = \frac{1}{2} m a^2 t^2$

When $t^2 = 5$ s^2, K.E. = 15000 J

$\therefore (15000) = \frac{1}{2}(1500)\, a^2\,(5)$

$\therefore a = 2$ m s^{-2}

70. A

✓ (1) Since the potential energy at R is the minimum, the kinetic energy at R is the maximum.

✓ (2) Since Q and S are at the same level, their P.E. and thus K.E. are the same, therefore, their speeds are the same.

× (3) As the ball at P possesses K.E., if this K.E. is equal to or greater than the difference of P.E. between level P and T, then the ball can reach T.

71. B

× (1) From P to Q, the acceleration is equal to g and should be constant.

✓ (2) Since the mass is decelerating from Q to R, the direction of a is upwards, thus the net force is upwards.

× (3) From P to R, the loss of P.E. should be equal to the work done against the water resistance. There is no gain of K.E. at R as the K.E. at R is zero.

72. C

The total mechanical energy (gravitational potential energy and kinetic energy) of a body is conserved in a free fall, since there is no work done on the body.

However, PE is decreasing and KE is increasing during the free fall.

73. D

× (1) They move down with the same acceleration due to gravity g.

✓ (2) By $s = \frac{1}{2} a t^2$ $\therefore t \propto \sqrt{h}$ $\therefore$ Time take for ball A is double that for B.

✓ (3) Gain of KE = Loss of PE = $m g h \propto m h$ $\therefore \frac{KE_A}{KE_B} = \frac{(1)(4h)}{(2)(h)} = 2$.

74. A

Since $KE = \frac{1}{2} m v^2$, thus, an increase in kinetic energy indicates an increase of velocity

Only car P has an increase of velocity.

75. C

Car P is undergoing acceleration, thus an unbalanced force (F_{net}) is acting on it.

Car Q is undergoing deceleration, thus an unbalanced force (F_{net}) is acting on it.

Car P is moving with uniform velocity, i.e. $a = 0$, thus no unbalanced force (F_{net}) is acting on it.

76. B

Useful work done by the motor = $F s$ = (10) (3) = 30 J

Energy wasted = Energy input – useful energy output = 54 – 30 = 24 J

77. A

Gain of potential energy of water = $m g h$ = (270) (10) (12) = 32400 J

Useful average power = $\frac{E}{t} = \frac{32400}{24\times 60\times 60}$ = 0.375 W

78. B

Work done by David = 500 × 3 = 1500 J

Work done against friction = 100 × 3 = 300 J

Gain of kinetic energy by the block = 1500 – 300 = 1200 J

79. C

As the cart is slowing down, it loses kinetic energy.

The cause of slowing down is due to friction, so work is done against friction.

Thus the main change is from kinetic energy to internal energy.

80. D

✓ (1) As the sand paper is very rough, there is friction acting on the wooden block.

✓ (2) Work done against friction must change to internal energy.

✓ (3) Gain of internal energy would cause the increase of temperature.

81. D

✓ A. acceleration is a vector

✓ B. displacement is a vector

✓ C. weight is a type of force which is a vector

× D. work is a form to transfer energy which does not have direction, work is a scalar

82. B

Area under the graph = work done on the block = gain of kinetic energy of the block

$\therefore$ area $= \frac{1}{2} m v^2$ $\quad\therefore \frac{1}{2}(10)(6) = \frac{1}{2}(0.25)v^2$ $\quad\therefore v = 15.5 \text{ m s}^{-1}$

83. B

$$P = \frac{E}{t} = \frac{mgh}{t} = \frac{(0.5)(9.81)(2.5)}{(1.5)} = 8.2 \text{ W}$$

84. A

Initial K.E. = Final K.E. + W.D. against the resistance force

$\frac{1}{2} m u^2 = \frac{1}{2} m v^2 + F s$

$\frac{1}{2}(0.050)(400)^2 = \frac{1}{2}(0.050)(250)^2 + F(0.06)$ $\quad\therefore F = 4.06 \times 10^4 \text{ N}$

85. D

Since both of them have the same potential energy at the same height H, by Conservation of energy, they have the same kinetic energy at the bottom, thus they should have the same speed at the bottom, therefore, $v_1 = v_2$

The acceleration along a smooth incline planes is $g \sin\theta$.
As the angle θ of the incline plane in Figure (a) is greater, thus its acceleration is greater.
Therefore, the time taken for the block to reach the bottom in Figure (a) is shorter. Thus, $t_1 < t_2$

OR

By $s = \frac{1}{2}(u+v)t$ As the initial speed u and final speed v are the same in both of the two figures, the displacement s in Figure (a) is smaller, thus the time is shorter. Therefore, $t_1 < t_2$

86. B

× (1) Air resistance always opposes the motion, thus air resistance R acts on the ball in upward direction.
The net force on the ball is then $mg - R$. Air resistance varies with the speed.
As the speed is increasing in downward motion, air resistance increases.
Thus, the net force acting on the object should be decreasing throughout the motion.

✓ (2) As the net force is decreasing, by Newton's second law : net force = $m a$
The magnitude of the acceleration a should be decreasing, not constant.

× (3) The loss of gravitational potential energy should be equal to
the sum of the gain of kinetic energy and the work done against air resistance.
Thus, gain of $K.E.$ $\neq$ loss of gravitational $P.E.$

87. C

Since the initial velocity is zero, thus, $v = u + a t = g t$

Kinetic energy :

$KE = \frac{1}{2} m v^2 = \frac{1}{2} m (g t)^2 \propto t^2$

$\therefore$ KE is a quadratic curve opening upwards.

As $PE + KE$ = constant

Thus, U - t graph is a quadratic curve opening downwards.

88. A

Work done = gain of gravitational potential energy
= $mg h$
= $W y$

89. B

× (1) As the block is moved in uniform velocity, there is no acceleration and forces are balanced.
In method (I), $T_1 = m g$. In method (II), $T_2 = m g \sin\theta$. Thus, the tension is not the same.

× (2) Since the speed is uniform, average power = $F v$.
As the applied force F (i.e. tension) is not the same in two cases, the average power is not the same.

✓ (3) Work done = gain of potential energy
Since the block reaches the same height in the two cases, it gains the same potential energy.
Thus the work done is the same in the two cases.

90. A

Loss of PE of Y = gain of KE of X + gain of KE of Y

$\therefore (1)(9.81)(1) = \frac{1}{2}(0.5)v^2 + \frac{1}{2}(1)v^2$

$\therefore v = 3.62 \text{ m s}^{-1}$

The following list of formulae may be found useful :

Gravitational potential energy	$E_P = mgh$
Kinetic energy	$E_K = \frac{1}{2}mv^2$
Mechanical power	$P = Fv = \frac{W}{t}$

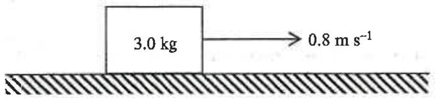
Use the following data wherever necessary :

Acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$	(close to the Earth)

Part A : HKCE examination questions

1. **< HKCE 1980 Paper I - 1 >**

A block of wood of mass 3.0 kg slides on a rough horizontal surface of uniform friction with an initial speed of 0.8 m s^{-1}. It is brought to rest after travelling a distance of 2.0 m.

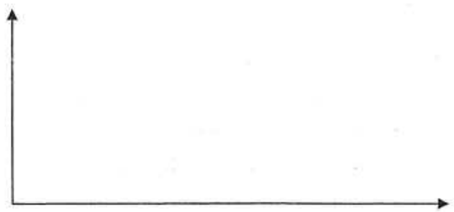


(a) Find the work done by the block in overcoming friction. (3 marks)

(b) What is the frictional force acting on the block ? (3 marks)

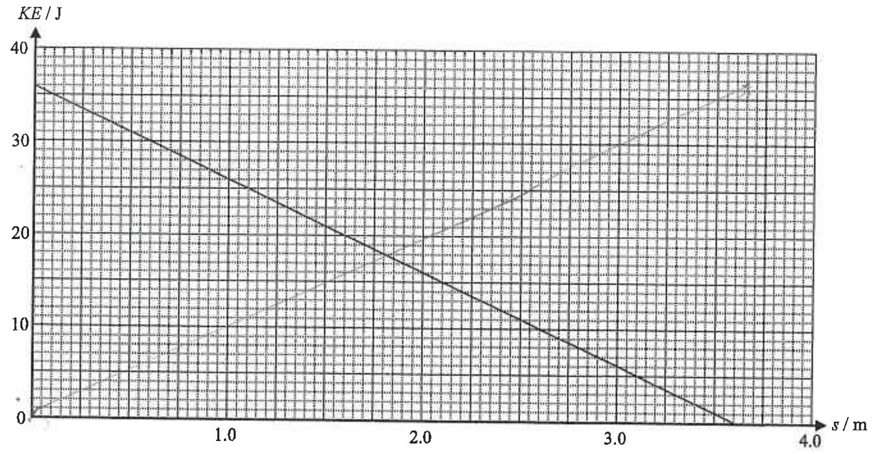
(c) Find the time taken by the block for the journey. (4 marks)

(d) In your answer book, roughly sketch a graph of the kinetic energy (E) of the block against the distance travelled (s) by the block. Write down the equation of the graph. (5 marks)



2. **< HKCE 1983 Paper I - 2 >**

A block of mass 2 kg is projected up a smooth inclined plane. After moving a certain distance up the plane it then slides back to its point of projection. The graph below shows how the kinetic energy (KE) of the block varies with the distance (s) moved during its upward motion.



(a) Read from the above graph the initial kinetic energy of the block and hence deduce its initial velocity of projection. (4 marks)

(b) What is the greatest distance moved by the block up the inclined plane ? (2 marks)

(c) (i) Find the slope of the graph and state its unit. (3 marks)

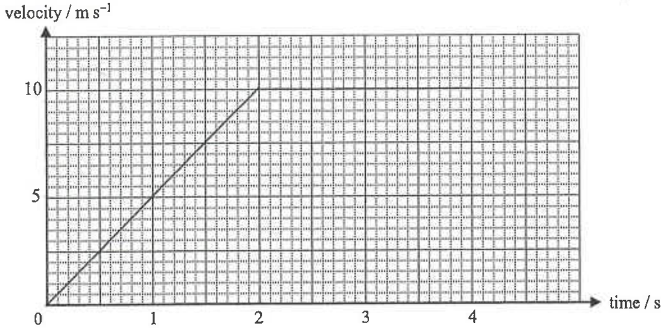
(ii) What physical quantity does the slope of the graph represent ? (1 mark)

(d) What is the deceleration of the block during its upward motion ? (2 marks)

(e) On the graph above, draw the graph of potential energy against distance up the slope. (Take the potential energy at the starting point as 0.) (3 marks)

3. **< HKCE 1984 Paper I - 3 >**

A man of mass 60 kg jumps down from a tower using a parachute. The velocity–time graph of the man for the first few seconds is as shown in the figure below. (Velocity in the downward direction is taken to be positive.)



(a) Sketch the acceleration-time graph from the figure above. (4 marks)

(b) Find the resultant force acting on the man at time

(i) t = 1 s, and

(ii) t = 4 s. (3 marks)

(c) Find the height the man falls in the first 4 seconds. (3 marks)

(d) Find

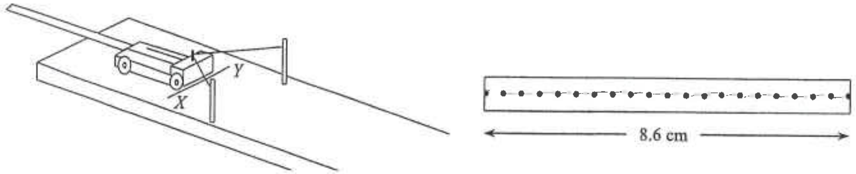
(i) the potential energy lost, and

(ii) the kinetic energy gained

by the man in the first 4 seconds.

Account for the difference in (i) and (ii), if any. (5 marks)

4. **< HKCE 1985 Paper I - 3 >**



The figure above shows an experimental set-up to study the relationship between the kinetic energy of a trolley and its speed. A catapult is set up using two upright posts and a rubber band. A trolley is drawn back to a position marked by the line XY and then released. The motion is recorded using the tape of the ticker timer which produces 50 dots per second.

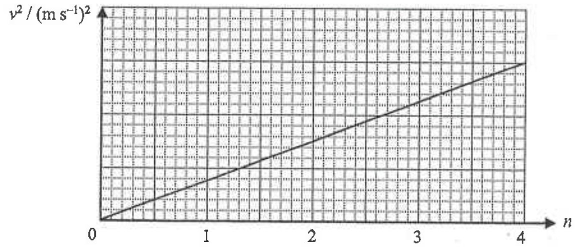
(a) A strip as shown above is selected.

(i) What is the time interval represented by the strip ? (2 marks)

(ii) What is the velocity of the trolley producing this strip ? (2 marks)

(iii) In this experiment, what kind of energy is converted to the kinetic energy of the trolley ? (2 marks)

(b) The experiment is repeated with two, three and four identical rubber bands used in parallel and the graph of velocity squared (v^2) against the number of rubber bands (n) used is shown in the figure shown.



(i) How does v^2 vary with n ? (1 mark)

(ii) State the conclusion about the relationship between the kinetic energy of the trolley and its speed. (2 marks)

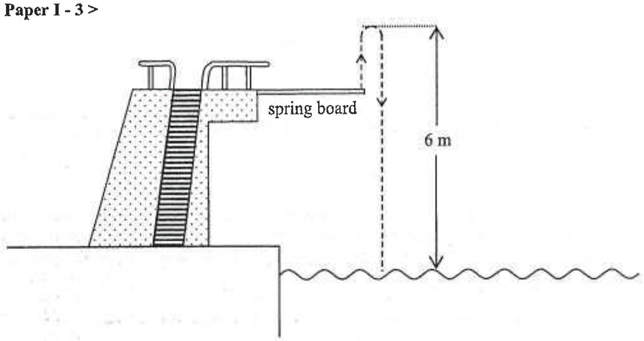
(c) What precaution(s) should be taken in order to

(i) compensate for friction in the motion, and

(ii) ensure that the rubber bands used are identical ? (4 marks)

(d) The strip should not be selected from the first portion of the tape when the trolley began its motion. Explain briefly. (2 marks)

5. < HKCE 1986 Paper I - 3 >



A diver of mass 50 kg climbs up a flight of 30 steps to reach a spring board by the side of a swimming pool as shown above. Each step is of height 0.15 m.

(a) (i) Find the potential energy gained by the diver after he has climbed the flight of steps. (2 marks)

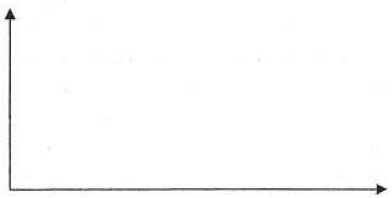
(ii) If the driver takes 10 s to climb up the flight of steps, what is his average power ? (3 marks)

(iii) Which type of energy stored inside the body of the diver is transformed in climbing the steps ? (1 mark)

(iv) Is the energy in (iii) greater than, equal to or smaller than the potential energy gained by the diver ? Explain briefly. (2 marks)

(b) The diver jumps up into the air, reaches a height of 6 m above the water surface and then falls down again.

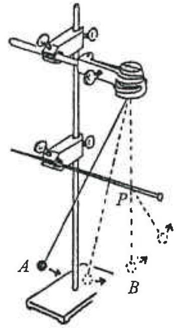
(i) Sketch a graph of the kinetic energy possessed by the diver against time, starting from the moment he leaves the spring board till the moment he reaches the water surface. (3 marks)



(ii) If the average resisting force due to water on the diver is 1500 N upwards, what is the maximum depth he can reach in the water ? (4 marks)

6. < HKCE 1987 Paper I - 2 >

A bob of mass 0.1 kg is suspended by a light inextensible string as shown in the figure below. The bob is released from rest at *A*, which is 0.2 m higher than *B*, the lowest point of suspension.



(a) (i) Find the potential energy loss of the bob when it swings from *A* to *B*. (2 marks)

(ii) Find the speed of the bob at *B*. (2 marks)

(iii) Is there any work done by the tension of the string when the bob moves from *A* to *B* ? Explain briefly. (3 marks)

(b) The swing is interrupted by a pin *P* when the bob reaches *B*. The highest point then reached by the bob on the other side is *C* (not shown in the diagram).

(i) What is the height of *C* above *B* ? (2 marks)

(ii) If the string breaks when the bob is at *C*, sketch a diagram to show the path of the subsequent motion of the bob. In your diagram, indicate the position of *C*. (2 marks)

7. < HKCE 1988 Paper I - 1 >

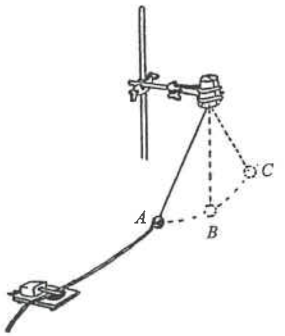


Figure 1

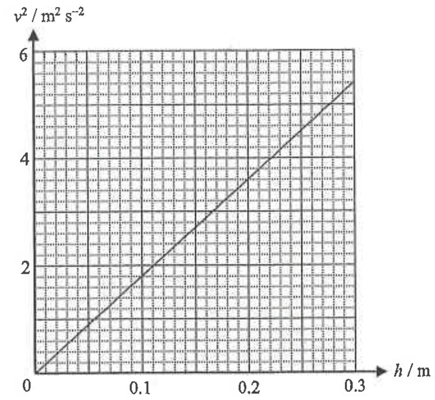


Figure 2

Figure 1 above shows an experimental set-up to study the motion of a bob hanging on an inelastic string. The bob is pulled aside to A which is h above the lowest point B. The bob is then released to swing to C through B and the motion is recorded through the ticker-tape of a ticker-tape timer with known frequency. The experiment is repeated with different values of h.

(a) Draw a rough diagram to show one of the ticker-tape obtained from the experiment. (3 marks)

(b) Describe briefly how the speed v of the bob at B can be obtained from this experiment. (3 marks)

(c) The variation of v^2 with h is as shown in Figure 2 above.

(i) Find the slope of the graph. (2 marks)

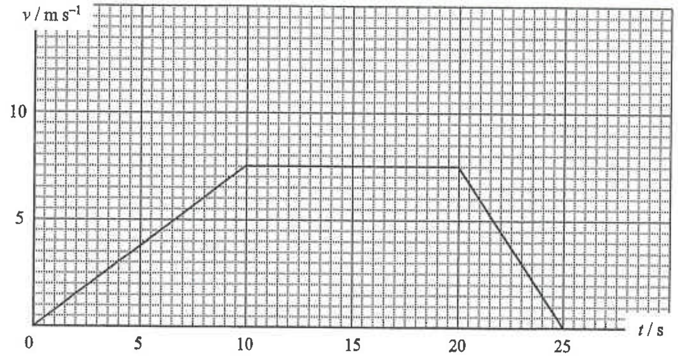
(ii) Write down the equation relating v^2 and h from the graph. (1 mark)

(iii) Find the acceleration due to gravity from this experiment. Explain briefly why it is different from the commonly-used value of 9.81 m s^{-2}. (4 marks)

(iv) State ONE precaution that should be taken so as to get a more accurate result of g. (2 marks)

8. < HKCE 1989 Paper I - 2 >

A lifting system consists of a lift pulled by a motor through a cable.



(a) The figure above shows the velocity-time graph of the lift moving upwards. The total mass of the passengers is 200 kg.

(i) What is the total distance travelled by the lift ? (2 marks)

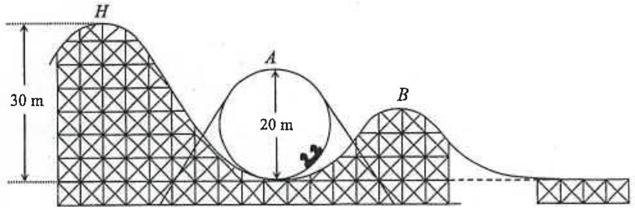
(ii) What is the average power output by the system ? (3 marks)

(b) As a safety measure, when the downward speed of the lift reaches 10 m s^{-1}, a braking device would stop the lift in 6 m. If the total mass of the lift and its passengers is 1000 kg, what should be the average value of the braking force ? (5 marks)

(c) Suggest another safety measure other than that in (b) ? (2 marks)

9. **< HKCE 1990 Paper I - 2 >**

The figure below shows part of the route of a roller-coaster in an amusement park. A cart full of passengers with total mass 1200 kg runs down from rest at the starting point *H* to the terminal platform. *H* is 30 m above the terminal platform. The track provides an average frictional force of 300 N throughout the journey.



(a) The cart travels a distance of 150 m to reach the highest point *A* of the vertical loop, which is 20 m above the platform.

(i) In moving from *H* to *A*, calculate (5 marks)

(1) the loss in potential energy,

(2) the work done against friction, and

(3) the gain in kinetic energy of the cart.

(ii) Find the speed of the cart at *A*. (2 marks)

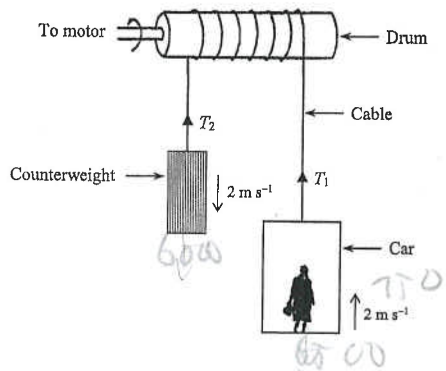
(b) The cart reaches the terminal platform at a speed of 10 m s^{-1}. A braking device at the platform stops the car in 2 seconds. Find the average force on the cart exerted by the device. (3 marks)

(c) Suggest one safety device for passengers riding on the roller-coaster. Explain briefly its function. (2 marks)

(d) In the design of the roller-coaster do you think the summit *B* can be higher than point *A* ? Explain briefly. (3 marks)

10. **< HKCE 1991 Paper I - 2 >**

The diagram shows a simplified lift system. The lift consists of a car connected to a counterweight over a drum. The weights of the car and the counterweight are 6500 N and 6000 N respectively. A motor connected to the drum is used to drive the car up with a uniform speed of 2 m s^{-1}. A passenger of weight 750 N is inside the car.



(a) (i) Find the tension T_1 in the part of the cable connected to the car. (1 mark)

(ii) Find the tension T_2 in the part of the cable connected to the counterweight. (1 mark)

(iii) Explain why the two tensions are different. (1 mark)

(b) Calculate the power output by the motor to raise the car. (2 marks)

(c) What is the function of the counterweight ? (1 mark)

(d) Explain why a frictionless drum cannot be used. (2 marks)

11. **< HKCE 1992 Paper I - 2 >**

(a)

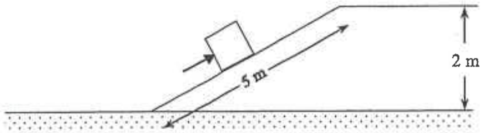


Figure 1

Figure 1 shows an inclined plane of length 5 m. A block of weight 800 N is pushed up the plane slowly from the ground to a height of 2 m by a force parallel to the inclined plane. The frictional force between the block and the inclined plane is 80 N.

(i) Find the potential energy gained by the block. (2 marks)

(ii) Find the work done against friction. (2 marks)

(iii) Find the total energy supplied by the force, assuming no energy loss other than that in (ii). (2 marks)

(b)

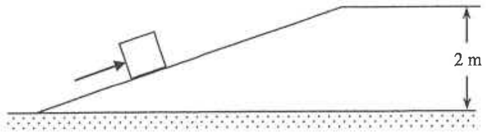


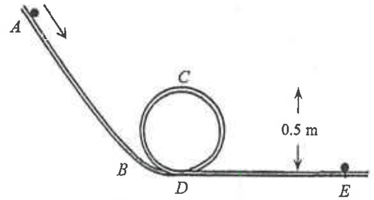
Figure 2

The process in (a) is repeated by using a longer inclined plane as shown in Figure 2 above. Assume that the frictional force between the block and the inclined plane remains unchanged.

A student says that the force required to push the block in (b) is smaller than that in (a).

State whether he is right or wrong and explain briefly. (3 marks)

12. **< HKCE 1995 Paper I - 1 >**



The figure above shows a rough track. The highest point C of the circular loop is 0.5 m above its lowest point D and DE is horizontal. A small object of mass 0.1 kg slides down from rest at A, completes the circular loop and finally stops at E. The speed of the object at C is 3 m s^{-1}. When it comes down to D after completing the loop, its speed becomes 4 m s^{-1}.

(a) Describe the energy changes when the object travels from A to C. (3 marks)

(b) Find

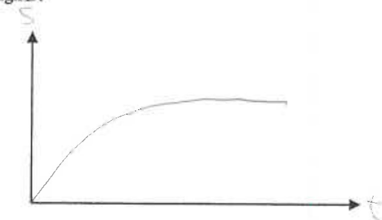
(i) the kinetic energy of the object at C, (1 mark)

(ii) the potential energy of the object at C (taking the potential energy at D as zero), (1 mark)

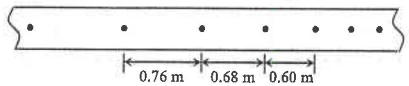
(iii) the work done against friction as the object travels from C to D. (3 marks)

(c) The object travels with uniform deceleration along DE.

(i) Sketch the displacement-time graph of the object as it travels from D to E, starting from the moment it passes through D. (2 marks)

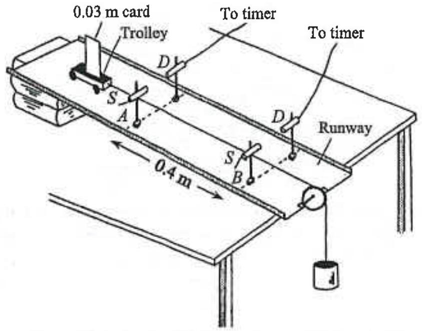


(ii)



The figure above shows a strobe photograph of the object as it travels along DE. The stroboscopic lamp is flashing at a frequency of 5 Hz. Find the deceleration of the object. (4 marks)

13. **< HKCE 1997 Paper I - 3 >**



The Figure above shows a trolley running down a friction compensated runway. The trolley is connected to a hanging weight by means of a light inelastic string. A card of width 0.03 m is attached to the trolley. Light sources S and light detectors D are fixed at two positions A and B along the runway. Each light detector is connected to a timer, which can measure the time taken by the card to pass the light detector.

(a) The timers record that it takes 0.050 s and 0.025 s for the 0.03 m card to pass the light detectors at A and B respectively.

(i) Calculate the average speed of the trolley as it passes

(1) position A, and

(2) position B. (3 marks)

(ii) If the mass of the trolley is 1.5 kg and the distance between A and B is 0.4 m, calculate

(1) the acceleration of the trolley,

(2) the tension in the string, and

(3) the gain in kinetic energy of the trolley as it travels from A to B. Where does this gain in kinetic energy come from ? (7 marks)

(b) Describe how you can use a data-logger to check whether the runway is friction compensated. (3 marks)

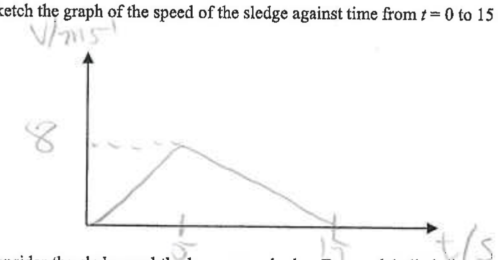
(c) If the string suddenly breaks, describe the subsequent motion of the trolley along the runway. (1 mark)

14. **< HKCE 1998 Paper I - 1 >**

Figure 1

Figure 1 shows the layout of a runway ABC in an amusement park. AB is an icy smooth inclined plane and BC is a rough horizontal surface. At time $t = 0$, a boy sitting on a sledge slides down from rest at A along the runway. At $t = 5$ s, the sledge reaches B with a speed of 8 m s^{-1}. The sledge then decelerates uniformly along BC and finally stops at point D at $t = 15$ s.

(a) Sketch the graph of the speed of the sledge against time from $t = 0$ to 15 s. (3 marks)



(b) Consider the sledge and the boy as one body. Draw a labelled diagram to show all the forces acting on the body as it slides along AB. (2 marks)

(c) Given : Total mass of the sledge and the boy = 60 kg. Find (6 marks)

(i) the acceleration of the sledge as it slides along AB ;

(ii) the stopping distance BD ;

(iii) the frictional force acting on the sledge as the sledge travels along BC.

(d)

Figure 2

Suppose the angle of inclination of the smooth plane is increased. (See Figure 2.) Then the boy sitting on the sledge slides down from rest at point P on this runway, where P is at the same height as point A in the original runway. Would there be any change in the stopping distance along BC when compared with (c)(ii) ? Explain your answer. (3 marks)

15. < HKCE 2004 Paper I - 7 >

Figure 1

In a road test, John drives his car along a straight horizontal road (see Figure 1). The car takes 9.3 s to accelerate from rest to 100 km h^{-1}. The total mass of John and his car is 1400 kg.

(a) Show that a speed of 100 km h^{-1} is approximately equal to 27.8 m s^{-1}. (1 mark)

(b) Find the total kinetic energy of John and his car when travelling at 100 km h^{-1}.

Hence estimate the average output power of the car when it is accelerating to 100 km h^{-1}. (3 marks)

(c)

Figure 2

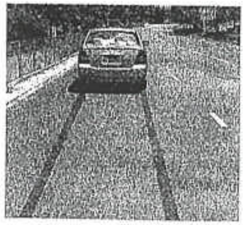
A similar road test is conducted on an inclined road. The car now takes 16.2 s to accelerate from rest to 100 km h^{-1} along the road (see Figure 2). Assume the output power of the car remains unchanged.

(i) Explain why it takes a longer time for the car to accelerate up an inclined road than along a horizontal road. (2 marks)

(ii) Find the increase in height of the car after accelerating for 16.2 s along the inclined road. (3 marks)

15. (d)

Figure 3



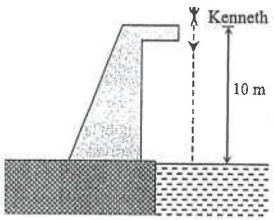
On a certain day, the car was involved in a traffic accident. John braked hard to stop the car and skid marks were left on a horizontal road (see Figure 3). Investigation by the police revealed the following information:

length of the skid marks = 30.5 m
average frictional force between the tyres of the car and the road surface = 11 200 N

(i) Describe the energy change involved when the car was braking. (2 marks)

(ii) John claimed that he was driving at a speed below 70 km h^{-1} before the accident. Explain whether John was telling the truth or not. (4 marks)

16. < HKCE 2005 Paper I - 2 >



Kenneth, of mass 60 kg, falls vertically from rest from a 10 m platform into a swimming pool (see the above Figure). In the following calculations, you may neglect the size of Kenneth.

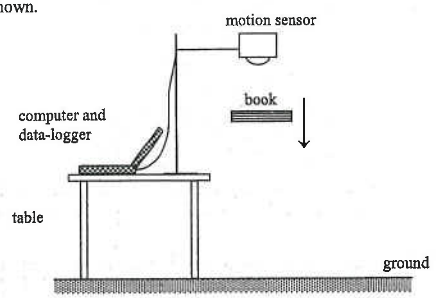
(a) Find the potential energy of Kenneth when he stands on the platform, taking potential energy at the water surface as zero. (1 mark)

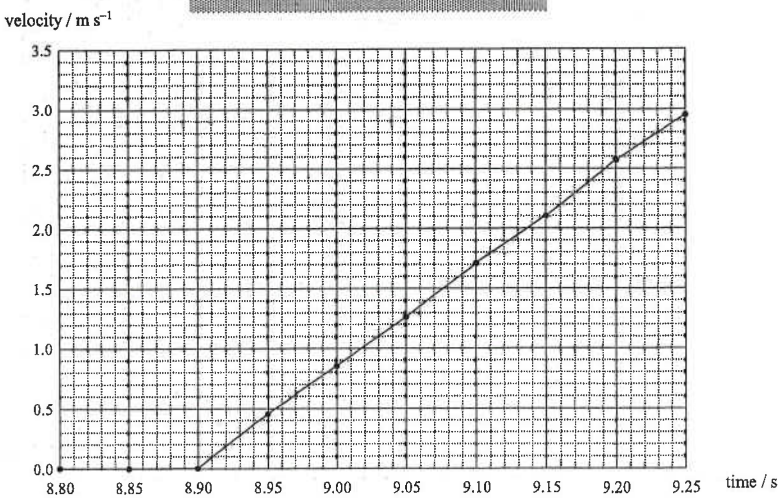
(b) Find the speed of Kenneth at the instant he reaches the water surface. (2 marks)

(c) If Kenneth reaches a maximum depth of 3 m in the water, estimate the average resistive force exerted by the water on Kenneth. (3 marks)

17. **< HKCE 2006 Paper I - 3 >**

A student releases a book of mass 0.154 kg from rest under a motion sensor as shown in the Figure below. The velocity-time graph is also recorded as shown.





(a) From the graph shown above, estimate the distance travelled by the book. (2 marks)

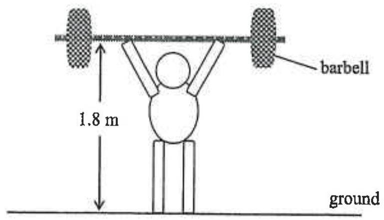
(b) Find the loss in potential energy of the book during the journey in (a). (1 mark)

(c) From the above graph, find the maximum kinetic energy of the book. (2 marks)

(d) Account for the difference in the values obtained in (b) and (c). (1 mark)

18. **< HKCE 2008 Paper I - 1 >**

The figure below shows an athlete lifting a barbell of mass 115 kg by a vertical distance of 1.8 m from the ground.



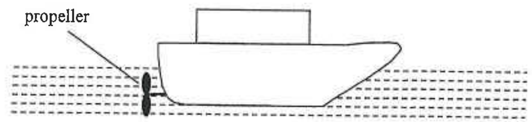
(a) Find the potential energy gained by the barbell after it is lifted up. (1 mark)

(b) The mass of the athlete is 70 kg. Find the normal reaction acting by the ground on the athlete when she has lifted the barbell and stands still. (2 marks)

(c) After finishing the lifting, the athlete releases the barbell. It falls from rest to the ground freely. Find the time required for the barbell to reach the ground. (2 marks)

19. **< HKCE 2008 Paper I - 2 >**

An electric toy boat of mass 1.2 kg shown in the figure below is moving horizontally in still water with a constant velocity of 1.5 m s^{-1}. The water resistance on the boat is 0.45 N.



(a) (i) Find the magnitude of the propelling force acting on the boat. (1 mark)

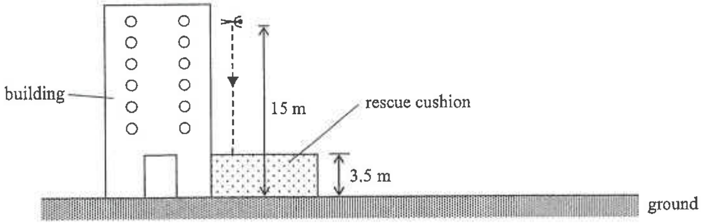
(ii) Find the power developed by this force. (2 marks)

(b) (i) Find the kinetic energy of the boat. (1 mark)

(ii) Using the result in (b)(i), find the distance travelled by the boat before it comes to rest after the propeller is turned off. Assume the water resistance on the boat remains constant throughout the motion. (2 marks)

20. < HKCE 2009 Paper I - 2 >

A fire breaks out in a building. A 60 kg man in the building falls vertically from rest from a height of 15 m. He is rescued by a cushion of thickness 3.5 m (see the Figure below). Neglect the size of the man.



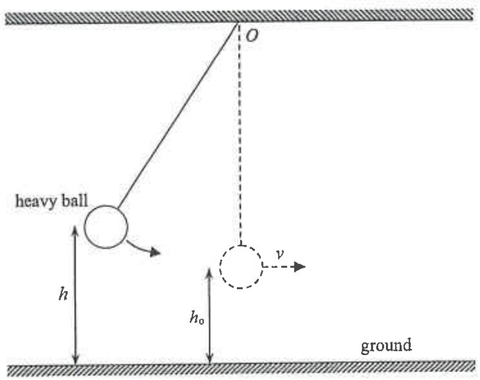
(a) Find the kinetic energy of the man just before reaching the cushion. (2 marks)

(b) The man is stopped by the cushion when he is 0.5 m above the ground. Find the average resistive force acting on the man by the cushion. (3 marks)

(c) If a thicker cushion is used and the man is again stopped when he is 0.5 m above the ground, explain why the thick cushion is better for rescuing the man. (3 marks)

21. < HKCE 2010 Paper I - 2 >

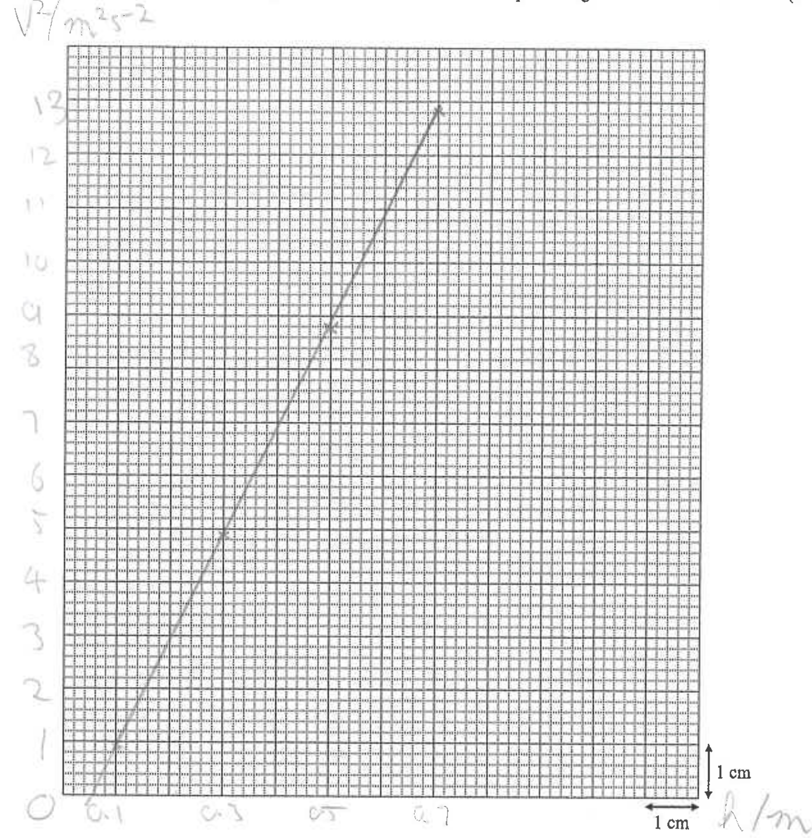
The Figure below shows an experimental setup. The setup is used to find the gravitational acceleration.



Height (h / m)	Speed (v / m s^{-1})
0.1	0.949
0.3	2.214
0.5	2.966
0.7	3.578

A heavy ball is hung from a fixed point O by a long inextensible light string. It is released from rest at a height h above the ground. The speed v of the ball is measured when it passes the lowest position, which is at a height h_o above the ground. The experiment is repeated with different values of h and the results obtained are shown in the Table above.

21. (a) Plot a graph of v^2 against h in the Figure below. Use a scale of 1 cm representing 1 m^2 s^{-2} and 0.1 m. (4 marks)



(b) (i) By the law of conservation of energy, show that

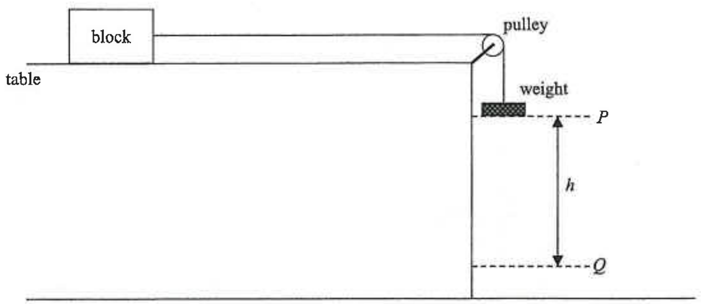
$$v^2 = 2g(h - h_o)$$ (1 mark)

(ii) From the slope of the graph plotted in (a), find the value of gravitational acceleration. (2 marks)

(c) Give **one** reason why the ball used should be heavy. (1 mark)

22. < HKCE 2011 Paper I - 11 >

The Figure below shows an experimental setup, which is used to find the friction between a block and a table. A weight is connected to the block through a frictionless pulley with a light inextensible string. The masses of the weight and the block are 0.02 kg and 1 kg respectively. The weight and the block are initially at rest.



The weight is released at P and falls with uniform acceleration. The time taken for the weight to fall a certain distance h (from P to Q) is measured. When $h = 0.7$ m, the time taken is 2.95 s. Neglect air resistance.

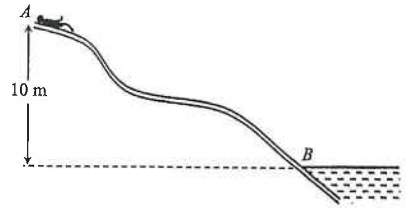
(a) Determine the acceleration of the weight. (2 marks)

(b) Find the speed of the weight at Q. (2 marks)

(c) By the law of conservation of energy, or otherwise, find the friction acting on the block. (4 marks)

Part B : Supplemental exercise

23.



The above figure shows a water chute in a swimming pool. A boy of mass 50 kg slides down from rest at point A and reaches point B with a speed 12 m s^{-1}, where A is 10 m above B.

(a) Find

(i) the potential energy of the boy at A (taking the potential energy at B as zero),

(ii) the kinetic energy of the boy at B. (2 marks)

(b) Describe the energy changes as the boy slides from A to B. (2 marks)

24. (a) A lift raises a passenger of mass 75 kg at a uniform speed of 2 m s^{-1}. Calculate the useful power output of the lift given to the passenger. (2 marks)

(b) What is the force acting on the passenger of mass 75 kg by the floor of a lift when it is rising with

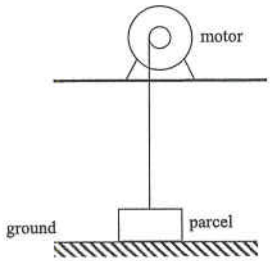
(i) an acceleration of 0.25 m s^{-2} ; and

(ii) a uniform speed of 1 m s^{-1} ? (4 marks)

Part C : HKDSE examination questions

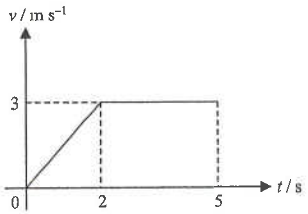
25. **< HKDSE Practice Paper IB - 2 >**

Figure (a)



A parcel of mass 4 kg is being raised from the ground by a light string connected to a motor at the rooftop of a building as shown in Figure (a). The speed-time graph of the parcel for the first 5 s is shown in Figure (b). Neglect air resistance.

Figure (b)



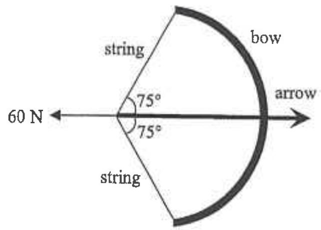
(a) Find the tension in the string at time $t = 1$ s. (3 marks)

(b) Calculate the output power of the motor between $t = 2$ s and 5 s. (2 marks)

(c) At $t = 5$ s, the string suddenly breaks. Describe the subsequent motion of the parcel. (2 marks)

26. **< HKDSE 2012 Paper IB - 5 >**

A bow and arrow is a kind of projectile weapon. The string of a bow is drawn taut by a hunter with a force of 60 N and an arrow of mass 0.2 kg is held stationary as shown in the Figure below.

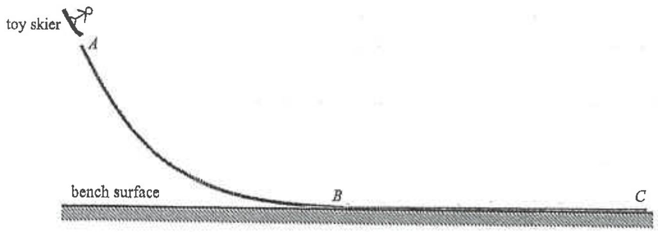


(a) Find the tension of the string. Neglect the weight of the arrow. (2 marks)

(b) Estimate the energy stored in the taut string if the initial speed of the arrow is 45 m s^{-1} when released. Assume that the bow is rigid and neglect the mass of the string. (2 marks)

27. **< HKDSE 2013 Paper IB - 5 >**

The Figure below shows a smooth sloping track *ABC* firmly fixed in a vertical plane with its horizontal part *BC* resting on a bench surface. You are given a toy skier, a metre rule and a long rough paper strip with adhesive tape on the bottom surface.



Using the apparatus provided, describe an experiment to study how the stopping distance of the toy skier depends on its height of release. Your description should include the physical quantities to be measured and the result expected. (5 marks)

28. **< HKDSE 2013 Paper IB - 3 >**

A lift car of weight 8000 N is going up with constant speed 2 m s^{-1} as shown in Figure (a). The upward force raising the lift car is provided by the cable wound on a drum which is driven by a motor. The other end of the cable is firmly attached to the drum at P. Neglect air resistance and the mass of the cable.

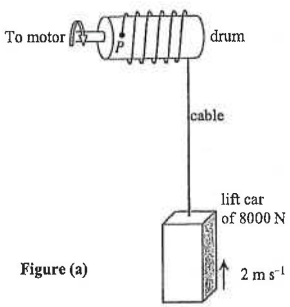


Figure (a)

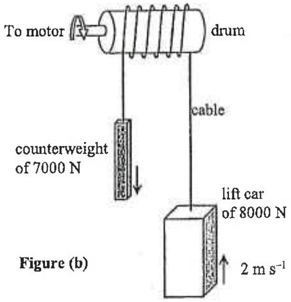


Figure (b)

(a) (i) Calculate the mechanical power delivered to the rising lift car by the motor. (2 marks)

(ii) The total mechanical power output of the motor is 20 kW. How much power is lost due to overcoming friction between the movable parts ? (1 mark)

(b) Now a 7000 N counterweight is installed at the other end of the cable as shown in Figure (b). The counterweight always moves in the opposite direction to the lift car which again moves up at 2 m s^{-1}. Assume that there is no slipping between the cables and the drum.

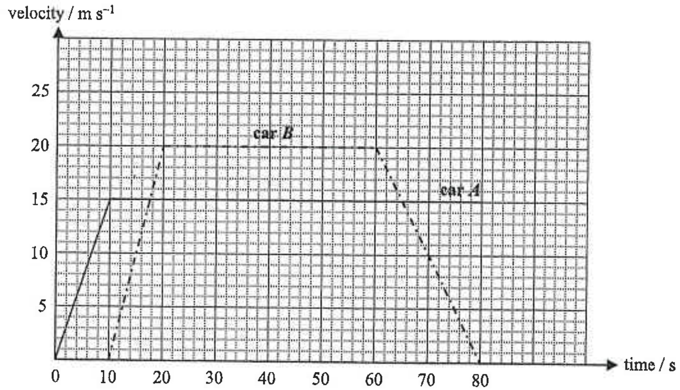
(i) Calculate the total mechanical power output of the motor required in this case, assuming the same power loss in overcoming friction between movable parts as found in (a). (2 marks)

(ii) State the advantage of having the counterweight installed. (1 mark)

(iii) A claim is made that as power is lost due to friction, a drum with frictionless surface can further reduce the power required from the motor. Comment on this claim. (2 marks)

29. **< HKDSE 2014 Paper IB - 3 >**

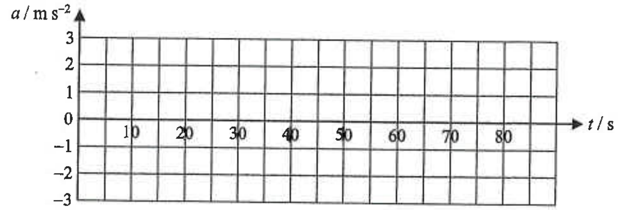
Two cars A and B initially at the same position, start to travel along the same straight horizontal road. The graph below shows how their velocities vary with time.



(a) Describe the motion of car A along the whole journey from $t = 0$ to $t = 80$ s. (2 marks)

(b) (i) Which car attained the greatest acceleration throughout the journey ? Find this acceleration. (2 marks)

(ii) Sketch the acceleration-time (a - t) graph of car B from $t = 0$ to $t = 80$ s. (2 marks)



(c) (i) At $t = 20$ s, what is the separation between cars A and B ? (2 marks)

(ii) Deduce the time at which car B catches up with car A. (2 marks)

(d) Both cars are of similar size and shape. It is known that the total resistive force experienced by each car is proportional to the square of its velocity. Determine the ratio of power output of the engine of car A to that of car B within the period $t = 20$ s to $t = 60$ s. (2 marks)

30. < HKDSE 2020 Paper 1B -4>

A small sphere is released from rest at point A and runs along a smooth track ABC as shown in Figure 4.1. The track around the lowest point B is approximately circular in shape.

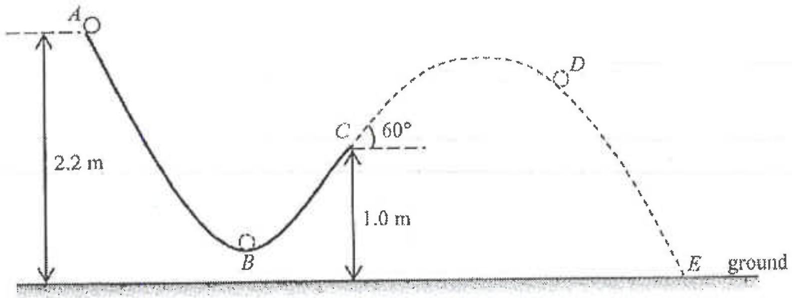


Figure 4.1

The sphere leaves the track at point C where the track makes an angle of 60° with the horizontal. It finally reaches point E on the ground. Neglect air resistance. ($g = 9.81\ \text{m s}^{-2}$)

(a) Arrange the speeds of the sphere at points A, B, C and D respectively in descending order. (1 mark)

....

....

*(b) On Figure 4.1, use arrows to indicate the acceleration of the sphere, if any, at point B and at point D respectively. (2 marks)

(c) (i) Describe the energy conversion of the sphere when it goes along the track ABC. (2 marks)

(ii) Hence find the speed of the sphere at point C.

*(iii) If the horizontal distance between points C and E is 2.55 m, calculate the time of flight of the sphere before reaching point E. (3 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) $W_f = \frac{1}{2} m u^2$ [1]

$= \frac{1}{2} \times (3) \times (0.8)^2$ [1]

$= 0.96$ J [1]

(b) $W_f = f s$ [1]

$(0.96) = f \times (2)$ [1]

$\therefore f = 0.48$ N [1]

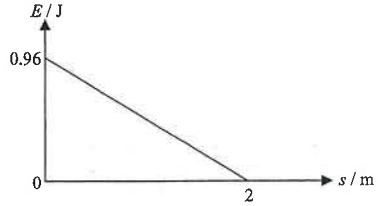
(c) By $f = m a$ $\therefore (-0.48) = (3)\, a$ **OR** $\therefore (0.48) = (3)\, a$ [1]

$\therefore a = -0.16$ m s^{-2} $\therefore a = 0.16$ m s^{-2} [1]

By $v = u + a t$ $\therefore (0) = (0.8) + (-0.16)\, t$ [1]

$\therefore t = 5$ s [1]

(d)



[3]

Equation : $KE = 0.96 - 0.48\, s$ [2]

2. (a) Initial kinetic energy = 36 J [1]

$KE = \frac{1}{2} m v^2$ [1]

$(36) = \frac{1}{2} (2)\, v^2$ [1]

$\therefore v = 6$ m s^{-1} [1]

(b) Greatest distance = 3.6 m [2]

(c) (i) slope $= -\frac{36}{3.6} = -10$ [2]

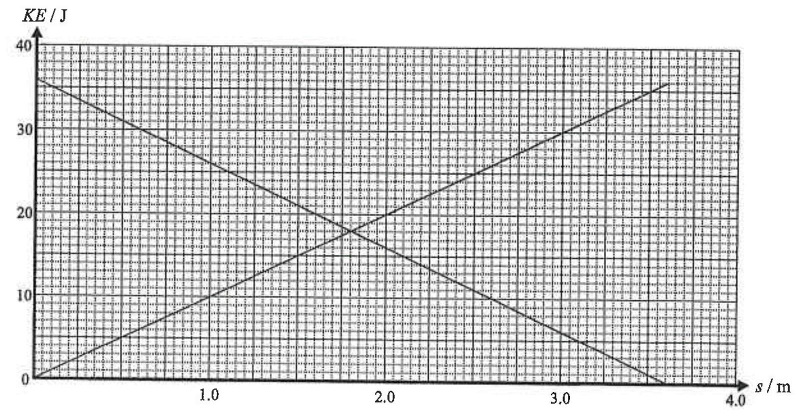
unit of slope = J m^{-1} (or N) [1]

(ii) Resultant force acting on the block < accept $m g \sin\theta$ > [1]

(d) deceleration $= \frac{10}{2}$ [1]

$= 5$ m s^{-2} [1]

2. (e)



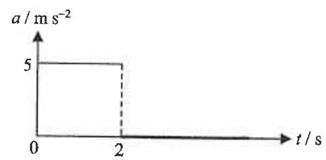
[3]

< straight line drawn > [1]

< start from the origin > [1]

< $PE = 36$ J at $s = 3.6$ m > [1]

3. (a)



< Correct shape > [2]

< At time = 2 s, a drops to 0 > [1]

< Initially, $a = 5$ m s^{-2} > [1]

(b) (i) At $t = 1$ s, $a = 5$ m s^{-2} [1]

$F = m a = (60) \times (5) = 300$ N [1]

(ii) At $t = 4$ s, $a = 0$ $\therefore F = 0$ N [1]

(c) h = area of the graph [1]

$= \frac{1}{2} (10) \times (2) + (10) \times (2)$ [1]

$= 30$ m [1]

(d) (i) PE lost $= m g h$

$= (60) \times (9.81) \times (30)$ [1]

$= 17658$ J ≈ 17700 J [1]

(ii) KE gained $= \frac{1}{2} m v^2$

$= \frac{1}{2} \times (60) \times (10)^2$ [1]

$= 3000$ J [1]

Some energy is lost due to work done against air resistance [1]

4. (a) (i) Time $= 20 \times \frac{1}{50} = 0.4$ s [2]

(ii) $v = \frac{8.6}{0.4} = 21.5$ cm s^{-1} [2]

(iii) Elastic potential energy stored in the rubber band [2]

(b) (i) $v^2 \propto n$ [1]

(ii) $KE \propto v^2$ [2]

(c) (i) Set up a friction compensated runway by inclining the runway at an angle [1]
so that the trolley when given a slight push will move down with uniform velocity [1]

(ii) The rubber bands should have same length and same thickness [2]

(d) The energy stored in the rubber band is not completely transferred to the trolley in the initial strip. [2]

OR

There is acceleration in the initial strip, thus the velocity has not reached the final value. [2]

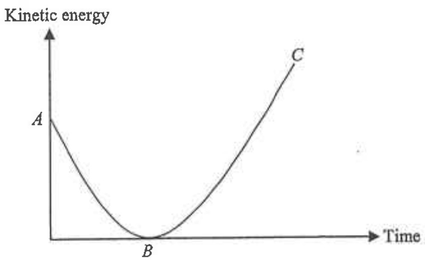
5. (a) (i) Gain in PE $= mgh = (50) \times (9.81) \times (30 \times 0.15)$ [1]
$= 2210$ J [1]

(ii) Power $= \frac{E}{t}$ [1]
$= \frac{2210}{10}$ [1]
$= 221$ W [1]

(iii) Chemical energy (**OR** food energy) stored in the diver [1]

(iv) It is greater than the potential energy gained because other forms of energy, [1]
such as internal energy and kinetic energy are produced. [1]

(b) (i)



< Curve > [1]
< B touches the time axis > [1]
< C higher than A > [1]

(ii) By $mgh = Fs$ [1]
$\therefore$ $(50) \times (9.81) \times (6 + d) = (1500)\,d$ [2]
$\therefore$ $d = 2.92$ m < accept 2.90 m to 3.00 m > [1]

6. (a) (i) PE loss $= mgh$
$= (0.1) \times (9.81) \times (0.2)$ [1]
$= 0.1962$ J < accept 0.196 J > [1]

(ii) $mgh = \frac{1}{2}mv^2$ [1]
$(0.1962) = \frac{1}{2}(0.1) \times v^2$
$\therefore$ $v = 1.98$ m s^{-1} [1]

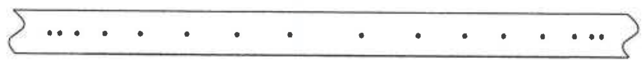
(iii) No work is done [1]
Since the force is always perpendicular to the motion (velocity) [2]

(b) (i) 0.2 m [2]

(ii)

< C marked correctly at the top > [1]
< a vertical line with arrow drawn > [1]

7. (a)



[3]

(b) Find the time interval t for two dots [1]
Choose two dots having the greatest separation and measure the distance d between them. [1]
Calculate the speed by $v = d / t$ [1]

(c) (i) Slope $= \frac{5.4}{0.3}$ [1]
$= 18$ m s^{-2} < 17.5 to 18.3 is acceptable > [1]

(ii) $v^2 = 18\,h$ [1]

(iii) $mgh = \frac{1}{2}mv^2$ [1]
$\therefore$ $v^2 = 2gh$
$\therefore$ Slope of the graph $= 2g = 18$ [1]
$\therefore$ $g = \frac{18}{2} = 9$ m s^{-2} [1]
The smaller g is due to work done against friction (**OR** work done against air resistance). [1]

(iv) Use a heavier pendulum bob so that air resistance is negligible. [2]

8. (a) (i) Total distance = area under the graph

$= \frac{(20-10)+25}{2} \times 7.5$ [1]

$= 131.25$ m [1]

(ii) Average power output $= \frac{W}{t}$ [1]

$= \frac{200 \times 9.81 \times 131.25}{25}$ [1]

$= 10.3$ kW [1]

(b) Loss in K.E. + Loss in P.E. = Work done against braking force [1]

$\frac{1}{2} \times (1000) \times (10)^2 + (1000) \times (9.81) \times (6) = F \times (6)$ [3]

$\therefore F = 18100$ N [1]

(c) Suggested measures : **(ANY ONE)** [2]

* Attach a strong spring on the ground under the lift
* Use thicker cable (**OR** Use more number of cables)

9. (a) (i) (1) Loss in PE $= m g h = (1200) \times (9.81) \times (10) = 117720 \approx 118000$ J [2]

(2) Work done against friction $= F s = (300) \times (150) = 45000$ J [2]

(3) Gain in K.E. $= 117720 - 45000 = 72720 \approx 72700$ J < accept 73000 J > [1]

(ii) $KE = \frac{1}{2} m v^2$ [1]

$(72720) = \frac{1}{2} \times (1200) \times v^2$

$\therefore v = 11.0 \text{ m s}^{-1}$ [1]

(b) $v = u + a t$

$\therefore (0) = (10) + a (2)$ $\therefore a = -5 \text{ m s}^{-2}$ [1]

$F + f = m a$

$\therefore F + (300) = (1200) \times (5)$ [OR $F + (-300) = (1200) \times (-5)$] [1]

$\therefore F = 5700$ N < **OR** $F = -5700$ N > [1]

(c) Use a **safety belt.** (**OR** seat-belt) [1]

To prevent the passengers from throwing out of the cart. [1]

(**OR** To increase the duration time of impact and thus reduce the impact force)

(d) Yes, [1]

the cart can move up a summit higher than A,

provided the height of the summit is lower than that of H. [2]

10. (a) (i) $T_1 = 6500 + 750 = 7250$ N [1]

(ii) $T_2 = 6000$ N [1]

(iii) There is **friction** between the drum and the cable. [1]

(b) Useful power output $= F v$

$= (7250 - 6000) \times (2)$ [1]

$= 2500$ W [1]

(c) To reduce the force exerted by the motor. **OR** To reduce the power output from the motor. [1]

(d) The lift cannot work (**OR** The car cannot be raised) [1]

as slipping between the cable and the drum occurs. (**OR** the drum cannot exert a force on the cable.) [1]

11. (a) (i) P.E. gained $= m g h$ [1]

$= (800) \times (2)$

$= 1600$ J [1]

(ii) Work done against friction $= F s$ [1]

$= (80) \times (5) = 400$ J [1]

(iii) Total energy supplied $= 1600 + 400$ [1]

$= 2000$ J [1]

(b) He is right. [1]

The component of the weight, $m g \sin \theta$ in (b) is smaller. [2]

12. (a) When the object travels from A to B, some of its potential energy is changed to kinetic energy and [1]
some is used to do work against friction (**OR** some is changed to internal energy). [1]
When the object travels from B to C, some of its kinetic energy is changed to potential energy [1]
and some is also used to do work against friction.

(b) (i) KE $= \frac{1}{2} m v^2 = \frac{1}{2} (0.1) \times (3)^2$

$= 0.45$ J [1]

(ii) PE $= (0.1) \times (9.81) \times (0.5)$

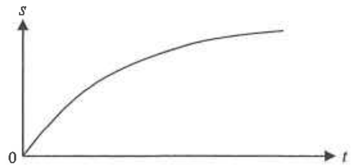
$= 0.4905$ J < accept 0.491 J > [1]

(iii) KE at C + PE at C = KE at D + W.D. against friction [1]

$0.45 + 0.4905 = \frac{1}{2} (0.1) \times (4)^2 + W$ [1]

$\therefore W = 0.1405$ J < accept 0.141 J > [1]

12. (c) (i)



< Two axes labeled correctly > [1]

< Shape of curve correct > [1]

(ii) Time between 2 dots = 0.2 s [1]

$u = \frac{0.76}{0.2} = 3.8\text{ m s}^{-1}$

$v = \frac{0.60}{0.2} = 3.0\text{ m s}^{-1}$ [1]

$a = \frac{v-u}{t} = \frac{3.8-3.0}{2\times0.2} = -2\text{ m s}^{-2}$ [1]

$\therefore$ deceleration = 2 m s^{-2} [1]

13. (a) (i) (1) $v_A = \frac{0.03}{0.05} = 0.6\text{ m s}^{-1}$ [2]

(2) $v_B = \frac{0.03}{0.025} = 1.2\text{ m s}^{-1}$ [1]

(ii) (1) $v^2 = u^2 + 2as$ [1]

$\therefore (1.2)^2 = (0.6)^2 + 2a(0.4)$

$\therefore a = 1.35\text{ m s}^{-2}$ [1]

(2) $T = ma$ [1]

$= (1.5)\times(1.35)$

$= 2.025$ N [1]

(3) Gain in K.E. $= \frac{1}{2}m{v_B}^2 - \frac{1}{2}m{v_A}^2$ [1]

$= \frac{1}{2}(1.5)\times(1.2)^2 - \frac{1}{2}(1.5)\times(0.6)^2$

$= 0.81$ J [1]

The gain in K.E. comes from the loss in potential energy of the hanging weight. [1]

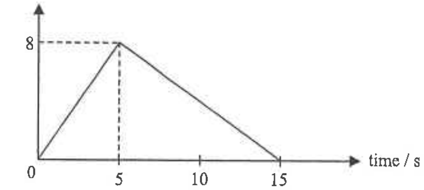
(b) A motion sensor connected to a data-logger is placed on top on the runway. [1]

The trolley is given a slight push and runs down the runway. [1]

The velocity-time graph displayed on the computer should be a horizontal line if it is friction-compensated. [1]

(c) The trolley will travel along the runway with a uniform speed. [1]

14. (a)

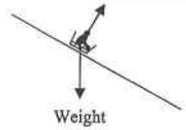


< For the graph from t = 0 to 5 s > [1]

< For the graph from t = 5 to 15 s > [1]

< For labelling the 2 axes with units > [1]

(b)



[1]

[1]

(c) (i) Acceleration $= \frac{8}{5} = 1.6\text{ m s}^{-2}$ [1]

(ii) Stopping distance = area under the graph [1]

$= \frac{1}{2}\times 8\times(15-5)$

$= 40$ m [1]

(iii) Deceleration along BC = slope of the graph

$= \frac{8}{15-5}$

$= 0.8\text{ m s}^{-2}$ [1]

Frictional force $= Ma$ [1]

$= (60)\times(0.8)$

$= 48$ N [1]

(d) The sledge is released from the same height in both cases. [1]

Thus the sledge acquires the same speed at B in both cases. [1]

So the stopping distance along BC would remain unchanged. [1]

OR

The potential energy of the sledge at points A and P are the same. [1]

The sledge thus gains the same kinetic energy at B in both cases. [1]

So the stopping distance along BC would remain unchanged. [1]

15. (a) $100\ km\ h^{-1} = \dfrac{100 \times 1000\ m}{3600\ s} = 27.8\ m\ s^{-1}$ [1]

(b) K.E. $= \frac{1}{2} m v^2 = \frac{1}{2}(1400)(27.8)^2$

$= 541\ 000\ J$ (<u>OR</u> 540 988 J) (<u>OR</u> 541 kJ) (<u>OR</u> 540 kJ) [1]

$P = \dfrac{E}{t} = \dfrac{541000}{9.3}$ [1]

$= 58\ 200\ W$ (<u>OR</u> 58.2 kW) (<u>OR</u> 58.1 kW) [1]

(c) (i) When the car is travelling up an inclined road, there is a component of weight $mg \sin\theta$ acts along the road. [1]
Thus the acceleration of the car is smaller, so it takes a longer time. [1]

<u>OR</u>

When the car is travelling up an inclined road, the potential energy of the car is increasing. [1]
As the power of the car remains unchanged, it takes a longer time to accelerate the car. [1]

(ii) $P t = \frac{1}{2} m v^2 + m g h$ [1]

$(58200) \times (16.2) = (541\ 000) + (1400)(9.81) h$ [1]

$h = 29.3\ m$ [1]

(d) (i) Kinetic energy of the car [1]
changes to internal energy. [1]

(ii) $\frac{1}{2} m v^2 = f s$ [1]

$\frac{1}{2}(1400) v^2 = (11200)(30.5)$ [1]

$v = 22.09\ m\ s^{-1}$

$= 22.09 \times \dfrac{3600}{1000}\ km\ h^{-1} = 79.5\ km\ h^{-1}$ [1]

As the speed of the car exceeds 70 km h^{-1}, John was not telling the truth. [1]

16. (a) $PE = m g h = (60)(9.81)(10) = 5886\ J$ < accept 5890 J > [1]

(b) $m g h = \frac{1}{2} m v^2$ [1]

$(5886) = \frac{1}{2}(60) v^2$

$v = 14.0\ m\ s^{-1}$ [1]

(c) $m g h = F s$ **< OR >** $m g h + \frac{1}{2} m v^2 = F s$ [1]

$(60)(9.81)(10 + 3) = F(3)$ **< OR >** $(60)(9.81)(3) + \frac{1}{2}(60)(14.1)^2 = F(3)$ [1]

$F = 2550\ N$ < accept 2500 to 2560 N > **< OR >** $F = 2580\ N$ < accept 2500 to 2560 N > [1]

17. (a) s = area of the graph

$= \frac{1}{2} \times 2.95 \times (9.25 - 8.90)$ [1]

$= 0.516\ m$ [1]

(b) $\Delta PE = m g h$

$= (0.154) \times (9.81) \times (0.516)$

$= 0.780\ J$ [1]

(c) $KE = \frac{1}{2} m v^2$

$= \frac{1}{2}(0.154) \times (2.95)^2$ [1]

$= 0.670\ J$ [1]

(d) There is air resistance acting on the book. [1]

18. (a) $PE = m g h = (115)(9.81)(1.8) = 2030\ J$ [1]

(b) $R = (115)(9.81) + (70)(9.81)$ [1]

$= 1810\ N$ [1]

(c) $s = u t + \frac{1}{2} a t^2$ [1]

$(1.8) = (0) + \frac{1}{2}(9.81) t^2$

$\therefore\ t = 0.606\ s$ [1]

19. (a) (i) $F = 0.45\ N$ [1]

(ii) $P = F v = (0.45)(1.5)$ [1]

$= 0.675\ W$ [1]

(b) (i) $KE = \frac{1}{2} m v^2 = \frac{1}{2}(1.2)(1.5)^2 = 1.35\ J$ [1]

(ii) $(1.35) = (0.45) s$ [1]

$\therefore\ s = 3\ m$ [1]

20. (a) KE = loss of $PE = m g h$

$= (60)(9.81)(15 - 3.5)$ [1]

$= 6770\ J$ [1]

(b) Loss of PE = Work done against resistive force

$(6770) + (60)(9.81)(3.5 - 0.5) = F \times (3.5 - 0.5)$ **OR** $(60)(9.81)(15 - 0.5) = F \times (3.5 - 0.5)$ [2]

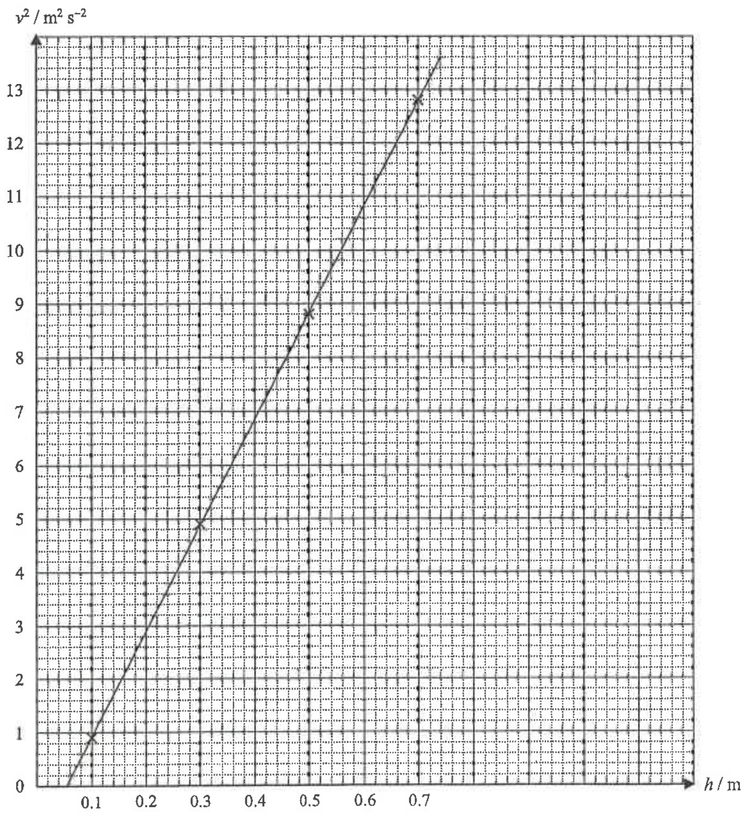
$F = 2850\ N$ < accept 2840 N > [1]

20. (c) The loss of *PE* is the same. [1]
The distance travelled by the man in the cushion is larger. [1]
The average resistive force by the cushion is smaller. [1]

OR

The momentum of the man reaching the cushion is smaller. [1]
The impact time in the thicker cushion is increased. [1]
By $F = (mv - mu) / t$, the impact force will be reduced, thus cause less injury to the man. [1]

21. (a)



< Correct label of the two axes with units > [1]
< Correct scale > [1]
< Any 3 points correctly plotted > [1]
< A correct straight line > [1]

21. (b) (i) By the law of energy conservation,

$\frac{1}{2} m v^2 = m g (h - h_o)$ [1]

$\therefore v^2 = 2 g (h - h_o)$

(ii) Slope $= \dfrac{10 - 2}{0.56 - 0.15} = 19.5$ < accept 19.2 to 20.4 >

By $v^2 = 2gh - 2gh_o$

Slope $= 2g$ [1]

$\therefore (19.5) = 2g$

$\therefore g = 9.75$ m s^{-2} < accept 9.6 to 10.2 m s^{-2} > [1]

(c) The air resistance can be neglected. [1]

< OR >

The effect of air resistance is smaller. [1]

< OR >

The effect of friction is smaller. [1]

22. (a) $s = ut + \frac{1}{2} a t^2$

$(0.7) = 0 + \frac{1}{2} a (2.95)^2$ [1]

$a = 0.161$ m s^{-2} [1]

(b) $v = u + at$

$= (0) + (0.161)(2.95)$ [1]

$= 0.475$ m s^{-1} [1]

(c) Loss of PE of the weight = gain of KE of the weight + gain of KE of the block + work done against friction

$(0.02)(9.81)(0.7) = \frac{1}{2}(0.02)(0.475)^2 + \frac{1}{2}(1)(0.475)^2 + f \times (0.7)$ [3]

$\therefore f = 0.0318$ N < accept 0.0316 to 0.0320 N > [1]

OR

$mg - f = (m + M) a$

$(0.02)(9.81) - f = (0.02 + 1)(0.161)$ [3]

$\therefore f = 0.0320$ N < accept 0.0316 to 0.0320 N > [1]

23. (a) (i) $PE = mgh = (50) \times (9.81) \times (10) = 4905$ J < accept 4910 J > [1]

(ii) $KE = \frac{1}{2} m v^2 = \frac{1}{2}(50) \times (12)^2 = 3600$ J [1]

23. (b) Some potential energy is changed into kinetic energy of the boy [1]
and some potential energy is changed into internal energy. [1]

OR

Some potential energy of the boy is changed into kinetic energy of the boy [1]
and some potential energy is used to do work against friction. [1]

24. (a) Power output $= F v = (75 \times 9.81) \times (2)$ [1]
$= 1470$ W [1]

(b) (i) $R - m g = m a$ [1]
$R - (75) \times (9.81) = (75) \times (0.25)$ $\therefore R = 755$ N < accept 754.5 N > [1]

(ii) $R = m g$ [1]
$= (75)(9.81) = 736$ N [1]

25. (a) a = slope $= \dfrac{3}{2} = 1.5$ m s^{-2} [1]
$T - m g = m a$
$T - (4)(9.81) = (4)(1.5)$ [1]
$T = 45.2$ N < accept 45.24 N > [1]

(b) $P = F v = (4 \times 9.81)(3)$ < note that at 2 s to 5 s, there is no acceleration, $T = mg$ > [1]
$= 118$ W < accept 117.72 W > [1]

(c) The parcel rises with deceleration and comes to rest momentarily at the highest point. [1]
It then falls freely with acceleration due to gravity. [1]

26. (a) $2\,T \cos 75° = 60$ [1]
$T = 116$ N [1]

(b) KE of the arrow $= \frac{1}{2}(0.2)(45)^2 = 202.5$ J [1]
Energy stored in the string = KE of the arrow $= 202.5$ J < accept 203 J > [1]

27. Stick the paper strip onto the horizontal part BC of the track. [1]
Release the toy from a certain height h from the bench surface and measure the corresponding stopping distance d. [1]
The stopping distance should be measured from the beginning of the horizontal part BC by the metre rule.
Repeat with the toy releasing at different heights h and measure the corresponding value of stopping distance d. [1]
Plot the graph of d against h. [1]
The graph should be a straight line passing through the origin. [1]
Thus, the stopping distance d is proportional to the height of release h.

28. (a) (i) $P = F v = (8000) \times (2)$ [1]
$= 16000$ W < **OR** 16 kW > [1]

(ii) $P_{loss} = 20000 - 16000 = 4000$ W < **OR** 4 kW > [1]

(b) (i) Power to move up the lift car $= (8000 - 7000) \times (2) = 2000$ W [1]
Total power output of the motor $= 2000 + 4000 = 6000$ W < **OR** 6 kW > [1]

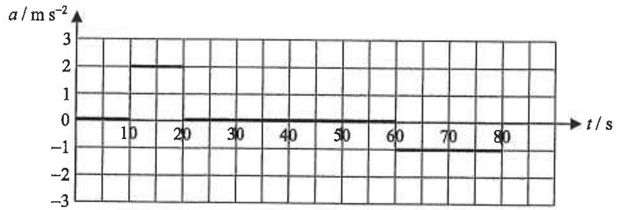
(ii) Output power required from the motor is smaller. **OR** Force exerted by the motor is smaller. [1]

(iii) No, the lift system could not work < **OR** the lift will fall down > [1]
as slipping would occur. < **OR** the drum cannot exert a force on the cable > [1]

29. (a) From $t = 0$ to 10 s, car A accelerates uniformly. [1]
From $t = 10$ to 80 s, car A travels with the uniform velocity. [1]

(b) (i) Car B attained the greater acceleration. [1]
a = slope $= \dfrac{20-0}{20-10} = 2$ m s^{-2} [1]

(ii)



< Acceleration from 10 s to 20 s and deceleration from 60 s to 80 s correct > [1]
< All correct > [1]

(c) (i) Displacement of car A at 20 s $= \frac{1}{2}(10 + 20) \times (15) = 225$ m [1]
Displacement of car B at 20 s $= \frac{1}{2}(10) \times (20) = 100$ m
Separation $= 225 - 100 = 125$ m [1]

(ii) Car B travels faster than car A by 5 m s^{-1}.
$\therefore \Delta s = \Delta v \times \Delta t$ $\therefore (125) = (5) \times \Delta t$ [1]
$\therefore \Delta t = 25$ s
The time that car B catches up with car A is at 45 s. [1]

(d) $F \propto v^2$
$P = F v \propto v^3$ [1]
$\dfrac{P_A}{P_B} = \left(\dfrac{v_A}{v_B}\right)^3 = \left(\dfrac{15}{20}\right)^3 = \dfrac{27}{64}$ < accept 27 : 64 > [1]

Hong Kong Diploma of Secondary Education Examination

DSE Physics - Section B : M.C. — PB - FM5 - M / 01
FM5 : Momentum

The following list of formulae may be found useful :

Gravitational potential energy	$E_P = m g h$
Kinetic energy	$E_K = \frac{1}{2} m v^2$
Mechanical power	$P = F v = \frac{W}{t}$
Force	$F = m \frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$

Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81 \text{ m s}^{-2}$ (close to the Earth)

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 1 >**

When a constant unbalanced force is applied to a particle, which of the following will change with time ?

(1) The acceleration of the particle
(2) The momentum of the particle
(3) The kinetic energy of the particle

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

2. **< HKCE 1980 Paper II - 2 >**

A ball is dropped from a height h above the ground. Each time it hits the ground, one-half of the original kinetic energy is lost. How high will the ball rise above the ground after the second impact ?

A. $\frac{h}{8}$
B. $\frac{h}{4}$
C. $\frac{h}{2}$
D. $\frac{h}{\sqrt{2}}$

3. **< HKCE 1980 Paper II - 6 >**

Two objects P and Q of mass 2 kg and 3 kg respectively have the same momentum. They are then subjected to the same constant resisting force and gradually brought to rest. What is the ratio of the stopping distance of P to that of Q ?

A. 4 : 9
B. 2 : 3
C. 3 : 2
D. 9 : 4

4. **< HKCE 1982 Paper II - 5 >**

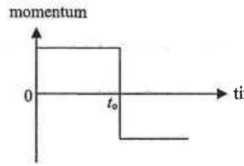
The diagram shows a gas molecule of mass m colliding with the wall of a container at a speed of 2 m s^{-1} and bounding back with the same speed. Which of the following is/are true ?

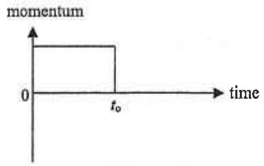
(1) The kinetic energy of the particle before and after the collision remains unchanged.
(2) The velocity of the particle before and after the collision remains unchanged.
(3) The momentum of the particle before and after the collision remains unchanged.

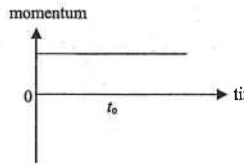
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

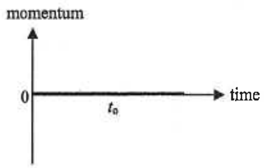
5. **< HKCE 1983 Paper II - 4 >**

A system consists of two identical masses travelling in opposite directions with equal speed. Suppose they collide elastically at time t_o. Which of the following graphs correctly shows the total momentum of the system before and after the collision ?

A.


B.


C.


D.


6. **< HKCE 1983 Paper II - 5 >**

A trolley of mass 1 kg travelling at 2 m s^{-1} on a smooth horizontal plane has a lump of plasticine dropped from a height 5 m onto it. If the mass of the plasticine is 2 kg, the velocity of the loaded trolley will be

A. 0.67 m s^{-1}
B. 1.00 m s^{-1}
C. 1.50 m s^{-1}
D. 1.33 m s^{-1}

7. **< HKCE 1983 Paper II - 10 >**

A particle is in motion with a constant force acting on it. Which of the following physical quantities will be changing during the time when the force is acting ?

(1) acceleration of the particle
(2) momentum of the particle
(3) kinetic energy of the particle

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

8. **< HKCE 1984 Paper II - 7 >**

A basketball falls freely from rest and hits the ground. It then rebounds to 1/4 of its original height. Neglecting air resistance, which of the following statements about the basketball is/are correct ?

(1) Its kinetic energy just before collision is four times its kinetic energy just after collision.
(2) Its potential energy just before collision is four times its potential energy just after collision.
(3) The speed just before collision is two times the speed just after collision.

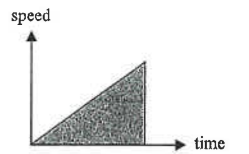
A. (1) only
B. (2) only
C. (2) & (3) only
D. (1) & (3) only

9. **< HKCE 1985 Paper II - 4 >**

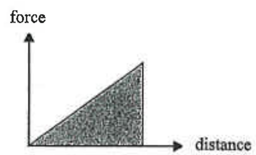
A ball of mass 2 kg drops from rest to the ground from a height 5 m and rebounds to the same height. If the time of duration of the impact between the ball and the ground is 0.2 s, what is the force acting on the ball by the ground ?
(Take the acceleration due to gravity be 10 m s^{-2})

A. 20 N
B. 100 N
C. 200 N
D. 220 N

10. **< HKCE 1985 Paper II - 3 >**



I



II

What physical quantity does the area of the shaded portion of each of the above graphs represent ?

	I	II
A.	acceleration	energy
B.	distance	power
C.	acceleration	change of momentum
D.	distance	energy

11. **< HKCE 1986 Paper II - 4 >**

Which of the following is a vector quantity with correct unit ?

A. speed, km h^{-1}
B. acceleration, m s^{-1}
C. power, W
D. momentum, kg m s^{-1}

12. **< HKCE 1987 Paper II - 7 >**

A mass of 3 kg initially at rest explodes into two fragments X and Y of masses 1 kg and 2 kg respectively. What is the ratio of the kinetic energy of X to that of Y just after the explosion ?

A. 1 : 4
B. 1 : 2
C. 2 : 1
D. 4 : 1

13. **< HKCE 1987 Paper II - 2 >**

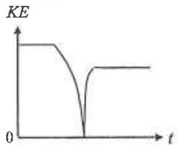
Which of the following is/are correct unit(s) for momentum ?

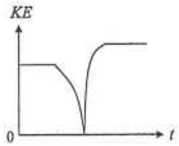
(1) kg m s^{-1}
(2) kg m s^{-2}
(3) N s

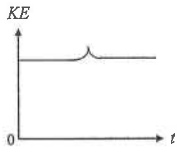
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

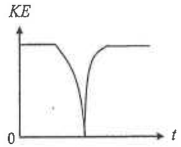
14. **< HKCE 1987 Paper II - 1 >**

A ball moving in a smooth horizontal plane hits against a wall and rebounds perfectly elastically. Which of the following graphs best represents the variation of kinetic energy with time ?

A.


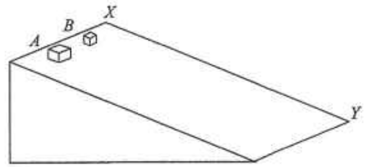
B.


C.


D.


15. **< HKCE 1987 Paper II - 8 >**

The figure shows a smooth plane on which two blocks *A* and *B* are released simultaneously from rest at *X* and slide down along the plane to *Y*. Block *A* is of mass 2*M* while block *B* is of mass *M*. On reaching *Y*, which of the following statements is/are correct ?

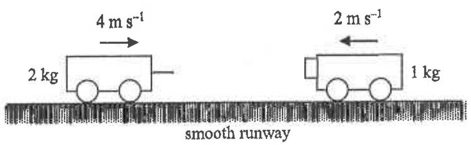


(1) The velocity of block *A* is double that of block *B*.
(2) The momentum of block *A* is double that of block *B*.
(3) The time taken by block *A* is double that of block *B*.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

16. **< HKCE 1988 Paper II - 2 >**

The figure shows two trolleys moving towards each other along a smooth runway. After collision, they stick together. What is the total loss in kinetic energy by the trolleys during the collision ?



A. 3 J
B. 6 J
C. 9 J
D. 12 J

17. **< HKCE 1989 Paper II - 4 >**

Two metal spheres of unequal masses are released from rest at the same time from a height of 2 m above the ground. When they have fallen 1 m, (neglecting air resistance) they have the same

A. speed.
B. momentum.
C. weight.
D. kinetic energy.

18. **< HKCE 1989 Paper II - 5 >**

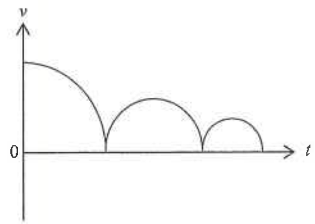
Bullets, each of mass *m*, are fired at the rate of *n* bullets per second. They hit a vertical wall with horizontal speed *v* and rebound from the wall with the same horizontal speed *v*. Which of the following statements is/are correct ?

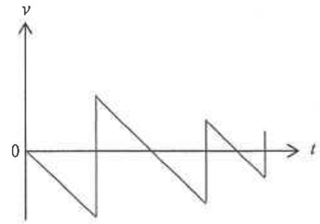
(1) The total change in momentum of the bullets is zero.
(2) The total change in momentum of the bullets in one second is 2 *m n v*.
(3) The average force exerted on the wall is 2 *m n v*.

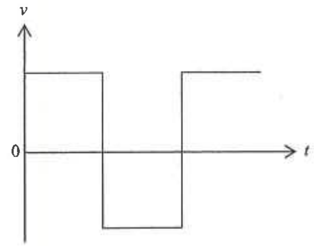
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

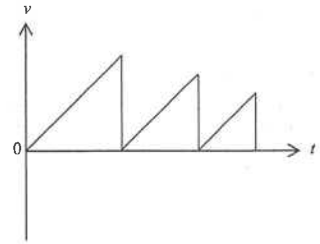
19. **< HKCE 1990 Paper II - 8 >**

A small metal ball is released from a point above the floor and bounces several times. Which of the following graphs best represents the variation of the velocity of the ball with time ?

A.


B.


C.


D.


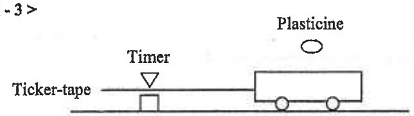
20. **< HKCE 1990 Paper II - 7 >**

Which of the following statements is/are correct when a collision between two particles is elastic ?

(1) None of the original kinetic energy is converted into other forms of energy.
(2) The linear momentum of each particle is conserved.
(3) The mechanical energy of each particle is conserved.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

21. **< HKCE 1990 Paper II - 3 >**

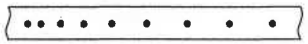


A trolley moves with constant speed along a horizontal surface. A lump of plasticine having the same mass as the trolley is dropped onto the trolley and sticks to it. Which one of the following ticker-tape best represents the motion of the trolley ?

A.


B.


C.


D.


22. **< HKCE 1991 Paper II - 11 >**

Two particles *A* and *B* of masses 2 kg and 1 kg respectively move in opposite directions. The initial velocity of *A* is 4 m s^{-1} towards the right, while that of *B* is 2 m s^{-1} towards the left. They collide head on. After the collision, the velocity of *A* becomes 1 m s^{-1} towards the right. What would be the velocity of particle *B* ?

A. 2 m s^{-1} towards the right
B. 3 m s^{-1} towards the right
C. 4 m s^{-1} towards the right
D. 6 m s^{-1} towards the right

23. **< HKCE 1991 Paper II - 8 >**

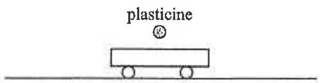
A ball collides with a fixed wall and bounces back with the same speed. Which of the following quantities of the ball remain(s) unchanged before and after the collision ?

(1) kinetic energy
(2) velocity
(3) momentum

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

24. **< HKCE 1992 Paper II - 5 >**

A trolley of mass 2 kg moves with a uniform speed of 4 m s^{-1} along a horizontal table. A lump of plasticine having the same mass as the trolley is dropped from a height slightly above the trolley and sticks to it. Find the total loss in kinetic energy.



A. 0 J
B. 4 J
C. 8 J
D. 12 J

25. **< HKCE 1993 Paper II - 1 >**

Which of the following pairs of physical quantities has/have the same unit ?

(1) Work and potential energy
(2) Power and momentum
(3) Specific heat capacity and specific latent heat of fusion

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

26. **< HKCE 1995 Paper II - 3 >**

A stone is thrown vertically upwards and it finally falls back to the starting point. Assume air resistance is negligible. Which of the following statements is/are true throughout the motion ?

(1) The acceleration of the stone is constant.
(2) The total mechanical energy of the stone is conserved.
(3) The momentum of the stone is conserved.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

27. **< HKCE 1997 Paper II - 4 >**

Which of the following physical quantities is **not** a vector ?

A. Acceleration
B. Momentum
C. Weight
D. Work

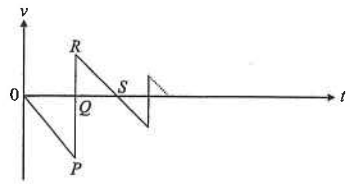
28. **< HKCE 1997 Paper II - 5 >**

A particle of mass *m* is thrown vertically upwards with initial speed *v*. When the particle returns to its starting point, what are the changes in momentum and kinetic energy of the particle ?

	Change in momentum	Change in kinetic energy
A.	0	0
B.	0	$m v^2$
C.	$2 m v$	0
D.	$2 m v$	$m v^2$

29. **< HKCE 1998 Paper II - 5 >**

At time t = 0, a table-tennis ball is released from a point above the ground and bounces several times on the ground. The graph shows the variation of the velocity v of the ball with time t. At which of the following points on the graph does the ball reach its maximum height above the ground after the first rebound ?



(Note : Velocity pointing upwards is taken to be positive.)

A. Point *P*
B. Point *Q*
C. Point *R*
D. Point *S*

30. **< HKCE 1998 Paper II - 3 >**

A block is pulled by a constant force and moves along a smooth horizontal surface. Which of the following describes the variations of the acceleration and momentum of the block during the time when the force is acting ?

	Acceleration	Momentum
A.	remains unchanged	remains unchanged
B.	remains unchanged	increases
C.	increases	remains unchanged
D.	increases	increases

31. < HKCE 1999 Paper II - 8 >

A rocket is initially at rest in space. It then explodes and breaks into two parts which move in opposite directions. If the mass of the rear part is larger than that of the front part, which of the following statements is correct ?

A. The speeds of the two parts are equal.

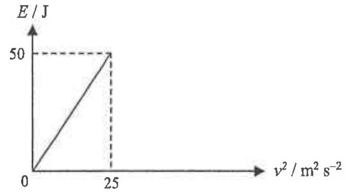
B. The speed of the rear part is higher than that of the front part.

C. The magnitudes of the momentum of the two parts are equal.

D. The magnitude of the momentum of the rear part is larger than that of the front part.

32. < HKCE 2000 Paper II - 10 >

The graph shows the variation of the kinetic energy E of an object with the square of its velocity v^2 moving on a straight line. What is the momentum of the object when it is moving at a velocity 4 m s^{-1} ?



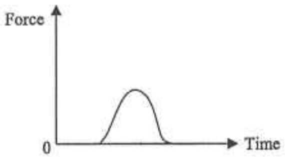
A. 4 kg m s^{-1}

B. 8 kg m s^{-1}

C. 16 kg m s^{-1}

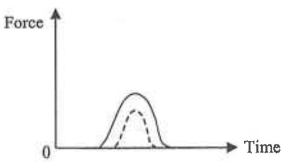
D. 32 kg m s^{-1}

33. < HKCE 2001 Paper II - 8 >

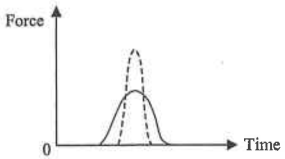


The figure above shows the variation of the force acting on a car driver with time when the car hits a wall. The driver is not wearing a seat-belt. Which of the following graphs (in dotted lines) best shows the force acting on the driver if he is wearing a seat-belt ?

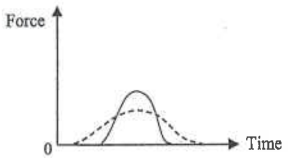
A.



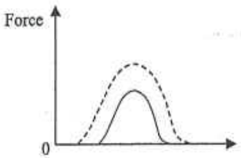
B.



C.



D.



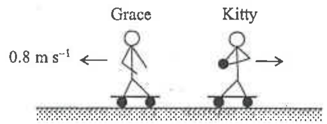
34. < HKCE 2001 Paper II - 11 >

A rocket of mass 5000 kg is at rest in space. It then explodes and breaks into two parts P_1 and P_2 of mass 1000 kg and 4000 kg respectively. Find the ratio of the kinetic energy of P_1 to P_2.

A. 1 : 16
B. 1 : 64
C. 4 : 1
D. 16 : 1

35. < HKCE 2002 Paper II - 12 >

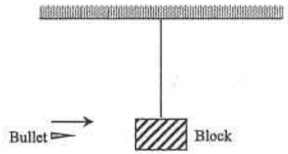
Grace and Kitty, of masses 50 kg and 40 kg respectively, stand on light rollers on a smooth horizontal floor. They are initially at rest with Grace holding a 2 kg ball. Grace throws the ball to Kitty and moves backward with a speed 0.8 m s^{-1} afterwards. After catching the ball, Kitty moves in the opposite direction as shown. Which of the following statements is/are correct ?



(1) The final speed of Kitty is 0.95 m s^{-1}.
(2) The horizontal momentum of the ball is conserved in this process.
(3) The total kinetic energy of Kitty and the ball decreases when Kitty catches the ball.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

36. < HKCE 2003 Paper II - 9 >



A wooden block of mass M is hanging freely in the air from a light string of length L. A bullet, of mass m travelling at a speed v, hits the block and becomes embedded in it. The block then swings upwards. Which of the following are employed in determining the maximum height reached by the block ?

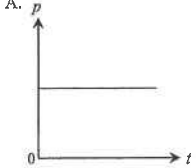
(1) Newton's first law
(2) Law of conservation of energy
(3) Law of conservation of momentum

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

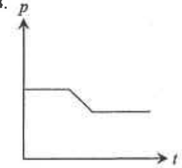
37. < HKCE 2004 Paper II - 9 >

A trolley moves along a smooth horizontal surface. A lump of plasticine is released from a height slightly above the trolley and sticks to it. Which of the following graphs shows the variation of the total horizontal momentum p of the trolley and plasticine with time t ?

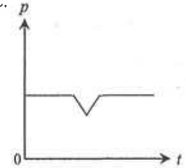
A.



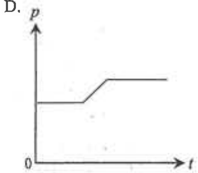
B.



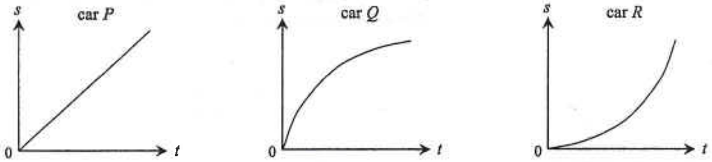
C.



D.



38. **< HKCE 2004 Paper II - 1 >**



Three cars P, Q and R move along a straight horizontal road. Their displacement-time graphs are shown above. Which of the cars experience a change in momentum during the motion ?

A. P and Q only
B. P and R only
C. Q and R only
D. P, Q and R

39. **< HKCE 2004 Paper II - 10 >**

The photograph shows an air-cushioned shoe. Which of the following statements about the air-cushion is/are correct ?

(1) It reduces the time of impact between the foot and the ground during running.
(2) It reduces the impact force acting on the foot during running.
(3) It reduces the friction between the shoe and the ground during running.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

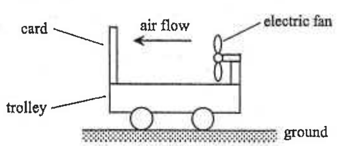
40. **< HKCE 2005 Paper II - 31 >**

A car P of mass 1000 kg moves with a speed of 20 m s^{-1} and makes a head-on collision with a car Q of mass 1500 kg, which was moving with a speed of 10 m s^{-1} in the opposite direction before the collision. If the two cars stick together after the collision, find their common velocity immediately after the collision.

A. 2 m s^{-1} along the original direction of P
B. 2 m s^{-1} along the original direction of Q
C. 14 m s^{-1} along the original direction of P
D. 14 m s^{-1} along the original direction of Q

41. **< HKCE 2006 Paper II - 6 >**

An electric fan is installed at one end of a trolley and a card is fixed at the other end with the plane of the card facing the fan. What happens to the trolley when the electric fan is turned on ?



A. The trolley remains stationary.
B. The trolley moves to the right.
C. The trolley moves to the left.
D. The trolley moves to and fro along the ground.

42. **< HKCE 2007 Paper II - 28 >**

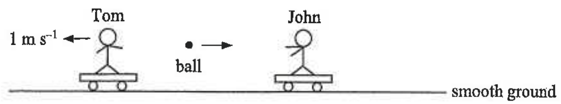
A body initially at rest, is exploded into two parts. Which of the following correctly describes the change in total momentum and total kinetic energy ?

	Total momentum	Total kinetic energy
A.	increases	increases
B.	increases	remains unchanged
C.	remains unchanged	increases
D.	remains unchanged	remains unchanged

43. **< HKCE 2007 Paper II - 29 >**

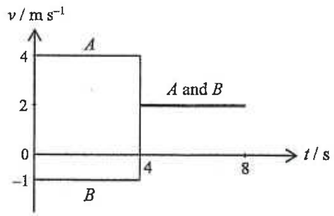
Tom and John stand on two trolleys of negligible masses. Both boys are initially at rest and Tom holds a ball of 3 kg. The masses of Tom and John are 30 kg and 27 kg respectively. After Tom has thrown the ball to John, Tom moves backwards with a speed of 1 m s^{-1}. What is the speed of John after he has caught the ball ?

A. 0.90 m s^{-1}
B. 1.00 m s^{-1}
C. 1.11 m s^{-1}
D. 1.22 m s^{-1}



44. **< HKCE 2008 Paper II - 31 >**

Trolleys A and B of masses m_A and m_B respectively travel along a horizontal road in opposite directions as shown.



Later they make a head-on inelastic collision and stick together. The graph below shows the velocity-time relationship of the two trolleys before and after the collision.

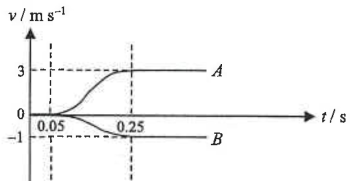
(Ignore the collision time and the friction acting on the trolleys.)

What is the ratio $m_A : m_B$?

A. 1 : 2
B. 2 : 3
C. 2 : 1
D. 3 : 2

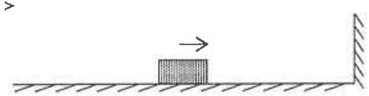
45. **< HKCE 2008 Paper II - 29 >**

In an explosion, an object is blown into 2 pieces, A and B, which fly off in opposite directions. The mass of A is 0.3 kg. The graph shows the variation of velocity of A and B with time before and after the explosion. What is the mass of B and the estimated magnitude of the average net force acting on B during the explosion ?

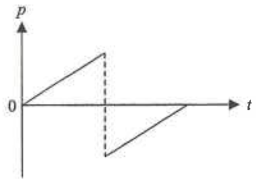


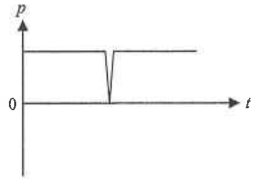
	Mass of B	Average net force acting on B
A.	0.1 kg	0.4 N
B.	0.1 kg	0.5 N
C.	0.9 kg	3.6 N
D.	0.9 kg	4.5 N

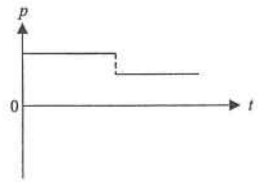
46. **< HKCE 2009 Paper II - 30 >**

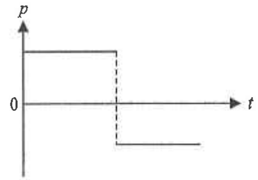


A block slides along a horizontal smooth surface as shown in the figure above. It collides with a vertical wall and rebounds along its original path. Which of the following graphs below best shows the variation of its momentum p with time t ?

A.


B.


C.


D.


47. **< HKCE 2010 Paper II - 32 >**

Ball A and ball B of masses 2 kg and 1 kg respectively collide head-on as shown above. Which of the following diagrams show(s) the possible result(s) after the collision ?

(1)


(2)

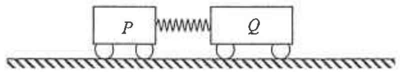

(3)


A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

48. **< HKCE 2011 Paper II - 33 >**

An egg will probably break if it is released at a height and lands on a hard surface. However, the egg may not break if it is released at the same height but lands on a soft cushion. It is because, when the cushion is used,
A. the momentum of the egg just before impact becomes smaller.
B. the egg rebounds after hitting the cushion.
C. the rate of change of momentum of the egg becomes smaller during the impact.
D. the force acting on the egg by the cushion is smaller than the force acting on the cushion by the egg.

49. **< HKCE 2011 Paper II - 32 >**



On a horizontal smooth track, two trolleys P and Q are held at rest with a light compressed spring in between as shown in the above figure. The masses of P and Q are m and $2m$ respectively. When the trolleys are released and separate, trolley Q moves to the right with speed v. Which of the following statements are correct ?
(1) After separation, the total momentum of the two trolleys is $4\ mv$.
(2) After separation, the kinetic energy of trolley P is twice that of trolley Q.
(3) The energy initially stored in the compressed spring is at least $3\ mv^2$.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Part B : HKAL examination questions

50. **< HKAL 1981 Paper I - 35 >**

In a racing competition, the momentum of each competitor during the race is greater than that before he starts running. Which of the below statements is/are correct ?
(1) This situation violates the law of conservation of momentum.
(2) The law of conservation of momentum applies only to collisions between two objects.
(3) A force acts on each competitor to increase his momentum as he starts running.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

51. **< HKAL 1982 Paper I - 3 >**

Two objects of masses m and $4m$ move towards each other along a straight line with kinetic energies K and $4K$ respectively. What is the total momentum of the two objects ?
A. $3\sqrt{2mK}$
B. $4\sqrt{2mK}$
C. $5\sqrt{2mK}$
D. $15\sqrt{2mK}$

52. **< HKAL 1984 Paper I - 3 >**

In the absence of external net force, if two bodies undergo an inelastic collision, then
A. kinetic energy and momentum are both conserved.
B. kinetic energy is not conserved but momentum is conserved.
C. kinetic energy is conserved but momentum is not conserved.
D. neither kinetic energy nor momentum is conserved.

53. **< HKAL 1986 Paper I - 4 >**

Ball X moving with velocity u on a smooth horizontal plane makes an elastic collision with ball Y initially at rest. If the two balls have the same mass, which of the following statements is/are correct ?
(1) Kinetic energy is conserved in the collision.
(2) Linear momentum is conserved in the collision.
(3) X and Y stick together and move off with the same velocity after the collision.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

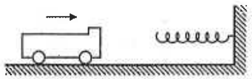
54. **< HKAL 1993 Paper I - 3 >**

A box moves at a uniform velocity of 2 m s^{-1} on a frictionless horizontal surface. Sand falls continuously into the box with negligible speed at a rate of 90 kg per minute. To keep the box moving uniformly at 2 m s^{-1}, the horizontal force needed is

A. 0 N
B. 3 N
C. 6 N
D. 90 N

55. **< HKAL 1995 Paper IIA - 3 >**

A trolley travels with constant velocity to the right on a smooth horizontal ground and collides with a light spring attached to a wall fixed to the ground (Earth) as shown in the figure. At the instant that the trolley comes momentarily to rest during collision, what has happened to the initial momentum of the trolley ?



A. The initial momentum has been transferred to the earth.
B. The initial momentum has been stored in the spring.
C. The initial momentum has changed into sound and heat.
D. The initial momentum has been destroyed by the friction due to the ground.

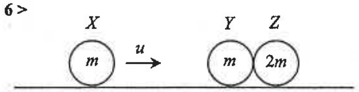
56. **< HKAL 1996 Paper IIA - 1 >**

Which of the following pairs of quantities of a moving object must be in the same direction ?

(1) acceleration and change in momentum
(2) displacement and instantaneous velocity
(3) instantaneous velocity and acceleration

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

57. **< HKAL 1996 Paper IIA - 6 >**



X, *Y* and *Z* are three balls with masses *m*, *m* and 2*m* respectively. They lie on a smooth horizontal surface with *Y* and *Z* in contact as shown. If now *X* is moving to the right with a velocity of *u* and it then makes a direct collision with *Y*, which of the following gives the possible velocities of the three balls after all collisions ? Assume all collisions are perfectly elastic. (Take the direction to the right as positive.)

	X	*Y*	*Z*
A.	0	0	$u/2$
B.	0	$u/3$	$u/3$
C.	$-u/3$	0	$2u/3$
D.	0	$-u/3$	$2u/3$

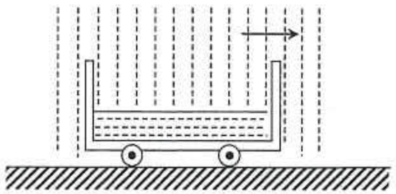
58. **< HKAL 1997 Paper IIA - 6 >**

A body initially at rest explodes into two parts of unequal mass. The part with smaller mass has a larger

(1) momentum.
(2) speed.
(3) kinetic energy.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

59. **< HKAL 1999 Paper IIA - 3 >**

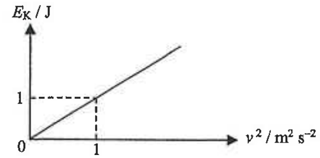


The figure shows an open trolley moving an initial speed on a smooth horizontal surface. Rain water falls continuously onto the trolley and accumulates there. What are the effects on the speed, horizontal momentum and kinetic energy of the trolley together with the rain ? (Ignore the initial kinetic energy of the rain water.)

	speed	**momentum**	**kinetic energy**
A.	decreased	unchanged	decreased
B.	decreased	unchanged	unchanged
C.	decreased	decreased	decreased
D.	unchanged	unchanged	unchanged

60. **< HKAL 1999 Paper IIA - 5 >**

The graph shows the variation of kinetic energy (E_K) with the square of velocity (v^2) of a moving ball of mass *m*. What is the momentum of the ball when it is moving at a speed of 2 m s^{-1} ?



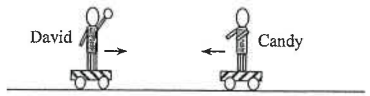
A. 1 N s
B. 2 N s
C. 4 N s
D. 8 N s

61. **< HKAL 2000 Paper IIA - 6 >**

Two bodies *X* and *Y* of masses *m* and 2*m* respectively are initially at rest on a smooth, horizontal surface. If a force of the same magnitude acts on each of them for the same period of time, the ratio of the kinetic energy of *X* to that of *Y* is

A. 2 : 1
B. 1 : 2
C. 1 : 1
D. 1 : 4

62. **< HKAL 2007 Paper IIA - 26 >**



David and Candy standing on light skateboards with frictionless rollers are moving towards each other as shown. Both of them have the same mass of 30 kg and move at a speed of 1.2 m s^{-1}. Initially David holds a ball of mass 1.0 kg. He then throws the ball straight towards Candy at a horizontal velocity of 15 m s^{-1}. Determine the velocity of Candy after she catches the ball.

A. 0.74 m s^{-1} to the right
B. 0.74 m s^{-1} to the left
C. 0.68 m s^{-1} to the right
D. 0.68 m s^{-1} to the left

Part C : Supplemental exercise

63. Which of the following statements concerning the design of cars is/are correct ?

(1) The front and rear parts of cars are designed to collapse during a serious traffic accident.

(2) The collapsible parts can reduce the time of collision when the car is involved in a serious accident.

(3) The collapsible parts can reduce the change of momentum in a serious accident.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

64. Which of the following statements concerning the air-cushioned sports shoes is/are correct ?

(1) Air-cushioned sports shoes can increase the time of impact between the feet and the ground during running.

(2) Air-cushioned sports shoes can reduce the change of momentum during jumping and running.

(3) Air-cushioned sports shoes can reduce the impact force acting on the feet during jumping and running.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

65. When a lorry makes a head-on collision with a motor-cycle, which of the following statements is/are correct ?

(1) The magnitude of the average force exerted by the lorry on the motorcycle is equal to that exerted by the motorcycle on the lorry.

(2) The magnitude of the change in momentum of the lorry is equal to that of the motorcycle.

(3) The magnitude of the change in velocity of the lorry is equal to that of the motorcycle.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

66. Which of the following concerning the wearing of seat-belts is/are correct ?

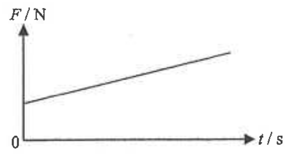
(1) Wearing seat-belts can reduce the change in momentum of passengers in a car during a collision.

(2) Wearing seat-belts can reduce the force acting on passengers in a car during a collision.

(3) Wearing seat-belts can prevent the passengers from jerking forwards when the car is suddenly stopped.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

67. The graph shows the variation with the time t of the resultant force F acting on a body moving along a straight line. The shaded area represents



A. the momentum of the body.

B. the change in momentum of the body.

C. the change in the velocity of the body.

D. the change in the kinetic energy of the body.

68.

before collision after collision

Ball A moving with speed u collides head-on with another ball B which is initially at rest on a smooth horizontal surface. After collision, A and B move together with a common velocity v.
Which of the following statements concerning the two balls during the collision is/are correct ?

(1) The change of momentum of ball A is equal in magnitude to that of ball B.
(2) The loss of kinetic energy of ball A is equal to the gain of kinetic energy of ball B.
(3) The final velocity v is halved of the initial velocity u.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

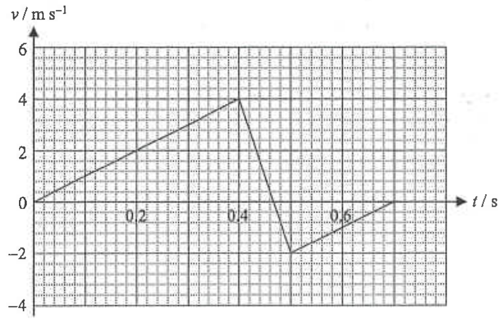
Part D : HKDSE examination questions

69. **< HKDSE Sample Paper IA - 13 >**

A car P of mass 1000 kg moves with a speed of 20 m s^{-1} and makes a head-on collision with a car Q of mass 1500 kg, which was moving with a speed of 10 m s^{-1} in the opposite direction before the collision. If the two cars stick together after the collision, find their common velocity immediately after the collision.

A. 2 m s^{-1} along the original direction of P
B. 2 m s^{-1} along the original direction of Q
C. 14 m s^{-1} along the original direction of P
D. 14 m s^{-1} along the original direction of Q

70. **< HKDSE Practice Paper IA - 13 >**



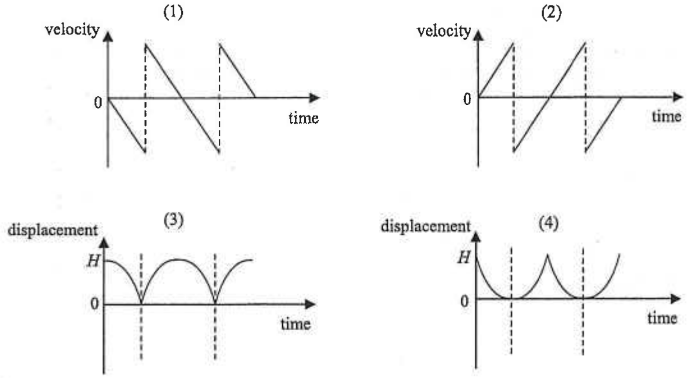
A ball of mass 0.2 kg is released from rest. It hits the ground and rebounds. The velocity-time graph of the ball is shown above. Which of the following statements are correct ?

(1) The magnitude of the change in momentum of the ball during the collision is 1.2 kg m s^{-1}.
(2) The magnitude of the average force acting on the ball by the ground during the collision is 12 N.
(3) There is mechanical energy loss during the collision.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

71. **< HKDSE 2012 Paper IA - 7 >**

Which of the following graphs (velocity-time and displacement-time) best represent the motion of a ball falling from rest under gravity at a height H and bouncing back from the ground two times ? Assume that the collision with the ground is perfectly elastic and neglect air resistance. (Downward measurement is taken to be negative.)

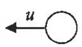


A. (1) and (3) only
B. (1) and (4) only
C. (2) and (3) only
D. (2) and (4) only

72. **< HKDSE 2013 Paper IA - 10 >**

Two identical spheres are moving in opposite directions with speeds u and v (with $u > v$) respectively as shown. They make a head-on collision. Which of the following diagrams show(s) a *possible* situation of the spheres after collision ?

(1)

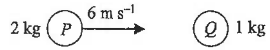


(2)

(3)

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

73. **< HKDSE 2014 Paper IA - 7 >**

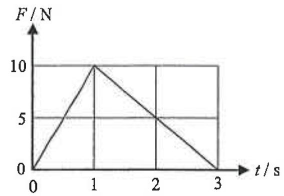


A sphere P of mass 2 kg makes a head-on collision with another sphere Q of mass 1 kg which is initially at rest. The speed of P just before collision is 6 m s^{-1}. If the two spheres move in the same direction after collision, which of the following could be the speed(s) of Q just after collision ?

(1) 2 m s^{-1}
(2) 4 m s^{-1}
(3) 6 m s^{-1}

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

74. **< HKDSE 2015 Paper IA - 6 >**



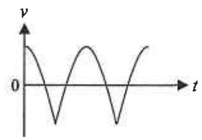
An object of mass 3 kg is initially at rest on a smooth horizontal ground. A force F is applied horizontally to the object such that the magnitude F varies with time t as shown. What is the speed of the object at t = 3 s ? Neglect air resistance.

A. 2.5 m s^{-1}
B. 5.0 m s^{-1}
C. 10 m s^{-1}
D. 15 m s^{-1}

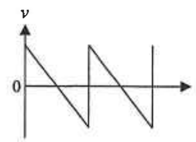
75. **< HKDSE 2015 Paper IA - 7 >**

A rubber ball bounces vertically up and down from the ground. Which graph best shows the variation of its velocity v with time t if the collisions are elastic ? Neglect air resistance.

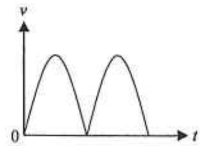
A.



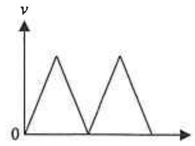
B.



C.

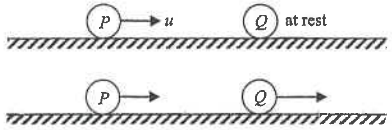


D.



76. **< HKDSE 2016 Paper IA - 12 >**

On a smooth horizontal surface, a marble P moving with speed u collides head-on with another marble Q, which is at rest. After collision, P and Q move with different speeds as shown.



Which of the following statements about this collision is/are correct ?

(1) During collision, the force acting on Q by P is equal and opposite to that acting on P by Q.

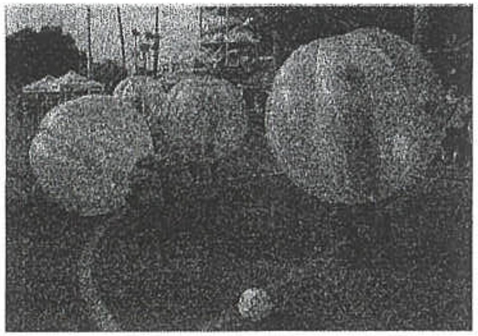
(2) The total momentum of the two marbles is conserved only when the collision is perfectly elastic.

(3) The kinetic energy lost by P must be equal to that gained by Q.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

77. **< HKDSE 2017 Paper IA - 12 >**

Players of "bubble soccer" wear air-filled plastic "bubbles" as shown.



Which of the following statements best explains why the bubble can reduce the chance of injury during a collision ?

A. The bubble increases the mass of the player, thus the momentum of the player increases.
B. The bubble increases the air resistance acting on the player.
C. The bubble lengthens the impact time during a collision.
D. Like a balloon, the bubble provides a lifting force to the player.

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. D	11. D	21. B	31. C	41. A
2. B	12. C	22. C	32. C	42. C
3. C	13. C	23. A	33. C	43. B
4. A	14. D	24. C	34. C	44. D
5. D	15. B	25. A	35. D	45. D
6. A	16. D	26. C	36. C	46. D
7. D	17. A	27. D	37. A	47. B
8. D	18. D	28. C	38. C	48. C
9. D	19. B	29. D	39. B	49. C
10. D	20. A	30. B	40. A	50. B

51. A	61. A	71. A
52. B	62. D	72. D
53. C	63. A	73. C
54. B	64. C	74. B
55. A	65. C	75. B
56. A	66. D	76. A
57. C	67. B	77. C
58. D	68. A	78. A
59. A	69. A	79. B
60. C	70. B	80. C

M.C. Solution

1. D

✗ (1) Constant net force ⇒ constant acceleration (by Newton's Second Law)

✓ (2) Constant acceleration ⇒ varying velocity ⇒ varying momen tum($m\ v$)

✓ (3) Constant acceleration ⇒ varying velocity ⇒ varying KE ($\frac{1}{2}m v^2$)

2. B

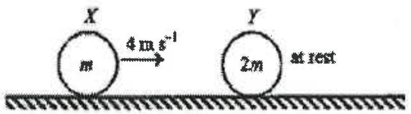
After the second impact : $KE_2 = \frac{1}{2} \times \frac{1}{2} \times KE_o = \frac{1}{4} KE_o$.

At the topmost point, loss of KE = gain in PE ∴ PE reduced to $\frac{1}{4}$ of its original value

As $PE = m g h$ ∴ $PE \propto h$ ∴ The ball will rise above the ground by $\frac{1}{4} h$.

78. <HKDSE 2019 Paper IA-10>

79. <HKDSE 2019 Paper IA-11>



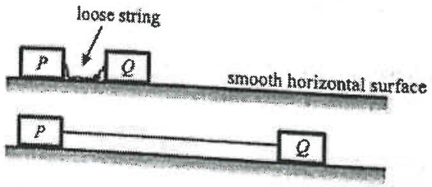
On a smooth horizontal surface, sphere X of mass m travels with speed 4 m s^{-1}. It collides head-on with another sphere Y of mass $2m$, which is at rest initially. Which of the following can be the speed of Y just after collision ?

(1) 1 m s^{-1} (2) 2 m s^{-1} (3) 3 m s^{-1}

A. (1) only
B. (2) only
C. (1) and (2) only
D. (2) and (3) only

80. <HKDSE 2020 Paper IA-8>

On a smooth horizontal surface, two identical blocks P and Q are connected by a light inextensible string. The blocks are at rest and the string is loose initially.



Q is given a speed of 4 m s^{-1} and moves to the right. Find the speeds of the blocks when the string just becomes taut and P starts to move.

	block P	block Q
A.	1 m s^{-1}	1 m s^{-1}
B.	2 m s^{-1}	1 m s^{-1}
C.	2 m s^{-1}	2 m s^{-1}
D.	4 m s^{-1}	2 m s^{-1}

3. C

$KE = \frac{1}{2} m v^2 = \frac{(mv)^2}{2m} \propto \frac{1}{m}$

Loss of KE = work done against the resistive force

$\therefore\ KE = F s$ $\qquad \therefore\ KE \propto s$

$\therefore\ s \propto \frac{1}{m}$

$\therefore\ \frac{s_P}{s_Q} = \frac{m_Q}{m_P} = \frac{3}{2}$

4. A

✓ (1) Same speed before and after collision.
By $KE = \frac{1}{2} mv^2$, thus same KE before and after collision

× (2) Same speed after collision but direction changes, as velocity is a vector, it changes after collision.

× (3) Momentum is also a vector.

5. D

No external net force acting on the system, thus, total momentum of the system is conserved

Total momentum $= (m\ v) + (-m\ v) = 0$

6. A

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$\therefore\ (1)(2) + (2)(0) = (1 + 2)\ v$

$\therefore\ v = 0.67\ \text{m s}^{-1}$

7. D

× (1) Constant net force ⇒ constant acceleration (by Newton's Second Law)

✓ (2) Constant acceleration ⇒ increasing velocity ⇒ increasing momentum ($m\ v$)

✓ (3) Constant acceleration ⇒ increasing velocity ⇒ increasing KE ($\frac{1}{2} m\ v^2$)

8. D

✓ (1) $PE = m g h$ $\quad \therefore\ PE \propto h$
Rises by $\frac{1}{4}$ of its original height ⇒ it has $\frac{1}{4}$ of its original PE at topmost point.
As loss of KE = gain in PE
$\therefore$ KE at the lowest point has $\frac{1}{4}$ of its original value after collision.

× (2) Same level at these 2 instants ⇒ same PE just before and just after collision

✓ (3) By $KE = \frac{1}{2} mv^2 \propto v^2$, the speed just before collision is double that just after collision.

9. D

$v^2 = u^2 + 2\,a\,s$ $\qquad \therefore\ v^2 = (0) + 2\,(10)(5)$ $\qquad \therefore\ v = 10\ \text{m s}^{-1}$

The force acting on the ball by the ground during impact is the normal reaction force R.

$R - m g = \frac{m v - m u}{t}$

$R - (2)(10) = \frac{(2)(10) - (2)(-10)}{0.2}$ $\qquad \therefore\ R = 220\ \text{N}$

10. D

I : Area of speed-time graph represents displacement or distance

II : Area of force-distance graph represents work or energy

11. D

			Vector		Unit
×	A.	×	Speed : scalar	✓	km h^{-1} : unit of speed.
×	B.	✓	Acceleration : vector	×	m s^{-2} is the correct unit of acceleration.
×	C.	×	Power : scalar	✓	W : unit of power.
✓	D.	✓	Momentum : vector	✓	kg m s^{-1} : unit of momentum.

12. C

Explosion without external net force ⇒ their momentum are equal and opposite

$KE = \frac{1}{2} m v^2 = \frac{(mv)^2}{2m} \propto \frac{1}{m}$ $\qquad \therefore\ \frac{KE_X}{KE_Y} = \frac{m_Y}{m_X} = 2$

13. C

✓ (1) momentum $= mv = (\text{kg})(\text{m s}^{-1}) = \text{kg m s}^{-1}$

× (2) It is a unit of force.

✓ (3) $\text{kg m s}^{-1} = (\text{kg m s}^{-2})(\text{s}) = \text{N s}$

14. D

As the ball rebounds perfectly elastically, there is no loss in KE, thus same KE before and after collision.

When the ball comes to rest at an instant, the KE is zero.

$\therefore$ D is the most suitable one.

15. B

× (1) Since the two blocks have the same acceleration : $g \sin\theta$, they must have the same final velocity

✓ (2) Momentum $= mv$. As mass of A is double with the same final velocity, thus momentum of A is double.

× (3) As both blocks have the same acceleration, they take the same time to reach the bottom Y.

16. D

$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$

$\therefore$ (2)(4) + (1)(−2) = (2 + 1) v $\therefore$ v = 2 m s^{-1}

$\Delta KE = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 - \frac{1}{2}(m_1 + m_2) v^2 = \frac{1}{2}(2)(4)^2 + \frac{1}{2}(1)(2)^2 - \frac{1}{2}(2+1)(2)^2 = 12$ J

17. A

✓ A. Both spheres have same acceleration due to gravity and same distance travelled, thus same speed

× B. Both spheres have the same velocity but different mass, thus different momentum

× C. Both spheres have the same acceleration due to gravity but different mass, thus different weight

× D. Both spheres have the same speed but different mass, thus different kinetic energy.

18. D

× (1) Change in momentum of one bullet = $m v - (-m v) = 2 m v$

✓ (2) Total change in momentum of n bullets in one second = $n \times [m v - (-m v)] = 2 m n v$

✓ (3) Average force = total change of momentum of n bullets in one second = $2 m n v$

19. B

Take upward direction as positive

Initially the velocity is zero since it is released from rest.

It then falls downwards with uniform acceleration due to gravity, thus v is (−) and is a straight line with (−) slope
During collision with the ground, the velocity changes from (−) to (+) in a very short time, thus give a vertical line.

20. A

✓ (1) As the collision is elastic, total KE is conserved, i.e. the final KE would equal the initial KE, thus no KE is lost and converted to other forms of energy.

× (2) The total momentum of the two particles is conserved, however, the momentum of one particle is not conserved, due to the impact force on the particle.

× (3) The total KE of the two particles is conserved, however, the KE of one particle is not conserved, as during the collision, there is transfer of KE from one particle to another particle.

21. B

After a plasticine has stuck on it, as momentum is conserved : $m v$ = constant

The increase of mass causes the decrease of velocity $\therefore$ separation of dots decreases

22. C

Take rightward direction as positive,

$m_A u_A + m_B u_B = m_A v_A + m_B v_B$

(2) (4) + (1) (−2) = (2) (1) + (1) v_B $\therefore$ v_B = 4 m s^{-1}

23. A

✓ (1) By $KE = \frac{1}{2} m v^2$, same speed indicates same KE before and after collision

× (2) Same speed after collision but direction changes, thus velocity changes since it is a vector

× (3) As the direction has changed after collision, momentum has changed as momentum is also a vector.

24. C

$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$

(2)(4) + (2)(0) = (2 + 2) v

$\therefore$ v = 2 m s^{-1}

$\Delta KE = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 - \frac{1}{2}(m_1 + m_2) v^2 = \frac{1}{2}(2)(4)^2 - \frac{1}{2}(2+2)(2)^2 = 8$ J

25. A

✓ (1) Both of them have the same unit : J

× (2) Unit of power : W = N m s^{-1} ; Unit of momentum : N s

× (3) Unit of specific heat capacity : J kg^{-1} °C^{-1}; Unit of specific latent heat of fusion : J kg^{-1}.

26. C

✓ (1) The acceleration is constant due to the same acceleration due to gravity g.

✓ (2) As no work is done on the stone and no air resistance, total mechanical energy ($KE + PE$) is conserved.

× (3) As there is an external force, the weight, acting on the stone, its momentum would not conserve.

27. D

✓ A. Acceleration is a vector.

✓ B. Momentum is a vector.

✓ C. Weight, a kind of force, is a vector.

× D. Work, a process to transfer energy, is a scalar.

28. C

① When it returns to the starting point, it has the same speed but in opposite direction, thus the change in momentum = $m v - (-m v) = 2 m v$

② When it returns to the starting point, it has the same speed and thus the same KE, change in KE is thus zero.

29. D

From O to P, the ball falls to the ground with acceleration under the acceleration due to gravity g.

At P, the ball just reaches the ground.

At Q, the ball has maximum compression and still at the ground.

At R, the ball restores its original shape and just leaves the ground.

From R to S, the ball moves upwards and decelerates under the acceleration due to gravity g.

At S, the ball reaches the maximum height

30. B

Acceleration : Constant force gives constant acceleration

Momentum : As the block accelerates, its velocity increases, thus the momentum ($m\,v$) also increases,

31. C

× A. By mv = constant , $m \propto \frac{1}{v}$. different masses have different speeds

× B. By mv = constant , $m \propto \frac{1}{v}$. $m_r > m_f$ ∴ $v_r < v_f$

✓ C. Upon explosion, no external force acts the system.

× D. By $m_1v_1 + m_2v_2 = 0$, both parts have the same magnitude of momentum.

32. C

$KE = \frac{1}{2} m v^2$

When KE = 50 J, v^2 = 25 m² s⁻²

∴ $(50) = \frac{1}{2} m (25)$

∴ m = 4 kg

∴ momentum of the object at a velocity of 4 m s^{-1} = $m\,v$ = 4 × 4 = 16 kg m s^{-1}

33. C

Wearing a seat-belt can increase the duration time of impact and thus reduce the impact force

34. C

As $KE = \frac{1}{2} m v^2 = \frac{(mv)^2}{m} \propto \frac{1}{m}$

KE of P_1 : KE of P_2 = mass of P_2 : mass of P_1 = 4000 : 1000 = 4 : 1

35. D

✓ (1) By conservation of momentum, $(50+2)(0) + (40)(0) = (50)(-0.8) + (40+2)v_2$ ∴ $v_2 = 0.95$ m s^{-1}

× (2) Total momentum of the system is conserved but the horizontal momentum of the ball is not conserved due to external force acting on the ball by Grace and later by Kitty

✓ (3) When Kitty catches the ball, it is an inelastic collision, thus total kinetic energy must decrease.

36. C

× (1) Newton's first law describes the inertia of a body that would not be used in calculation

✓ (2) The law of conservation of energy is used during the motion when the block swings upwards.

✓ (3) The law of conservation of momentum is used when the bullet hits the block.

37. A

Since there is no external force, the total horizontal momentum p of the trolley and the plasticine is conserved.

Thus the graph should be a horizontal straight line.

38. C

Car P has constant velocity and thus no change in momentum since the slope of s-t graph is constant.

Car Q has decreasing velocity and thus decrease in momentum since the slope of s-t graph is decreasing.

Car R has increasing velocity and thus increase in momentum since the slope of s-t graph is increasing.

39. B

× (1) Air-cushion increases the time of impact.

✓ (2) Air-cushion reduces the impact force since $F = (m\,v - m\,u) / t$

× (3) Friction should be related to the roughness of the bottom of the shoe, but not the air-cushion.

40. A

By $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

∴ $(1000)(+20) + (1500)(-10) = (1000 + 1500)\,v$

∴ $v = +2$ m s^{-1}

Their common velocity is along the positive direction, i.e. the original direction of P.

41. A

Since the air flow is stopped by the card, no air moves out towards the left.

By Conservation of momentum,

the trolley remains at rest, i.e. stationary.

42. C

Since there is no external force acting on the body, the total momentum of the two parts is conserved and is unchanged.

When they are at rest, the total kinetic energy is zero.

After explosion, the two parts move off from each other.

These two parts gain kinetic energy.

43. B

The total momentum of Tom, John and the ball is zero initially.

By Conservation of momentum : $0 = (30)(-1) + (27 + 3)\,v$ ∴ v = 1 m s^{-1}

< OR >

Consider Tom and the ball : $0 = (30)(-1) + (3)\,v_b$ ∴ v_b = 10 m s^{-1}

Consider the ball and John : $(3)(10) = (3 + 27)\,v$ ∴ v = 1 m s^{-1}

44. D

From the graph, the initial velocity of A is $+4\ \text{m s}^{-1}$ and that of B is $-1\ \text{m s}^{-1}$.

By the Law of conservation of momentum :

$m_A u_A + m_B u_B = (m_A + m_B) v$

$m_A (4) + m_B (-1) = (m_A + m_B)(2)$

$\therefore\ 2 m_A = 3 m_B \qquad \therefore\ \frac{m_A}{m_B} = \frac{3}{2}$

45. D

① By Conservation of momentum : $m_A u_A + m_B u_B = m_A v_A + m_B v_B$

$(0) + (0) = (0.3)(3) + m_B(-1) \qquad \therefore\ m_B = 0.9$ kg

② By $F_B = \frac{mv - mu}{t} = \frac{(0.9)(-1) - 0}{(0.25 - 0.05)} = -4.5$ N

$\therefore$ Magnitude of average net force on B = 4.5 N

46. D

Before collision, the momentum is unchanged and is positive, with direction towards the right.

After collision, the momentum becomes negative, with direction towards the left.

47. B

Check that whether the total momentum before and after collision is conserved or not.

Take the rightward direction as positive.

× (1) $(2)(6) + (1)(-4) \neq (2)(-3) + (1)(2)$

× (2) $(2)(6) + (1)(-4) \neq (2)(2) + (1)(12)$

✓ (3) $(2)(6) + (1)(-4) = (2)(1) + (1)(6)$

48. C

The cushion is soft, thus it can increase the duration time of impact,

thus the rate of change of momentum becomes smaller,

therefore, the impact force is also smaller.

49. C

× (1) After separation, the total momentum is conserved and is equal to zero.

✓ (2) After separation, by conservation of momentum : $(m) v_P = (2m)(v) \qquad \therefore\ v_P = 2v$

Ratio of KE of trolley P to Q = $\frac{1}{2}(m)(2v)^2 : \frac{1}{2}(2m)(v)^2 = 2 : 1$

✓ (3) Total KE of the two trolleys after separation = $\frac{1}{2}(m)(2v)^2 + \frac{1}{2}(2m)(v)^2 = 3\,m\,v^2$

Some energy may be lost in the separation, thus the initial energy stored in the spring is at least $3\,m\,v^2$.

50. B

× (1) The momentum change is due to the friction which is an external force acting on the competitor.
The Law of conservation of momentum has not been violated
as it has stated that momentum would only conserve under no external net force.

× (2) Conservation of momentum can be applied to all types of motion with no external force acting.

✓ (3) Force (friction) acting on the competitor by the ground increases the momentum of competitor.

51. A

For mass m : $K = \frac{1}{2} \cdot \frac{(mv)^2}{m} \qquad \therefore$ momentum of the mass m = $mv = \sqrt{2mK}$

For mass $4m$: $4K = \frac{1}{2} \cdot \frac{(4mv)^2}{4m} \qquad \therefore$ momentum of the mass $4m$ = $4mv = 4\sqrt{2mK}$

As m and $4m$ moves in opposite direction,

$\therefore$ total momentum of the two bodies = $(4\sqrt{2mK}) + (-\sqrt{2mK}) = 3\sqrt{2mK}$

52. B

Absence of external forces ⇒ momentum is conserved

Inelastic collision ⇒ KE is not conserved

53. C

✓ (1) Elastic collision ⇒ KE is conserved

✓ (2) No external net force ⇒ Linear momentum is conserved

× (3) Stick together will only occur for an inelastic collision

54. B

$F = \frac{mv - mu}{t} = \frac{m}{t}(v - u) = \frac{90}{60}(2 - 0) = 3$ N

55. A

As the trolley makes collision with the earth, there is no external force acting on the system of trolley and the earth

$\therefore$ total momentum of the trolley and the earth is conserved

$\therefore$ momentum of trolley is transferred to the earth.

56. A

✓ (1) Acceleration : same direction as force ; Force : same direction as change of momentum

× (2) Counter example : Moving backward to starting point at the left ⇒ rightward s and leftward v

× (3) Counter example : Throwing an object upward ⇒ upward v and downward a

57. C

Initial momentum = mu — Initial energy = $\frac{1}{2}mu^2$

Conservation of momentum (No external force ⇒ momentum is conserved) — **Conservation of kinetic energy** (Perfectly elastic collision ⇒ KE is conserved)

× A. $m(0)+m(0)+2m\left(\frac{u}{2}\right)=mu$ ✓ $\frac{1}{2}m(0)^2+\frac{1}{2}m(0)^2+\frac{1}{2}\cdot 2m\left(\frac{u}{2}\right)^2=\frac{mu^2}{4}$ ×

× B. $m(0)+m\left(\frac{u}{3}\right)+2m\left(\frac{u}{3}\right)=mu$ ✓ $\frac{1}{2}m(0)^2+\frac{1}{2}m\left(\frac{u}{3}\right)^2+\frac{1}{2}\cdot 2m\left(\frac{u}{3}\right)^2=\frac{mu^2}{6}$ ×

✓ C. $m\left(\frac{-u}{3}\right)+m(0)+2m\left(\frac{2u}{3}\right)=mu$ ✓ $\frac{1}{2}m\left(\frac{-u}{3}\right)^2+\frac{1}{2}m(0)^2+\frac{1}{2}\cdot 2m\left(\frac{2u}{3}\right)^2=\frac{mu^2}{2}$ ✓

× D. $m(0)+m\left(\frac{-u}{3}\right)+m\left(\frac{2u}{3}\right)=mu$ ✓ $\frac{1}{2}m(0)^2+\frac{1}{2}m\left(\frac{-u}{3}\right)^2+\frac{1}{2}\cdot 2m\left(\frac{2u}{3}\right)^2=\frac{mu^2}{2}$ ✓

After all collisions, X is at rest and Y moves to the left and Z moves to the right.
That means, Y would move towards X and would hit X again, thus it is NOT reasonable.

58. D

× (1) Explosion ⇒ $0=m_Av_A+m_Bv_B$ ⇒ Magnitude of momentum $p_A=p_B$

✓ (2) By $mv=\text{constant}$, smaller mass ⇒ larger speed

✓ (3) By $KE=\frac{1}{2}mv^2=\frac{(mv)^2}{2m}\propto\frac{1}{m}$ ∴ smaller mass ⇒ larger kinetic energy

59. A

Speed : By the law of conservation of momentum, $m\uparrow\Rightarrow v\downarrow$

Momentum : Since there is no horizontal external net force acts on the trolley, its momentum must be conserved.

Kinetic energy : Since the collision is inelastic, the total kinetic energy must decrease.

60. C

As kinetic energy $E_K=\frac{1}{2}mv^2$

∴ $(1)=\frac{1}{2}m(1)^2$

∴ $m=2$ kg

∴ Momentum of the ball moving at 2 m s^{-1} = (2) × (2) = 4 N s

61. A

As $Ft=mv-mu=mv$ as $u=0$

∴ Same applied force F for the same period of time t ⇒ same momentum mv

$KE=\frac{1}{2}mv^2=\frac{(mv)^2}{2m}\propto\frac{1}{m}$ ∴ $\frac{KE_X}{KE_Y}=\frac{m_Y}{m_X}=\frac{2m}{m}=2$

62. D

The total momentum of the ball and Candy is conserved and the collision is inelastic as Candy catches the ball.

By $m_1u_1+m_2u_2=(m_1+m_2)v$

∴ (1)(15) + (30)(−1.2) = (1 + 30) v ∴ $v=-0.68$ m s^{-1}

Candy should move to the left with speed of 0.68 m s^{-1}.

63. A

✓ (1) These parts are collapsible so that the duration time of impact can be increased.

× (2) The time of collision should be increased, not reduced.

× (3) Even with the collapsible parts, the final momentum is zero when the car stops.
Thus, the change of momentum should be the same.

64. C

✓ (1) Air-cushion can increase the time of impact due to the elastic nature.

× (2) The change of momentum should be the same even with the air-cushion.

✓ (3) As the time of impact is increased, the impact force is reduced, by $F=(mv-mu)/t$.

65. C

✓ (1) These two forces are action and reaction, thus they must be equal and opposite.

✓ (2) By $F=(mv-mu)/t$, as the forces are equal,
the change of momentum $(mv-mu)$ must also be equal in magnitude.

× (3) As their masses are not equal, their change of velocity $(v-u)$ must not be equal.

66. D

× (1) As the passengers would finally come to rest, the change of momentum is the same
even if they wear seat-belts.

✓ (2) As the seat-belts are elastic, they can increase the time of impact, thus reduce the impact force.

✓ (3) Due to inertia, the passengers would jerk forwards when the car is suddenly stopped.
Wearing seat-belts can prevent the passenger from throwing forwards.

67. B

Since $Ft=mv-mu$.

The area of $F-t$ graph represents the change of momentum of a body

68. A

✓ (1) Since the total momentum of the two balls is conserved no matter the collision is elastic or not,
thus the decrease of momentum of A must be equal to the increase of momentum of B.

× (2) Since the collision is inelastic, total kinetic energy of the two balls is not conserved.
Thus, the loss of $K.E.$ of A is not equal to the gain of $K.E.$ of B, as some $K.E.$ changes to internal energy.

× (3) By $m_Au=(m_A+m_B)v$
Since the mass of the two balls may not be equal, v may not be equal to $\frac{1}{2}u$.

69. A

By $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$\therefore$ (1000)(+20) + (1500)(−10) = (1000 + 1500) v $\therefore$ $v = +2 \text{ m s}^{-1}$

Their common velocity is along the positive direction, i.e. the original direction of P.

70. B

✓ (1) Change in momentum of the ball = (0.2) (−2) − (0.2) (4) = − 1.2 kg m s^{-1}

× (2) Average force acting on the ball by the ground is the normal reaction R :

$R - mg = \frac{mv - mu}{t}$ $\therefore$ $R - (0.2)(9.81) = \frac{1.2}{0.1}$ $\therefore$ $R = 12 + 1.96 = 14.0$ N

✓ (3) Since the speed after the collision is smaller, there is loss of KE during the collision.

71. A

① After release, the ball falls down with acceleration due to gravity in downward direction, thus a is downwards and is negative, therefore, (1) is correct as the initial slope is negative.

② The slope of the displacement - time graph is velocity.
After release, the magnitude of velocity gradually increases,
thus the magnitude of the slope should also gradually increase, therefore, (3) is correct.

72. D

× (1) Initial momentum = $mu + m(-v) > 0$ Final momentum = $m(-u) < 0$ $\therefore$ Momentum is not conserved.

✓ (2) Initial momentum = $mu + m(-v) > 0$ Final momentum = $m(-v) + mu$ $\therefore$ Momentum is conserved.

✓ (3) Initial momentum = $mu + m(-v) > 0$ Final momentum = $mv > 0$ $\therefore$ Momentum is conserved..

73. C

The total momentum must be conserved in the collision. $\therefore$ $m_P u_P = m_P v_P + m_Q v_Q$

× (1) (2) (6) = (2) v_P + (1) (2) $\therefore$ $v_P = 5 \text{ m s}^{-1}$
This situation is impossible since the speed of P cannot be greater than Q in front after collision.

✓ (2) (2) (6) = (2) v_P + (1) (4) $\therefore$ $v_P = 4 \text{ m s}^{-1}$
It is possible since the collision may be inelastic and the two particles move together after collision.

✓ (3) (2) (6) = (2) v_P + (1) (6) $\therefore$ $v_P = 3 \text{ m s}^{-1}$
Total K.E. before collision = $\frac{1}{2}(2)(6)^2 = 36$ J
Total K.E. after collision = $\frac{1}{2}(2)(3)^2 + \frac{1}{2}(1)(6)^2 = 27$ J
This situation is possible since the collision may be partly elastic with some loss of K.E.

74. B

Area of the F-t graph = change of momentum = $mv - mu$

$\therefore$ $\frac{1}{2} \times (3) \times (10) = (3)v - 0$ $\therefore$ $v = 5 \text{ m s}^{-1}$

75. B

Suppose the ball is thrown up with an initial velocity.

It then moves upwards (v is positive) with constant deceleration g to reach the highest point where its velocity is zero, then moves downward (v is negative) with uniform acceleration g.

The graph should be a straight line with constant slope equal to $-g$.

When the ball reaches the ground, its velocity changes from downward direction to upward direction in a very short time. Thus, the value of v should change sign after impact with the ground.

76. A

✓ (1) During collision, the force acting on P by Q and the force acting on Q by P form an action-reaction pair. Thus, they must be equal in magnitude.

× (2) Since there is no external net force acting on the two balls during collision, the total momentum of the two balls must be conserved no matter the collision is elastic or not.

× (3) Since the collision may not be perfectly elastic, total kinetic energy of the two balls may not conserve. Thus, the loss of *K.E.* of P may not equal to the gain of *K.E.* of Q, as some *K.E.* may change to internal energy.

77. C

Since the bubble is elastic, it can increase the impact time during the collision, thus reduce the impact force to reduce the chance of injury.

The following list of formulae may be found useful :

Gravitational potential energy	$E_P = m g h$
Kinetic energy	$E_K = \frac{1}{2} m v^2$
Mechanical power	$P = F v = \frac{W}{t}$
Force	$F = m \frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$

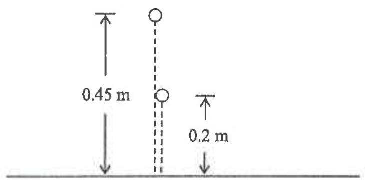
Use the following data wherever necessary :

Acceleration due to gravity	$g = 9.81 \text{ m s}^{-2}$	(close to the Earth)

Part A : HKCE examination questions

1. **< HKCE 1982 Paper I - 1 >**

A metal sphere of mass 0.4 kg is released from a height of 0.45 m onto a marble floor. It rebounds to a height of 0.2 m as shown in the figure below. Assume air resistance is negligible.



(a) Calculate the velocity (magnitude and direction) of the sphere just before and after impact. (4 marks)

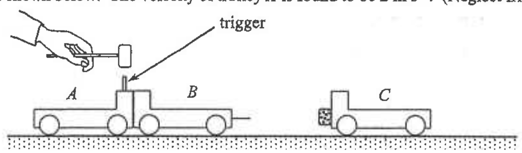
(b) If the sphere is in contact with the floor for 0.01 s, what is the magnitude of the normal reaction force exerted by the floor on the sphere during impact ? (3 marks)

(c) What is the difference in the kinetic energy of the sphere just before and after impact with the floor ? Briefly account for this difference. (4 marks)

1. (d) Sketch a graph showing the variation of the velocity of the sphere with time, starting at the time that the ball is released to the time that the ball reaches its maximum height after the first impact. No need to mark the values. (Take velocity in the downward direction to be positive.) (4 marks)

2. **< HKCE 1984 Paper I - 1 >**

Trolleys *A*, *B* and *C*, all of the same mass 1 kg, are placed on a horizontal runway with *A* and *B* in contact. Trolley *A* has a compressed spring. When the trigger is tapped, the spring quickly relaxes and the trolleys *A* and *B* start to move apart in opposite directions as shown below. The velocity of trolley *A* is found to be 2 m s^{-1}. (Neglect friction)



(a) What is the velocity of trolley *B* ? (2 marks)

(b) Estimate the potential energy stored in the compressed spring. (3 marks)

(c) Assuming that the time taken for the two trolleys to separate is 0.1 s, find the average force (in magnitude and direction) acting on

(i) trolley *A* , and

(ii) trolley *B*. (4 marks)

(d) After separation, trolley *B* collides with *C* and the two move together.

(i) What is the velocity of the two trolleys, *B* and *C* , after collision ? (2 marks)

(ii) Is the kinetic energy conserved in this case ? If not, calculate the kinetic energy loss. (4 marks)

3. < HKCE 1987 Paper I - 1 >

The mass of a metal ball is 0.5 kg. It is released from rest at a height of 1 m above the floor. Air resistance is assumed to be negligible.

(a) Calculate the speed of the ball just before it strikes the floor. (2 marks)

(b) Calculate the average force the ball would exert on the floor, assuming that the ball was stopped by the floor in 0.1 s and the ball did not rebound. (3 marks)

4. < HKCE 1988 Paper I - 3 >

A private car of mass 900 kg travelling at a speed of 70 km h^{-1} collides head-on with a truck of mass 3000 kg travelling in the opposite direction. Both vehicles are brought to rest by the collision and the duration of the impact is 0.2 s.

(a) What is the speed of the truck just before the impact ? (3 marks)

(b) State whether the magnitude of force acting on the truck is greater than, equal to or smaller than that acting on the private car during the impact. Explain briefly. (3 marks)

(c) If the drivers of both vehicles are taken to be 70 kg, what is the average force acting on

(1) the driver of the private car,

(2) the driver of the truck

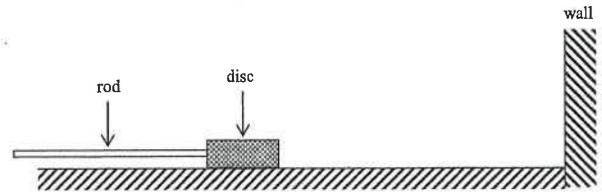
during the collision ?

Which driver is likely to be injured more seriously ? (6 marks)

(d) State ONE design on a vehicle which could reduce the degree of the injury of the driver during impact. Explain briefly. (3 marks)

5. < HKCE 1989 Paper I - 1 >

A disc of mass 0.1 kg is set to move on a frictionless horizontal table by a strike of a rod as shown in the figure below. The average force exerted on the disc by the rod is 50 N. The displacement of the disc while it is in contact with the rod is 0.1 m. Afterwards, the disc collides on a vertical wall at a certain speed and rebounds backwards at the same speed. The time of contact between the disc and the wall is 0.2 s.



(a) (i) Find the work done by the force exerted on the disc by the rod. (2 marks)

(ii) Find the speed of the disc on leaving the rod. (3 marks)

(b) Find the average force exerted on the wall during collision. (4 marks)

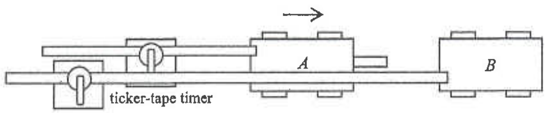
(c) A student makes the following statements concerning the experiment :

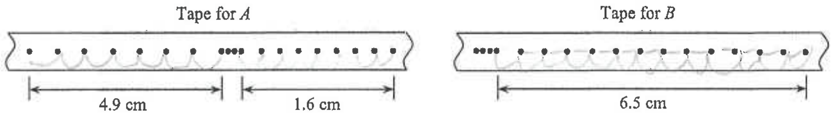
Statement 1 : When the disc has left the rod and is moving on the smooth horizontal table, there must be a force driving the disc to keep it moving.

Statement 2 : The faster the disc moves, the greater is the average force exerted on the wall during collision.

State whether statement 1 and statement 2 are true or false and explain briefly using Newton's Laws in each case. (6 marks)

6. < HKCE 1989 Paper I - 3 >





The figure above shows two trolleys *A* and *B* standing at rest on a friction compensated runway. *A* is then given a push and collides with *B*. The ticker tapes obtained from the experiment are also shown in the above diagram. It is given that the ticker-tape timers produce 50 dots per second.

(a) Using the scale on the metre rule as shown above, choose a suitable portion of the tapes and find the speed of

(1) *A* before the collision,

(2) *A* after the collision, and

(3) *B* after the collision. (3 marks)

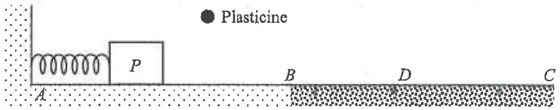
(b) Find the ratio of the mass of *A* to that of *B* from (a). (4 marks)

(c) A student reported the following results without doing any experiment :

	A	*B*
speed before the collision	0.2 m s^{-1}	0
speed after the collision	0.1 m s^{-1}	0.4 m s^{-1}
mass ratio	4 : 1	

If you were the teacher, how would you show that the results are impossible ? (4 marks)

7. < HKCE 1993 Paper I - 2 >



The figure above shows a horizontal runway *ABC* consisting of two parts, a smooth portion *AB* and a rough portion *BC*. A block *P* of mass 0.8 kg undergoes the below motion :

Step (1) : *P* is pressed against a spring at A and then released. After 0.05 s, *P* loses contact with the spring and moves with a speed of 1.8 m s^{-1}.

Step (2) : When *P* moves along *AB*, a lump of plasticine is dropped from a height slightly above *P* and sticks to it. The speed of *P* is reduced to 1.6 m s^{-1}.

Step (3) : *P* enters the rough portion and stops at point *D*.

(a) Calculate

(i) the average force acting on the block by the spring in Step (1),

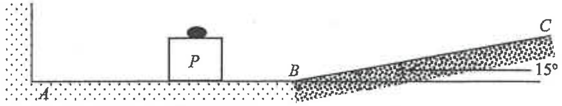
(ii) the mass of the plasticine,

(iii) the distance *BD*, given that the frictional force between *P* and the rough portion is 3 N. (7 marks)

(b) Describe the energy change in Step (1). (2 marks)

(c) Is kinetic energy conserved in Step (2) ? Explain briefly. (2 marks)

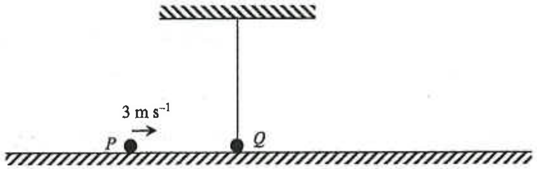
(d)



The above process is repeated with the rough portion *BC* inclined at an angle 15° to the horizontal. If the frictional force is still 3 N, what happens to *P* after it reaches the highest point ? Explain your answer. (4 marks)

8. **< HKCE 1994 Paper I - 2 >**

A bob P of mass 0.4 kg moves on a smooth horizontal ground with speed 3 m s^{-1}. A bob Q of mass 0.6 kg is suspended by a light inextensible string as shown in the figure below and is initially at rest. After colliding with Q, P comes to a rest.



(a) Find

(i) the momentum of P before the collision,

(ii) the speed of Q immediately after the collision,

(iii) the average force acting on P during the collision, given that the time of contact is 0.05 s. (5 marks)

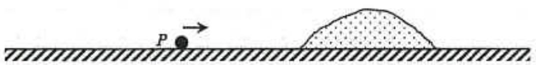
(b) Is the collision elastic ? Show your calculation. (3 marks)

(c) After the collision, bob Q swings upwards.

(i) Find the maximum height reached by Q.

(ii) The string exerts a tension on Q. Is there any work done by the tension when Q swings upwards ? Explain briefly. (5 marks)

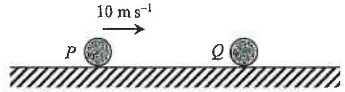
(d)



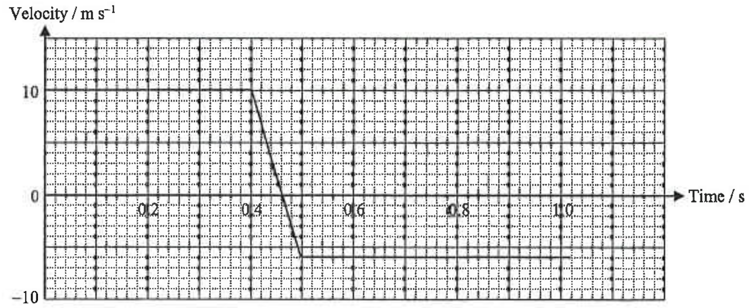
In another experiment, bob P moves towards and sticks to a lump of plasticine, which is fixed to the ground. In this collision, the total momentum of P and the plasticine is not conserved. Explain briefly. (2 marks)

9. **< HKCE 1995 Paper I - 2 >**

(a)



A metal ball P of mass 0.5 kg moves with speed 10 m s^{-1} on smooth horizontal ground. It collides with a heavier metal ball Q, which is initially at rest. After collision, P moves backwards in the opposite direction. The figure below shows the variation of the velocity of P with time.



(i) Find

(1) the momentum of P before the collision,

(2) the change in momentum of P in the collision,

(3) the time of contact of P and Q,

(4) the average force acting on P during the collision. (6 marks)

(ii) Is the average force acting on Q during the collision equal in magnitude to that acting on P ? Explain briefly. (2 marks)

(iii) Comment on the following statement :

"Momentum and kinetic energy must be conserved in this collision." (4 marks)

(b) For safety reasons, the front and rear parts of cars should not be made of very strong material. Explain briefly. (2 marks)

10. **< HKCE 1996 Paper I - 3 >**

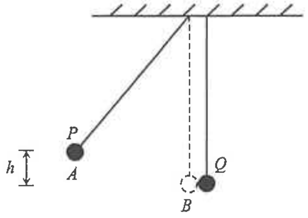


Figure 1

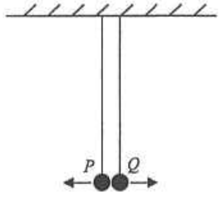


Figure 2

Two metal balls *P* and *Q* are suspended by light inextensible strings. Ball *P* is pulled to a point *A* which is at a height *h* above its initial position *B* and is then released. (See Figure 1.) After colliding at *B*, the two balls move away in opposite directions. (See Figure 2.)

(a) Draw a diagram to show all the forces acting on *P* when it swings from *A* to *B*. Label the forces. (2 marks)

(b) Describe the energy changes in the two balls, from the moment *P* is released until the balls swing up to their maximum heights after the collision. (3 marks)

(c) The mass of *P* is 0.3 kg and its speeds immediately before and after the collision are found to be 1.0 m s^{-1} and 0.5 m s^{-1} respectively.

(i) Find *h*. (2 marks)

(ii) Find the average force acting on *P* during the collision, assuming that the time of contact is 0.02 s. (2 marks)

(iii) Consider the following set of data :

	P	*Q*
Mass / kg	0.3	0.75
Velocity before collision / m s^{-1}	1.0 (towards the right)	0
Velocity after collision / m s^{-1}	0.5 (towards the left)	0.6 (towards the right)

(1) Show that the above set of data obeys the law of conservation of momentum.

(2) Explain why the above set of data is impossible. (5 marks)

11. **< HKCE 1998 Paper I - 2 >**

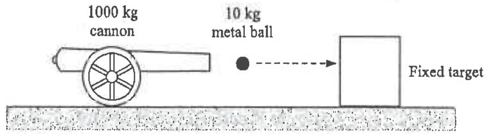


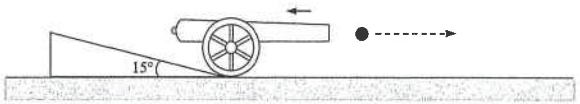
Figure 1 shows a cannon of mass 1000 kg. It fires a metal ball of mass 10 kg in order to destroy a fixed target. Assume the ball travels with a constant horizontal speed of 100 m s^{-1} towards the target.

(a) Suppose that the minimum energy required to destroy the target is 60 000 J. Explain whether the ball will destroy the target. (2 marks)

(b) The cannon recoils as the ball is fired.

(i) Find the recoil speed of the cannon. (2 marks)

(ii)



To stop the cannon, a smooth plane inclined at 15° to the horizontal is placed behind the cannon as shown in the figure. How far will the cannon move up along the inclined plane ? (3 marks)

(c) Suppose that in firing the ball, 80 000 J of energy is lost as heat, light and sound. Find the efficiency of the cannon in firing the ball. Kinetic energy of the ball is considered as the useful energy output. (3 marks)

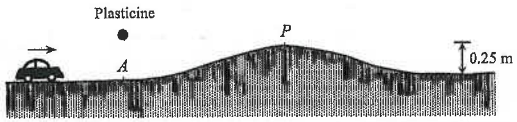
(d) The ball hits the target and becomes embedded in it.

(i) If the ball takes 0.05 s to come to a rest inside the target, find the average force exerted by the target on the ball. (2 marks)

(ii) A student thinks that as the ball and the target are both at rest after the impact, momentum has been lost. He asks why the law of conservation of momentum does not apply in this process.

If you were a teacher, how could you answer this question ? (3 marks)

12. < HKCE 1999 Paper I - 3 >



A toy car of mass 0.2 kg is moving at a speed 3 m s^{-1} on a smooth horizontal runway. When the car passes through a point *A* on the runway, a lump of plasticine of mass 0.1 kg is dropped from a height slightly above it and sticks to it.

(a) Find the speed of the car after the plasticine sticks to it. (2 marks)

(b) The runway is curved upwards to a height 0.25 m at point *P* as shown in the above figure. Can the car pass point *P* ? Show your calculations. (3 marks)

13. < HKCE 2000 Paper I - 4 >

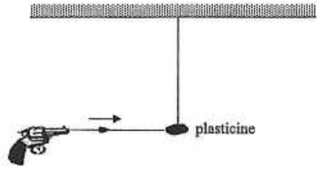
A car of mass 1000 kg moves along a straight road with a speed 10 m s^{-1}. It collides with a lorry of mass 3000 kg, which is initially at rest. Immediately after the collision, the lorry moves forward with a speed 4.5 m s^{-1}. The time of contact of the car and the lorry is 0.5 s. Find

(a) the speed of the car immediately after the collision, (2 marks)

(b) the average force acting on the lorry during the collision, (2 marks)

(c) the average force acting on the car during the collision. (1 mark)

14. < HKCE 2001 Paper I - 1 >



A lump of plasticine of mass 0.2 kg is hanging freely in air from a string as shown in the above figure. A bullet of mass 0.01 kg is fired from an air gun. It hits the plasticine and becomes embedded in it. The plasticine then swings to a maximum height of 0.06 m above its initial position.

(a) Find the speed of the plasticine immediately after the bullet is embedded in it. (2 marks)

(b) Hong Kong Ordinance states that the kinetic energy of bullets fired from air guns should not exceed 2 J. By considering the speed of the bullet before it hits the plasticine, explain why the above gun violates the Ordinance. (3 marks)

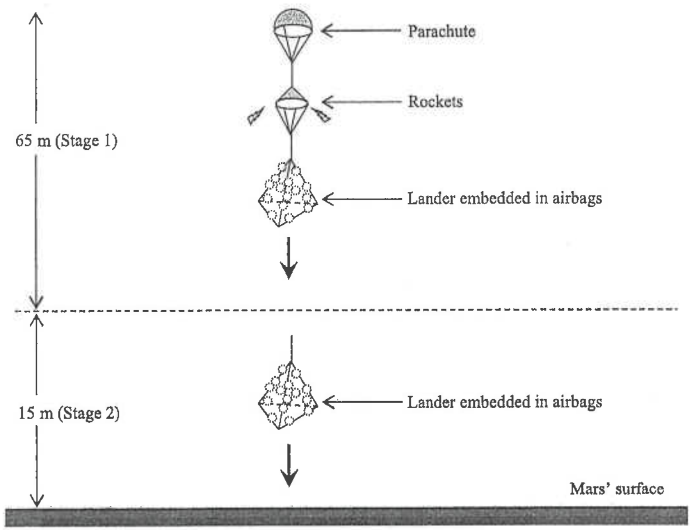
15. < HKCE 2003 Paper I - 3 >

A squash ball of mass 0.024 kg travelling with a horizontal speed of 16 m s^{-1} is hit by a racket. After the impact, the ball travels with a speed of 20 m s^{-1} in the opposite direction. Assume the time of contact between the ball and the racket is 0.15 s.

(a) Find the increase in kinetic energy of the ball. (2 marks)

(b) Find the average force acting on the ball by the racket during the impact. (3 marks)

16. **< HKCE 2003 Paper I - 11 >**



In 4 July, 1997, the lander 'Mars Pathfinder' landed on the surface of Mars. A teacher presents the following simplified information about the last two stages of the landing process as shown in the above figure.

Stage 1 : When the spacecraft (including the lander embedded in some airbags, a parachute and decelerating rockets) was at a height of 80 m above Mars' surface, it was falling with a speed of 75 m s^{-1}. At this instant, the rockets were fired. The parachute and rockets then exerted a total upward force of 16 900 N on the lander and brought it to an instantaneous rest at a height of 15 m above the surface.

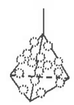
Stage 2 : At the instant when the lander was 15 m above the surface, the parachute and rockets were separated from it. The lander then fell from rest to the surface under the action of the gravity of Mars.

You may assume that the lander descended vertically and the air resistance exerted by the atmosphere on the lander was negligible.

(a) Consider Stage 1 and answer the following :

(i) Find the deceleration of the lander. (2 marks)

(ii) Draw a labelled diagram to show all the forces acting on the lander. (2 marks)



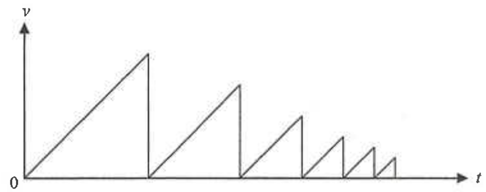
16. (a) (iii) The mass of the lander was 360 kg. Estimate the acceleration due to gravity on Mars' surface. (3 marks)

(b) Consider Stage 2 and answer the following :

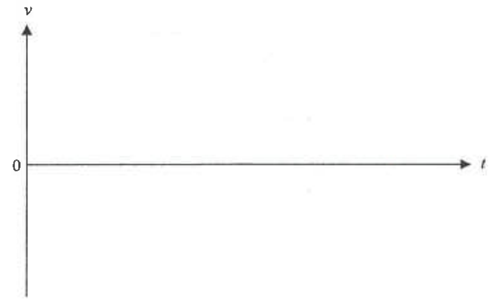
(i) Find the time required for the lander to reach the surface. (2 marks)

(ii) Explain how the airbags helped the lander to land on the surface safely. (2 marks)

(iii) The lander bounced a few times on the surface before coming to rest. As shown in the below figure, a student draws a sketch of the velocity-time graph of the lander, with $t = 0$ denoting the instant when the lander was 15 m above the surface. Assume that the motion took place in a vertical direction.



Explain whether the sketch is correct or not. If it is **incorrect**, draw a correct sketch for the graph. (4 marks)



17. **< HKCE 2006 Paper I - 9 >**

Read the following descriptions about a 'crash cushion system' and answer the questions that follow.

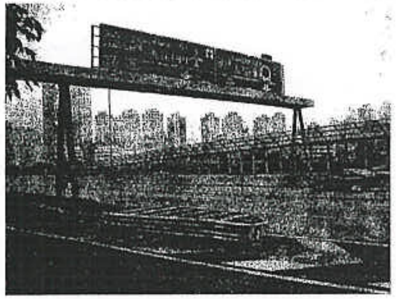


Figure 1

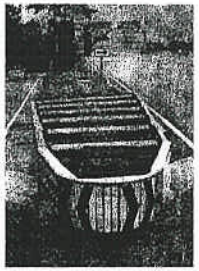


Figure 2

Figure 1 and Figure 2 show a crash cushion system installed at some junctions on highways. The system consists of a number of identical cushion boxes, containing sand or water, lined up and fixed on the road surface. During a crash, the boxes will burst one after another when the car runs through them. The boxes will act as a series of cushions and offer protection to the passengers.

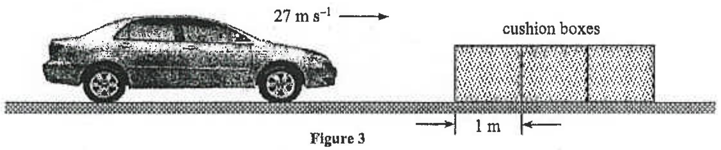


Figure 3

In a pilot test on the cushion boxes, a car of mass 1600 kg travelling at a speed of 27 m s^{-1} runs through the boxes on a road (see Figure 3). The speed v of the car after running through all the boxes is recorded. The test is repeated by varying the number of boxes N installed in the system. The Table below shows the results obtained.

N	1	2	3	4
v / m s^{-1}	25.2	22.8	21.1	18.2

Source : http://www.hk-phy.org/contextual/mechanics/ene/act_crash_cushion_e.html

17. (a) Assume that the deceleration of the car remains unchanged in the test.

(i) Using the data in the Table, plot a graph of v^2 against N in Figure 4, with v^2 ranging from 0 to 1000 m^2 s^{-2} and N from 0 to 10.

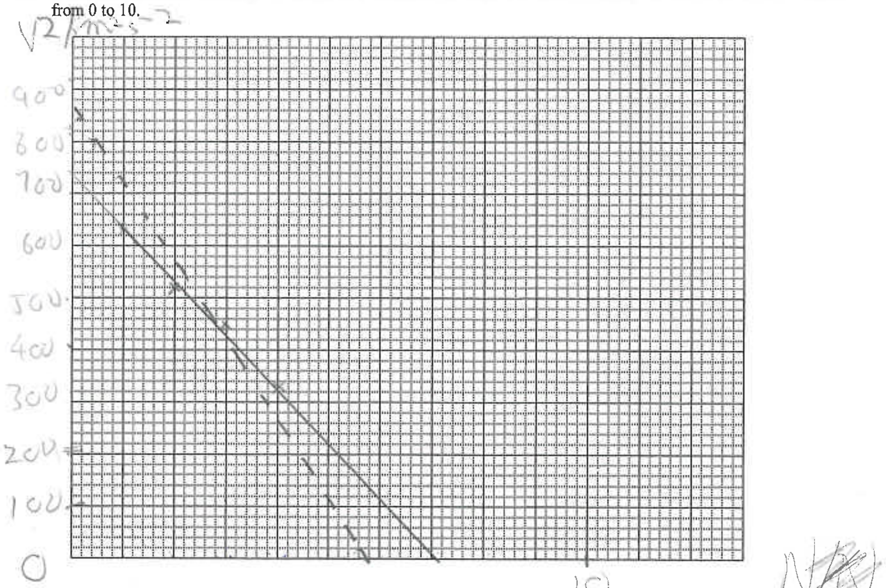


Figure 4

Hence or otherwise, estimate

(1) the average resistive force exerted by the cushion boxes on the car during the collision (given that the thickness of each cushion box is 1 m),

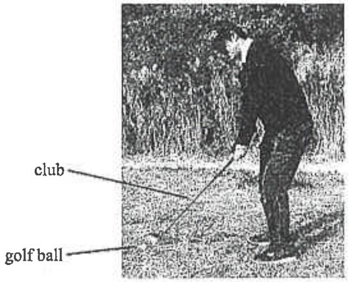
(2) the minimum number of cushion boxes required in order to stop the car in the test.(8 marks)

(ii) If the above test is repeated with a heavier car travelling at an initial speed lower than 27 m s^{-1}, sketch a graph of v^2 against N in Figure 4 that you would expect to obtain. Use a dotted line to sketch the graph. Assume that the average resistive force acting on the car remains unchanged throughout all the tests.(2 marks)

(b) Explain why it is undesirable to replace the cushion boxes with concrete blocks. (2 marks)

18. **< HKCE 2007 Paper I - 9 >**

A golf ball, of mass 40 g and initially at rest, is struck with a club in teeing off as shown in the figure below. The ball leaves the club with a speed of 44 m s^{-1}. Assume that air resistance is negligible.

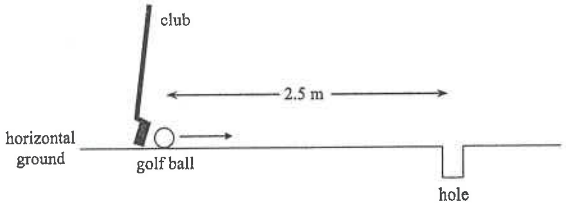


(a) (i) Calculate the change in momentum of the golf ball before and after teeing off. (2 marks)

(ii) The time of impact between the club and the ball during teeing off is 1 ms. Determine the average force acting on the ball during the impact. (2 marks)

(b) Robert finds that the club is harder than the golf ball. He claims that the force exerted on the club is smaller than that exerted on the golf ball during teeing off. Explain whether his claim is correct or not. (2 marks)

(c) When the golf ball is 2.5 m away from the hole, it is given a sharp horizontal push from rest and just reaches the hole as shown below. Estimate the initial speed of the golf ball if the average resistive force exerted on the ball is 0.03 N. (3 marks)



19. **< HKCE 2008 Paper I - 9 >**

Figure 1 shows a cable car system for transporting passengers from station *A* to station *B* on the top of a hill.

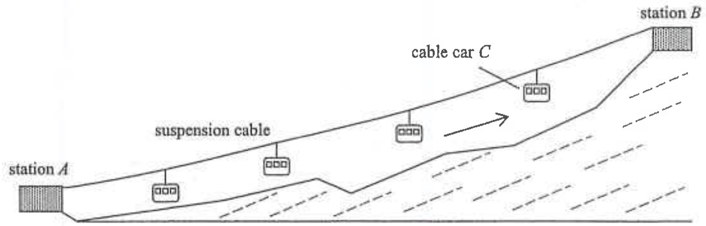


Figure 1

(a) The mass of the cable car *C* is 600 kg. State the magnitude and the direction of its weight. (2 marks)

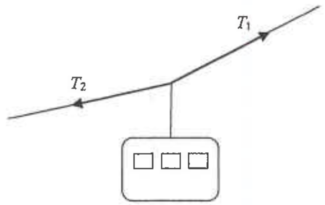


Figure 2

(b) Figure 2 shows cable car *C* which is suspended by the cable with tensions T_1 and T_2 on two sides. The cable car is moving at a constant velocity towards the top of the hill. Assume air resistance is negligible. Complete the vector diagram in Figure 3 to show T_1, T_2 and their resultant *T*. T_1 is already drawn in the figure. (2 marks)

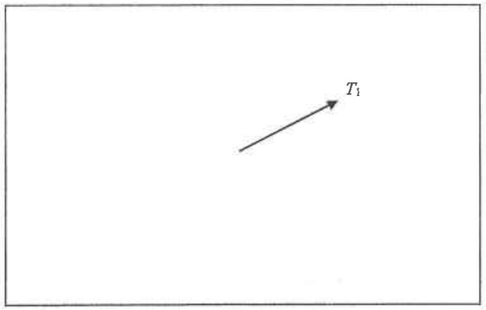


Figure 3

19. (c) The cable car C enters terminal B with a constant velocity 4.5 m s^{-1} in a horizontal direction. In order to allow the passengers to leave the cabin, the cable car C begins to slow down with a constant deceleration after it passes X. The velocity is reduced to 0.5 m s^{-1} at Y (see Figure 4). Then it moves with a constant velocity again. It takes 8 s for the cable car C to travel from X to Y.

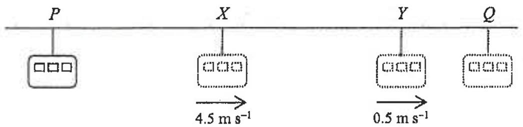


Figure 4

(i) Sketch the velocity-time graph of the cable car for the journey between X and Q in Figure 5.

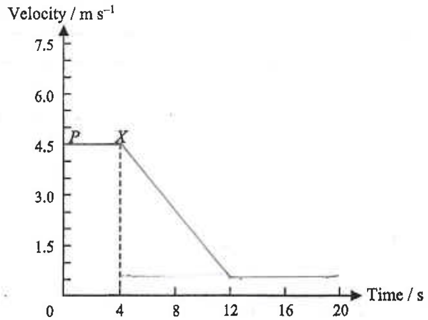


Figure 5

(2 marks)

(ii) Hence or otherwise, find the distance between X and Y. (2 marks)

Take the direction of the motion of the cable car as the positive direction.

(iii) A 60 kg person sits in the cable car. Find the change of momentum of the person during the journey between X and Y. (2 marks)

(iv) Hence or otherwise, find the net force acting on the person during the deceleration period. (2 marks)

20. **< HKCE 2010 Paper I - 10 >**

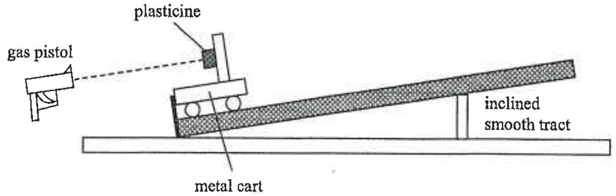


Figure 1

A metal cart with some plasticine fixed on it has a total mass of 40 g. It is initially at rest on an inclined smooth track (see Figure 1). A bullet of mass 0.43 g is shot from a gas pistol towards the car. Upon collision, the bullet is embedded in the plasticine, and the car moves along the track and rises to a maximum vertical distance of 5 cm. Neglect air resistance and take g to be 10 m s^{-2}.

(a) State the kind of collision between the bullet and the cart. (1 mark)

(b) Find the speed of the cart just after the collision. (2 mark)

(c) Find the speed of the bullet just before the collision. (2 marks)

(d) Suggest **two reasons** why the maximum potential energy gained by the cart with the embedded bullet is less than the kinetic energy of the bullet just leaving the pistol. (2 marks)

(e) After the first trial, Peter repeats the experiment with the same set up. He makes an error in aiming (see Figure 2) so that the bullet hits the metal part of the cart (instead of the plasticine) and rebounds backward. Describe and explain how this would affect the maximum vertical distance reached by the cart. (3 marks)

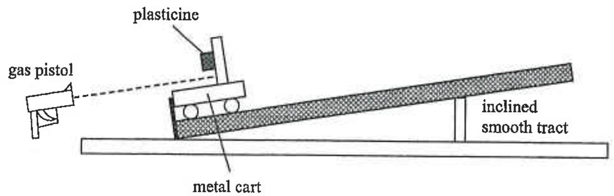


Figure 2

21. **< HKCE 2011 Paper I - 9 >**

Construction workers nowadays must wear safety helmets in construction sites. A safety helmet is made of a hard plastic shell and is held in place on the worker's head by elastic bands as shown in Figure (a).

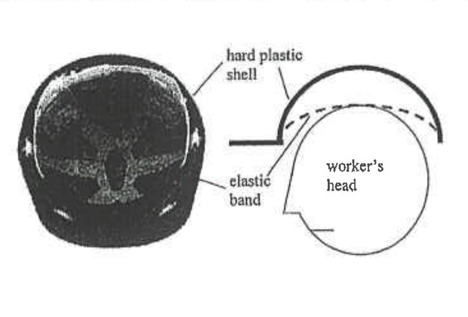


Figure (a)

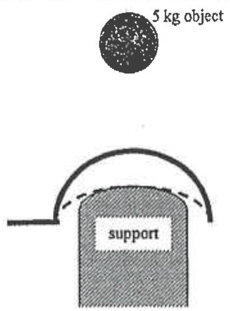
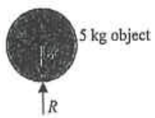


Figure (b)

During a safety test as shown in Figure (b), the helmet is put on a support. A small object of mass 5 kg is released from rest at 1 m above the helmet. The impact time between the object and the plastic shell is found to be 0.03 s. Assume that the object is at rest at the instant the impact ends.

(a) Figure (c) shows the forces acting on the object during the impact.

Figure (c)



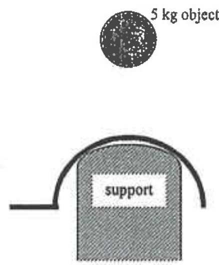
Is R (reaction force from the helmet) and W (weight of the object) an action and reaction pair ? Explain. (2 marks)

(b) (i) Find the speed of the object just before the impact. (1 mark)

(ii) Hence, find the magnitude of the average force acting on the plastic shell by the object during the impact. (4 marks)

21. (c) The safety test is repeated with elastic band removed as shown in Figure (d). It is found that the force acting on the plastic shell by the object becomes much larger during the impact. Hence, explain the function of the elastic band. (2 marks)

Figure (d)



Part B : HKAL examination questions

22. **< HKAL 2005 Paper I - 6 >**

A spacecraft is launched by a rocket. The rocket and the spacecraft have a total initial mass of 4.80×10^5 kg at take-off. The rocket engine propels hot exhaust gas at a constant speed of 2600 m s^{-1} in a downward direction. Assume that 2.30×10^3 kg of gas is expelled in the first second. (Neglect air resistance.)

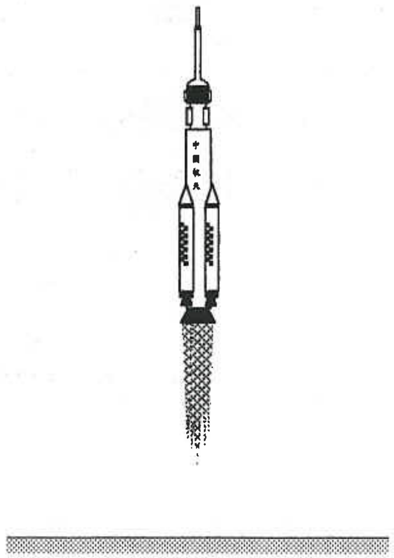
(a) Calculate the average force acting on the rocket due to the exhaust gas during the first second. (3 marks)

(b) Assuming that the change of mass of the rocket during the first second is negligible, estimate the acceleration of the rocket. (2 marks)

(c) If the rocket keeps on expelling exhaust gas at the same rate for the first 20 s, explain how the acceleration of the rocket will change. (2 marks)

Part C : HKDSE examination questions

23. < HKDSE Sample Paper IB - 11 >



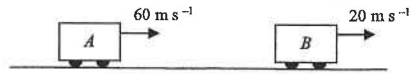
A spacecraft with an astronaut on board is launched on a rocket. The rocket with the spacecraft has an initial mass of 4.80×10^5 kg at take-off. The rocket engine propels hot exhaust gas at a constant speed of 2600 m s^{-1} downwards relative to the rocket. Assume that 1.15×10^3 kg of gas is expelled in the first 0.5 s. (Neglect air resistance.)

(a) Calculate the average force acting on the exhaust gas by the rocket during the first 0.5 s. (2 marks)

(b) In the figure shown, draw and label an arrow for each force acting on the rocket. Assuming that the change in mass of the rocket during the first 0.5 s is negligible, estimate the acceleration of the rocket. (3 marks)

24. < HKDSE 2012 Paper IB - 4 >

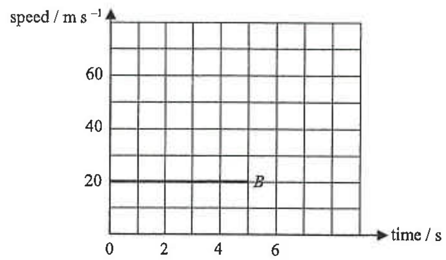
Train *A* initially travels at a speed of 60 m s^{-1} along a straight horizontal railway. Another identical train *B* travels ahead of *A* in the same direction on the same railway. Due to mechanical failure, *B* is only travelling at 20 m s^{-1}.



At time $t = 0$, *A* and *B* are x m apart, the captain of *A* receives a stopping signal and immediately *A* decelerates at 4 m s^{-2} while *B* continues to travel at 20 m s^{-1}. *A* eventually collides with *B* after 5 s. Neglect air resistance.

(a) (i) Find the speed of *A* just before collision. (2 marks)

(ii) The graph below shows how the speed of *B* varies with time within this 5 s. Sketch on the same graph the variation of the speed of *A* within the same period. (1 mark)



(iii) Based on the above information, determine the separation x of the two trains at $t = 0$. (3 marks)

(b) *A* and *B* locked together after collision.

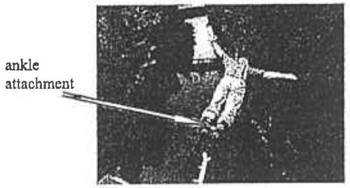
(i) Find the speed of them just after collision. (2 marks)

(ii) If the collision time between the trains is 0.2 s and the mass of each train is 5000 kg, find the magnitude and direction of the average impact force acted on *A* during collision. (3 marks)

25. < HKDSE 2014 Paper IB - 6 >

Read the following description about '**Bungee jumping**' and answer the questions that follow.

Bungee jumping is an activity that involves jumping from a tall structure while the person is connected to it via a thick elastic cord. When the bungee jumper jumps, the cord stretches after falling a certain distance. The bungee jumper is momentarily at rest at the lowest point but then bounces back up into the air. The bungee jumper continues to oscillate up and down a few times before he comes to a complete stop.



A simple 'ankle attachment' (as shown in the above photo) can be used to secure the player to the cord. However, due to accidents where the ankle attachment became detached from the bungee jumper, many operators now uses a 'fully body harness'.

When answering the following questions, neglect the effects of air resistance.

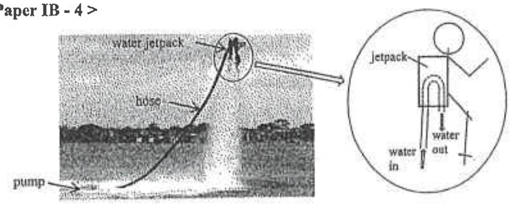
(a) (i) Describe the acceleration of the bungee jumper during the first downward fall to the lowest point. (3 marks)

(ii) State the energy change during the period from the beginning of the jump to the moment when the bungee jumper is at the lowest point of his first downward fall. (2 marks)

(b) In terms of the net force acting on the bungee jumper, explain why the cord has to be elastic. (2 marks)

(c) In terms of contact area, explain why a 'full body harness' is less likely to cause injuries to or detach from the bungee jumper than a simple 'ankle attachment' during a fall. (2 marks)

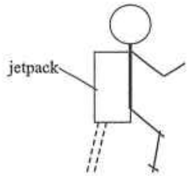
26. < HKDSE 2016 Paper IB - 4 >



A person wears a water jetpack which enables him to stay 'afloat' in equilibrium in the air as shown in the above figure. A pump on the sea surface continuously pumps water to the jetpack via a hose and the water is then ejected downwards.

(a) Referring to the above figure, water enters the U-shape hose inside the jetpack with a certain speed and is then ejected out vertically downwards. Use Newton's law(s) of motion to explain why a lifting force acting on the person is produced. (3 marks)

(b) Draw and label all the forces acting on the person wearing the jetpack as a whole in the free-body diagram below. Neglect the pulling force due to the hose connected to the jetpack. (1 mark)



(c) Suppose that water enters the jetpack with a speed of 10 m s^{-1} vertically upwards and is then ejected out at the same speed vertically downwards. Take $g = 9.81$ m s^{-2}.

(i) Just by considering the change of momentum of the water, estimate how much water, in kg, has to be ejected per second to provide a lifting force of 1000 N needed. (2 marks)

(ii) Water is pumped continuously to the water jetpack at a height of 7.5 m above sea surface and then ejected from it. By considering the gain in mechanical energy of the water, estimate the minimum output power of the pump. (3 marks)

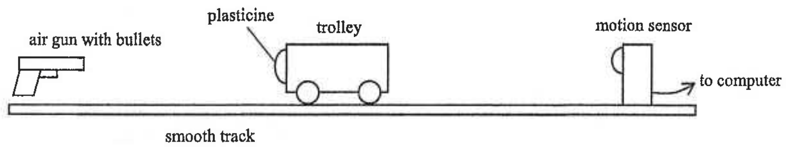
(d) The person changes to stay 'afloat' in equilibrium at a higher position. If the speed by which water enters and is ejected from the jetpack remains the same, would the amount of water ejected per second be greater than, equal to or smaller than the result found in (c) (i) ? Explain. (Neglect the weight of the hose.) (2 marks)

27. **< HKDSE 2017 Paper IB - 2 >**

The following experimental items are provided to set up an experiment to estimate the speed of a bullet fired from an air gun.

a smooth track
a trolley
a motion sensor used to measure the speed of the trolley
some plasticine
an air gun and bullets
an electronic balance

The set-up is shown in the following figure.



Describe the procedures of the experiment. State the physical quantities to be measured and an equation for finding the speed of the bullet. Write down **ONE** precaution for getting a more accurate result. (5 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) $m g h = \frac{1}{2} m v^2$

$\therefore v = \sqrt{2 g h}$ [1]

Velocity before impact $= \sqrt{2 \times 9.81 \times 0.45} = 2.97 \text{ m s}^{-1}$ (downwards) [1]

Velocity after impact $= \sqrt{2 \times 9.81 \times 0.2} = 1.98 \text{ m s}^{-1}$ (upwards) [2]

(b) $R - m g = \frac{m v - m u}{t}$ [1]

$R - (0.4)(9.81) = \frac{(0.4)(1.98) - (0.4)(-2.97)}{0.01}$ [1]

$R = 202 \text{ N}$ [1]

(c) $\Delta KE = \frac{1}{2} m v^2 - \frac{1}{2} m u^2$ [1]

$= \frac{1}{2}(0.4) \times (2.97)^2 - \frac{1}{2}(0.4) \times (1.98)^2 = 0.98 \text{ J}$ [1]

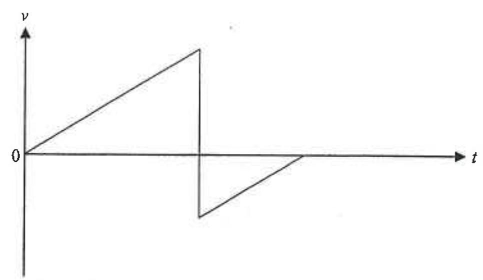
KE decreases [1]

since some kinetic energy changes to internal energy during impact. [1]

OR

the collision is not elastic. [1]

(d)



< initial portion is positive > [1]
< all straight line > [1]
< changes to negative during impact > [1]
< speed smaller after impact > [1]

2. (a) $m_A u_A + m_B u_B = m_A v_A + m_B v_B$ [1]

$0 = (1) \times (-2) + (1) \times v_B$

$\therefore v_B = 2 \text{ m s}^{-1}$ [1]

2. (b) Total KE after separation $= \frac{1}{2} m_A v_A^2 + \frac{1}{2} m_B v_B^2$ [1]

$= \frac{1}{2}(1) \times (2)^2 + \frac{1}{2}(1) \times (-2)^2 = 4$ J [1]

Potential energy stored in spring = 4 J [1]

(c) $F_A = \frac{m_A v_A - m_A u_A}{t} = \frac{(1)(-2) - 0}{0.1} = -20$ N [2]

$F_B = 20$ N [1]

Direction : F_A – towards the left F_B – towards the right [1]

(d) (i) $m_B u_B + m_C u_C = m_B v_B + m_C v_C$ [1]

$(1) \times (2) + 0 = (1 + 1) v$ $\therefore v = 1$ m s^{-1} [1]

(ii) No ! [1]

KE before impact $= \frac{1}{2}(1) \times (2)^2 = 2$ J [1]

KE after impact $= \frac{1}{2}(1 + 1) \times (1)^2 = 1$ J [1]

KE lost $= 2 - 1 = 1$ J [1]

3. (a) By $v^2 = u^2 + 2as$ $\therefore v^2 = 0 + 2 \times (9.81) \times (1)$ [1]

$\therefore v = 4.43$ m s^{-1} [1]

OR

By $mgh = \frac{1}{2} m v^2$ $\therefore (9.80)(1) = \frac{1}{2} v^2$ [1]

$\therefore v = 4.43$ m s^{-1} [1]

(b) Average force R acting on the ball by the floor : $R - mg = \frac{mv - mu}{t}$ [1]

$\therefore R - (0.5)(9.81) = \frac{(0.5)(0) - (0.5)(-4.43)}{(0.1)}$ $\therefore R = 27.1$ N [1]

By Newton's 3rd law, average force acting on floor by the ball is 27.1 N. [1]

4. (a) $u = \frac{70 \times 1000}{3600} = 19.44$ m s^{-1}

By $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$ [1]

$\therefore (900)(19.44) + (3000) u_2 = 0$ [1]

$\therefore u_2 = -5.83$ m s^{-1}

$\therefore$ speed of truck is 5.83 m s^{-1} [1]

(b) Both vehicles will experience equal magnitude of force. [1]

Since the two forces are action and reaction pair. [1]

By Newton's third law, they must be equal in magnitude. [1]

4. (c) For the private car driver

$F = \frac{mv - mu}{t}$ [1]

$= \frac{0 - (70)(19.44)}{0.2}$ [1]

$= -6800$ N [1]

For the truck driver

$F = \frac{mv - mu}{t} = \frac{0 - (70)(-5.83)}{0.2}$ [1]

$= 2040$ N [1]

The private car driver will be injured more seriously. [1]

(d) Seat belt [1]

To prevent the driver from throwing forward and hitting the glass. [2]

(or Seat belt is elastic to increase the time of impact, thus decrease the impact force.) [2]

OR

Bumper of the car collapsible during impact [1]

To increase the duration time of impact and thus reduce the impact force. [2]

5. (a) (i) $W = Fs = (50) \times (0.1)$ [1]

$= 5$ J [1]

(ii) Work done by force = KE gained by disc [1]

$\therefore (5) = \frac{1}{2}(0.1) v^2$ [1]

$\therefore v = 10$ m s^{-1} [1]

(b) $F = \frac{mv - mu}{t}$ [1]

$= \frac{(0.1)(10) - (0.1)(-10)}{0.2}$ [2]

$= 10$ N [1]

(c) Statement 1 – false [1]

Reason : By Newton's 1st law, the disc will keep on moving with uniform velocity [1]

even when there is no net force acting on it. [1]

Statement 2 – true [1]

Reason : The greater the speed, the greater the change of momentum.

By Newton's 2nd law, force is proportional to the rate of change of momentum [1]

$\therefore$ The force is greater. [1]

6. (a) (1) $u_A = \frac{4.9}{7\times0.02} = 35\ \text{cm s}^{-1}$ [1]

(2) $v_A = \frac{1.6}{8\times0.02} = 10\ \text{cm s}^{-1}$ [1]

(3) $v_B = \frac{6.5}{13\times0.02} = 25\ \text{cm s}^{-1}$ [1]

(b) $m_A u_A + m_B u_B = m_A v_A + m_B v_B$ [1]

$m_A (35) + 0 = m_A (10) + m_B (25)$ [1]

$\therefore\ m_A : m_B = 1$ [2]

(c) Total KE before collision $= \frac{1}{2}\times(4)\times(0.2)^2 = 0.08$ [1]

Final KE after collision $= \frac{1}{2}\times(4)\times(0.1)^2 + \frac{1}{2}\times(1)\times(0.4)^2 = 0.10$ [1]

By the Principle of conservation of energy, it is impossible that
the kinetic energy after collision becomes greater than the kinetic energy before collision. [2]

7. (a) (i) $F = \frac{mv-mu}{t} = \frac{(0.8)(1.8)-(0.8)(0)}{0.05}$ [1]

$= 28.8\ \text{N}$ [1]

(ii) $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$(0.8)\times(1.8) + 0 = (0.8+m)\times(1.6)$ [1]

mass of plasticine $m = 0.1\ \text{kg}$ [1]

(iii) Work done against friction = loss in kinetic energy [1]

$(3)\times s = \frac{1}{2}(0.9)\times(1.6)^2$ [1]

$\therefore\ s = 0.384\ \text{m}$ [1]

(b) Chemical energy is changed into elastic potential energy stored in the spring, [1]
which is then changed into kinetic energy of the block when it is released. [1]

(c) Kinetic energy is not conserved because the collision between the block and the plasticine is inelastic. [1]
Some energy is changed into internal energy during the collision. [1]

(d) After the block reaches the highest point, it will stop and remain at rest at that point [1]
because component of weight along the plane $= mg\sin\theta$ [1]
$= 0.9\times9.81\times\sin 15° = 2.29\ \text{N}$ [1]
which is smaller than the frictional force. [1]

8. (a) (i) Momentum of $P = mv = 0.4\times3 = 1.2\ \text{kg m s}^{-1}$ [1]

(ii) $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$ [1]

$1.2 + 0 = 0 + (0.6)\times v \qquad \therefore\ v = 2\ \text{m s}^{-1}$ [1]

(iii) $F = \frac{mv-mu}{t} = \frac{(0.4)(0)-(0.4)(3)}{0.05} = -24\ \text{N}$ [2]

(b) Initial K.E. $= \frac{1}{2}(0.4)\times(3)^2 = 1.8\ \text{J}$ [1]

Final K.E. $= \frac{1}{2}(0.6)\times(2)^2 = 1.2\ \text{J}$ [1]

Since K.E. is lost in the collision, it is not elastic. [1]

(c) (i) $mgh = \frac{1}{2}mv^2$ [1]

$(0.6)\times(9.81)h = \frac{1}{2}(0.6)\times(2)^2 \qquad \therefore\ h = 0.204\ \text{m}$ [1]

(ii) There is no work done [1]
because the tension is always perpendicular to the motion of the bob. [2]

(d) An external force acts on the plasticine [1]
by the ground during the collision. [1]

OR

The total momentum of *P*, the plasticine and the Earth is conserved. [2]

9. (a) (i) (1) Momentum of *P* before collision $= 0.5\times10 = 5\ \text{kg m s}^{-1}$ [1]

(2) Change in momentum of $P = mv - mu$ [1]
$= (0.5)\times(-6)-(0.5)\times(10) = -8\ \text{kg m s}^{-1}$ [1]

(3) Time of contact $= 0.1\ \text{s}$ [1]

(4) Average force on $P = \frac{mv-mu}{t} = \frac{-8}{0.1}$ [1]
$= -80\ \text{N}$ [1]

(ii) Yes! The average force acts on *Q* is equal in magnitude to that acting on *P* [1]
because the two forces are action and reaction pair according to Newton's 3rd law. [1]

(iii) Momentum must be conserved [1]
because there is no external force acting on *P* and *Q* during the collision. [1]
However kinetic energy may or may not be conserved. [1]
It depends on whether the collision is elastic or not. [1]

(b) If the car is made of very strong material, it will be brought to rest in a very short time during a collision. [1]
A large force then acts on the passengers which may cause serious injuries. [1]

10. (a)

< label with T or tension > [1]

< label with W, mg or weight > [1]

(b) When P swings from A to B, its potential energy is converted to kinetic energy. [1]

When P collides with Q, some of its kinetic energy is converted to the kinetic energy of Q. [1]

When P and Q swing upward after impact,
their kinetic energies are converted back into potential energies. [1]

(c) (i) By conservation of energy,

$\frac{1}{2} m v^2 = m g h$ [1]

$\therefore \frac{1}{2} \times (1)^2 = (9.81) \times h$

$\therefore h = 0.0510$ m [1]

(ii) Average force $= \dfrac{mv - mu}{t}$

$= \dfrac{(0.3)(0.5) - (0.3)(-1)}{0.02}$ **OR** $= \dfrac{(0.3)(-0.5) - (0.3)(1)}{0.02}$ [1]

$= 22.5$ N $\qquad = -22.5$ N [1]

(iii) (1) Momentum before collision $= 0.3 \times (1.0) + 0.75 \times (0) = 0.3$ kg m s^{-1} [1]

Momentum after collision $= 0.3 \times (-0.5) + 0.75 \times (0.6) = 0.3$ kg m s^{-1} [1]

$\therefore$ Momentum is conserved in the collision.

(2) Total kinetic energy before the collision $= \frac{1}{2}(0.3) \times (1.0)^2 = 0.15$ J [1]

Total kinetic energy after the collision $= \frac{1}{2}(0.3) \times (0.5)^2 + \frac{1}{2}(0.75) \times (0.6)^2 = 0.1725$ J [1]

Since the kinetic energy after the collision increases, the data are impossible. [1]

11. (a) Kinetic energy of the ball $= \frac{1}{2} m v^2 = \frac{1}{2} \times 10 \times 100^2 = 50000$ J [1]

As the kinetic energy of the ball is less than 60000 J, so the ball cannot destroy the target. [1]

(b) (i) By conservation of momentum,

$1000\ V = 10 \times 100$ [1]

$\therefore V = 1$ m s^{-1} [1]

11. (b) (ii) $\frac{1}{2} m v^2 = m g h = m g s \sin\theta$ [1]

$\frac{1}{2} \times 1000 \times 1^2 = 1000 \times 9.81 \times s \sin 15°$ [1]

$\therefore s = 0.197$ m [1]

(c) Total input energy $=$ KE of cannon $+$ KE of ball $+$ energy loss [1]

$= \frac{1}{2} \times 1000 \times 1^2 + \frac{1}{2} \times 10 \times 100^2 + 80000$

$= 130500$ J

Efficiency $= \dfrac{\text{useful output energy}}{\text{total input energy}} \times 100\%$ [1]

$= \dfrac{50000}{130500} \times 100\% = 38.3\%$ [1]

(d) (i) $F = \dfrac{mv - mu}{t}$ [1]

$= \dfrac{0 - 10 \times 100}{0.05}$

$= -20000$ N [1]

(ii) Momentum of the ball and the target is not conserved [1]

because there is an external force [1]

acting on the target by the ground. [1]

< OR >

The total momentum of the ball, the target together with the Earth is conserved. [3]

12. (a) By Conservation of momentum,

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$(0.2) \times (3) = (0.2 + 0.1)\, v$ [1]

$\therefore v = 2$ m s^{-1} [1]

(b) Total kinetic energy of the car and plasticine $= \frac{1}{2} m v^2$

$= \frac{1}{2} \times (0.3) \times (2)^2$

$= 0.6$ J [1]

Potential energy gained by the car in order to reach P $= m g h$

$= (0.3) \times (9.81) \times (0.25)$

$= 0.736$ J [1]

Since the KE is less than the PE, the car cannot pass P. [1]

13. (a) $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$ [1]

$(1000) \times (10) + (3000) \times (0) = (1000)\, v_1 + (3000) \times (4.5)$

$v_1 = -3.5 \text{ m s}^{-1}$ [1]

(b) $F_2 = \dfrac{mv - mu}{t}$

$= \dfrac{3000 \times 4.5 - 0}{0.5}$ [1]

$= 27000 \text{ N}$ [1]

(c) $F_1 = \dfrac{mv - mu}{t} = \dfrac{(1000)\times(-3.5) - (1000)\times(10)}{0.5}$

$= -27000 \text{ N}$ [1]

14. (a) Loss in KE = Gain in PE

$\therefore\ \frac{1}{2} m v^2 = m g h$ [1]

$\therefore\ v^2 = 2 g h = 2 \times 9.81 \times 0.06$

$\therefore\ v = 1.08 \text{ m s}^{-1}$ [1]

(b) $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$(0.01)\, u_1 = (0.01 + 0.2)\, (1.08)$

$\therefore\ u_1 = 22.7 \text{ m s}^{-1}$ [1]

Kinetic energy of the bullet $= \frac{1}{2} m v^2$ [1]

$= \frac{1}{2} (0.01)\, (22.7)^2$

$= 2.58 \text{ J} > 2 \text{ J}$ [1]

$\therefore$ The gun violates the ordinance.

15. (a) Increase of KE $= \frac{1}{2} m v^2 - \frac{1}{2} m u^2$

$= \frac{1}{2} (0.024)\, (20)^2 - \frac{1}{2} (0.024)\, (16)^2$ [1]

$= 1.728 \text{ J}$ [1]

(b) Average force on the ball $= \dfrac{mv - mu}{t}$ [1]

$= \dfrac{(0.024)(20) - (0.024)(-16)}{0.15}$ [1]

$= 5.76 \text{ N}$ [1]

16. (a) (i) $v^2 = u^2 + 2 a s$

$(0) = (75)^2 + 2\, a\, (65)$ [1]

$a = -43.27 \approx -43.3 \text{ m s}^{-2}$ [1]

(ii)

[1]

[1]

(iii) $T - W = m a$

$(16900) - W = (360)\, (43.27)$ [1]

$W = 1322.8 \text{ N}$ [1]

$g = \dfrac{W}{m} = \dfrac{(1322.8)}{(360)} = 3.67 \text{ m s}^{-2}$ < accept 3.64 m s^{-2} > [1]

OR

$T - m g = m a$ [1]

$(16900) - (360)\, g = (360)\, (43.27)$ [1]

$g = 3.67 \text{ m s}^{-2}$ < accept 3.64 m s^{-2} > [1]

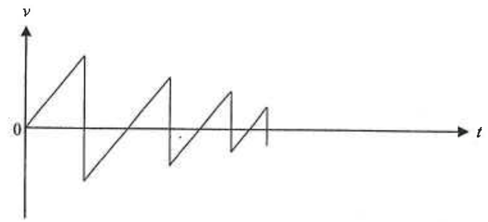
(b) (i) $s = u t + \frac{1}{2} a t^2$

$\therefore\ (15) = (0) + \frac{1}{2} (3.64)\, t^2$ [1]

$\therefore\ t = 2.87 \text{ s}$ [1]

(ii) They are elastic to increase the duration time of impact [1]
and thus reduce the impact force on landing. [1]

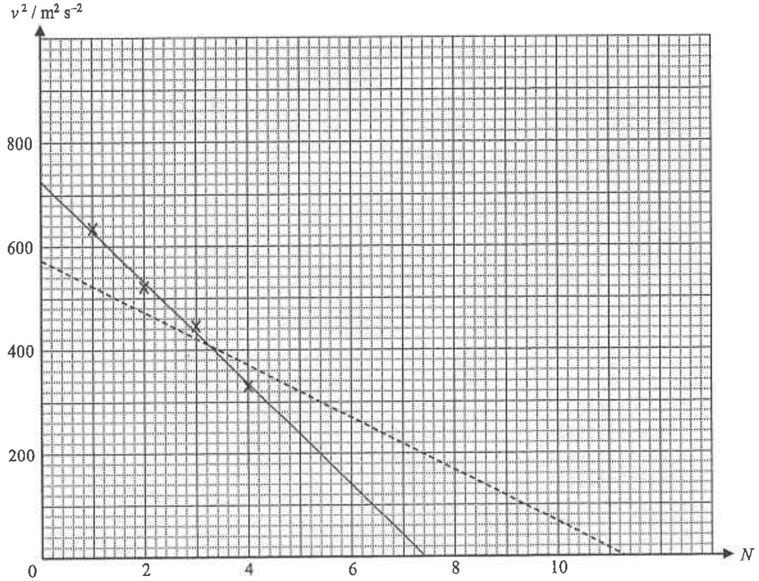
(iii) The sketch is not correct since the velocity should have positive and negative values [1]
as the direction of the velocity of the lander may be upwards and downwards during the bouncing.



[3]

17. (a) (i)

N	1	2	3	4
v / m s^{-1}	25.2	22.8	21.1	18.2
v^2 / m^2 s^{-2}	635	520	445	331



< Correct label of two axes with correct unit > [1]

< Suitable scale > [1]

< Points plotted correctly > [1]

< Straight line drawn > [1]

(1) When $v^2 = 0$, $N = 7.4$ < 7.2 to 8.0 acceptable >

Stopping distance = 7.4 m

By $\frac{1}{2} m u^2 = F s$ [1]

$\therefore$ $\frac{1}{2}(1600)(27)^2 = F(7.4)$ [1]

$\therefore$ F = 78800 N < 70000 to 84800 acceptable > [1]

(2) Minimum number of boxes = 8 [1]

(ii) < Magnitude of the slope is smaller > [1]

< Smaller y-intercept > (x-intercept may be greater or smaller than the original one) [1]

(b) The time of collision would become smaller, [1]

and thus the impact force would become greater. [1]

18. (a) (i) Change of momentum $= m v - m u$ [1]

$= (0.04)(44) - 0$

$= 1.76$ N s [1]

(ii) Average force $= \dfrac{mv - mu}{t} = \dfrac{(1.76)}{(1 \times 10^{-3})}$ [1]

$= 1760$ N [1]

(b) He is not correct [1]

since they are action and reaction pair, the force exerted on the club is equal to that exerted on the ball. [1]

(c) $\frac{1}{2} m u^2 = f s$ [1]

$\frac{1}{2}(0.04)u^2 = (0.03)(2.5)$ [1]

$u = 1.94$ m s^{-1} [1]

< OR >

$F = m a$ $\therefore$ $(-0.03) = (0.04) a$ $\therefore$ $a = -0.75$ m s^{-2} [1]

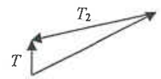
$v^2 = u^2 + 2as$ [1]

$(0) = u^2 + 2(-0.75)(2.5)$ $\therefore$ $u = 1.94$ m s^{-1} [1]

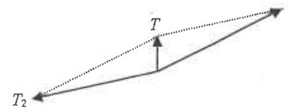
19. (a) 6000 N [1]

downwards [1]

(b)



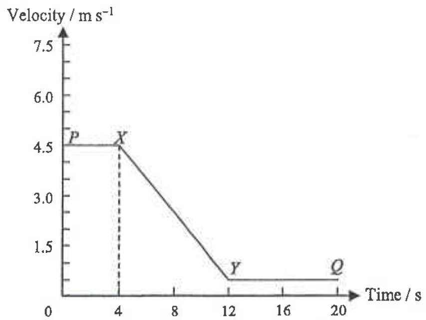
OR



< tip-to-tail method or parallelogram > [1]

< resultant T is vertical and upward > [1]

(c) (i)



< XY : straight line with negative slope and Y is at 12 s and 0.5 m s^{-1} > [1]

< YQ : horizontal straight line, velocity at 0.5 m s^{-1} > [1]

19. (c) (ii) XY = area under the graph between X and Y [1]

$= \frac{1}{2}(4.5 + 0.5) \times (8)$

$= 20$ m [1]

OR

a = slope = -0.5 m s^{-2} [1]

$s = ut + \frac{1}{2}at^2$ **OR** $v^2 = u^2 + 2as$

$s = (4.5)(8) + \frac{1}{2} \times (-0.5)(8)^2$ $(0.5)^2 = (4.5)^2 + 2(-0.5)s$

$s = 20$ m $s = 20$ m [1]

(iii) Change of momentum $= mv - mu$ [1]

$= (60)(0.5 - 4.5)$

$= -240$ N s (OR -240 kg m s^{-1}) [1]

(iv) Net force = change of momentum / time

$= -\dfrac{240}{8}$ [1]

$= -30$ N [1]

OR

Net force $= ma$ [1]

$= (60)(-0.5)$

$= -30$ N [1]

20. (a) inelastic collision [1]

(b) $\frac{1}{2}mv^2 = mgh$ [1]

$\frac{1}{2}v^2 = (10)(0.05)$

$\therefore v = 1$ m s^{-1} [1]

(c) $m_1 u = (m_1 + m_2) v$ [1]

$(0.43) u = (0.43 + 40)(1)$

$\therefore u = 94.0$ m s^{-1} [1]

(d) Mechanical energy (OR kinetic energy) is lost during the inelastic collision between the bullet and the cart. [1]

Some kinetic energy of the bullet changes to potential energy before it hits the cart. [1]

(e) Maximum height reached increases. [1]

As the bullet rebounds after the collision, its change of momentum increases. [1]

By the law of conservation of momentum, the momentum of the cart increases, thus it rises to a higher height. [1]

21. (a) The forces are not action and reaction pair. [1]

It is because (any **ONE** of the following) [1]

∗ they are acting on the same object

∗ they have different magnitude

∗ they belong to different type of force

(b) (i) $v^2 = u^2 + 2as = 0 + 2(9.81)(1)$ $\therefore v = 4.43$ m s^{-1} [1]

OR

$mgh = \frac{1}{2}mv^2$ $\therefore (9.81)(1) = \frac{1}{2}v^2$ $\therefore v = 4.43$ m s^{-1}

(ii) Average force R acting on the object by the shell :

$R - mg = \dfrac{mv - mu}{t}$ [1]

$R - (5)(9.81) = \dfrac{0-(5)(-4.43)}{0.03}$ [1]

$R = 787$ N [1]

By Newton's 3rd law, the magnitude of the average force acting on the shell by the object = 787 N [1]

(c) The elastic extends during the impact. [1]

The impact time becomes longer, thus the average force becomes smaller. [1]

OR

Without the elastic band, the impact time becomes shorter. [1]

22. (a) Force on the exhaust gases :

$F = \dfrac{mv - mu}{t} = \dfrac{m}{t}(v-u) = (2.30\times10^3)(2600-0)$ [1]

$= 5.98 \times 10^6$ N [1]

By Newton's third law of action-reaction, force acting on the rocket by the exhaust gases is 5.98×10^6 N. [1]

(b) $F - mg = ma$ [1]

$(5.98 \times 10^6) - (4.80 \times 10^5)(9.81) = (4.80 \times 10^5) a$

$\therefore a = 2.65$ m s^{-2} [1]

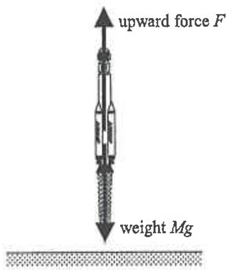
(c) Since the average thrust remains unchanged, as the mass of the rocket gradually decreases, [1]

the acceleration of the rocket would gradually increase. [1]

23. (a) $F = \dfrac{m}{t}(v-u) = \dfrac{(1.15\times10^3)}{(0.5)}\times(2600-0)$ [1]

$= 5.98 \times 10^6$ N [1]

23. (b)



[1]

$F - Mg = Ma$ [1]

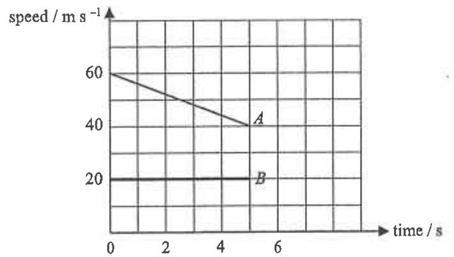
$(5.98 \times 10^6) - (4.80 \times 10^5)(9.81) = (4.80 \times 10^5)\, a$

$a = 2.65 \text{ m s}^{-2}$ [1]

24. (a) (i) $v = u + at = (60) + (-4)(5)$ [1]

$= 40 \text{ m s}^{-1}$ [1]

(ii)



[1]

(iii) Distance travelled by $A = \frac{1}{2}(40 + 60) \times (5) = 250 \text{ m}$ [1]

Distance travelled by $B = 20 \times 5 = 100 \text{ m}$ [1]

Separation $x = 250 - 100 = 150 \text{ m}$ [1]

OR

$x = \frac{1}{2}(40 + 60) \times (5) - 20 \times 5$ [2]

$= 150 \text{ m}$ [1]

(b) (i) $m_1 u_1 + m_2 u_2 = (m_1 + m_2)\, v$

$(m)(40) + (m)(20) = (m + m)\, v$ [1]

$v = 30 \text{ m s}^{-1}$ [1]

(ii) $F_A = \dfrac{mv - mu}{t} = \dfrac{(5000)(30) - (5000)(40)}{(0.2)}$ [1]

$= -250\,000 \text{ N}$ [1]

The magnitude of the impact force on A is 250 000 N and in the backward (**OR** leftward) direction. [1]

25. (a) (i) Before the elastic cord stretches, the acceleration of the jumper is equal to g. [1]

As the cord stretches, the acceleration of the jumper decreases. [1]

As the cord further stretches that the tension is greater than mg, the jumper decelerates until it comes to rest. [1]

(ii) At the beginning, gravitational potential energy of the jumper changes to its kinetic energy, [1]

and then to the elastic potential energy of the cord at the lowest point. [1]

(b) Elastic cord increases the stopping time, [1]

thus reduces the force acting on the player. [1]

(c) The contact area is larger, [1]

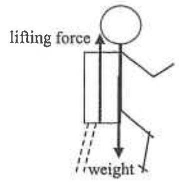
hence the pressure is smaller during the fall and thus less likely to cause injuries. [1]

26. (a) By Newton's second law, a force acts on the water to change its momentum from upwards to downwards. [1]

By Newton's third law, [1]

as a force acts downwards on the water by the jetpack, the water exerts an upward reaction on the jetpack. [1]

(b)



< upward lifting force and downward weight drawn and labelled correctly > [1]

[weight can be labelled with W or mg] [lifting force labelled with F is not accepted]

(c) (i) $F = \dfrac{m}{t}(v - u)$ [1]

$\therefore\ (1000) = \dfrac{m}{t}[(10) - (-10)]$

$\therefore\ \dfrac{m}{t} = 50 \text{ kg s}^{-1}$ [1]

(ii) Consider time of 1 s.

Work done by the pump = gain of PE + gain of KE

$\therefore\ W = mgh + \frac{1}{2}mv^2$ [1]

$= (50)(9.81)(7.5) + \frac{1}{2}(50)(10)^2$ [1]

$= 6180 \text{ J}$

$\therefore\ P = 6180 \text{ W}$ [1]

(d) To stay afloat in equilibrium, same lifting force is required. [1]

Thus, amount of water ejected per second would be the same. [1]

27. Measure the mass of a bullet m and the mass of the trolley with plasticine M. [1]

Fire the bullet towards the plasticine. [1]

Read the speed of the trolley v immediately after the bullet hit the plasticine. [1]

By conservation of the momentum,

$m u = (M + m) v$

Speed u of the bullet is found by $u = \dfrac{M + m}{m} v$ [1]

Precaution : (any **ONE** of the following) [1]

* The bullet should be fired close to the plasticine.
* The bullet should be fired along the direction of travel of the trolley.
* The track must be horizontal.

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普通氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恒星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

The following list of formulae may be found useful :

For uniformly accelerated motion	$v = u + a t$
	$s = u t + \frac{1}{2} a t^2$
	$v^2 = u^2 + 2 a s$
Equation of a straight line	$y = m x + c$

Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81 \text{ m s}^{-2}$ (close to the Earth)

Part A : HKAL examination questions

1. **< HKAL 1981 Paper I - 34 >**

Two small balls A and B are launched simultaneously from the top of a building. A is projected horizontally with an initial velocity of 10 m s^{-1} and B is projected at an angle of 60° above the horizontal with an initial velocity of 20 m s^{-1}. The motion of both A and B is in the same plane and air resistance is negligible. Which of the following statements is/are correct when they are travelling in air ?

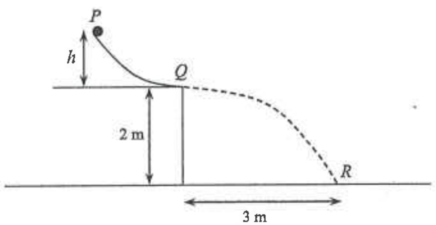
(1) Balls A and B travel equal vertical distances in equal times.

(2) Balls A and B travel equal horizontal distances in equal times.

(3) Balls A and B never meet.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

2. **< HKAL 1983 Paper I - 7 >**



A small particle is released from P and slips down a smooth curve to Q, at the edge of a table 2 m high, where it travels horizontally. It then leaves the table and travels freely under gravity until it hits the ground at R, at a horizontal distance of 3 m from Q. What is the vertical distance h of P above Q ?

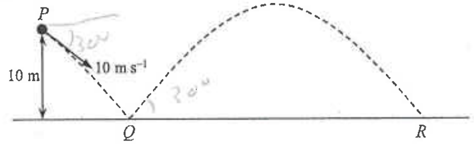
A. 1.13 m
B. 1.33 m
C. 2.50 m
D. 3.00 m

3. **< HKAL 1984 Paper I - 2 >**

A ball is thrown horizontally from the top of a building at a speed of 20 m s^{-1}. What will be the speed of the object after 3 s ?

A. 20.0 m s^{-1}
B. 25.0 m s^{-1}
C. 30.0 m s^{-1}
D. 35.6 m s^{-1}

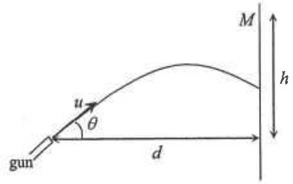
4. **< HKAL 1987 Paper I - 5 >**



A particle is projected with a speed of 10 m s^{-1} downwards from P at an angle of 30° to the horizontal. The particle rebounds from the ground at Q as shown in the above figure. If the collision is perfectly elastic, and assume the ground is smooth, what is the horizontal distance QR when it reaches the ground at R ? (Take g to be 10 m s^{-2})

A. 10.0 m.
B. 13.0 m.
C. 26.0 m.
D. 43.5 m.

5. **< HKAL 1990 Paper I - 4 >**



As shown in the above figure, a hunter aims his gun at a monkey which is at rest at the point M, and his gun makes an angle θ with the horizontal. When the gun is fired, the monkey releases itself from M with zero initial velocity. In order that the bullet can hit the monkey, the angle θ depends on

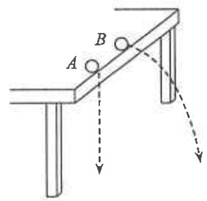
(1) u, the initial speed of the bullet.
(2) h, the vertical height of the monkey above the level of the gun.
(3) d, the horizontal distance of the gun from the monkey.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

6. **< HKAL 1993 Paper I - 4 >**

Two small balls A and B are placed at the edge of a table. When ball A is pushed slightly to fall vertically to the ground, ball B is projected horizontally at the same instant and it reaches the ground through a parabolic path. If air resistance is neglected, which of the following statements is/are correct ?

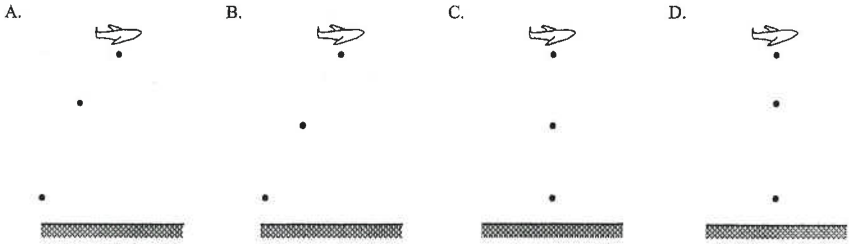
(1) Balls A and B reach the ground at the same time.
(2) Balls A and B have the same acceleration during their motion in air.
(3) Balls A and B have the same vertical velocity on reaching the ground.



A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

7. < HKAL 1994 Paper IIA - 6 >

A bomber is flying horizontally to the right with constant velocity. It releases three bombs one by one at a constant time interval. If air resistance is neglected, which of the following diagrams best shows the positions of the bomber and the bombs at a certain time instant ?



8. < HKAL 1997 Paper IIA - 3 >

A ball is projected horizontally from a table surface with an initial speed u. It hits the ground with a speed v. If air resistance is neglected, what is the time of flight of the ball in air ?

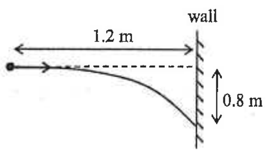
A. $\frac{v-u}{2g}$

B. $\frac{v-u}{g}$

C. $\frac{\sqrt{v^2-u^2}}{2g}$

D. $\frac{\sqrt{v^2-u^2}}{g}$

9. < HKAL 1998 Paper IIA - 6 >



A particle is projected horizontally towards a vertical wall at a horizontal distance of 1.2 m away. It hits the wall at a point which is 0.8 m below its initial horizontal level. If air resistance is neglected, what is the speed of the particle when it hits the wall ?

A. 2.65 m s^{-1}
B. 3.45 m s^{-1}
C. 3.95 m s^{-1}
D. 4.95 m s^{-1}

10. < HKAL 2001 Paper IIA - 3 >

A ball is projected at an elevation angle of 45° to the horizontal with an initial kinetic energy E_o. Neglecting air resistance, what is the kinetic energy of the ball when it is moving halfway up ?

A. $\frac{1}{4}E_o$

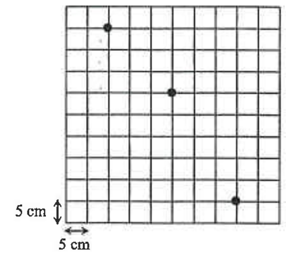
B. $\frac{1}{2}E_o$

C. $\frac{1}{3}E_o$

D. $\frac{3}{4}E_o$

11. < HKAL 2003 Paper IIA - 3 >

A small particle is projected horizontally into the air. The figure shows **part** of the stroboscopic picture. The side of each square of the grid is 5 cm long. Estimate the frequency of the stroboscopic lamp used. (Neglect air resistance and take g to be 10 m s^{-2}.)



A. 5.8 Hz

B. 7.1 Hz

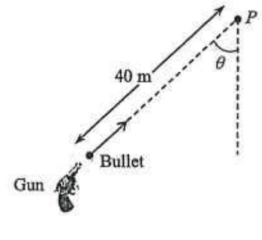
C. 10.0 Hz

D. 12.5 Hz

12. < HKAL 2004 Paper IIA - 3 >

As shown in the figure, a gun aims directly at a point P which is 40 m from the gun. The barrel of the gun makes an angle θ with the vertical. If the speed of the bullet is 50 m s^{-1}, what is the separation between the bullet and point P when the bullet is vertically below P ?

(Neglect air resistance and take g to be 10 m s^{-2}.)



A. 3.2 m
B. 4.8 m
C. 7.8 m
D. It cannot be found as the value of θ is not known.

13. < HKAL 2005 Paper IIA - 4 >

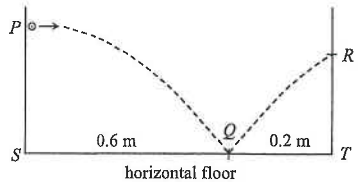
Five bombs are released from a bomber flying horizontally with a constant velocity. They are released one by one at one-second intervals. Neglecting air resistance, state

(1) the positions of the five bombs in the air at any instant before landing on the ground,

(2) the landing positions of the five bombs on the ground ?

	(1)	(2)
A.	They lie on a parabola.	They are evenly spaced.
B.	They lie on a parabola.	They are unevenly spaced.
C.	They lie on a straight line.	They are evenly spaced.
D.	They lie on a straight line.	They are unevenly spaced.

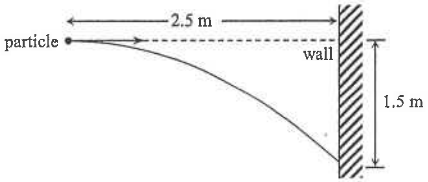
14. < HKAL 2006 Paper IIA - 3 >



As shown in the above figure, a small ball is projected horizontally with a speed of 1.6 m s^{-1} from the point P on a wall inside a room. The ball hits the smooth horizontal floor at Q and rebounds to the point R on the opposite wall. If air resistance is neglected, which of the following statements must be true ?

A. There is no loss of kinetic energy of the ball for the collision at Q.
B. The ball hits R with a horizontal velocity.
C. The total time of flight along the path PQR is 0.5 s.
D. If the ball is projected with the same horizontal speed at a point P', vertically above P, the total time of flight from P' to the opposite wall would be longer.

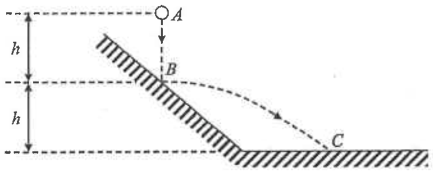
15. < HKAL 2008 Paper IIA - 7 >



A small particle is projected horizontally towards a vertical wall 2.5 m away. It hits the wall 1.5 m below the initial horizontal level. At what angle to the vertical does the particle hit the wall ?

A. 34°
B. 40°
C. 53°
D. 56°

16. < HKAL 2009 Paper IIA - 7 >

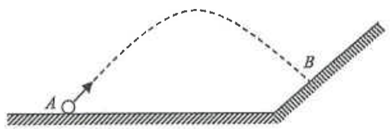


As shown in the above figure, a small ball is released from the point *A*. It makes a perfectly elastic collision at *B* on a slope and then rebounds horizontally. The ball finally reaches *C* on the ground. The vertical separation of *AB* and *BC* are both equal to *h*. If air resistance is neglected, which of the following statements is/are correct ?

(1) The acceleration of the ball is constant throughout the motion from *A* to *C*.
(2) The time for the ball to move from *A* to *B* is equal to that for it to move from *B* to *C*.
(3) The kinetic energy of the ball just before colliding at *C* is twice that at *B*.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

17. < HKAL 2010 Paper IIA - 4 >

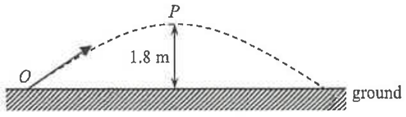


As shown in the figure, a small ball is projected from the point *A* on the ground with an angle of elevation. It rebounds at *B* on the incline and travels back to *A* along the same path. Which statements about the ball must be correct ?

(1) The ball hits the incline at *B* normally.
(2) The ball undergoes perfectly elastic collision at *B*.
(3) The time taken for the ball to go from *A* to *B* is equal to that for it to return from *B* to *A*.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

18. < HKAL 2012 Paper IIA - 7 >



A small ball of mass 0.2 kg is projected from point *O* on the ground with a certain initial velocity as shown. It reaches a maximum height of 1.8 m at point *P*. Find the magnitude of the change in momentum, in N s, of the ball from *O* to *P*. Neglect air resistance and take g to be 10 m s^{-2}.

A. 1.2
B. 1.6
C. 2.4
D. It cannot be determined since the angle of projection is not given.

19. < HKAL 2013 Paper IIA - 6 >

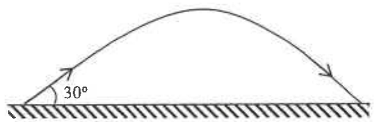
A small ball is released from rest at the top of a building. After a while another ball is projected horizontally from the same position. Before reaching the ground, which quantity of the two balls will remain unchanged ? Neglect air resistance.

(1) their acceleration
(2) the difference in the vertical component of their velocities
(3) the difference in their heights above the ground

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Part B : Supplemental exercise

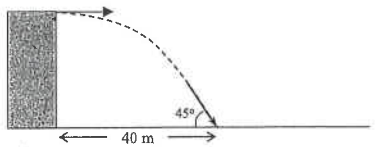
20.



A ball of mass 2 kg is projected upwards with an angle of 30° inclined with the horizontal. It was found that the kinetic energy of the ball at the maximum height is 108 J. What is the initial speed of the ball ?

A. 8 m s^{-1}
B. 12 m s^{-1}
C. 15 m s^{-1}
D. 18 m s^{-1}

21.



A ball is projected horizontally from the top of a building. It reaches the ground at a point 40 m from the building, making an angle of 45° with the horizontal as shown in the above figure. What is the height of the building ? Take the acceleration due to gravity g to be 10 m s^{-2}.

A. 20 m
B. 30 m
C. 40 m
D. 80 m

22. An angry bird is at a height of 10 m above the ground. A green pig is at a horizontal distance of 55 m from the angry bird with a height of 12 m above the ground. In order that the angry bird can hit the green pig, what should be the launch angle (made with the horizontal) of the shot if the time of flight is 2.5 s ?

A. 28.5°
B. 30.7°
C. 32.5°
D. 35.2°

23. A ball is projected horizontally with an initial speed of u at a certain height above the ground. It then reaches the ground after a time t and the landing position is at a horizontal distance R from the starting point. What would the corresponding values be if the initial speed of the ball is changed to $2u$?

	Time taken to reach the ground	Horizontal distance travelled
A.	$2t$	$2R$
B.	$2t$	R
C.	t	$4R$
D.	t	$2R$

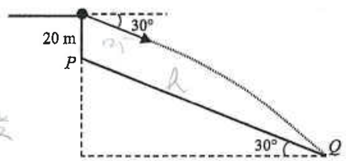
24. A particle is projected from the ground with a certain speed making an angle of 35° with the ground. After 4.5 s, it reaches the ground. Determine the horizontal distance moved by the particle.

A. 128 m
B. 142 m
C. 164 m
D. 186 m

25. A heavy ball is projected horizontally from top of a building with an initial speed of 10 m s^{-1}. It hits the ground with a speed of 15 m s^{-1}. If air resistance is neglected, what is the height of the building ?

A. 3.09 m
B. 6.37 m
C. 8.15 m
D. 9.28 m

26.



A particle is projected with speed 25 m s^{-1} at an angle of dip of 30° on the edge of a vertical cliff 20 m above point P as shown in the above figure. The particle then follows a parabolic path to reach the point Q at the bottom of an incline which makes an angle of 30° with the horizontal. Calculate the distance PQ of the incline. Take g to be 10 m s^{-2}.

A. 40 m
B. 50 m
C. 60 m
D. 70 m

27. A ball is projected horizontally at the top of a building with a speed of 12 m s^{-1}. The height of the building above the ground is 18 m. What is the speed of the ball when it lands on the ground if air resistance is negligible ?

A. 15.6 m s^{-1}
B. 22.3 m s^{-1}
C. 25.6 m s^{-1}
D. 28.9 m s^{-1}

Part C : HKDSE examination questions

28. **< HKDSE Practice Paper IA - 11 >**

A football player kicks a ball on the ground. The ball leaves the ground with speed v and hits the bar at X with a speed of 17 m s^{-1}. X is 2 m above the ground. Neglect air resistance, what is the value of v ?

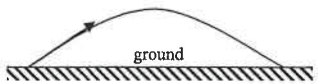
A. 15.8 m s^{-1}
B. 18.1 m s^{-1}
C. 19.0 m s^{-1}
D. 23.3 m s^{-1}

29. **< HKDSE 2012 Paper IA - 12 >**

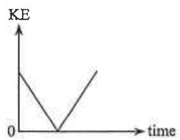
A bomber aircraft is 1 km above the ground and is flying horizontally at a speed of 200 m s^{-1}. The aircraft is going to release a bomb to destroy a target on the ground. How long before flying over the target should the bomb be released ? Assume that the bomber aircraft and the target are in the same vertical plane and neglect air resistance.

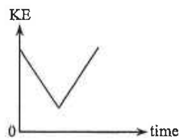
A. 5.6 s
B. 10.1 s
C. 14.3 s
D. It cannot be calculated as the horizontal distance between the aircraft and the target is not known.

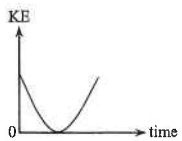
30. **< HKDSE 2013 Paper IA - 13 >**

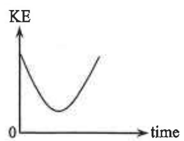


A particle is projected into the air at time t = 0 and it performs a parabolic motion before landing on the ground as shown. Which graph represents the variation of the kinetic energy (KE) of the particle with time before landing ? Neglect air resistance.

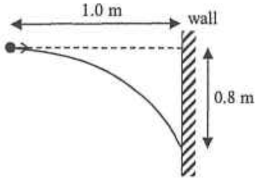
A.


B.


C.


D.


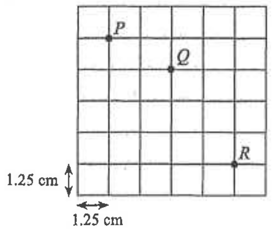
31. < HKDSE 2014 Paper IA - 10 >



A particle is projected horizontally towards a vertical wall 1.0 m away. It hits the wall at a position 0.8 m vertically below its point of projection. At what speed is it projected ? Neglect air resistance.

A. 2.0 m s^{-1}
B. 2.5 m s^{-1}
C. 5.0 m s^{-1}
D. 6.3 m s^{-1}

32. < HKDSE 2016 Paper IA - 10 >

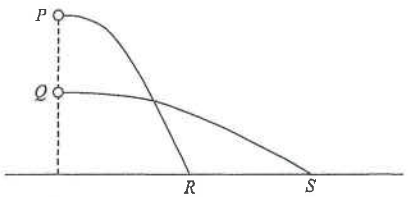


The above stroboscopic picture shows a particle projected horizontally at position *P* into the air in a vertical plane. Subsequently the particle reaches positions *Q* and *R* such that the time interval between *P* and *Q* is equal to that between *Q* and *R*. Each square of the grid measures 1.25 cm × 1.25 cm. Find the particle's speed of projection at *P*. Neglect air resistance.

A. 0.3 m s^{-1}
B. 0.4 m s^{-1}
C. 0.5 m s^{-1}
D. 0.6 m s^{-1}

33. < HKDSE 2017 Paper IA - 9 >

Marbles *P* and *Q* of the same mass are shot horizontally. They hit the horizontal ground at points *R* and *S* respectively as shown. Neglect air resistance.



Which of the following statements is **INCORRECT** ?

A. The initial speed of marble *P* is smaller than that of marble *Q*.
B. The time of flight of marble *P* is shorter than that of marble *Q*.
C. The potential energy loss of marble *P* is greater than that of marble *Q*.
D. The acceleration of marbles *P* and *Q* is the same during the flight.

There is question in next page

M.C. Answers

1. D	11. C	21. A	31. B
2. A	12. A	22. B	32. C
3. D	13. C	23. D	33. B
4. C	14. C	24. B	**34. C**
5. D	15. B	25. B	**35 C**
6. D	16. D	26. B	
7. D	17. D	27. B	
8. D	18. A	28. B	
9. D	19. C	29. C	
10. D	20. B	30. D	

M.C. Solution

1. D

× (1) Vertical speed of $A = 0 \text{ m s}^{-1}$; Vertical speed of $B = 20 \times \sin 60° = 17.3 \text{ m s}^{-1}$
Different initial vertical speed ⇒ travel different vertical distance in equal times

✓ (2) Horizontal speed of $B = 20 \times \cos 60° = 10 \text{ m s}^{-1}$ = Horizontal speed of A.
Same initial horizontal speed ⇒ travel same horizontal distance in equal times

✓ (3) Balls *A* and *B* experience same acceleration due to gravity but different initial speed
⇒ *B* is always above *A* ∴ they never meet

2. A

From *Q* to *R* :

$y = u_y t + \frac{1}{2} a_y t^2$ ∴ $(2) = (0) + \frac{1}{2}(9.81)\, t^2$ ∴ $t = 0.6386 \text{ s}$

$x = u_x t$ ∴ $(3) = u\,(0.6386)$ ∴ $u = 4.70 \text{ m s}^{-1}$

From *P* to *Q* :

loss of *P.E.* = gain of *K.E.*

∴ $m g h = \frac{1}{2} m u^2$ ∴ $(9.81)\, h = \frac{1}{2}(4.70)^2$ ∴ $h = 1.13 \text{ m}$

3. D

Vertical direction : $v_y = u_y + g t = (0) + (9.81)(3) = 29.43 \text{ m s}^{-1}$

Horizontal direction : $v_x = u = 20 \text{ m s}^{-1}$

Speed : $v = \sqrt{29.43^2 + 20^2} = 35.6 \text{ m s}^{-1}$

4. C

From P to Q :

$v_y^2 = u_y^2 + 2\,a_y\,y$ $\quad\therefore\ v_y^2 = (10\sin 30°)^2 + 2\,(10)\,(10)$ $\quad\therefore\ v_y = 15\ \text{m s}^{-1}$

Since the collision at Q is perfectly elastic, the vertical velocity of the sphere just after collision is also $15\ \text{m s}^{-1}$.

From Q to R, the vertical displacement is zero.

By $y = u_y t + \frac{1}{2} a_y t^2$ $\quad\therefore\ (0) = (15)\,t + \frac{1}{2}(-10)\,t^2$ $\quad\therefore\ t = 3\ \text{s}$

Horizontal distance $QR = v_x t = (10 \times \cos 30°)\,(3) = 26.0\ \text{m}$

5. D

In order to hit the monkey, the angle θ of projection must satisfy : $\tan\theta = \dfrac{h}{d}$ $\quad\therefore\ \theta$ depends on h and d.

Since both the bullet and the monkey have the same acceleration due to gravity,

thus, the bullet and the monkey must meet irrespective of the value of the initial speed u.

6. D

✓ (1) Both A and B have zero initial vertical velocity and both have same acceleration due to gravity, ∴ they reach the ground at the same time.

✓ (2) Both A and B experience the same acceleration due to gravity g since the net force is the weight mg.

✓ (3) Both A and B have zero initial vertical velocity and both have same acceleration due to gravity, they have the same final vertical velocity.

7. D

Bomber moves with constant velocity

∴ bombs and bomber always move with the same horizontal displacement

∴ all the bombs must always be vertically below the bomber

∴ all the bombs and the bomber must be in a vertical line

Gravitational acceleration exists ⇒ bombs move for a longer vertical distance as time increases

∴ D is the correct answer.

8. D

The horizontal component of velocity is constant and is equal to u.

Consider the final velocity v :

By $v_x^2 + v_y^2 = v^2$

$\therefore\ u^2 + v_y^2 = v^2$ $\quad\therefore\ v_y = \sqrt{v^2 - u^2}$

Consider the vertical component :

By $v_y = u_y + a\,t$ $\quad\therefore\ \sqrt{v^2 - u^2} = (0) + (g)\,t$

$\therefore\ t = \dfrac{\sqrt{v^2 - u^2}}{g}$

9. D

Vertically : $y = u_y t + \frac{1}{2} a_y t^2$ $\quad\therefore\ (0.8) = (0)\,t + \frac{1}{2}(10)\,t^2$ $\quad\therefore\ t = 0.404\ \text{s}$

Vertically : $v_y = u_y + g\,t = (0) + (9.81)\,(0.404) = 3.96\ \text{m s}^{-1}$

Horizontally : $x = v_x t$ $\quad\therefore\ (1.2) = v_x\,(0.404)$ $\quad\therefore\ v_x = 2.97\ \text{m s}^{-1}$

Final speed : $v = \sqrt{v_x^2 + v_y^2} = \sqrt{(2.97)^2 + (3.96)^2} = 4.95\ \text{m s}^{-1}$

10. D

As $E_o = \frac{1}{2} m u^2$

∴ kinetic energy of the horizontal component $= \frac{1}{2} m\,(u\cos 45°)^2 = \frac{1}{2} m u^2 \times \frac{1}{2} = \frac{1}{2} E_o$

∴ initial kinetic energy of the vertical component $= \frac{1}{2} E_o$

When the ball is moving halfway up, half of the initial kinetic energy of vertical component is changed into *P.E.*

∴ kinetic energy of the vertical component at halfway up $= \frac{1}{4} E_o$

∴ total kinetic energy at halfway up $= \frac{1}{2} E_o + \frac{1}{4} E_o = \frac{3}{4} E_o$

OR

potential energy of the stone at halfway up $= \frac{1}{2} E_o \times \frac{1}{2} = \frac{1}{4} E_o$

∴ total kinetic energy at halfway up $= E_o - \frac{1}{4} E_o = \frac{3}{4} E_o$

11. C

Assume T is the period of the strobe lamp, which is the time interval between two images of the particle.

By $y = u_y t + \frac{1}{2} a_y t^2$

① $(0.15) = u_y\,(T) + \frac{1}{2}(10)\,(T)^2$

② $(0.40) = u_y\,(2\,T) + \frac{1}{2}(10)\,(2\,T)^2$

Eliminate u_y : $T = 0.1\ \text{s}$

Frequency of the strobe lamp : $f = \dfrac{1}{0.1} = 10\ \text{Hz}$

12. A

Assume the bullet takes time t to reach the point vertically below P.

Consider the horizontal motion of the bullet : $x = v_x t$ $\quad\therefore\ (40\sin\theta) = (50\sin\theta)\,t$ $\quad\therefore\ t = 0.8\ \text{s}$

Method ① : By the concept of Monkey and hunter experiment, the displacement of the monkey dropped from P is

$s = \frac{1}{2} g t^2 = \frac{1}{2}(10)\,(0.8)^2 = 3.2\ \text{m}$

Method ② : Consider the vertical motion of the bullet :

$y = u_y t + \frac{1}{2} g t^2 = (50\cos\theta) \times (0.8) + \frac{1}{2}(-10)\,(0.8)^2 = 40\cos\theta - 3.2$

Vertical separation between P and the bullet : $s = (40\cos\theta) - (40\cos\theta - 3.2) = 3.2\ \text{m}$

13. C

(1) Since every bomb has the same horizontal velocity as the aircraft, it must always be vertically under the aircraft. Thus, at any instant, they lie on a vertical straight line.

(2) The spacing between the landing position of any two bombs is $\Delta x = v_x \times \Delta t$. Thus, Δx is a constant.

14. C

× A. Since the collision may be elastic or not elastic, kinetic energy may or may not be conserved.

× B. The ball may or may not hit R at the topmost point, thus it may or may not hit R with a horizontal velocity.

✓ C. Since the horizontal component of the velocity remains unchanged

$\therefore\ t = \dfrac{(0.6+0.2)}{(1.6)} = 0.5\ \text{s}$

× D. If the horizontal projected velocity is the same, the time of flight should remain unchanged.

15. B

Time taken to hit the wall : $y = \frac{1}{2} g t^2$ $\quad\therefore (1.5) = \frac{1}{2}(9.81)\, t^2$ $\quad\therefore t = 0.553\ \text{s}$

Horizontal motion : $x = v_x t$ $\quad\therefore (2.5) = v_x (0.553)$ $\quad\therefore v_x = 4.52\ \text{m s}^{-1}$

Vertical motion : $v_y^2 = 2 g y$ $\quad\therefore v_y^2 = 2\,(9.81)\,(1.5)$ $\quad\therefore v_y = 5.42\ \text{m s}^{-1}$

$\therefore\ \tan\theta = \dfrac{v_x}{v_y} = \dfrac{4.52}{5.42}$ $\quad\therefore \theta = 40°$

16. D

× (1) From A to B and from B to C, the acceleration is equal to g and is constant. However, during the impact with the slope at B, the acceleration is not equal to g due to the normal reaction force acting on the ball by the slope.

✓ (2) Time taken from A to B is found by $h = \frac{1}{2} g t^2$
and time taken from B to C is also found by $h = \frac{1}{2} g t^2$
as the initial vertical velocity is zero in both cases, thus the times taken are the same.

✓ (3) KE just before colliding B = loss of PE from A to B = $m g h$
KE just before colliding C = loss of PE from A to C = loss of PE from A to B × 2 = $m g \times 2h$

17. D

✓ (1) As the ball rebounds along the same path, it must hit the incline at B normally, i.e. perpendicular to the incline.

✓ (2) As the ball can reach the original position, the collision must be perfectly elastic. If it is not perfectly elastic, some KE is lost, the ball cannot reach the same maximum height.

✓ (3) As the distance of the path is the same and the speed at corresponding points are the same, the time taken must be the same.

18. A

Consider the vertical component. At the maximum height, $v_y = 0$.

By $v_y^2 = u_y^2 + 2\, a_y\, y$ $\quad\therefore (0) = u_y^2 + 2\,(-10)\,(1.8)$ $\quad\therefore u_y = 6\ \text{m s}^{-1}$

Since there is no change of horizontal component of velocity, there is no change of horizontal momentum.

The change in momentum = change in vertical momentum

Initial vertical momentum = $m\, u_y$ = (0.2) (6) = 1.2 N s

At highest point, the vertical momentum is zero, thus the change in vertical momentum = 1.2 N s

19. C

✓ (1) Both the vertical fall and the projectile motion have the same acceleration due to gravity.

✓ (2) Since the projected ball starts the motion later, their vertical velocities would differ by a constant value.

× (3) The difference in their vertical heights would increase with time.

20. B

At maximum height, the vertical component of the velocity is zero.

$\therefore\ KE = \frac{1}{2} m\, u^2 \cos^2\theta$

$\therefore\ (108) = \frac{1}{2}(2)\, u^2 \cos^2 30°$ $\quad\therefore u = 12\ \text{m s}^{-1}$

21. A

$\dfrac{v_y}{v_x} = \tan 45° = 1$ $\quad\therefore v_y = v_x = u$

Vertical component : $v_y = g t = (10)\, t = 10\, t$

Horizontal component : $x = v_x t$ $\quad\therefore (40) = (10\, t)\, t$ $\quad\therefore t = 2\ \text{s}$

$\therefore\ y = \frac{1}{2} g t^2$ $\quad\therefore h = \frac{1}{2}\,(10)\,(2)^2 = 20\ \text{m}$

22. B

Horizontal component :

$x = u_x t$ $\quad\therefore (55) = u_x (2.5)$ $\quad\therefore u_x = 22\ \text{m s}^{-1}$

Vertical component :

$y = u_y t + \frac{1}{2} a_y t^2$ $\quad\therefore (12 - 10) = u_y (2.5) + \frac{1}{2}(-9.81)\,(2.5)^2$ $\quad\therefore u_y = 13.06\ \text{m s}^{-1}$

$\tan\theta = \dfrac{u_y}{u_x} = \dfrac{13.06}{22}$ $\quad\therefore \theta = 30.7°$

23. D

① Time taken to reach the ground depends on the height of projection and is independent of the initial speed. Thus the time taken is still t.

② Horizontal distance travelled is $R = u\, t$.
If $u \to 2u$, then $R \to 2R$.

24. B

By $y = u_y t + \frac{1}{2} a_y t^2$

$\therefore$ $(0) = (u \sin 35°) \times (4.5) + \frac{1}{2}(-9.81) \times (4.5)^2$ $\therefore$ $u = 38.48 \text{ m s}^{-1}$

Horizontal range : $x = u_x t = (38.48 \cos 35°) \times (4.5) = 142 \text{ m}$

25. B

The horizontal component of velocity is constant and is equal to 10 m s^{-1}.

Consider the final velocity v :

$v^2 = v_x^2 + v_y^2$

$\therefore$ $(15)^5 = (10)^2 + v_y^2$ $\therefore$ $v_y = 11.18 \text{ m s}^{-1}$

Consider the vertical component :

$v_y^2 = u_y^2 + 2 a_y y$

$\therefore$ $(11.18)^2 = (0) + 2(9.81) y$ $\therefore$ $y = 6.37 \text{ m}$

26. B

Let the distance PQ be d.

Consider the horizontal component :

$x = u_x t$

$\therefore$ $(d \cos 30°) = (25 \cos 30°) \times t$ $\therefore$ $d = 25 t$

Consider the vertical component :

$y = u_y t + \frac{1}{2} a_y t^2$

$\therefore$ $(20 + d \sin 30°) = (25 \sin 30°) t + \frac{1}{2}(10) t^2$

$\therefore$ $(20 + 25 t \times \sin 30°) = (25 \sin 30°) t + \frac{1}{2}(10) t^2$

$\therefore$ $20 = \frac{1}{2}(10) t^2$

$\therefore$ $t = 2 \text{ s}$

Distance PQ : $d = 25 \times 2 = 50 \text{ m}$

27. B

By Conservation of energy :

$\frac{1}{2} m u^2 + m g h = \frac{1}{2} m v^2$

$\therefore$ $\frac{1}{2}(12)^2 + (9.81)(18) = \frac{1}{2} v^2$ $\therefore$ $v = 22.3 \text{ m s}^{-1}$

28. B

Let v_x be the speed of the ball at position X.

By Conservation of energy :

$\frac{1}{2} m v^2 = \frac{1}{2} m v_x^2 + m g h$

$\therefore$ $\frac{1}{2} v^2 = \frac{1}{2}(17)^2 + (9.81)(2)$ $\therefore$ $v = 18.1 \text{ m s}^{-1}$

29. C

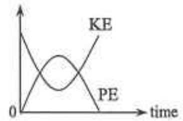
Consider the vertical component :

$y = \frac{1}{2} g t^2$ $\therefore$ $(1 \times 10^3) = \frac{1}{2}(9.81) t^2$

$\therefore$ $t = 14.3 \text{ s}$

30. D

As the time variation of PE is a quadratic curve,
the time variation of KE should also be a quadratic curve.
At the highest point, the speed is equal to $u \cos \theta$ which is not zero,
thus the KE at the highest point is not zero.



31. B

Vertical component : $y = \frac{1}{2} g t^2$ $\therefore$ $(0.8) = \frac{1}{2}(9.81) t^2$ $\therefore$ $t = 0.404 \text{ s}$

Horizontal component : $x = u t$ $\therefore$ $(1.0) = u (0.404)$ $\therefore$ $u = 2.5 \text{ m s}^{-1}$

32. C

As the particle is projected horizontally at P, the initial vertical velocity is zero.

Assume the time interval between two images be T.

For the first two images, vertical displacement y is 1.25 cm and horizontal displacement x is 2.5 cm.

By $y = \frac{1}{2} g t^2$ $\therefore$ $(0.0125) = \frac{1}{2}(9.81) T^2$ $\therefore$ $T = 0.0505 \text{ s}$

By $x = u t$ $\therefore$ $(0.025) = u (0.0505)$ $\therefore$ $u = 0.5 \text{ m s}^{-1}$

33. B

✓ A. By $x = u t$, since the horizontal range x of P is shorter and the time of flight t of P is longer, the initial speed u of P must be smaller.

✗ B. By $y = \frac{1}{2} g t^2$, as the vertical displacement y of P is greater, the time of flight t of P should be longer.

✓ C. Since P is at a higher height, by $PE = mgh$, P has a greater potential energy.

✓ D. During the projectile motion in air, both of them experience the same acceleration due to gravity.

The following list of formulae may be found useful :

For uniformly accelerated motion $v = u + at$

$s = ut + \frac{1}{2}at^2$

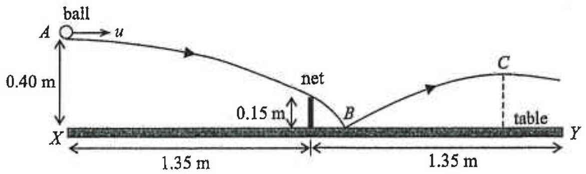
$v^2 = u^2 + 2as$

Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81\ \text{m s}^{-2}$ (close to the Earth)

Part A : HKAL examination questions

1. < HKAL 1996 Paper I - 1 >

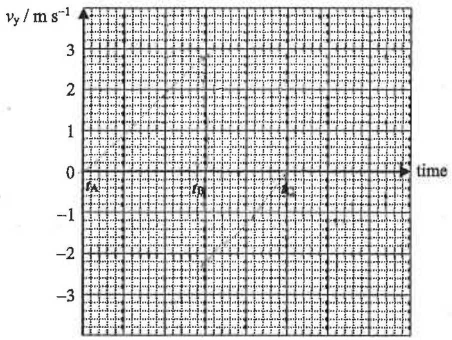


A ping-pong ball is struck at the point A, which is 0.40 m vertically above the edge X of the table. The ball then moves with a horizontal velocity u. It then just passes the net to reach the table at point B. After rebounding from the table, it reaches the highest point C, which is 0.25 m above the table. The length of the table XY is 2.70 m. The net is 0.15 m high and it is placed exactly at the middle of the table. Take g to be 10 m s^{-2}. Neglect the effect of air resistance.

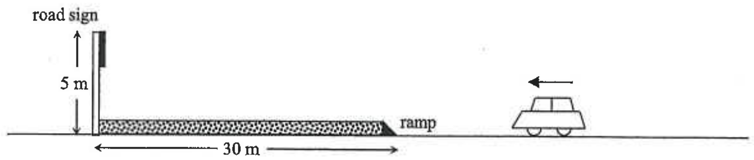
(a) Calculate the initial velocity u of the ping-pong ball. (2 marks)

(b) Calculate the speed of the ball just before it hits the table at B. (2 marks)

(c) If point C is at 0.25 m above the table, draw the graph of vertical velocity, v_y, of the ball against time from A to C. Take downward direction as positive. (t_A, t_B and t_C on the time axis are the times when the ball is at A, B and C respectively.) (3 marks)



2. < HKAL 2000 Paper I - 1 >



As shown in the above figure, a car travels on a horizontal road towards the left. When it hits the ramp, it takes off from the ramp with an initial speed u and follows a projectile path to hit the top of the road sign which is 5 m high above the road and 30 m away from the ramp. Take the acceleration due to gravity to be 10 m s^{-2}.

(a) Sketch the possible trajectories of the car in the air for a certain take-off speed in the above figure. (2 marks)

(b) Assume that the car hit the road sign at the highest point in its trajectory. Neglect air resistance and the size of the car.

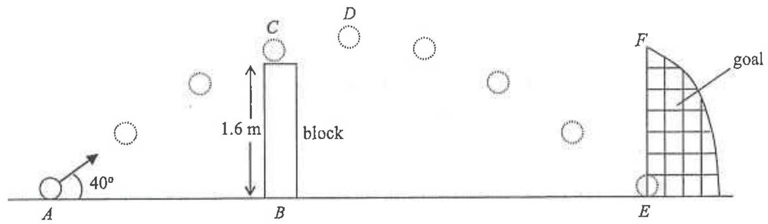
(i) Calculate the time t of flight before the car hit the road sign. (2 marks)

(ii) Calculate the take-off speed u and the projection angle θ of the car. (3 marks)

(c) Braking marks of 39 m long was found on the road in front of the ramp. Forensic measurements on the marks by the police indicated that the braking force was about 8000 N on the car of mass 1000 kg. Estimate the speed of the car just before applying the brakes. Assume that the speed of the car on hitting the ramp is equal to the projection speed of the car from the ramp. (2 marks)

3. < HKAL 2003 Paper I - 7 >

A ball is kicked to move with an initial velocity of 10 m s^{-1}, making an angle of 40° with the horizontal. The ball then just passes a block of height 1.6 m, reaching the highest point *D*, and finally hits the ground at *E* as shown in the below figure. Neglect air resistance and the size of the ball.



(a) Draw an arrow to indicate the direction of acceleration of the ball at *C*. (1 mark)

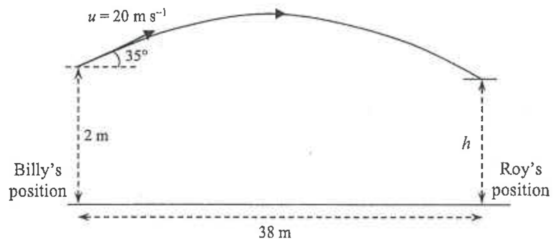
(b) Calculate the speed of the ball at *C*. (2 marks)

(c) Calculate the height of the ball at *D*. (2 marks)

(d) The ball finally reaches the point *E*. Calculate the distance between *A* and *E*. (3 marks)

DSE Physics - Section B : Question PB - FM6 - Q / 04
FM6 : Projectile Motion

4. < HKAL 2007 Paper I - 1 >



As shown in the above figure, Billy tries to pass a ball to Roy, standing 38 m away from him. Billy throws the ball from a point 2 m above the ground with an initial speed of 20 m s^{-1} at an angle of elevation of 35°. The mass of the ball is 0.42 kg. Take the acceleration due to gravity to be 10 m s^{-2}. Neglect air resistance and the size of the ball.

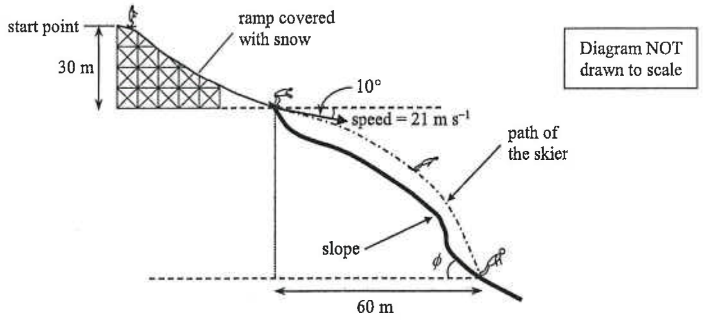
(a) Assume the throwing action of Billy starts from rest and the gain in gravitational potential energy of the ball during the throwing action can be neglected.

(i) Find the work done on the ball by Billy in the throwing action. (2 marks)

(ii) If the throwing action lasts for 0.15 s, calculate the average power that Billy delivers to the ball. (2 marks)

(b) Determine the height *h* that Roy should place his hands there so as to catch the ball. (3 marks)

5. **< HKAL 2009 Paper I - 2 >**



As shown in the above figure, a skier of mass 84 kg slides down a ramp from rest at the start point which is 30 m above the end of the ramp. The skier attains a speed of 21 m s^{-1} when he leaves the ramp and makes the ski jump at an angle 10° below the horizontal. He eventually lands on a slope at horizontal distance of 60 m from the lower end of the ramp. Neglect air resistance and take the acceleration due to gravity to be 10 m s^{-2}.

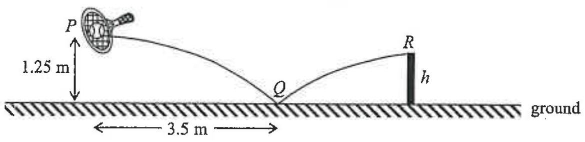
(a) Find the work done against friction by the skier when he slides down the ramp. (3 marks)

(b) Calculate the skier's time of flight in air after he leaves the ramp. (2 marks)

(c) Find the magnitude and direction of the skier's velocity at landing. (3 marks)

(d) For safety reasons, the direction of the skier's velocity just before landing and the slope there should differ by no more than 5°. Find the minimum value of the angle of inclination ϕ of the slope there. (1 mark)

6. **< HKAL 2011 Paper I - 1 >**



In the above figure, a player strikes a tennis ball of mass 60 g horizontally with a racket at P at a height of 1.25 m above the ground. The ball then hits the ground at Q and rebounds to that it just goes over an obstacle at R at its highest point of its path. The horizontal distance between PQ is 3.5 m. Neglect air resistance and take g to be 10 m s^{-2}.

(a) Calculate the time of flight of the ball from P to Q. (2 marks)

(b) Find the horizontal and vertical components of the velocity of the ball at Q just before it hits the ground. (2 marks)

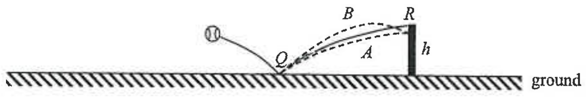
(c) During the impact with the ground at Q, the vertical component of the ball's velocity is reduced by 20%.

(i) Assume that the ground is smooth, calculate the speed of the ball just after impact at Q. (2 marks)

(ii) Find the magnitude of the average force exerted by the ground on the ball during the impact at Q if the contact time of the ball and the ground is 0.04 s. (3 marks)

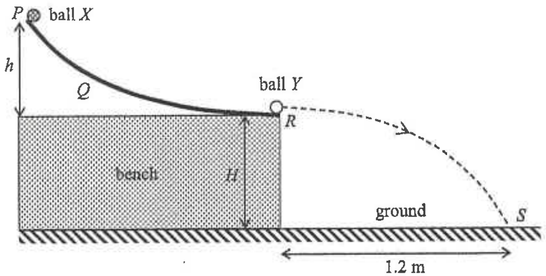
(d) Estimate the height h of the obstacle. (2 marks)

(e) If friction exists between the ball and the ground, decide whether the ball would take path A or B as shown in the Figure below. Explain your answer. (2 marks)



Part B : HKDSE examination questions

7. **< HKDSE Practice Paper IB - 3 >**



A smooth curved rail PQR is fixed on a horizontal bench as shown. P is at a height h above the bench surface. A small metal ball X of mass 0.03 kg is released from rest at P. When the ball X reaches R, it moves horizontally and collides head-on with another metal ball Y of mass 0.04 kg which is initially at rest on the rail. Immediately after the collision, ball X comes to rest while ball Y moves off the bench horizontally with a speed of 3 m s^{-1}. Neglect air resistance.

(a) What is the speed of ball X just before it collides with ball Y? (1 mark)

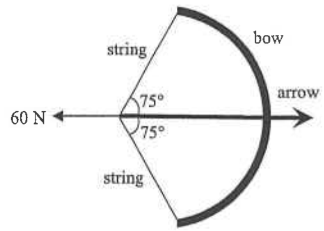
(b) Find the value of h. (2 marks)

(c) Ball Y lands on the ground at S which is at a horizontal distance of 1.2 m from the bench. Find the height H of the bench. (3 marks)

(d) Ball X is now released at Q such that ball Y moves off the bench horizontally with a smaller speed after collision. Would the time of flight of ball Y change ? Explain briefly. (2 marks)

8. **< HKDSE 2012 Paper IB - 5 >**

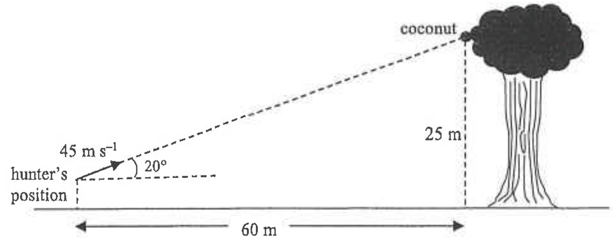
(a) A bow and arrow is a kind of projectile weapon. The string of a bow is drawn taut by a hunter with a force of 60 N and an arrow of mass 0.2 kg is held stationary as shown in the Figure below.



(i) Find the tension of the string. Neglect the weight of the arrow. (2 marks)

(ii) Estimate the energy stored in the taut string if the initial speed of the arrow is 45 m s^{-1} when released. Assume that the bow is rigid and neglect the mass of the string. (2 marks)

(b) The hunter stands at about 60 m away from a tree as shown in the Figure below. He uses the bow to release the arrow in order to shoot a coconut held by a monkey (not shown in the figure) in the tree. The coconut is at a height of 25 m from the ground. The hunter aims directly at the coconut and the arrow leaves the bow at a speed of 45 m s^{-1} making an angle of 20° to the horizontal. At the moment the hunter releases the arrow, the monkey drops the coconut such that it falls vertically from rest. Neglect air resistance and the arrow's size.



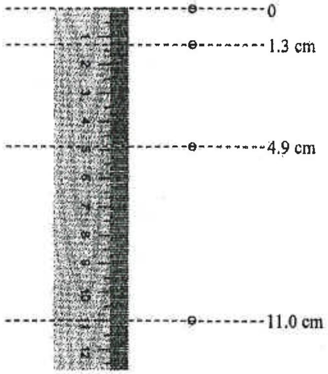
(i) Find the time taken for the arrow to hit the coconut. (2 marks)

(ii) Find the height of the coconut from the ground at the moment the arrow hits it. (2 marks)

9. < HKDSE 2017 Paper IB - 4 >

(a) A steel ball bearing is released from rest at time $t = 0$. A stroboscopic photo is taken at 0.05 s time intervals. The results are shown in Figure 1. Neglect air resistance.

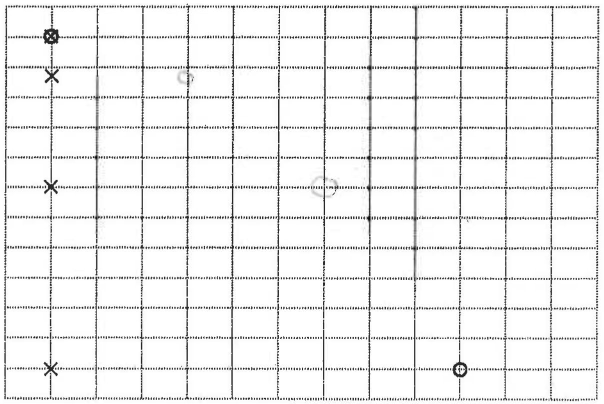
Figure 1



(i) Estimate the acceleration due to gravity using the data in Figure 1. (2 marks)

(ii) The bearing is now projected horizontally instead of released from rest. The bearing is projected at time $t = 0$, and a stroboscopic photo is taken at 0.05 s time intervals. The first and the last image of the stroboscopic photo are shown using circles (O) in Figure 2. For reference, the stroboscopic photo of the bearing released from rest is also shown in the figure using crosses (X).

Figure 2



(1) In Figure 2, mark the positions of the projected bearing in the stroboscopic photo using circles (O). (2 marks)

9. (a) (ii) (2) Given that the bearing is projected horizontally with an initial speed of 1 m s^{-1}, use the results of (a)(i) to calculate the speed of the projected bearing when the last image was taken. (3 marks)

(b) If a small ball is released from rest from the top of a cliff, the speed of the ball becomes constant after a period of time. By considering the forces acting on the ball and using Newton's laws of motion, explain why the speed of the ball becomes constant. (3 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) By $y = \frac{1}{2} g t^2$ (consider the motion from A to the net)

$\therefore$ $(0.40 - 0.15) = \frac{1}{2}(10) t^2$ [1]

$\therefore$ $t = 0.224$ s

By $x = u t$

$\therefore$ $(1.35) = u (0.224)$

$\therefore$ $u = 6.03$ m s^{-1} [1]

(b) Conservation of energy from A to B :

$\therefore$ $\frac{1}{2} m u^2 + m g h = \frac{1}{2} m v^2$ [1]

$\therefore$ $\frac{1}{2} m (6.03)^2 + m (10) \times (0.40) = \frac{1}{2} m v^2$ [1]

$\therefore$ $v = 6.66$ m s^{-1} [1]

OR

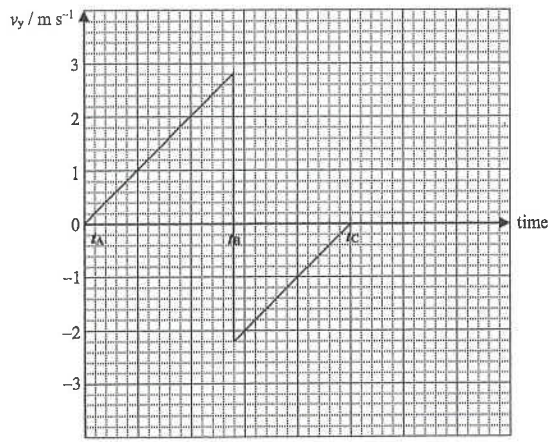
By $v_y^2 = u_y^2 + 2 a s$

$\therefore$ $v_y^2 = (0) + 2 (10)(0.4)$

$\therefore$ $v_y = 2.828$ m s^{-1} [1]

$\therefore$ $v = \sqrt{(6.03)^2 + (2.828)^2} = 6.66$ m s^{-1} [1]

(c)



Before collision :

$v_y = \sqrt{2 \times 10 \times 0.4} = 2.8$ m s^{-1}

After collision :

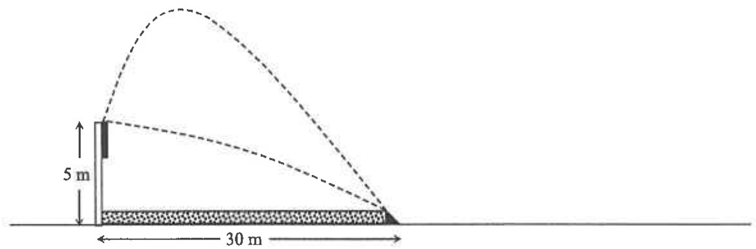
$v_y = \sqrt{2 \times 10 \times 0.25} = 2.2$ m s^{-1}

< uniform acceleration shown > [1]

< correct slope > [1]

< correct shape > [1]

2. (a)



< one trajectory hits the road sign at a shorter time > [1]

< one trajectory hits the road sign after reaching the highest point > [1]

(b) (i) At the highest point, $v_y = 0$

By $v_y^2 = u_y^2 + 2 a y$

$\therefore$ $(0) = u_y^2 + 2(-10)(5)$

$\therefore$ $u_y = 10$ m s^{-1} [1]

By $v_y = u_y + a t$

$\therefore$ $(0) = (10) + (-10) t$

$\therefore$ $t = 1$ s [1]

(ii) By $x = u_x t$

$\therefore$ $(30) = u_x (1)$

$\therefore$ $u_x = 30$ m s^{-1} [1]

$\therefore$ $u = \sqrt{(10)^2 + (30)^2} = 31.6$ m s^{-1} [1]

By $\tan\theta = \frac{u_y}{u_x} = \frac{10}{30}$

$\therefore$ $\theta = 18.4°$ [1]

(c) By $F = m a$

$\therefore$ $(8000) = (1000) a$

$\therefore$ $a = 8$ m s^{-2} < accept -8 m s^{-2} > [1]

By $v^2 = u^2 + 2 a s$

$\therefore$ $(31.6)^2 = u^2 + 2(-8) \times (39)$

$\therefore$ $u = 40.3$ m s^{-1} [1]

OR

Initial KE = Final KE + work done against the braking force

$\frac{1}{2} m u^2 = \frac{1}{2} m v^2 + F s$

$\frac{1}{2}(1000) u^2 = \frac{1}{2}(1000)(31.6)^2 + (8000)(39)$ [1]

$\therefore$ $u = 40.3$ m s^{-1} [1]

3. (a)

< arrow should be vertically downwards, as it is the acceleration due to gravity > [1]

(b) $\frac{1}{2} m u^2 = \frac{1}{2} m v^2 + m g h$

$\therefore \ \frac{1}{2} m (10)^2 = \frac{1}{2} m v^2 + m (9.81)(1.6)$ [1]

$\therefore \ v = 8.28 \text{ m s}^{-1}$ [1]

OR

$v_y^2 = (10 \sin 40°)^2 + 2(-9.81)(1.6)$ $\therefore \ v_y = 3.15 \text{ m s}^{-1}$ [1]

$v_x = 10 \cos 40° = 7.66 \text{ m s}^{-1}$

$v = \sqrt{(3.15)^2 + (7.66)^2} = 8.28 \text{ m s}^{-1}$ [1]

(c) $v_y^2 = u_y^2 + 2 a y$

$(0) = (10 \sin 40°)^2 + 2(-9.81) h$ [1]

$\therefore \ h = 2.11 \text{ m}$ [1]

(d) At E, the vertical displacement y is zero.

By $y = u_y t + \frac{1}{2} a t^2$

$\therefore \ (0) = (10 \sin 40°) t + \frac{1}{2}(-9.81) t^2$ [1]

$\therefore \ t = 1.31 \text{ s}$ [1]

Distance AE : $x = (10 \cos 40°) \times (1.31) = 10.0 \text{ m}$ [1]

4. (a) (i) $W = \frac{1}{2} m u^2 = \frac{1}{2}(0.42)(20)^2$ [1]

$= 84 \text{ J}$ [1]

(ii) $P = \frac{W}{t} = \frac{84}{0.15}$ [1]

$= 560 \text{ W}$ [1]

(b) Horizontally :

$x = u \cos \theta \times t$

$\therefore \ (38) = (20) \cos 35° \times t$ $\therefore \ t = 2.32 \text{ s}$ [1]

Vertically :

$y = u_y t + \frac{1}{2} a_y t^2$

$= (20 \sin 35°) \times (2.32) + \frac{1}{2}(-10)(2.32)^2 = -0.298 \text{ m}$ [1]

$\therefore \ h' = 2 - 0.298 = 1.70 \text{ m}$ [1]

5. (a) $m g h = \frac{1}{2} m v^2 + W$ [1]

$(84)(10)(30) = \frac{1}{2}(84)(21)^2 + W$ [1]

$W = 6678 \text{ J}$ < accept 6670 J to 6700 J > [1]

(b) $x = u_x \times t$

$\therefore \ (60) = (21 \cos 10°) \times t$ [1]

$\therefore \ t = 2.90 \text{ s}$ [1]

(c) $v_x = (21) \cos 10° = 20.7 \text{ m s}^{-1}$

$v_y = (21) \sin 10° + (10)(2.90) = 32.6 \text{ m s}^{-1}$ [1]

Resultant speed :

$v = \sqrt{(20.7)^2 + (32.6)^2} = 38.6 \text{ m s}^{-1}$ < accept 38.6 m s⁻¹ to 39.1 m s⁻¹ > [1]

By $\tan \theta = \frac{32.6}{20.7}$

$\therefore \ \theta = 57.6°$ < accept 57.5° to 58.0° > [1]

(d) $\phi = 57.6° - 5°$

$= 52.6°$ < accept 52.5° to 53.0° > [1]

6. (a) By $y = \frac{1}{2} g t^2$

$\therefore \ (1.25) = \frac{1}{2}(10) t^2$ [1]

$\therefore \ t = 0.5 \text{ s}$ [1]

(b) By $x = v_x t$

$\therefore \ (3.5) = v_x (0.5)$

$\therefore \ v_x = 7 \text{ m s}^{-1}$ [1]

By $v_y = g t$

$\therefore \ v_y = (10)(0.5) = 5 \text{ m s}^{-1}$ [1]

(c) (i) $v_y' = 5 \times 80\% = 4 \text{ m s}^{-1}$ [1]

$v = \sqrt{4^2 + 7^2} = 8.06 \text{ m s}^{-1}$ [1]

(ii) The average force acting on the ball by the ground is the normal reaction R.

By $R - m g = \frac{m v_y' - m v_y}{t}$ [1]

$\therefore \ R - (0.06)(10) = \frac{(0.06)(4) - (0.06)(-5)}{(0.04)}$ [1]

$\therefore \ R = 14.1 \text{ N}$ [1]

6. (d) By $v_y^2 = u_y^2 + 2\,a_y\,y$

$\therefore$ $(0) = (4)^2 + 2\,(-10)\,h$ [1]

$\therefore$ $h = 0.8$ m [1]

(e) Path *B*.

Horizontal speed is reduced after impact at *Q* due to friction.α [1]

Ball rebounds at a larger angle with the horizontal, thus the ball takes the path *B*. [1]

7. (a) Conservation of momentum :

$\therefore$ $(0.03)\,v = (0.04)\,(3)$

$\therefore$ $v = 4$ m s^{-1} [1]

(b) $m\,g\,h = \frac{1}{2}\,m\,v^2$ [1]

$(0.03)\,(9.81)\,h = \frac{1}{2}\,(0.03)\,(4)^2$

$\therefore$ $h = 0.815$ m [1]

(c) By $x = u_x\,t$

$\therefore$ $(1.2) = (3)\,t$ $\therefore$ $t = 0.4$ s [1]

By $y = \frac{1}{2}\,g\,t^2$ [1]

$\therefore$ $H = \frac{1}{2}\,(9.81)\,(0.4)^2 = 0.785$ m [1]

(d) The time of flight remains unchanged [1]

as the time of flight is independent of the horizontal speed of the projectile. [1]

OR

as the vertical speed and the vertical displacement remain unchanged. [1]

8. (a) (i) $2\,T\cos 75° = 60$ [1]

$T = 116$ N [1]

(ii) Energy stored in the taut string = kinetic energy of the arrow = $\frac{1}{2}\,m\,v^2$ [1]

$= \frac{1}{2}\,(0.2)\,(45)^2 = 202.5$ J < accept 203 J > [1]

(b) (i) By $x = u_x\,t$

$\therefore$ $(60) = (45\cos 20°)\,t$ [1]

$\therefore$ $t = 1.42$ s [1]

(ii) For coconut : $s = \frac{1}{2}\,g\,t^2 = \frac{1}{2}\,(9.81)\,(1.42)^2 = 9.89$ m [1]

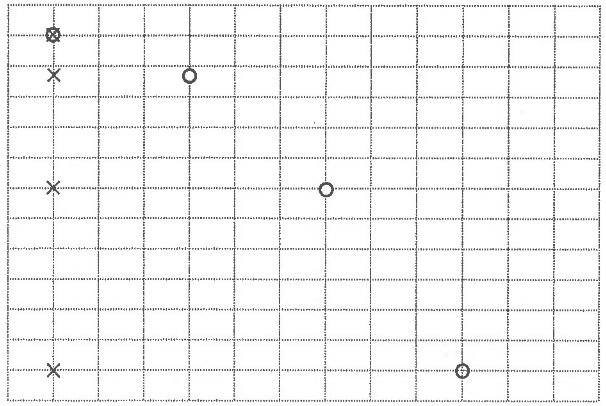
Height of coconut from the ground = 25 − 9.89 = 15.1 m [1]

9. (a) (i) By $s = u\,t + \frac{1}{2}\,a\,t^2$

$\therefore$ $(0.11) = \frac{1}{2}\,g\,(0.05 \times 3)^2$ [1]

$\therefore$ $g = 9.78$ m s^{-2} [1]

(ii) (1)



< correct horizontal positions > [1]

< correct vertical positions > [1]

(2) $v_x = 1$ m s^{-1}

$v_y = u_y + a\,t = (0) + (9.78) \times (0.05 \times 3) = 1.47$ m s^{-1} [1]

$v = \sqrt{(1)^2 + (1.47)^2}$ [1]

$\therefore$ $v = 1.78$ m s^{-1} [1]

OR

By $\frac{1}{2}\,m\,u^2 + m\,g\,h = \frac{1}{2}\,m\,v^2$ [1]

$\therefore$ $\frac{1}{2}\,(1)^2 + (9.78)\,(0.11) = \frac{1}{2}\,v^2$ [1]

$\therefore$ $v = 1.78$ m s^{-1} [1]

(b) The air resistance acting on the ball increases as its speed increases. [1]

When the air resistance equals to the weight of the ball, net force on the ball is zero. [1]

By Newton's first law, the ball then travels with constant speed. [1]

OR

By Newton's second law, the ball will not accelerate and travels with constant speed. [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

DSE Physics - Section B : M.C. PB - FM7 - M / 01

FM7 : Circular Motion

The following list of formulae may be found useful :

Centripetal acceleration $a = \frac{v^2}{r} = \omega^2 r$

Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81 \text{ m s}^{-2}$ (close to the Earth)

Part A : HKAL examination questions

1. < HKAL 1980 Paper I - 37 >

In corners of some racing tracks for motor cars, the tracks are banked at an angle to the horizontal. Which of the following is/are the advantage(s) for this feature ?

(1) To reduce the friction between the car and the track.
(2) To reduce the radius of curvature of the track that a car can travels safely at a given speed.
(3) To increase the component of the weight of the car towards the centre of its path.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

2. < HKAL 1982 Paper I - 5 >

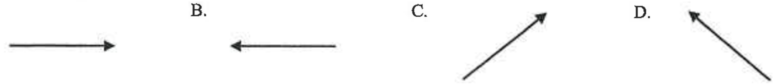
A particle of weight W tied to an inextensible string is swung in a vertical circle. At the topmost point of its path, the tension in the string is T and the centripetal force is F. Which of the following statements is true ?

A. $F = W + T$.
B. $F = W - T$.
C. The net force acting downwards on the stone is $F + T + W$.
D. The net force acting downwards on the stone is $F - T + W$.

3. < HKAL 1984 Paper I - 4 >

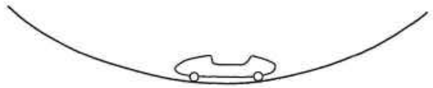
The above diagram represents the front view of a vehicle moving on a level road at a constant speed around a bend of which the centre of curvature is at P. Which of the arrows below best represents the direction of the resultant force exerted by the road on the car ?

A. B. C. D.



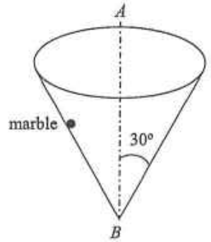
4. < HKAL 1988 Paper I - 6 >

A toy car of mass m is travelling along a track which is an arc of a vertical circle with radius r. At the bottom of this arc, the speed of the car is v. What is the vertical force exerted on the car by the track at this position ?



A. $\frac{mv^2}{r}$
B. mg
C. $\frac{mv^2}{r} - mg$
D. $\frac{mv^2}{r} + mg$

5. < HKAL 1989 Paper I - 8 >



A small marble is rotating on a horizontal circle in a smooth conical container with vertical axis AB as shown. The vertical axis makes an angle of 30° with the side of the cone. If the speed of the marble is v and the radius of rotation is r, which of the following relation must be correct ?

A. $v^2 = g\,r \sin 30°$.

B. $v^2 = g\,r \tan 30°$.

C. $v^2 = g\,r / \tan 30°$.

D. $v^2 = g\,r \cos 30°$.

6. < HKAL 1990 Paper I - 6 >

A small particle of mass 0.25 kg is attached to an inextensible string, with the other end fixed to the ceiling. When the particle is set to rotate in a horizontal circle, the tension of the string is 3.5 N. The angle between the string and the vertical is

A. 25.5°

B. 32.5°

C. 45.5°

D. 58.5°

7. < HKAL 1995 Paper IIA - 5 >

A small particle of mass of 0.05 kg is released from rest at the rim of a smooth semi-spherical bowl of radius 10 cm. Find the force acting on the object by the bowl when it passes the bottom of the bowl.

A. 0.5 N

B. 1.0 N

C. 1.5 N

D. 2.0 N

8. < HKAL 1995 Paper IIA - 6 >

An aircraft flies along a horizontal circle of radius 15 km with a constant speed of 175 m s^{-1}. Calculate the angle between its wings and the horizontal.

Take g to be 10 m s^{-2}.

A. 11.5°

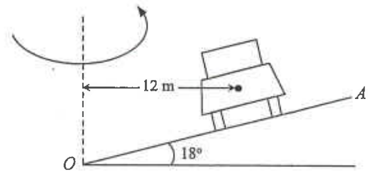
B. 12.5°

C. 13.0°

D. 13.5°

9. < HKAL 1997 Paper IIA - 4 >

The figure shows a car moving round a corner with a radius of 12 m on a banked road of inclination 18°. At what speed would there be no friction acting on the car along OA ? Take g to be 10 m s^{-2}.



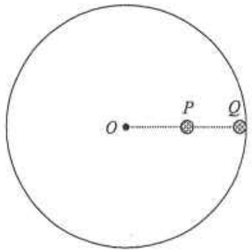
A. 4.8 m s^{-1}

B. 5.4 m s^{-1}

C. 6.2 m s^{-1}

D. 7.6 m s^{-1}

10. < HKAL 1998 Paper IIA - 7 >



Two small identical coins P and Q are placed on a horizontal turntable which is rotating at a constant angular speed about its centre O. The radius of Q from the centre is twice that of P. Which of the following statements is/are correct ?

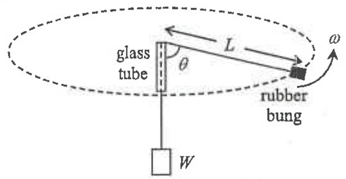
(1) The kinetic energy of Q is four times that of P.

(2) The friction acting on Q is double that acting on P.

(3) If the angular speed of the turntable gradually increases, Q will slip before P.

A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

11. < HKAL 2000 Paper IIA - 11 >



In the experiment of demonstrating centripetal force, a rubber bung is whirled in a horizontal circle. The rubber bung is attached to one end of a string which passes through a glass tube with smooth openings, and attached to a load of weight W hanging at its other end. The rubber bung is set to swirl with angular speed ω while the length of the string beyond the upper opening of the glass tube is L and this portion of the string makes an angle θ with the vertical as shown. Which of the following statements is/are correct ?

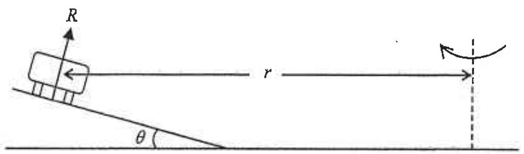
(1) If the length L is kept constant, θ will decrease with ω.

(2) If the angle θ is kept constant, L will increase with ω.

(3) If the weight of the load W increases, θ will increase.

A. (1) only
B. (2) only
C. (3) only
D. (1) & (2) only

12. **< HKAL 2000 Paper IIA - 8 >**



A vehicle of mass m is moving with speed v on a banked road along a circular path of horizontal radius r. The angle of inclination of the road is θ. If the centripetal force is provided entirely from a component of the normal reaction R from the road, which of the following relations is correct ?

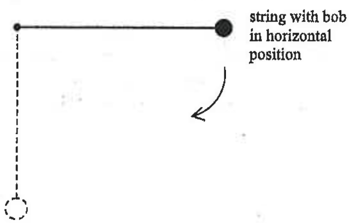
A. $R \cos \theta = m g$

B. $R = m g \cos \theta$

C. $v^2 = \dfrac{g r}{\sin \theta}$

D. $v^2 = \dfrac{g r}{\tan \theta}$

13. **< HKAL 2003 Paper IIA - 7 >**



A small bob is attached to an inextensible string. The string is pulled horizontally and then released from rest with the string taut. Which of the following statements about the tension in the string is NOT correct when the string reaches its vertical position ?

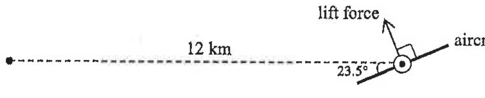
A. The tension equals the weight of the bob in magnitude.

B. The tension attains its greatest value.

C. The tension does not depend on the length of the string.

D. The tension depends on the mass of the bob.

14. **< HKAL 2007 Paper IIA - 4 >**



An aircraft flies with a constant speed in a horizontal circle of radius 12 km. If its wings slant at an angle of 23.5° to the horizontal, find the speed of the aircraft.

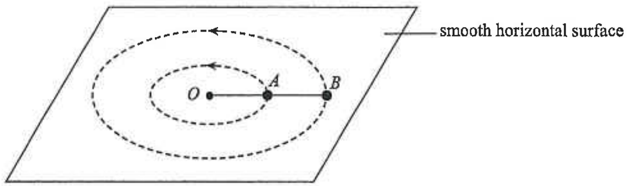
A. 280 m s^{-1}

B. 226 m s^{-1}

C. 140 m s^{-1}

D. 100 m s^{-1}

15. **< HKAL 2010 Paper IIA - 8 >**



Two identical small particles A and B are connected by inextensible threads to a fixed point O as shown. The threads OA and AB are of the same length. Both A and B perform uniform horizontal circular motion about O with the same period. Suppose T_1 and T_2 denote the tensions in the threads OA and AB respectively. Find the ratio $T_1 : T_2$.

A. 3 : 2

B. 2 : 1

C. 3 : 1

D. 4 : 1

16. **< HKAL 2011 Paper IIA - 6 >**

A particle is performing uniform horizontal circular motion about a fixed point on a smooth horizontal plane. Which of the following physical quantities of the particle remain(s) unchanged ?

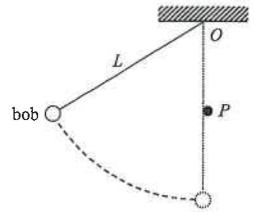
(1) the linear momentum of the particle

(2) the centripetal acceleration of the particle

(3) the kinetic energy of the particle

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

17. **< HKAL 2012 Paper IIA - 9 >**



A heavy bob is suspended from a fixed point O by an inextensible thread of length L. A small peg P is fixed at a distance $\frac{1}{2} L$ vertically below O. The bob is pulled to one side and then released from rest as shown. When the thread just touches the peg, which of the following physical quantities will increase suddenly ?

(1) the linear speed of the bob

(2) the centripetal acceleration of the bob

(3) the tension in the thread

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

Part B : Supplemental exercise

18. The maximum frictional force between the road surface and the wheels of a certain vehicle at a horizontal road is halved when the road is wet. If the maximum safety speed for turning round the bend is 15 m s^{-1} when the road is wet, what is the maximum safety speed when the road is dry ?

A. 21.2 m s^{-1}
B. 22.5 m s^{-1}
C. 26.0 m s^{-1}
D. 30.0 m s^{-1}

19. Which of the following statements is correct for a particle moving in a horizontal circle with constant angular velocity ?

A. The linear momentum is constant but the kinetic energy varies.
B. The linear momentum varies but the kinetic energy is constant.
C. Both the linear momentum and the kinetic energy are constant.
D. Both the linear momentum and the kinetic energy vary.

20. A mass of 2 kg rotates at constant speed in a horizontal circle of radius 5 m and the time for one complete revolution is 3 s. The centripetal force acting on the mass is

A. 2.19 N
B. 4.39 N
C. 43.9 N
D. 109.7 N

21. A particle travels in uniform circular motion with constant radius of curvature. Which of the following statements concerning the motion of the particle is/are correct ?

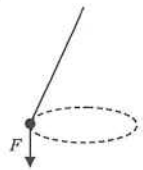
(1) The linear velocity is constant.
(2) The angular velocity is constant.
(3) The centripetal acceleration is constant.

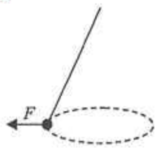
A. (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

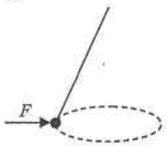
22. An aircraft is moving in a horizontal plane at a constant speed of 650 m s^{-1}. The radius of its circular path is 80 km. What is the ratio of the centripetal force to the weight of the aircraft ?

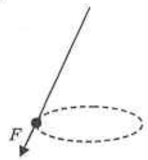
A. 0.019
B. 0.54
C. 1.85
D. 52

23. A particle is attached to an inextensible string and is set into circular motion in a horizontal plane. Which of the following diagrams correctly shows the direction of the resultant force F acting on the particle ?

A.


B.


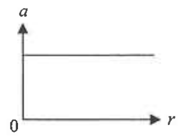
C.


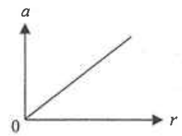
D.


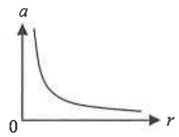
24. The minute hand of a large clock is 1.2 m long. What is its average angular speed ?

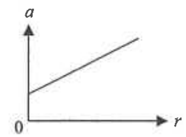
A. 0.87 × 10^{-3} rad s^{-1}
B. 1.45 × 10^{-3} rad s^{-1}
C. 1.75 × 10^{-3} rad s^{-1}
D. 2.09 × 10^{-3} rad s^{-1}

25. A record on a turntable is rotating at a constant period. Which graph shows correctly the relation between the acceleration a of particles fixed on the surface of the record and their distance r from the centre of rotation ?

A.


B.


C.


D.


26. An aircraft is travelling at constant speed in a horizontal circle with centre O. The diagrams below show the tail-view of the aircraft, the dotted line representing the line of the wings and the circle representing the centre of gravity of the aircraft. Which one of the diagrams correctly shows the forces acting on the aircraft ?

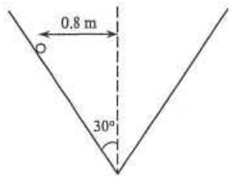
A.


B.


C.


D.


27.

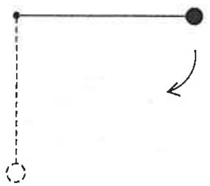


A small ball bearing of mass 0.2 kg is whirling in a horizontal circle with radius 0.8 m inside a smooth inverted cone. What is the linear speed of the ball bearing ?

A. 2.1 m s^{-1}
B. 3.0 m s^{-1}
C. 3.7 m s^{-1}
D. 4.0 m s^{-1}

Part C : HKDSE examination questions

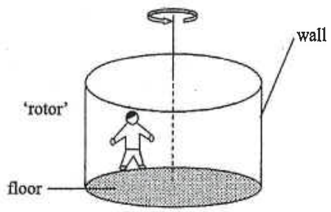
28. < HKDSE Sample Paper IA - 10 >



A simple pendulum is pulled horizontally and then released from rest with the string taut. Which of the following statements about the tension in the string is **not correct** when the pendulum reaches its vertical position ?

A. The tension equals the weight of the pendulum bob in magnitude.
B. The tension attains its greatest value.
C. The tension does not depend on the length of the pendulum.
D. The tension depends on the mass of the pendulum bob.

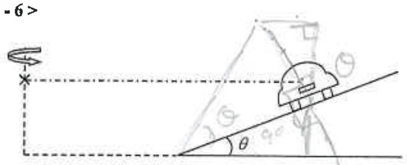
29. < HKDSE Practice Paper IA - 12 >



A man is rotating with constant speed inside a cylindrical 'rotor' and the he remains pressed against the wall. The floor of the 'rotor' is smooth. Which of the following forces provides the centripetal force for the man ?

A. the weight of the man
B. the frictional force from the wall
C. the normal reaction from the wall
D. the supporting force from the floor.

30. < HKDSE 2015 Paper IA - 6 >

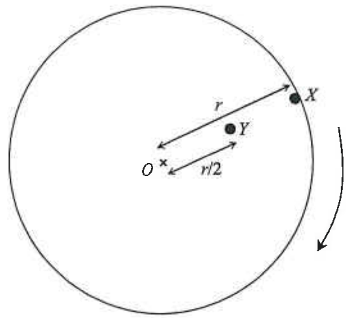


The figure shows the rear view of a car of mass m which travels along a circular road banked with an angle θ to the horizontal. The car moves at a certain speed such that it experiences no frictional force along the inclined surface. Which of the following represents the centripetal force on the car ?

A. $mg\sin\theta$
B. $mg\sin\theta\cos\theta$
C. $mg\cos\theta / \sin\theta$
D. $mg\sin\theta / \cos\theta$

31. < HKDSE 2016 Paper IA - 13 >

Particles X and Y are fixed at distances r and $r/2$ respectively from the centre O of a horizontal circular platform which is rotating uniformly as shown.



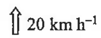
TOP VIEW

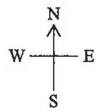
The ratio of the acceleration of X to that of Y is

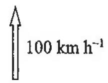
A. 1 : 2
B. 2 : 1
C. 1 : 4
D. 4 : 1

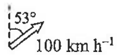
32. < HKDSE 2016 Paper IA - 5 >

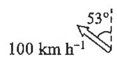
A car travelling at 80 km h^{-1} due east changes direction and travels at 60 km h^{-1} due north. Which diagram represents the change in velocity of the car ?

A.




B.


C.


D.


3. (b) (iv) v decreases [1]

θ decreases as v decreases, i.e. $v\downarrow \Rightarrow \theta\downarrow$, from (3): $v^2 = gL\cdot\tan\theta\cdot\sin\theta$ [1]

From (2), $T = \dfrac{mg}{\cos\theta}$ so T decreases, i.e. $\theta\downarrow \Rightarrow \cos\theta\uparrow \Rightarrow T\downarrow$ [1]

4. (a)

< Weight drawn, labelled with W or mg > [1]
< Tension drawn, labelled with T > [1]
[Deduct 1 mark if extra force or centripetal force is drawn]

(b) Resolve the tension T into two components.

$T\sin\theta = mL\sin\theta\,\omega^2$ [1]

$T\cos\theta = mg$ [1]

$\therefore \dfrac{mg}{\cos\theta} = mL\omega^2$ $\quad\therefore \omega^2 = \dfrac{g}{L\cos\theta}$ [1]

Period $= \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{L\cos\theta}{g}}$ [1]

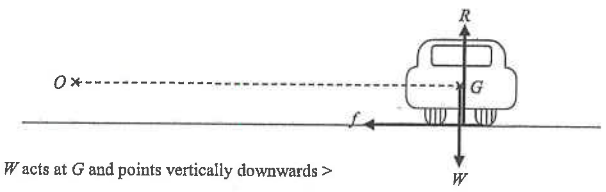
(c) Period $= 2\pi\times\sqrt{\dfrac{(0.8)\cos 25^\circ}{(9.81)}}$ [1]

$= 1.71$ s [1]

(d) (i) If the angle θ is increased, $\cos\theta$ would decrease, [1]
thus the period would decrease. [1]

(ii) If the angle θ is increased, by $T\cos\theta = mg$ [1]
the tension would increase. [1]

5. (a)



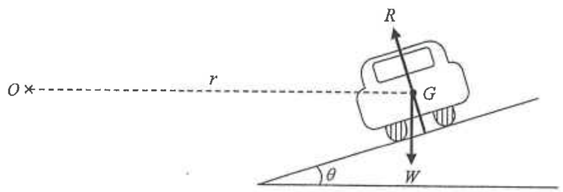
< weight W acts at G and points vertically downwards > [1]
< normal reaction R points vertically upwards > [1]
< friction f acts on the wheels and points leftwards > [1]
[if the force towards O is labelled as centripetal force, no mark should be given]
[if centrifugal force is drawn, deduct 1 mark]

5. (b) $f = \dfrac{mv^2}{r}$

$= \dfrac{(1800)(15)^2}{(75)}$ [1]

$= 5400$ N [1]

(c) (i)



< normal reaction R acts on the car perpendicular to the inclined plane > [1]
< weight W acts at G vertically downwards > [1]
[if friction is drawn, deduct 1 mark]
[if centripetal force is drawn, deduct 1 mark]

(ii) The centripetal force is provided by the horizontal component of the normal reaction. [1]

(iii) $R\sin\theta = \dfrac{mv^2}{r}$ [1]

$R\cos\theta = mg$ [1]

$\therefore \tan\theta = \dfrac{v^2}{gr}$ [1]

(iv) ① To give greater speed without skidding. [1]

② A smaller radius of bending road can be designed for vehicles without skidding. [1]

6. (a) $P\cos 36^\circ = (4.5\times10^5)(9.81)$ [1]

$\therefore P = 5.46\times10^6$ N [1]

(b) Centripetal force $= P\sin\theta$

$= (5.46\times10^6)\sin 36^\circ$ [1]

$= 3.21\times10^6$ N [1]

(c) $F = ma$

$\therefore (3.21\times10^6) = (4.5\times10^5)\,a$ [1]

$\therefore a = 7.13$ m s^{-2} [1]

The direction of the acceleration is towards the centre O. [1]

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) F_A : friction [1]

F_B : normal reaction [1]

(b) $F_A = m g$ [1]

maximum $F_A = 0.4 F_B$

$\therefore\ m g = 0.4 \times m r \omega^2$ [1]

$\therefore\ (9.81) = 0.4 \times (3.2)\,\omega^2$

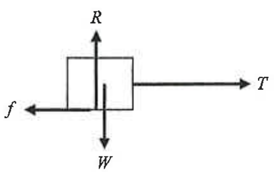
$\therefore\ \omega = 2.77$ rad s^{-1} [1]

(c) The result is unchanged. [1]

As the centripetal force is proportional to maximum F_A which is equal to the weight $m g$,

the minimum angular speed is independent of the mass m. [1]

2. (a) (i)



< Any two forces drawn correctly > [1]

< All four forces drawn correctly > [1]

(ii) Applied horizontal force $= T - f_{max}$ [1]

$= 10 - 3 = 7$ N [1]

(b) (i) Minimum angular speed occurs when the maximum friction directs away from the centre, so that the centripetal force is the minimum.

$\therefore\ T - f_{max} = m r \omega_1^2$ [1]

$\therefore\ (10) - (3) = (0.5) \times (0.1)\,\omega_1^2$

$\therefore\ \omega_1 = 11.8$ rad s^{-1} [1]

(ii) Maximum angular speed occurs when the maximum friction directs towards the centre, so that the centripetal force is the maximum.

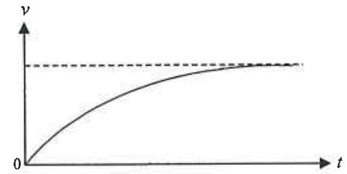
$\therefore\ T + f_{max} = m r \omega_2^2$

$\therefore\ (10) + (3) = (0.5) \times (0.1)\,\omega_2^2$ [1]

$\therefore\ \omega_2 = 16.1$ rad s^{-1} [1]

(c) The tension is unchanged. [1]

3. (a)



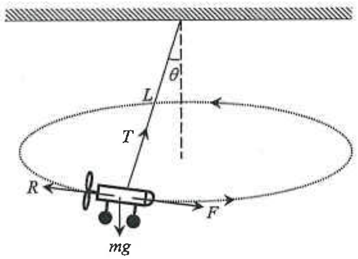
[1]

As the toy increases its velocity, the air resistance on the toy increases. [1]

The net force and thus the acceleration of the toy decrease. [1]

Finally, when the air resistance equals the propelling force of the fan, the toy reaches its final terminal velocity. [1]

(b) (i)



R is air resistance [1]

F is propelling force [1]

mg is weight and T is tension [1]

[Deduct 1 mark if "centripetal force" is drawn]

[Deduct 1 mark if the forces are only labelled without naming]

(ii) $T \sin\theta = \dfrac{m v^2}{L \sin\theta}$ $\quad (r = L \sin\theta)$

$\therefore\ T \sin^2\theta = \dfrac{m v^2}{L}$ ..... (1) [1]

$T \cos\theta = m g$ ..... (2) [1]

(iii) $\dfrac{(1)}{(2)}: \ \dfrac{\sin^2\theta}{\cos\theta} = \dfrac{v^2}{gL}$ ..... (3)

$\therefore\ \dfrac{1-\cos^2\theta}{\cos\theta} = \dfrac{(2)^2}{(10)(0.8)}$ [1]

$\therefore\ 2 - 2\cos^2\theta = \cos\theta$

$\therefore\ 2\cos^2\theta + \cos\theta - 2 = 0$

$\therefore\ \cos\theta = 0.7808$ $\qquad \therefore\ \theta = 38.7°$ [1]

By (2) : $T = 1.28$ N [1]

10. <HKDSE 2019 Paper-IB-4>

(ii) Indicate on Figure 4.1 the centripetal force F_C required for the motion of the bob. Find F_C. (3 marks)

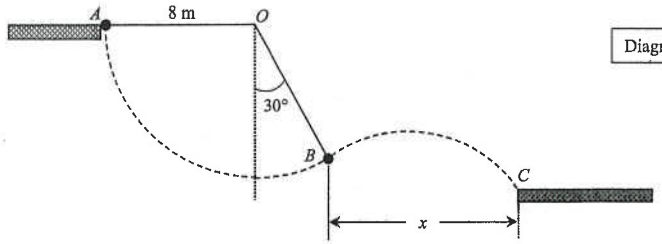
(iii) Explain whether the magnitude of the tension in the string is greater than, equal to or smaller than the centripetal force F_C found in (a)(ii). (2 marks)

(b) The moon is orbiting around the Earth uniformly in a circular path under the influence of the Earth's gravitational attraction.

(i) Explain why the speed of the moon remains unchanged although it is acted upon by gravitational force. (2 marks)

(ii) A student claimed that as the moon is much less massive than the Earth, it exerts negligible force on the Earth. Comment on the student's claim. (2 marks)

8. **< HKDSE 2015 Paper IB - 3 >**



The above Figure shows two horizontal platforms with end points A and C. An acrobat tries to swing from A to C by using a light rope of 8 m long and with one end fixed at point O, which is at the same level as A. He leaves A by holding the end of the rope and then releases it when reaching point B at which the angle between the rope and the vertical is 30°. The acrobat can be treated as a point mass and the rope remains taut and not extended throughout the motion. Neglect air resistance. ($g = 9.81\ m\ s^{-2}$)

(a) Mark on the above Figure the velocity v_B of the acrobat at B. If the speed of the acrobat when leaving A is zero, find the magnitude of v_B. (3 marks)

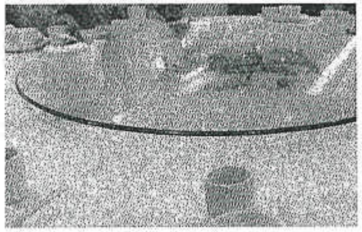
(b) (i) It takes 1.25 s for the acrobat to reach C after releasing the rope at B. By considering his horizontal motion, find the horizontal separation x between B and C. (2 marks)

(ii) Calculate the vertical distance of C below B. (3 marks)

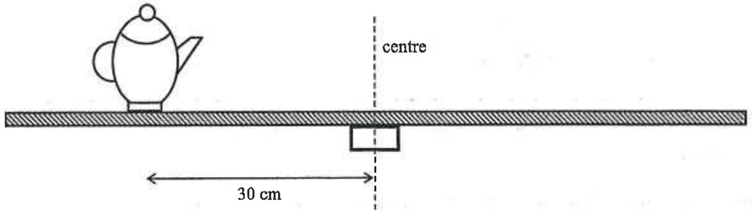
(c) Before reaching the lower platform, is there any change to the acrobat's mechanical energy among the points A, B and C? (1 mark)

9. **< HKDSE 2017 Paper IB - 5 >**

The photo shows a turntable commonly used in restaurants.



A teapot of mass 1 kg is put 30 cm from the centre of a horizontal turntable, and the Figure below shows the side view. When the turntable is rotating, the teapot remains at the same position on the turntable.

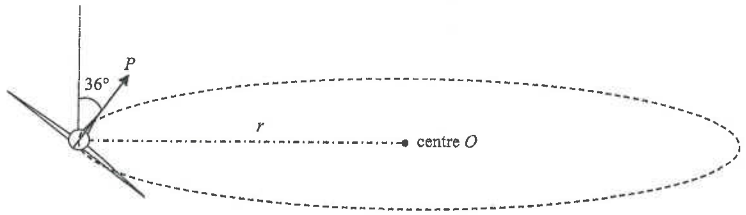


(a) On the above Figure, draw and label all the forces acting on the teapot when the turntable is rotating. (2 marks)

(b) Taking the teapot as a point mass, estimate the net force acting on the teapot when the turntable is rotating at a rate of 0.5 revolutions per second. (3 marks)

(c) The turntable is suddenly stopped and the teapot slips. The turntable is rotating at a rate of 0.5 revolutions per second just before it stops, and the frictional force acting on the teapot is 10 N when it is slipping. Determine the distance travelled by the teapot after the turntable stops. (3 marks)

6. An aircraft flies with its wings tilted 36° in order to fly in a horizontal circle of radius r as shown below. The aircraft has a mass of 4.5×10^5 kg and it moves with a constant speed of 240 m s^{-1}. The figure shows that there is a lift force P acting on the aircraft.



(a) Calculate the lift force P shown in the figure. (2 marks)

(b) Determine the centripetal force acting on the aircraft. (2 marks)

(c) Find the acceleration of the aircraft. What is the direction of the acceleration ? (3 marks)

(d) Calculate the radius r of the circular path of the aircraft's flight. (2 marks)

(e) Suppose the aircraft moves with the same speed but tilts with a greater angle. What are the effects on the following :

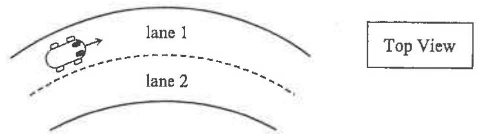
(i) the lift force P ; (1 mark)

(ii) the centripetal acceleration ; (1 mark)

(iii) the radius of the circular path r. (1 mark)

Part C : HKDSE examination questions

7. < HKDSE 2012 Paper IB - 3 >



The Figure above shows the top view of a horizontal road with two circular lanes. A car of mass 1200 kg moves with constant speed in lane 1 of radius 45 m.

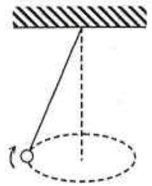
(a) (i) Name the force that provides the centripetal force for the car. If the maximum value of this force is 8000 N, calculate the highest speed of the car such that it can keep in lane 1. (3 marks)

(ii) Suppose the car takes lane 2 instead of lane 1 and the maximum value of the force providing the centripetal force is still 8000 N. Would the car's highest speed in lane 2 be smaller than, larger than or the same as that found in (a) (i) ? Explain. (2 marks)

(b) Explain why the chance of skidding would increase if there are oil patches on the road surface in the above Figure. (2 marks)

Part B : Supplemental exercise

4. A bob is attached to a string and made to revolve in a horizontal circle as shown.



(a) Draw and label the forces acting on the bob at the instant shown. (2 marks)

(b) If the length of the string is L and the angle that the string made with the vertical is θ, derive an expression for the period of the circular motion. (Neglect air resistance.) (4 marks)

(c) Calculate the period of the circular motion if the length of the string is 0.8 m and the string makes an angle of 25° during the circular motion. (2 marks)

(d) Explain and describe the effects on

(i) the period of revolution ; and

(ii) the tension of the string,

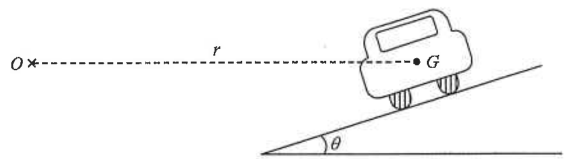
if the angle made with the vertical is increased during the revolution. (4 marks)

5. The figure shows the rear view of a car with mass 1800 kg which turns round a horizontal circular road with a uniform speed of 15 m s^{-1}. G is the centre of gravity of the car and O is the centre of its circular motion. The radius of the circular road is 75 m. Neglect air resistance.

(a) Let R be the normal reaction on the car, and let f be the friction on the wheels, draw all the forces acting on the car in the above figure. (3 marks)

(b) Calculate the magnitude of friction acting on the car. (2 marks)

(c) Now the road is banked with an angle θ to the horizontal as shown. The ideal banking angle is designed so that there is no friction acting on the car.



(i) Draw the forces acting on the car in the figure. (2 marks)

(ii) State which force provides the centripetal force for the car to travel in circular motion. (1 mark)

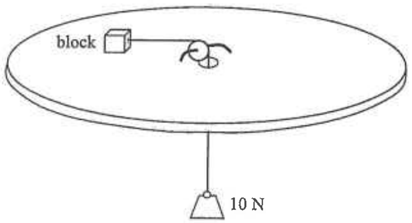
(iii) Derive an expression for the ideal banking angle in terms of v and r. (3 marks)

(iv) Give **TWO** advantages of banking at a bend in highways. (2 marks)

2. < HKAL 2003 Paper I - 1 >

A small block of mass 0.5 kg is placed at 10 cm from the centre of a horizontal turntable. The block is connected to one end of a light inextensible string which passes over a small smooth pulley fixed at the centre of the turntable, as shown in the below figure. The string runs through a hole at the centre of the turntable and a weight of 10 N is suspended at its other end. The maximum friction between the block and the turntable is 3 N.

(Note : The axle of the turntable is not shown in the diagram.)



(a) Suppose the turntable is stationary.

(i) Draw a diagram to show all the force(s) acting on the block. (2 marks)

(ii) Find the minimum external force applied to the block that needs to keep the block stationary. (2 marks)

(b) Suppose the turntable is rotating with a certain angular speed about its centre.

(i) Calculate the minimum angular speed ω_1 of the turntable such that the block can remain at its original position without slipping. (2 marks)

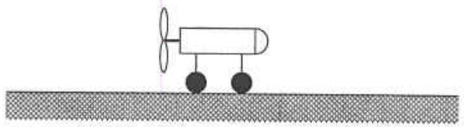
(ii) Calculate the maximum angular speed ω_2 of the turntable such that the block can remain at its original position without slipping. (2 marks)

(c) When the angular speed of the turntable is increased gradually from ω_1 to ω_2 and the block does not slip. State the change, if any, of the tension in the string. (1 mark)

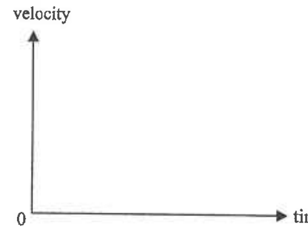
3. < HKAL 2008 Paper I - 5 >

In Figure 1, a toy is placed on a smooth horizontal surface. It is equipped with a fan powered by a battery. When the fan is switched on, the toy starts moving to the right and it finally reaches a constant velocity.

Figure 1

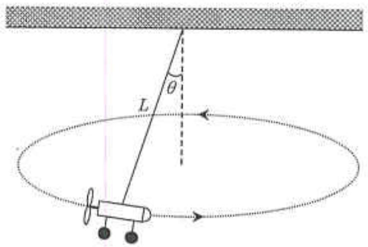


(a) With the aid of a velocity-time graph, explain the motion of the toy after the fan is switched on. (4 marks)



(b) The toy of mass m is now attached to a fixed point on the ceiling by a light string of length L. It is set into a uniform horizontal circular motion as shown in Figure 2. The string makes an angle θ to the vertical when the velocity of the toy is v. Take g to be 10 m s^{-2}.

Figure 2



(i) Draw and name all the force(s) acting on the toy in Figure 2. (3 marks)

(ii) Write down **TWO** equations for the vertical and horizontal components of forces on the toy. (2 marks)

(iii) If $m = 0.1$ kg, $L = 0.8$ m and $v = 2$ m s^{-1}, show that the angle θ satisfy the equation : $2\cos^2\theta + \cos\theta - 2 = 0$
Hence calculate the values of θ and tension T. (3 marks)

(iv) If the output voltage of the battery inside the toy drops slightly, describe and explain its subsequent motion in terms of v, θ and T. (3 marks)

The following list of formulae may be found useful :

Centripetal acceleration $a = \frac{v^2}{r} = \omega^2 r$

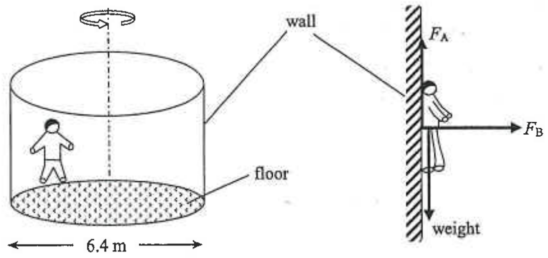
Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81 \text{ m s}^{-2}$ (close to the Earth)

Part A : HKAL examination questions

1. **< HKAL 2001 Paper I - 1 >**

The figure below shows a man of mass 80 kg standing against the wall of a cylindrical compartment called a 'rotor'. The level of the rotor's floor can be adjusted. The diameter of the rotor is 6.4 m.



The rotor is spun at a certain angular speed about its central vertical axis. At this angular speed, the man inside remains 'pinned' against the wall even if the floor of the rotor is pulled downwards.

(a) Name the forces F_A and F_B acting on the man. (2 marks)

(b) It is known that the maximum value of F_A equals 0.4 F_B. Find the minimum angular speed, in rad s^{-1}, of the rotor that needed to keep the man 'pinned' against the wall. (3 marks)

(c) If the mass of the man is greater than 80 kg, would the result in (b) increase, decrease or remain unchanged ? Explain briefly. (2 marks)

19. B

Since the direction of the velocity is always changing,
the direction of the linear momentum varies, thus linear momentum varies

As the magnitude of the velocity is constant, the kinetic energy is constant as kinetic energy is a scalar without direction.

20. C

$F = m r \omega^2$

$= m r (\frac{2\pi}{T})^2 = (2)(5)(\frac{2\pi}{3})^2 = 43.9 \text{ N}$

21. A

× (1) As the direction of the velocity is always changing, the linear velocity varies.

✓ (2) The direction of angular velocity is constant (either always in clockwise or in anticlockwise direction), and the magnitude of angular velocity ($\omega = v / r$) is also constant, thus angular velocity is constant.

× (3) The direction of the centripetal acceleration is always towards the centre, thus its direction is always changing, therefore, centripetal acceleration varies.

22. B

$\frac{F}{W} = \frac{m v^2 / r}{m g} = \frac{v^2}{g r} = \frac{(650)^2}{(9.81)(80 \times 10^3)} = 0.54$

23. C

The resultant force is the centripetal force which must be directed towards the centre of the circular path.

24. C

The period of the minute hand of a clock is 60 minutes for one revolution.

Angular speed :

$\omega = \frac{2\pi}{T} = \frac{2\pi}{(60 \times 60)} = 1.75 \times 10^{-3} \text{ rad s}^{-1}$

25. B

Angular speed : $\omega = 2\pi / T$, as period is constant, ω is constant.

By $a = r\omega^2$, as ω for the particle on the record is the same $\therefore v \propto r$

A graph of v against r should be a straight line through the origin.

26. B

There are two forces acting on the aircraft :

① the weight which is vertically downwards

② the lift force which is perpendicular to the wings

27. C

There is two forces acting on the ball bearing : the weight mg and the normal reaction R.

Vertically, $R \sin 30° = m g$

Horizontally, $R \cos 30° = \frac{m v^2}{r}$

$\therefore \tan 30° = \frac{g r}{v^2}$

$\therefore \tan 30° = \frac{(9.81)(0.8)}{v^2}$ $\therefore v = 3.7 \text{ m s}^{-1}$

28. A

× A. At the lowest point, $T - W = \frac{mv^2}{r}$. Thus the tension should be greater than the weight.

✓ B. The tension is the greatest at the lowest point since it supports the weight and provide the greatest centripetal force as the speed of bob is maximum.

✓ C. During the swing from horizontal position to vertical position, $m g r = \frac{1}{2} m v^2$ $\therefore v^2 = 2 g r$

At the vertical position, tension of the string : $T = W + \frac{mv^2}{r} = m g + \frac{m(2gr)}{r} = 3\,mg$

The tension is thus not affected by the length of the pendulum.

✓ D. The tension is 3 mg which depends on the mass of the bob m.

29. C

The centripetal force must be directed towards the centre.

This force should be provided by the normal reaction from the wall on the man.

The normal reaction by the wall is horizontally acting on the back of the man away from the wall towards the centre.

30. D

There is two forces acting on the car : weight mg and normal reaction R.

Since the vertical forces are balanced :

$R \cos\theta = mg$ $\therefore R = \frac{mg}{\cos\theta}$

The horizontal component of the normal reaction provides the centripetal force.

Thus, the centripetal force on the car :

$F = R \sin\theta = \frac{mg}{\cos\theta} \times \sin\theta = \frac{mg \sin\theta}{\cos\theta}$

31. B

Since the two particles are moving in the same rotating platform, their angular velocity ω must be the same .

Centripetal acceleration : $a = r\omega^2$

Since ω is the same, thus $a \propto r$

$\therefore a_X : a_Y = r_X : r_Y = 2 : 1$

9. C

If no friction is required, the horizontal component of the normal reaction force gives centripetal force.

Horizontally : $R\sin 18° = \frac{mv^2}{r}$

Vertically : $R\cos 18° = mg$

$\therefore \tan 18° = \frac{v^2}{(10)(12)}$ $\therefore v = 6.2 \text{ m s}^{-1}$

10. D

Since coin P and coin Q are rotating on the same disc, they must have the same angular speed ω (also same period).

✓ (1) By $v = r\omega$, $v \propto r$, thus speed of Q is two times that of P.
By $KE = \frac{1}{2}mv^2$, kinetic energy of Q is four times that of P.

✓ (2) By $f = mr\omega^2$, $f \propto r$, thus friction acting on Q is double that acting on P.

✓ (3) If the angular speed gradually increases, the friction that provides the centripetal force must increase.
As the friction of Q is greater, the friction on Q would reach the maximum friction first, thus B slips first.

11. C

× (1) By $T\sin\theta = m(L\sin\theta)\omega^2$ If L is kept constant, $\omega\uparrow$, $T\uparrow$ (T can be increased by increasing W)
By $T\cos\theta = mg$ When $T\uparrow$, $\cos\theta\downarrow$ $\therefore \theta\uparrow$ $\therefore \theta$ should be increased with ω.

× (2) By $T\cos\theta = mg$, if θ is constant, then T is also constant.
By $T\sin\theta = mL\sin\theta\,\omega^2$ $\therefore \omega\uparrow \Rightarrow L\downarrow$ $\therefore L$ will decrease with ω.

✓ (3) By $T = W$ $\therefore W\uparrow \Rightarrow T\uparrow$
By $T\cos\theta = mg$ $\therefore T\uparrow \Rightarrow \cos\theta\downarrow \Rightarrow \theta\uparrow$

12. A

Consider vertical component : $R\cos\theta = mg$ ... (1) $\therefore$ A is correct but B is incorrect.

Consider horizontal component : $R\sin\theta = \frac{mv^2}{r}$ ... (2)

Combine (1) and (2) : $v^2 = gr\tan\theta$ $\therefore$ C and D are incorrect.

13. A

× A. At the lowest point, $T - W = \frac{mv^2}{r}$. Thus the tension should be greater than the weight of the bob.

✓ B. The tension is the greatest at the lowest point
since it supports the weight bob and provides the greatest centripetal force.

✓ C. During the swing from horizontal position to vertical position, $mgr = \frac{1}{2}mv^2$ $\therefore v^2 = 2gr$
At the vertical position, tension of the string : $T = W + \frac{mv^2}{r} = mg + \frac{m(2gr)}{r} = 3\,mg$
Thus, the tension is not affected by the length of the string.

✓ D. The tension is 3 mg at the vertical position, thus it depends on the mass of the bob m.

14. B

By $\tan\theta = \frac{v^2}{g\cdot r}$

$\therefore \tan 23.5° = \frac{v^2}{(9.81)(12\times10^3)}$

$\therefore v = 226 \text{ m s}^{-1}$

15. A

Since the two particles have the same period, they must have the same angular speed ω.

Let the mass of each particle be m, and let OA be r and OB be $2r$.

Consider A : $T_1 - T_2 = mr\omega^2$

Consider B : $T_2 = m(2r)\omega^2$

Combine the two equations :

$\therefore 2(T_1 - T_2) = T_2$

$\therefore T_1 : T_2 = 3 : 2$

16. B

× (1) Momentum is a vector. As the direction of velocity changes, direction of momentum also changes.

× (2) Centripetal acceleration is a vector. Its direction is always towards the centre.
Thus the direction of centripetal acceleration is always changing.

✓ (3) Kinetic energy is a scalar. For uniform circular motion, the speed is constant, thus KE is constant.

17. D

As the thread just touches the peg, the radius of the circular motion suddenly becomes halved.

× (1) The speed would not change as the kinetic energy does not change when the thread touches the peg.

✓ (2) Centripetal acceleration : $a = \frac{v^2}{r}$.
As r is halved, a is doubled, thus the acceleration will increase.

✓ (3) Tension : $T - mg = \frac{mv^2}{r}$. As r is halved, T will increase.

18. A

In a horizontal road, friction is the only force that can provide the centripetal force.

$\therefore f = \frac{mv^2}{r}$ $\therefore f \propto v^2$

$\therefore \frac{f_w}{f_d} = (\frac{v_w}{v_d})^2$

$\therefore \frac{1}{2} = (\frac{15}{v_d})^2$

$\therefore v_d = 21.2 \text{ m s}^{-1}$

M.C. Answers

1. C	11. C	21. A	31. B
2. A	12. A	22. B	32. D
3. D	13. A	23. C	**33. D**
4. D	14. B	24. C	34. A
5. C	15. A	25. B	
6. C	16. B	26. B	
7. C	17. D	27. C	
8. A	18. A	28. A	
9. C	19. B	29. C	
10. D	20. C	30. D	

M.C. Solution

1 C

✓ (1) Horizontal component of the normal reaction $R \sin \theta$ can be used to provide the centripetal force, thus the need of frictional force for providing the centripetal force is reduced.

✓ (2) The horizontal component of the normal reaction helps to provide the centripetal force, thus the centripetal acceleration can be increased.
As $a = v^2 / r$,
the increase of centripetal acceleration a can give a smaller radius of curvature r of a circular path.

× (3) As the direction of the weight is vertical, it can never give a horizontal component to provide the centripetal acceleration which is horizontal.

2. A

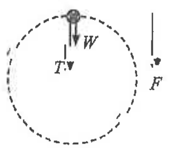
There are only two forces acting on the stone:

① the weight W

② the tension T

As centripetal force F is the net force,

$\therefore \quad F = W + T$

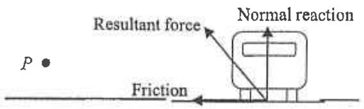


3. D

Friction exerted by the road provides the centripetal force, thus its direction is towards the centre P to the left.

Normal reaction exerted by the road acts to balance the weight.

The resultant of these two forces exerted by the road is shown.



4. D

The vertical force exerted on the car by the track is the normal reaction R.

The centripetal force is the net force towards the centre, thus the centripetal force is $R - mg$.

$$\therefore \quad R - mg = \frac{m v^2}{r}$$

$$\therefore \quad R = m g + \frac{m v^2}{r}$$

5. C

Consider vertical motion, $\quad R \sin 30° = mg \quad \ldots (1)$

Consider horizontal motion, $\quad R \cos 30° = \dfrac{mv^2}{r} \quad \ldots (2)$

$\therefore \quad \tan 30° = \dfrac{g r}{v^2} \qquad \therefore \quad v^2 = \dfrac{g r}{\tan 30°}$

6. C

When the mass is set to rotate, it is a conical pendulum.

$T \cos \theta = m g$

$\therefore \quad (3.5) \cos \theta = (0.25)(9.81)$

$\therefore \quad \theta = 45.5°$

7. C

Consider the motion from the rim to the bottom :

$m g h = \frac{1}{2} m v^2$

$\therefore \quad m (9.81)(0.10) = \frac{1}{2} m v^2 \qquad \therefore \quad v = 1.40 \text{ m s}^{-1}$

At the bottom, the resultant of the normal reaction and the weight gives the centripetal force.

$$R - mg = \frac{m v^2}{r}$$

$\therefore \quad R - (0.05)(9.81) = \dfrac{(0.05)(1.4)^2}{(0.10)} \qquad \therefore \quad R = 1.47 \text{ N} \approx 1.5 \text{ N}$

8. A

The lift force L on the aircraft should be resolved into two components :

vertical component $= L \cos \theta$

horizontal component $= L \sin \theta$

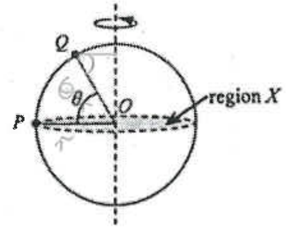
$\therefore \quad L \sin \theta = \dfrac{m v^2}{r} \quad$ and $\quad L \cos \theta = m g$

$\therefore \quad \tan \theta = \dfrac{v^2}{g r} = \dfrac{(175)^2}{(10)(15 \times 10^3)} \qquad \therefore \quad \theta = 11.5°$

33.<HKDSE 2020 Paper IA-8>

34. <HKDSE 2020 Paper IA-9>

Particles P and Q are fixed on the surface of a sphere rotating about a vertical axis passing through the centre O of the sphere as shown. The horizontal shaded region X divides the sphere into two halves. P is at the edge of region X while Q is at an angle of elevation θ above region X.



Find the ratio of the centripetal acceleration of P to that of Q.

A. $1 : \cos\theta$
B. $1 : \sin\theta$
C. $\cos\theta : 1$
D. $\sin\theta : 1$

6. (d) $a = \frac{v^2}{r}$

$\therefore\ (7.13) = \frac{(240)^2}{r}$ [1]

$\therefore\ r = 8080$ m [1]

(e) (i) increase [1]

(ii) increase [1]

(iii) decrease [1]

7. (a) (i) Friction provides the centripetal force for the car. [1]

$f = \frac{m v^2}{r}$ [1]

$\therefore\ (8000) = \frac{(1200)\, v^2}{(45)}$

$\therefore\ v = 17.3$ m s^{-1} [1]

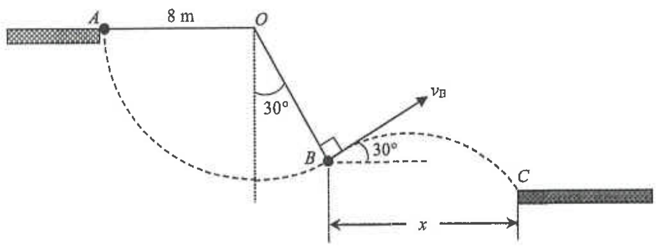
(ii) The car's highest speed in lane 2 would be smaller. [1]

For the same f, $v^2 \propto r$, as the radius r of lane 2 is smaller, the speed v is smaller. [1]

(b) If there are oil patches, the maximum friction acting on the car by the road would decrease. [1]

Thus the highest speed without skidding would decrease. [1]

8. (a)



< direction of v_B marked perpendicularly to the rope OB > [1]

By Conservation of energy :

$\therefore\ m g h = \frac{1}{2} m v^2$

$\therefore\ (9.81) \times (8 \cos 30°) = \frac{1}{2} v_B^2$ [1]

$\therefore\ v_B = 11.7$ m s^{-1} [1]

8. (b) (i) $x = u_x t$

$= (11.7 \cos 30°) \times (1.25)$ [1]

$= 12.7$ m < accept 12.6 m to 12.8 m > [1]

(ii) $y = u_y t + \frac{1}{2} a_y t^2$ [1]

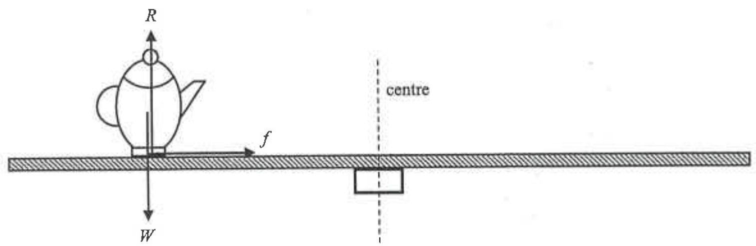
$= (11.7 \sin 30°) \times (1.25) + \frac{1}{2}(-9.81) \times (1.25)^2$ [1]

$= -0.352$ m [1]

C is at 0.352 m below B. < accept 0.352 m to 0.414 m >

(c) No ! The mechanical energy is unchanged. [1]

9. (a)



< Weight W and normal reaction R correctly drawn and labelled > [1]

< Friction f correctly drawn and labelled > [1]

[W can be labelled with mg or weight]

[R can be labelled with N or normal reaction]

[f can be labelled with friction]

(b) $F = m r \omega^2$ [1]

$= (1)\,(0.3)\,(0.5 \times 2\pi)^2$ [1]

$= 2.96$ N [1]

(c) $v = r\omega = (0.3)\,(0.5 \times 2\pi) = 0.942$ m s^{-1} [1]

By $\frac{1}{2} m v^2 = f s$

$\therefore\ \frac{1}{2}(1)\,(0.942)^2 = (10)\, s$ [1]

$\therefore\ s = 0.0444$ m < accept 0.044 m > [1]

OR

By $f = m a$ $\therefore\ (10) = (1)\, a$ $\therefore\ a = 10$ m s^{-2} [1]

By $v^2 = u^2 + 2as$

$\therefore\ (0) = (0.3\pi)^2 + 2(-10)\, s$ [1]

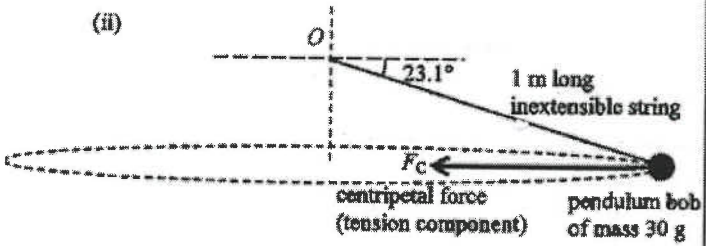
$\therefore\ s = 0.0444$ m [1]

10. (a) (i) Rotation rate $= \frac{\omega}{2\pi} = \frac{5.0}{2\pi}$

$= 0.795775\ (\text{rev s}^{-1}) \approx 0.80\ (\text{rev s}^{-1})$ — 1M/1A

| 1 |

(ii)



F_C correctly indicated. — 1A

$F_C = mr\omega^2$

$= (0.03)(1 \times \cos 23.1°)(5.0)^2$ — 1M

$= 0.689866\ \text{N} \approx 0.690\ \text{N}$ — 1A

($F_C = 0.7033402\ \text{N} \approx 0.703\ \text{N}$ for $g = 10\ \text{m s}^{-2}$)

OR

$T\cos\theta = F_C$ and $T\sin\theta = mg$ — 1M

$F_C = \frac{mg}{\sin\theta}\cos\theta = 0.689866\ \text{N} \approx 0.690\ \text{N}$ — 1A

| 3 |

The following list of formulae may be found useful :

Centripetal acceleration $a = \frac{v^2}{r} = \omega^2 r$

Newton's law of gravitation $F = \frac{G m_1 m_2}{r^2}$

Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81 \text{ m s}^{-2}$ (close to the Earth)

Universal gravitational constant $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$

Part A : HKAL examination questions

1. **< HKAL 1980 Paper I - 2 >**

Two identical spheres, each of mass M and radius r are in contact. One sphere is displaced by a distance $4r$, along the line of centres, away from the first sphere. What is the ratio of the final gravitational force between the sphere to the initial gravitational force between them ?

A. 1 : 3
B. 1 : 9
C. 1 : 16
D. 1 : 25

2. **< HKAL 1984 Paper I - 40 >**

Taking the Earth to be a perfect sphere with uniform density, which of the following statements concerning the gravitational field g of the Earth is/are correct ?

(1) The gravitational field at the surface of the Earth is greater than that at the top of a high mountain.
(2) If the density of the Earth increases with its radius remaining unchanged, g at the surface increases.
(3) If the radius of the Earth increases with its density remaining unchanged, g at the surface decreases.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

3. **< HKAL 1991 Paper I - 1 >**

In which of the following situations is the magnitude of the normal reaction R of the supporting surface equal to the weight mg of the body ?

(1) A body is resting on a rough inclined plane.
(2) A body placed on the floor inside a spacecraft in circular orbit around the Earth.
(3) A body placed on the floor of a lift moving upwards with uniform velocity.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

4. **< HKAL 1993 Paper I - 12 >**

A parking satellite appears stationary vertically above an observer at the equator of the Earth. The radius of the satellite from the Earth is 4.24×10^7 m. Calculate the mass of the Earth.

A. 4.5×10^{24} kg
B. 5.0×10^{24} kg
C. 5.5×10^{24} kg
D. 6.0×10^{24} kg

5. **< HKAL 1996 Paper IIA - 2 >**

In which of the following cases would the resultant force on the object become zero ?

(1) a satellite moving round the Earth
(2) a feather falling freely in a vacuum cylinder in a laboratory
(3) a parachutist falling with terminal velocity in air

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

6. **< HKAL 1997 Paper IIA - 10 >**

A close-orbit satellite near the Earth's surface has a speed of 7900 m s^{-1}. The radius of the Earth is 4 times that of the Moon and the ratio of the average density of the Earth to that of the Moon is 5 : 4. What would be the speed of a close-orbit satellite near the Moon's surface ?

A. 1770 m s^{-1}
B. 2210 m s^{-1}
C. 2470 m s^{-1}
D. 3570 m s^{-1}

7. **< HKAL 2000 Paper IIA - 9 >**

There are two planets X and Y. Each of them has a close-orbit satellite revolving close to the planet. If the two satellites are observed to have the same period, then X and Y must have nearly the same

A. mass.
B. average density.
C. radius.
D. acceleration due to gravity at the planet's surface.

8. **< HKAL 2000 Paper IIA - 2 >**

In the following situations, which of the cases would the normal reaction acting on a body and the weight of the body have the same magnitude ?

(1) A ball bouncing vertically on a horizontal ground is in contact with the ground.
(2) An astronaut in a spacecraft which performs circular motion around the Earth.
(3) A boy standing in a lift which is moving vertically upward with a uniform velocity.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

9. **< HKAL 2003 Paper IIA - 11 >**

Assume that the Earth is a perfect sphere. If the radius of the Earth is 6.4×10^6 m, what is its average density ?

A. 5.5×10^3 kg m^{-3}
B. 7.3×10^3 kg m^{-3}
C. 2.3×10^4 kg m^{-3}
D. 6.0×10^{24} kg m^{-3}

10. < HKAL 2004 Paper IIA - 8 >

There are many satellites revolving around the Saturn. Different satellites have different speed v and radius r. Which of the following correctly express the relation between these two values ?

A. $v \propto r$
B. $v \propto \sqrt{r}$
C. $v \propto \frac{1}{r}$
D. $v \propto \frac{1}{\sqrt{r}}$

11. < HKAL 2004 Paper IIA - 7 >

A planet has a mass 3 times that of the Earth and a diameter 2 times that of the Earth. What is the gravitational field strength on the planet's surface ?

A. 7.36
B. 9.81
C. 14.7
D. 19.6

12. < HKAL 2005 Paper IIA - 28 >

An object of mass 25 kg has a weight of 41 N on the surface of the moon. The radius of the moon is R. What is the gravitational field strength in N kg^{-1}, at a point distance $2R$ from the centre of the moon ?

A. 1.64
B. 0.82
C. 0.41
D. 0.21

13. < HKAL 2006 Paper IIA - 28 >

The Earth is at a distance r from the centre of the Sun. It takes 365 days for the Earth to revolve once around the sun in a circular path. Find the mass of the Sun in terms of r.

A. $2.45 \times 10^{-4} r^3$
B. $5.95 \times 10^{-4} r^3$
C. $3.85 \times 10^{4} r^3$
D. $1.75 \times 10^{6} r^3$

14. < HKAL 2007 Paper IIA - 5 >

In which of the following situations does the person concerned experience 'weightlessness' ?

(1) an astronaut in a spacecraft which is decelerating to make a soft landing on the moon
(2) a parachutist descending with a constant velocity in the air
(3) an astronaut in a spacecraft which is orbiting around the Earth with its rocket engines shut off

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

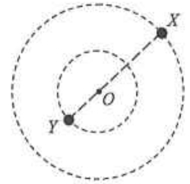
15. < HKAL 2008 Paper IIA - 27 >

Which of the following statements about parking orbits around the Earth are correct ?

(1) All satellites in a parking orbit must have the same speed.
(2) No satellite in a parking orbit can pass vertically above Hong Kong.
(3) There is only one parking orbit around the Earth.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

16. < HKAL 2008 Paper IIA - 28 >



The above figure shows a binary star system in which X and Y are two stars revolving about O with uniform circular motion under their mutual gravitational attraction. If the radius of the orbit of X is twice that of Y, which of the following deductions are correct ?

(1) The acceleration of X is twice that of Y.
(2) The orbital speed of X is equal to that of Y.
(3) The mass of X is half that of Y.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

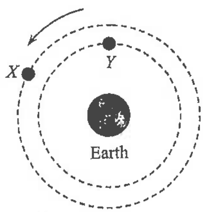
17. < HKAL 2010 Paper IIA - 12 >

Ganymede is one of the satellites of Jupiter. The radius of Ganymede's orbit around Jupiter is about 3 times that of the Moon around the Earth. The mass of Jupiter is 318 times that of the Earth. If the period of the Moon around the Earth is 27.3 days, what is the period of Ganymede revolving around Jupiter ?

A. 2.7 days
B. 8.0 days
C. 91 days
D. 273 days

Part B : Supplemental exercise

18. Two identical satellites X and Y are moving in two circular orbits around the Earth as shown. Which statement is/are correct ?



(1) The period of X is greater than that of Y.
(2) The speed of X is smaller than that of Y.
(3) The gravitational force on X is smaller than that on Y.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

19. Given that the radius of the Earth is 6380 km. Find the acceleration due to gravity at a height of 3200 km.

A. 3.65 N kg^{-1}
B. 4.35 N kg^{-1}
C. 5.85 N kg^{-1}
D. 6.75 N kg^{-1}

20. The radius of the Earth is R. Satellite X orbits around the Earth at a height of R, while satellite Y orbits around the Earth at a height of $2R$. Find the ratio of the speed of X to that of Y.

A. $\sqrt{\frac{1}{2}}$

B. $\sqrt{\frac{2}{1}}$

C. $\sqrt{\frac{2}{3}}$

D. $\sqrt{\frac{3}{2}}$

21. On a certain planet, an object is thrown vertically upwards with an initial velocity of v_1 and it returns to the ground after time t. If v_2 is the orbital speed of a satellite circling close to the planet, what is the radius of the planet ?

A. $\frac{2v_1^2 t}{v_2}$

B. $\frac{4v_1^2 t}{v_2}$

C. $\frac{2v_2^2 t}{v_1}$

D. $\frac{v_2^2 t}{2v_1}$

22. If the gravitational constant G becomes larger while the orbital radius of the Moon around the Earth and the masses of the Moon and the Earth remain unchanged, which physical quantity of the Moon would change ?

(1) orbital speed
(2) period revolving around the Earth
(3) acceleration

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

23. A small sphere X of mass M is placed at a distance d from a point mass. The gravitational force the sphere X is 120 N. The sphere X is removed and another sphere Y of mass $3M$ is placed at a distance $2d$ from the same point mass. What would then be the gravitational force on the sphere Y?

A. 80 N
B. 90 N
C. 160 N
D. 180 N

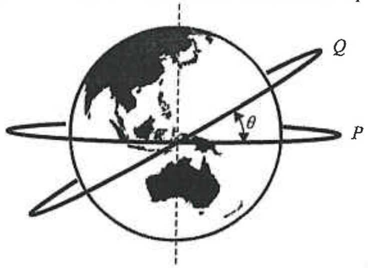
24. A parking satellite is moving at a constant speed in a circular orbit around the Earth. At any instant, the resultant force acting on the satellite is

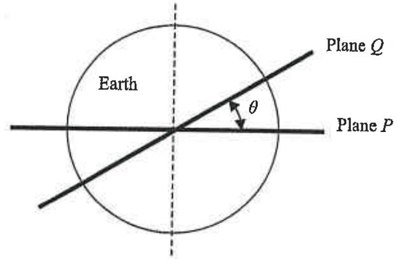
A. zero.
B. equal to the gravitational force on the satellite.
C. equal to the resultant force of the gravitational force on the satellite and the centripetal force.
D. equal to the force exerted by the rockets of the satellite.

Part C : HKDSE examination questions

25. **< HKDSE 2012 Paper IA - 14 >**

Two satellites move in circular orbits of the same radius R around the Earth (mass M). The orbits are in two different planes P and Q as shown. Plane P coincides with the Earth's equator while plane Q is inclined to the equator at θ.





Which of the following statement is INCORRECT ?

A. The speed of satellite P is $\sqrt{\frac{GM}{R}}$.
B. The centripetal force acting on satellite Q is pointing along the plane Q.
C. The acceleration of both satellites is the same in magnitude.
D. The period of satellite Q is longer than that of satellite P.

26. **< HKDSE 2013 Paper IA - 15 >**

It is known that the mass of Mars is about $\frac{1}{10}$ of that of the Earth while its radius is about $\frac{1}{2}$ of the Earth's radius. In terms of the gravitational acceleration g on the Earth's surface, the approximate gravitational acceleration on the surface of Mars is

A. $0.2\,g$
B. $0.4\,g$
C. $2.5\,g$
D. $4\,g$

27. **< HKDSE 2014 Paper IA - 11 >**

An astronaut inside a spacecraft moving in a circular orbit around the Earth is apparently weightless because

A. the astronaut is too far from the Earth to feel the Earth's gravitational force.
B. the astronaut and the spacecraft are both moving with the same acceleration due to gravity towards the Earth.
C. the Earth's gravitational force on the astronaut is balanced by the reaction force of the spacecraft's floor.
D. the Earth's gravitational force on the astronaut is balanced by the centripetal force.

28. **< HKDSE 2014 Paper IA - 12 >**

An artificial satellite revolves in a circular orbit above the Earth's surface at a height equal to the radius of the Earth. Find the acceleration of the satellite in terms of the acceleration due to gravity g on the Earth's surface.

A. $\frac{1}{8}g$
B. $\frac{1}{4}g$
C. $\frac{1}{2}g$
D. g

29. < HKDSE 2015 Paper IA - 11 >

The gravitational force exerted on the Earth by the Sun is F_o. The gravitational force exerted on the Sun by the Earth is

A. equal to F_o and in the same direction.
B. equal to F_o and in the opposite direction.
C. much smaller than F_o and in the same direction.
D. much smaller than F_o and in the opposite direction.

30. < HKDSE 2016 Paper IA - 14 >

A satellite orbits the Earth in a circular path of radius 7.2×10^6 m. What is the period of the satellite ?

Given : mass of the Earth = 6.0×10^{24} kg

A. 1.4 hours
B. 1.7 hours
C. 1 day
D. Answer cannot be found as the mass of the satellite is not known.

31. < HKDSE 2017 Paper IA - 13 >

A small object is released from rest at a point very far away from a planet X. The object then starts moving towards X. X does not have an atmosphere. Neglect the effect of other celestial bodies.

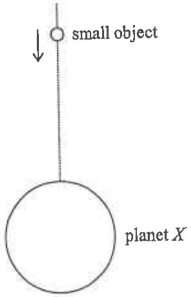
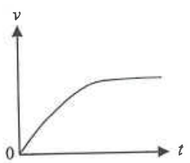


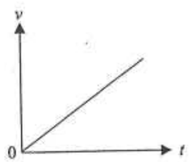
Diagram **NOT** shown to scale

Which of the following graphs best shows the variation of the velocity v of the object with time t before it hits X ?

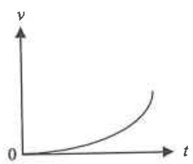
A.



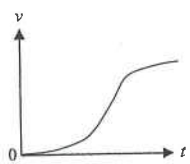
B.



C.



D.



32. < HKDSE 2018 Paper IA - 13 >

A satellite of mass m moves around a planet of mass M in circular orbit of radius r. What does the angular velocity of the satellite depend on ?

(1) r
(2) m
(3) M

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

33. <HKDSE 2020 Paper IA-10>

The diameter of Neptune is about 4 times that of the Earth and its mass is about 17 times that of the Earth. Estimate the acceleration due to gravity on Neptune's surface.
Given: acceleration due to gravity on Earth's surface g = 9.81 m s^{-2}

A. 2.3 m s^{-2}
B. 9.2 m s^{-2}
C. 10.4 m s^{-2}
D. 41.7 m s^{-2}

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. B	11. A	21. D	31. C
2. C	12. C	22. D	32. C
3. B	13. B	23. B	33. C
4. D	14. B	24. B	
5. B	15. D	25. D	
6. A	16. B	26. B	
7. B	17. B	27. B	
8. B	18. D	28. B	
9. A	19. B	29. B	
10. D	20. D	30. B	

M.C. Solution

1. B

$$F = \frac{G M M}{r^2} \propto \frac{1}{r^2}$$

$$\frac{F_2}{F_1} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{r+r}{r+4r+r}\right)^2 = \frac{1}{9}$$

2. C

✓ (1) By $g \propto \frac{1}{r^2}$. At the top of a high mountain, r is greater, thus g is smaller.

✓ (2) Let ρ be the density of the Earth and V be the volume of the Earth.
By $g = \frac{G M}{R^2} \propto \frac{\rho V}{R^2} \propto \frac{\rho V}{R^2} \propto \frac{\rho R^3}{R^2} \propto \rho R$
As radius R is unchanged, $g \propto \rho$, thus g increases if density ρ increases.

× (3) As density ρ is unchanged, $g \propto R$, thus g should increase if radius R increases.

3. B

× (1) Resting on a rough inclined plane : $R = m g \cos\theta \neq m g$

× (2) Since the weight is completely used to provide the centripetal force, the body is not in contact with the floor, $R = 0$.

✓ (3) Moving upwards with uniform velocity means no acceleration, thus $R = m g$.

4. D

$$\frac{G M m}{r^2} = m r \omega^2 = m r \left(\frac{2\pi}{T}\right)^2$$

$$(6.67\times10^{-11}) M = (4.24\times10^7)^3 \left(\frac{2\pi}{24\times60\times60}\right)^2$$

$\therefore$ $M = 6.0 \times 10^{24}$ kg

5. B

× (1) A satellite moving round the earth is in circular motion, there must be a resultant force towards the centre (centripetal force) acting on the satellite.

× (2) The resultant force of a feather falling freely in vacuum is the gravitational attraction force (the weight).

✓ (3) For any object moving in terminal velocity (uniform velocity), acceleration = 0, thus, net force = 0

6. A

$$\frac{G M m}{R^2} = \frac{m v^2}{R}$$

$$v = \sqrt{\frac{GM}{R}} \propto \sqrt{\frac{\rho \cdot V}{R}} \propto \sqrt{\frac{\rho \cdot R^3}{R}} \propto \sqrt{\rho \cdot R^2} \propto \sqrt{\rho} \cdot R$$

$$\frac{v_m}{v_e} = \sqrt{\frac{\rho_m}{\rho_e}} \cdot \frac{R_m}{R_e}$$

$\therefore$ $\frac{v_m}{790\ 0} = \sqrt{\frac{4}{5}} \cdot \frac{1}{4}$ $\therefore$ $v_m = 1770$ m s^{-1}

7. B

$$\frac{G M m}{R^2} = m R \omega^2$$

$\therefore$ $\frac{G M}{R^3} = \omega^2 = \left(\frac{2\pi}{T}\right)^2$

$\therefore$ Same $T \Rightarrow$ same $\frac{M}{R^3} \Rightarrow$ same $\frac{M}{V} \Rightarrow$ same ρ

(Volume : $V = \frac{4}{3}\pi R^3 \propto R^3$) (density : $\rho = \frac{M}{V}$)

8. B

× (1) When the bouncing ball is in contact with the ground, normal reaction R is given by $R - m g = (m v - m u) / t$ $\therefore$ $R > m g$.

× (2) Since the weight is completely used to provide the centripetal force in circular motion, the body is not in contact with the floor, $R = 0$.

✓ (3) Moving upwards with uniform velocity means no acceleration, thus $R = m g$.

9. A

At the surface of the Earth,

$$g = \frac{GM}{R^2}$$

$$\therefore\ (9.81) = \frac{(6.67\times10^{-11})M}{(6.4\times10^6)^2}$$

$\therefore\ M = 6.024\times10^{24}$ kg

Average density of the Earth :

$$\rho = \frac{M}{V} = \frac{M}{\frac{4}{3}\pi R^3} = \frac{(6.024\times10^{24})}{\frac{4}{3}\pi(6.4\times10^6)^3} = 5500\ \text{kg m}^{-3}$$

10. D

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$\therefore\ v^2 = \frac{GM}{r}$$

$$\therefore\ v \propto \frac{1}{\sqrt{r}}$$

11. A

$$g = \frac{GM}{R^2} \propto \frac{M}{d^2}$$

$$\therefore\ \frac{g_P}{g_E} = \left(\frac{M_P}{M_E}\right)\cdot\left(\frac{d_E}{d_P}\right)^2 = (3)\times(\frac{1}{2})^2 = \frac{3}{4}$$

$$\therefore\ g_P = \frac{3}{4}\times9.81 = 7.36$$

12. C

① $W = mg$ $\therefore$ $(41) = (25)g$ $\therefore$ $g = 1.64$ N kg^{-1}

② $g \propto \frac{1}{r^2}$ $\therefore$ $g' = 1.64 \times (\frac{R}{2R})^2 = 0.41$ N kg^{-1}

13. B

By $\frac{GMm}{r^2} = mr\omega^2$

$$\therefore\ \frac{GM}{r^3} = \omega^2 = (\frac{2\pi}{T})^2$$

$$\therefore\ M = \frac{4\pi^2r^3}{GT^2} = \frac{4\pi^2r^3}{(6.67\times10^{-11})\cdot(365\times24\times3600)^2} = 5.95\times10^{-4}\,r^3$$

14. B

× (1) When the spacecraft decelerates downwards, normal reaction acts on the astronaut so that $R - mg = ma$, the astronaut feels heavier.

× (2) The air resistance that is equal to the weight acts on the parachutist to give him the feeling of weight.

✓ (3) When the rocket engines are shut off, the weight of the astronaut is used completely to provide his centripetal acceleration. As no normal reaction acts on him, he experiences weightlessness.

15. D

✓ (1) Speed of satellites depends on the radius of the orbit, as the radius of parking orbit is fixed, the speed is also a specified value.

✓ (2) Hong Kong is not at the equator of the Earth, thus there is no parking satellite directly above HK.

✓ (3) Parking orbit must be at the equatorial plane and at a certain height above the Earth surface, thus there is only one orbit. Note that parking orbit is geostationary orbit.

16. B

Their mutual gravitational attraction forces F are the same since they are action and reaction pair.

Since both X and Y takes the same time to revolve 1 cycle, they must have the same period, thus the same angular speed ω.

✓ (1) By $a = r\omega^2$, as the radius of X is twice that of Y, the acceleration of X is also twice that of Y.

× (2) By $v = r\omega$, as the radius of X is twice that of Y, the speed of X should also be twice that of Y.

✓ (3) By $F = mr\omega^2$, as the radius of X is twice that of Y, the mass of X is half that of Y.

17. B

The satellite moves round the planet in circular motion, thus the gravitational force provides the centripetal force.

As $\frac{GMm}{r^2} = mr\omega^2$

$$\therefore\ \frac{GM}{r^3} = \omega^2 = (\frac{2\pi}{T})^2$$

$$\therefore\ T^2 = \frac{4\pi^2r^3}{GM} \propto \frac{r^3}{M}$$

$$\therefore\ (\frac{T_1}{T_2})^2 = (\frac{r_1}{r_2})^3(\frac{M_2}{M_1}) \qquad \therefore\ (\frac{T_1}{27.3})^2 = (\frac{3}{1})^3(\frac{1}{318})$$

$\therefore\ T_1 = 8.0$ days

18. D

✓ (1) $\frac{GMm}{r^2} = mr\omega^2$ $\therefore\ \frac{GM}{r^3} = \omega^2 = (\frac{2\pi}{T})^2$ $\therefore\ T^2 \propto r^3$ $\therefore\ r_X > r_Y \Rightarrow T_X > T_Y$

✓ (2) $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $\therefore\ v^2 = \frac{GM}{r}$ $\therefore\ r_X > r_Y \Rightarrow v_X < v_Y$

✓ (3) $F = \frac{GMm}{r^2} \propto \frac{1}{r^2}$ $\therefore\ r_X > r_Y \Rightarrow F_X < F_Y$

19. B

$$g = \frac{GM}{r^2} \propto \frac{1}{r^2}$$

$$g = (9.81)\times(\frac{6380}{6380+3200})^2 = 4.35\text{ N kg}^{-1}$$

20. D

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$\therefore\ v \propto \sqrt{\frac{1}{r}}$$

$$\therefore\ \frac{v_X}{v_Y} = \sqrt{\frac{r_Y}{r_X}} = \sqrt{\frac{(R+2R)}{(R+R)}} = \sqrt{\frac{3}{2}}$$

21. D

① $s = ut + \frac{1}{2}at^2$ $\therefore\ (0) = v_1 t + \frac{1}{2}(-g)t^2$ $\therefore\ g = \frac{2v_1}{t}$

② $mg = \frac{m{v_2}^2}{R}$ $\therefore\ g = \frac{{v_2}^2}{R}$

Combining the two expressions :

$\therefore\ \frac{{v_2}^2}{R} = \frac{2v_1}{t}$ $\therefore\ R = \frac{{v_2}^2 \cdot t}{2v_1}$

22. D

✓ (1) $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $\therefore\ v^2 = \frac{GM}{r}$ $\therefore$ v depends on G

✓ (2) $\frac{GMm}{r^2} = mr\omega^2$ $\therefore\ \frac{GM}{r^3} = \omega^2 = (\frac{2\pi}{T})^2$ $\therefore\ T^2 = \frac{4\pi^2 r^3}{GM}$ $\therefore$ T depends on G

✓ (3) $a = g = \frac{GM}{r^2}$ $\therefore$ a depends on G

23. B

Let the mass of the point mass be m.

By $F = \frac{GMm}{r^2}$

For sphere X: $(120) = \frac{G(M)m}{d^2}$

For sphere Y: $F = \frac{G(3M)m}{(2d)^2} = \frac{3}{4}\times\frac{G(M)m}{(d)^2} = \frac{3}{4}\times(120) = 90\text{ N}$

24. B

× A. In circular motion, there is centripetal acceleration, thus the resultant force cannot be zero.

✓ B. The only force acting on the satellite is the gravitational force (weight), thus it is the resultant force. This force also provides the centripetal force for the circular motion.

× C. Centripetal force itself is the resultant force towards the centre.

× D. For a satellite moving in constant speed, the rockets of the satellite is shut down without exerting force.

25. D

✓ A. $\frac{GMm}{R^2} = \frac{mv^2}{R}$ $\therefore\ v = \sqrt{\frac{GM}{R}}$

✓ B. The centripetal force must be directing towards the centre, thus along the orbital plane of Q.

✓ C. Acceleration of the satellite is equal to the acceleration due to gravity at that position.

By $a = g = \frac{GM}{r^2}$ Since they have the same radius r, they must have the same acceleration g.

× D. $\frac{GMm}{R^2} = mR\omega^2 = mR\left(\frac{2\pi}{T}\right)^2$ $\therefore$ They have the same period.

26. B

$$g_E = \frac{GM}{R^2} = g$$

$$g_M = \frac{G(\frac{1}{10}M)}{(\frac{1}{2}R)^2} = \frac{4}{10}\times\frac{GM}{R^2}$$

$$\therefore\ g_M = 0.4\,g_E = 0.4\,g$$

27. B

× A. In circular orbit, the Earth's gravitational force must provide the centripetal force for the circular motion. Thus, the spacecraft and astronaut cannot be so far that the gravitational force is negligible.

✓ B. Since the astronaut and the spacecraft are both moving with the same acceleration due to gravity, their own weight provides their own acceleration, $mg = ma$, thus $a = g$. Therefore, there is no normal reaction acting on the astronaut, and thus weightlessness is experienced.

× C. At the state of weightlessness, there is no reaction force acting on the astronaut.

× D. The gravitational force is the only force acting on the astronaut. Centripetal force is the net force towards the centre. Thus, the gravitational force provides the centripetal force, but not balanced.

28. B

The acceleration g at different position of the Earth is inversely proportional to the square of radius of that position.

$g \propto \frac{1}{r^2}$ $\therefore\ \frac{g_2}{g_1} = \left(\frac{r_1}{r_2}\right)^2$ $\therefore\ \frac{g_2}{(g)} = \left(\frac{R}{R+R}\right)^2$ $\therefore\ g_2 = \frac{1}{4}g$

29. B

These two forces are action and reaction pair, thus, they must be equal in magnitude but opposite in direction.

30. B

As $\frac{G M m}{r^2} = m r \omega^2$

$\therefore \frac{G M}{r^3} = \omega^2 = (\frac{2\pi}{T})^2$

$\therefore \frac{(6.67\times10^{-11})(6.0\times10^{24})}{(7.2\times10^6)^3} = (\frac{2\pi}{T})^2$

$\therefore T = 6067$ s = 1.7 hours

31. C

The acceleration due to gravity : $a = g = \frac{G M}{r^2}$

Thus, when the object is closer to the planet, r decreases, the acceleration due to gravity g increases.

As the slope of the v - t graph represents acceleration,

greater acceleration means greater slope,

thus, the slope of the graph should gradually increase, as shown in C.

32. C

By $\frac{G M m}{r^2} = m r \omega^2$

$\therefore \omega^2 = \frac{G M}{r^3}$

$\therefore \omega^2$ depends on r and M only but not depend on m.

The following list of formulae may be found useful :

Centripetal acceleration	$a = \frac{v^2}{r} = \omega^2 r$
Newton's law of gravitation	$F = \frac{G m_1 m_2}{r^2}$

Use the following data wherever necessary :

Acceleration due to gravity	$g = 9.81$ m s^{-2}	(close to the Earth)
Universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}	

Part A : HKAL examination questions

1. **< HKAL 1985 Paper IIB - 2 >**

(a) Billy and Lily have heard about the possibility of placing a communications satellite in an orbit such that it remains vertically above the same place on the surface of the Earth. Comment on each of the following statements.

(1) Billy said, "The satellite must be so far away that it is not affected by the Earth's gravity."

(2) Lily said, "There is a communication satellite directly above Hong Kong." (4 marks)

(b) Newton once argued that if a cannon-ball were fired horizontally at high enough speed from any point on the Earth surface, it would eventually return and strike the cannon from behind, by considering the Earth to be a non-rotating sphere.

(i) Take the radius of the Earth to be 6400 km, and assume that the cannon-ball moves close to the Earth's surface, what would be the least time for it to arrive at the cannon again ? (3 marks)

(ii) Give any three reasons with brief explanations that in reality, why the cannon-ball would not arrive at the cannon again. (3 marks)

2. < HKAL 1990 Paper IIB - 7 >

(a) Explain the meaning of the 'parking orbit' for satellites moving around the Earth. (2 marks)

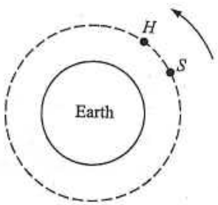
(b) Assume the Earth to be a sphere of uniform density. Calculate the height of a satellite which is in a 'parking orbit', given that the radius of the Earth is 6400 km. (4 marks)

3. < HKAL 1991 Paper IIB - 7 >

A spacecraft has just finished its mission and is returning to the earth. As the spacecraft is moving at a very high speed, air resistance acting on the spacecraft by the atmosphere would cause its surface to reach a very high temperature. State and explain one property of the surface material of the spacecraft for protecting the astronauts inside the spacecraft. (2 marks)

4. < HKAL 1998 Paper I - 1 >

A space shuttle S is sent to service the Hubble Space Telescope H which is in a circular orbit 6.0×10^5 m above the Earth's surface. The space shuttle finally reaches the same orbit as H and its thrust rockets are shut down. Given that the radius of the Earth is 6.4×10^6 m.



(a) What is the apparent weight (feeling of weight) of an astronaut of mass 70 kg inside the shuttle ? (1 mark)

(b) (i) Calculate the value of the gravitational field strength in the orbit. (3 marks)

(ii) Calculate the speed of the space-shuttle S in the orbit. (2 marks)

(iii) Calculate the time take for the space-shuttle S to revolve one revolution in the orbit. (2 marks)

5. < HKAL 2002 Paper I - 6 >

A space shuttle is launched into a circular orbit around the Earth at an altitude of 2.4×10^5 m. Given that the radius of the Earth is 6.4×10^6 m.

(a) Calculate the orbital speed of the shuttle in the orbit. (3 marks)

(b) Calculate the gravitational force acting on an astronaut of mass 80 kg in the shuttle. (2 marks)

6. < HKAL 2005 Paper I - 6 >

(a) A spacecraft is launched with a total initial mass of 4.80×10^5 kg at take-off. The rocket engine propels hot exhaust gas at a constant speed of 2600 m s^{-1} relative to the rocket in a downward direction. Assume that 2300 kg of gas is expelled in the first second. Neglect air resistance.

(i) Calculate the average upward force acting on the rocket due to the exhaust gas during the first second. (2 marks)

(ii) Calculate the acceleration of the rocket during the first second, if the change of mass of the rocket is assumed to be negligible in the first second. (2 marks)

(iii) If the rocket keeps expelling exhaust gas at the same rate for the first 20 s, explain how the acceleration of the rocket will change. (2 marks)

6. (b) The spacecraft of mass 7800 kg then enters a circular orbit around the Earth at a height of 3.43×10^5 m above the surface of the Earth. The radius of the Earth is 6.37×10^6 m.

(i) Calculate the speed of the spacecraft in the orbit. (4 marks)

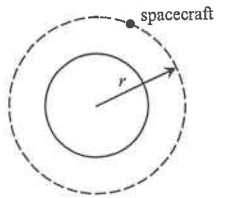
(ii) Calculate the time taken for the spacecraft to orbit around the Earth for 24 times. (2 marks)

(c) Give **TWO** reasons why an aircraft is unable to fly in space where there is no air. (2 marks)

Part B : HKDSE examination questions

7. **< HKDSE Sample Paper IB - 11 >**

A spacecraft of mass 7.80×10^3 kg enters a circular orbit of radius r around the Earth.



(a) Show that the speed of the spacecraft in the orbit is given by $\sqrt{\frac{g}{r}}R_E$ where g is the acceleration due to gravity at the Earth's surface and R_E is the radius of the Earth. (2 marks)

(b) How long does it take for the spacecraft to orbit the Earth 14 times ? (3 marks)

Given : radius of the orbit $r = 6.71 \times 10^6$ m ; radius of the Earth $R_E = 6.37 \times 10^6$ m

8. **< HKDSE Practice Paper IB - 4 >**

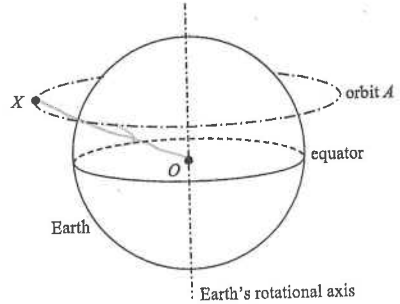
A communication satellite moves in a circular orbit around the Earth with a period of 24 hours and remains above a certain place on the equator.

Given : radius of the Earth $r_E = 6400$ km

(a) (i) Find the orbital radius of the communication satellite. (3 marks)

(ii) Determine the orbital speed of the communication satellite. (2 marks)

(b) In the Figure below, X is a point in space and O is the centre of the Earth.



(i) A satellite is at X. In the above Figure, draw the gravitational force acting on the satellite due to the Earth. (1 mark)

(ii) Briefly explain why the satellites cannot move in a circular orbit A as shown in the Figure under the influence of the Earth's gravitational force only. (1 mark)

Question Solution

1. (a) (1) Billy is wrong,

since the satellite moves in circular orbit, it needs a centripetal force to provide its centripetal acceleration, [1]

so it must be in the Earth's gravitational field so that the gravitational force provides the centripetal force. [1]

(2) Lily is wrong,

since the orbit of a communication satellite must be on the equatorial plane of the Earth, [1]

but Hong Kong is not at the equator, thus no communication satellite is directly above Hong Kong. [1]

(b) (i) $mg = \frac{mv^2}{R}$ [1]

$v = \sqrt{gR} = \sqrt{(9.81)(6.4\times10^6)} = 7924\text{ m s}^{-1}$

Time : $T = \frac{2\pi R}{v}$ [1]

$= \frac{2\pi\times6.4\times10^6}{7924} = 5070\text{ s}$ [1]

< OR >

$mg = mR\omega^2 = mR(\frac{2\pi}{T})^2$ [1]

$T = 2\pi\sqrt{\frac{R}{g}} = 2\pi\sqrt{\frac{6.4\times10^6}{9.81}}$ [1]

$= 5070\text{ s}$ [1]

(ii) **Reasons :** (Any 3 of the following) [3]

* Earth is not a perfect sphere; g varies over the Earth's surface.

* Earth rotates; when cannon-ball comes back, the cannon may have moved to a different location.

* Air resistance may reduce the speed of the cannon-ball, thus the speed cannot be constant.

* The cannon may hit high buildings (**OR** high mountains), thus it cannot reach the final position.

2. (a) These satellites appear stationary relative to observers on Earth. [2]

(b) $g = \frac{GM}{R^2}$ $\therefore GM = gR^2 = (9.81)(6.4\times10^6)^2 = 4.018\times10^{14}$ [1]

$\frac{GMm}{(R+h)^2} = m(R+h)\omega^2$ $\therefore \frac{GM}{(R+h)^3} = \omega^2 = (\frac{2\pi}{T})^2$ [1]

$\therefore \frac{(4.018\times10^{14})}{(6.4\times10^6+h)^3} = (\frac{2\pi}{24\times3600})^2$ [1]

$\therefore h = 3.60\times10^7\text{ m}$ < accept $3.58 - 3.62\times10^7$ m > [1]

3. It should have poor thermal conductivity [1]

so that heat will hardly be conducted into spacecraft. [1]

< OR >

It should have high specific heat capacity [1]

so that the rise of temperature is smaller. [1]

< OR >

It should have high melting point [1]

so that the surface of the spacecraft would not melt easily. [1]

4. (a) Feeling of weight = 0 N **OR** He feels weightless. [1]

(b) (i) $g = \frac{GM_E}{r^2} \propto \frac{1}{r^2}$ [1]

$\therefore \frac{g'}{(9.81)} = (\frac{6.4\times10^6}{6.4\times10^6+6\times10^5})^2$ [1]

$\therefore g' = 8.20\text{ N kg}^{-1}$ [1]

(ii) $mg = \frac{mv^2}{r}$ $\therefore (8.20) = \frac{v^2}{(6.4\times10^6+6\times10^5)}$ [1]

$\therefore v = 7580\text{ m s}^{-1}$ < accept 7570 to 7600 m s^{-1} > [1]

(iii) $T = \frac{2\pi r}{v} = \frac{2\pi(6.4\times10^6+6\times10^5)}{(7580)}$ [1]

$= 5800\text{ s}$ < accept 5790 s to 5810 s > [1]

5. (a) $g = \frac{GM}{R^2}$ $\therefore GM = gR^2 = (9.81)(6.4\times10^6)^2 = 4.018\times10^{14}$ [1]

By $\frac{GMm}{r^2} = \frac{mv^2}{r}$ [1]

$\therefore v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{4.018\times10^{14}}{(2.4\times10^5+6.4\times10^6)}} = 7780\text{ m s}^{-1}$ < accept 7800 m s^{-1} > [1]

OR

$g' = (9.81)\times\left(\frac{6.4\times10^6}{6.4\times10^6+2.4\times10^5}\right)^2 = 9.114$ [1]

By $mg' = \frac{mv^2}{r}$ [1]

$\therefore v = \sqrt{g'r} = \sqrt{(9.114)(6.4\times10^6+2.4\times10^5)} = 7780\text{ m s}^{-1}$ [1]

5. (b) $F = \dfrac{mv^2}{r} = \dfrac{(80)(7780)^2}{(2.4\times10^5 + 6.4\times10^6)}$ [1]

$= 729\ \text{N}$ [1]

OR

$g \propto \dfrac{1}{r^2}$ $\therefore$ $\dfrac{g}{(9.81)} = \dfrac{(6.4\times10^6)^2}{(6.4\times10^6 + 2.4\times10^5)^2}$ [1]

$\therefore\ g = 9.11\ \text{N kg}^{-1}$

$F = mg = (80)\times(9.11) = 729\ \text{N}$ [1]

6. (a) (i) Force on exhaust gas by rocket :

$F = \dfrac{mv - mu}{t} = \dfrac{m}{t}(v-u) = (2.30\times10^3)(2600-0)$ [1]

$= 5.98\times10^6\ \text{N}$ [1]

By Newton's 3rd law, force on rocket by exhaust gas is also 5.98×10^6 N

(ii) $F - mg = ma$ [1]

$\therefore\ (5.98\times10^6) - (4.80\times10^5)(9.81) = (4.80\times10^5)\,a$

$\therefore\ a = 2.65\ \text{m s}^{-2}$ [1]

(iii) Since the average thrust remains unchanged, as the mass of the rocket gradually decreases, [1]
the acceleration of the rocket would gradually increase. [1]

(b) (i) At the Earth's surface,

$g = \dfrac{GM}{R^2}$ $\therefore\ GM = gR^2$ [1]

For circular motion, $\dfrac{GMm}{r^2} = \dfrac{mv^2}{r}$ [1]

$v = \sqrt{\dfrac{GM}{r}} = \sqrt{\dfrac{gR^2}{r}} = \sqrt{\dfrac{(9.81)(6.37\times10^6)^2}{(3.43\times10^5 + 6.37\times10^6)}}$ [1]

$= 7700\ \text{m s}^{-1}$ [1]

(ii) $t = \dfrac{2\pi\cdot r}{v}\times 24$

$= \dfrac{2\pi\times(3.43\times10^5 + 6.37\times10^6)}{7700}\times 24$ [1]

$= 1.31\times10^5\ \text{s}$ < accept 1.3×10^5 s > < accept 36.5 h > [1]

(c) ① Aircraft needs air to provide a lift force on its wings. [1]

② Aircraft draws air into the engine for combustion of the fuel. [1]

7. (a) $g = \dfrac{GM}{R_E^{\ 2}}$ $\therefore\ GM = gR_E^2$

$\dfrac{GMm}{r^2} = \dfrac{mv^2}{r}$ [1]

$v = \sqrt{\dfrac{GM}{r}} = \sqrt{\dfrac{gR_E^{\ 2}}{r}} = \sqrt{\dfrac{g}{r}}\cdot R_E$ [1]

(b) $v = \sqrt{\dfrac{gR_E^{\ 2}}{r}} = \sqrt{\dfrac{(9.81)(6.37\times10^6)^2}{(6.71\times10^6)}} = 7702\ \text{m s}^{-1}$ [1]

$t = \dfrac{2\pi\cdot r}{v}\times 14 = \dfrac{2\pi\times(6.71\times10^6)}{7702}\times 14$ [1]

$= 7.66\times10^4\ \text{s}$ < accept 7.7×10^4 s > < accept 21.3 hr > [1]

8. (a) (i) $g = \dfrac{GM}{r_E^{\ 2}}$ $\therefore\ GM = g r_E^{\ 2} = (9.81)(6.4\times10^6)^2 = 4.018\times10^{14}$ [1]

$\dfrac{GMm}{r^2} = mr\omega^2$ $\therefore\ \dfrac{GM}{r^3} = \omega^2 = (\dfrac{2\pi}{T})^2$ [1]

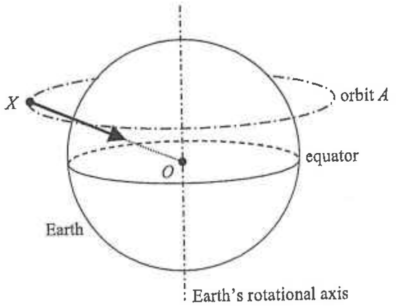
$\therefore\ \dfrac{(4.018\times10^{14})}{r^3} = (\dfrac{2\pi}{24\times3600})^2$

$\therefore\ r = 4.24\times10^7\ \text{m}$ < accept 4.26×10^7 m > [1]

(ii) $v = \dfrac{2\pi r}{T}$ [1]

$= \dfrac{2\pi(4.24\times10^7)}{(24\times3600)} = 3080\ \text{m s}^{-1}$ [1]

(b) (i) [1]



(ii) Any **ONE** of the followings : [1]

* The centre of the orbit is not at the centre of the Earth.
* The direction of the centripetal force is different from the direction of the gravitational force on the satellite.
* The plane of orbit of a satellite must pass through the centre of the Earth.