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）

FM4 : Work, Energy & Power

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	$P = Fv = \frac{W}{t}$

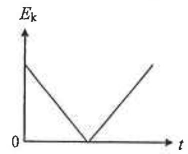
Use the following data wherever necessary :

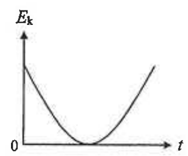
Acceleration due to gravity $g = 9.81\ \text{m s}^{-2}$ (close to the Earth)

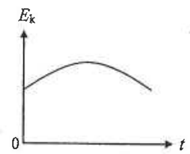
Part A : HKCE examination questions

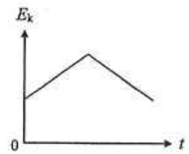
1. **< HKCE 1980 Paper II - 5 >**

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 ?

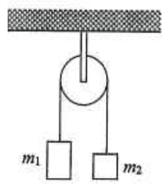
A.


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 >**

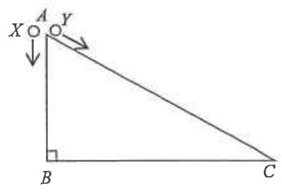
A vehicle moving with uniform speed travels up a road of constant gradient. The power developed by the vehicle's engine is

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 ?

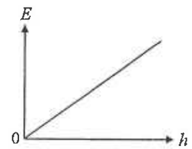
(1) The kinetic energy of the block is increasing.
(2) The potential energy of the block is increasing.
(3) The resultant force acting on the block is zero.

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

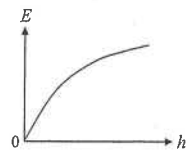
13. **< HKCE 1985 Paper II - 6 >**

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 ?

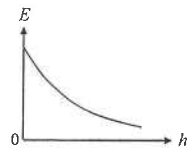
A.



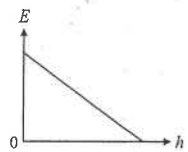
B.



C.



D.



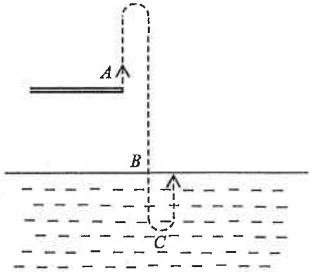
14. **< HKCE 1985 Paper II - 14 >**

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

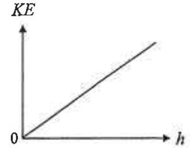
16. **< HKCE 1987 Paper II - 4 >**

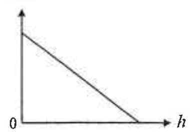
An escalator is said to be able to carry 120 passengers to a height of 10 m in one minute. Assuming each passenger has a weight of 500 N, the possible power output by the escalator must be at least

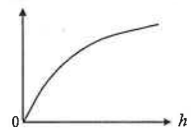
A. 1 000 W
B. 5 000 W
C. 10 000 W
D. 50 000 W

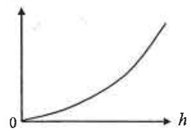
17. **< HKCE 1987 Paper II - 5 >**

An object is projected vertically upwards. Which of the graphs below correctly describes the variation of its kinetic energy (*KE*) with height (*h*) ?

A.


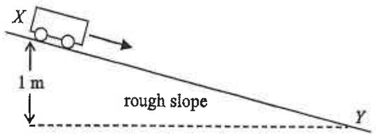
B.


C.


D.


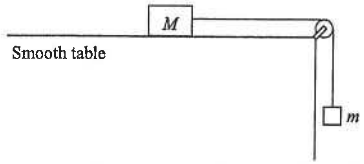
18. **< HKCE 1988 Paper II - 4 >**

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 >**



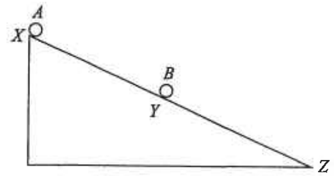
The figure above shows a mass *m* connected to another mass *M* by a string passing over a smooth pulley. The system is moving freely under gravity. Assuming that the table is smooth, which of the following statements is/are correct ?

(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 ?



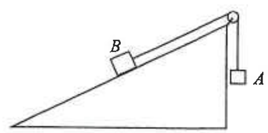
(1) The time required for *A* to reach *Z* is double that for *B* to reach *Z*.
(2) The potential energy for *A* at *Z* is double that for *B* at *Z*.
(3) The kinetic energy for *A* at *Z* is double that for *B* at *Z*.

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

21. **< HKCE 1989 Paper II - 4 >**

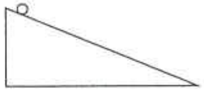
Two equal masses *A* and *B* are connected by a light string passing over a smooth pulley as shown in the below figure. The inclined plane is smooth. Which of the following is/are correct ?

(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*.

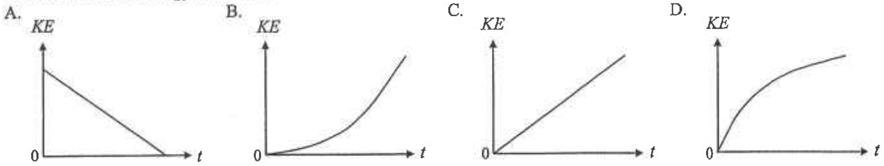


A. (1) only
B. (2) only
C. (3) only
D. (1) & (2) only

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 ?



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

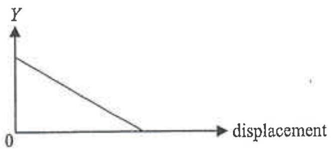
A. 40 J
B. 90 J
C. 160 J
D. 400 J

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.

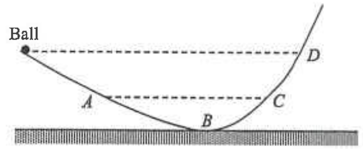
27. < HKCE 1992 Paper II - 7 >

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 >

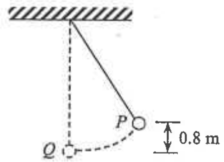


A ball is released from rest from one end of a smooth curved rail as shown in the above diagram. Neglecting air resistance and friction, which of the following statements about the motion of the ball is/are correct ?

(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)

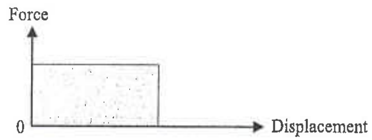
29. < HKCE 1993 Paper II - 6 >



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 >

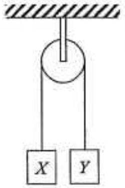


The figure shows the variation of the force acting on an object. What physical quantity does the area of the shaded portion represent ?

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.

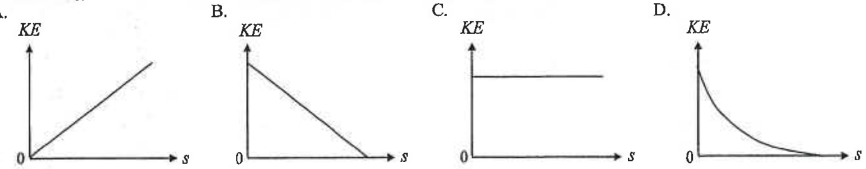
(3) The potential energy lost by X is equal to the sum of kinetic energies gained by X and Y.

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

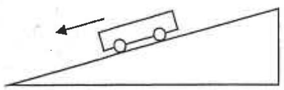
32. **< HKCE 1994 Paper II - 9 >**

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 ?

A. B. C. D.



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 >**

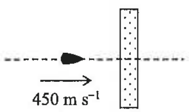


Figure (a)

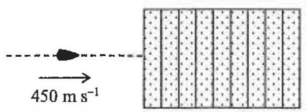


Figure (b)

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 ?

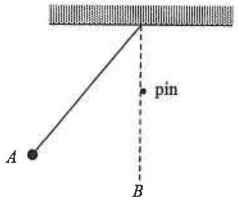
A. 3
B. 4
C. 5
D. 9

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

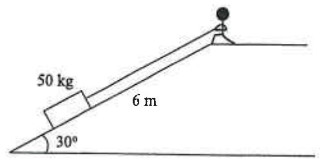
38. **< HKCE 1998 Paper II - 1 >**

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}.



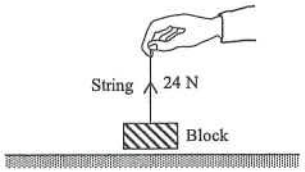
A. 5 W
B. 10 W
C. 50 W
D. 87 W

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 >



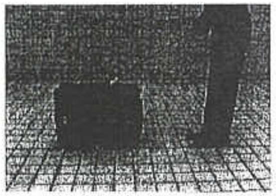
A 2 kg block is initially at rest on the ground. A man uses a force to pull up the block as shown above. If the tension in the string is kept at 24 N and the block reaches a height of 4 m in 2 s, which of the following statements is/are correct ?

(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. $500 \sin\theta$ J
B. $500 \cos\theta$ J
C. $500 / \sin\theta$ J
D. $500 / \cos\theta$ J

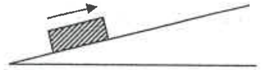
43. < HKCE 2001 Paper II - 3 >

A stone is thrown vertically upwards. Assuming air resistance is negligible, which of the following statements is/are correct ?

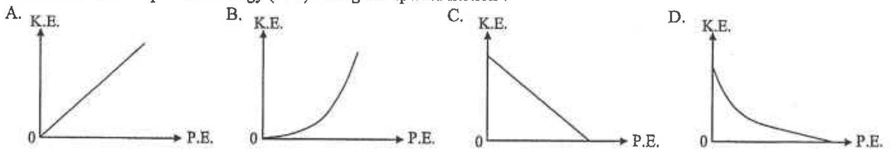
(1) The acceleration of the stone decreases throughout the upward motion.
(2) The net force acting on the stone becomes zero when the stone reaches the highest point.
(3) The total energy of the stone remains unchanged throughout the motion.

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

44. < HKCE 2002 Paper II - 8 >

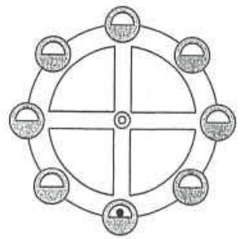


A block is projected up a smooth inclined plane. Which of the graphs below shows the variation of the kinetic energy (K.E.) of the block with its potential energy (P.E.) during the upward motion ?



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.

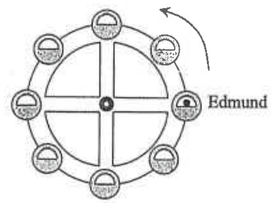
Let F = horizontal force exerted by Amy on the push-chair, and
m = total mass of the baby and the push-chair.

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 >

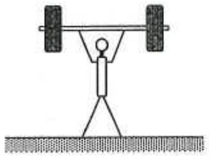
The diagram shows Edmund riding the 'Ferris Wheel' in an amusement park. If the wheel is rotating at a uniform speed, which of the following physical quantities of Edmund would remain unchanged ?



A. velocity
B. kinetic energy
C. potential energy
D. total mechanical energy

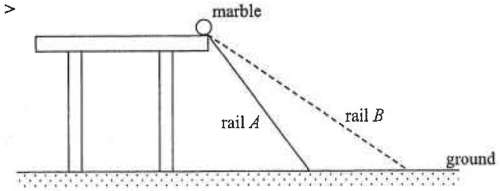
48. **< HKCE 2005 Paper II - 5 >**

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)

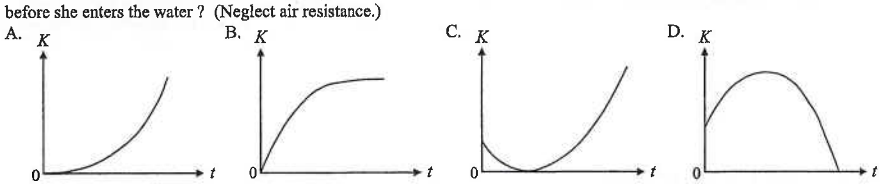
50. **< HKCE 2006 Paper II - 4 >**

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.)

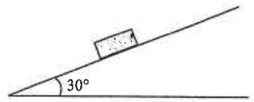


52. **< HKCE 2007 Paper II - 31 >**

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. $2mgv$

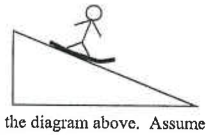
53. **< HKCE 2007 Paper II - 32 >**



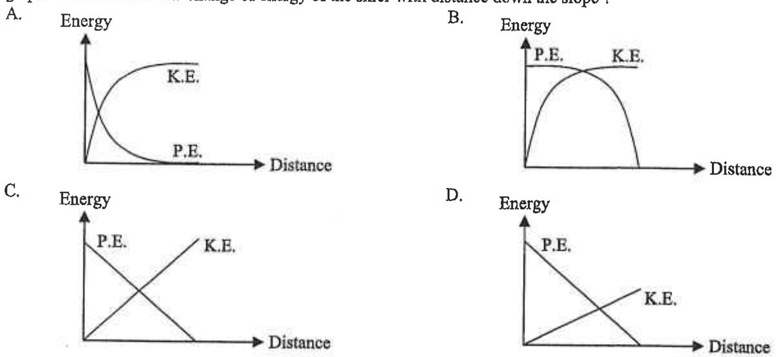
A block of mass 1 kg is sliding down with constant speed along an inclined plane of inclination 30° to the horizontal. What are the gain in kinetic energy and the work done against friction by the block after travelling a distance of 2 m along the plane ? (Take the acceleration due to gravity to be 10 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.

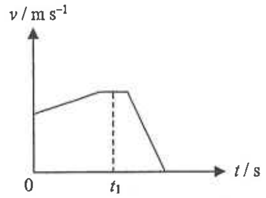
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

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 >



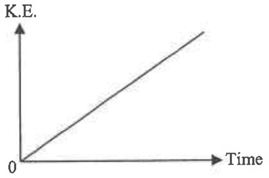
The figure above shows the velocity - time graph of a car travelling on a horizontal straight road. Which of the following statements is/are correct ?

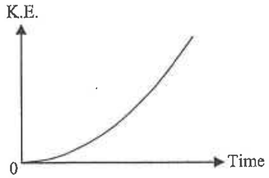
(1) Area under the graph is equal to the total displacement of the car.
(2) The acceleration of the car is maximum at time t_1.
(3) The kinetic energy of the car remains unchanged throughout the whole journey.

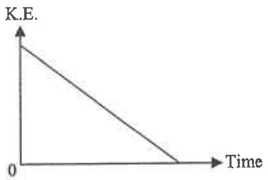
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

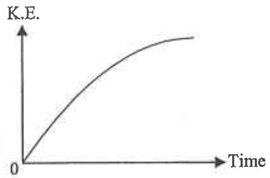
58. < HKCE 2008 Paper II - 8 >

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.


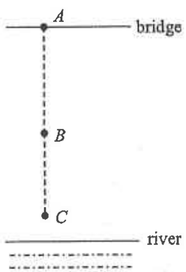
B.


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 ?

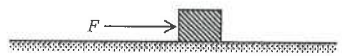
	Gravitational potential energy	Kinetic energy	Power in overcoming air resistance
A.	decreases	increases	increases
B.	decreases	increases	remains unchanged
C.	decreases	remains unchanged	remains unchanged
D.	remains unchanged	increases	increases

61. < HKCE 2009 Paper II - 3 >

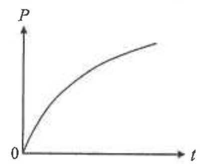
A ball of mass 0.5 kg resting on a horizontal ground is kicked by a player. The ball travels along a straight path and come to rest after travelling a horizontal distance of 10 m. If the average resistive force acting on the ball during the motion is 3 N, what is its initial speed ?

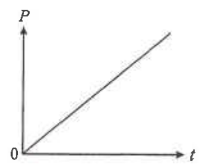
A. 3.2 m s^{-1}
B. 7.7 m s^{-1}
C. 11.0 m s^{-1}
D. 15.0 m s^{-1}

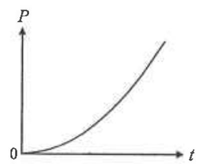
62. < HKCE 2009 Paper II - 6 >

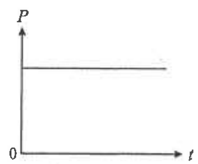


A constant force F is applied to an object which is initially at rest on a horizontal smooth surface. Which of the graphs below best represents the variation of the power P developed by the force F with time t ?

A.


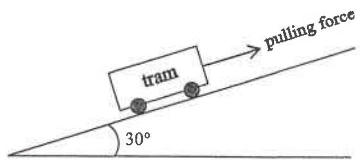
B.


C.


D.


63. < HKCE 2009 Paper II - 31 >

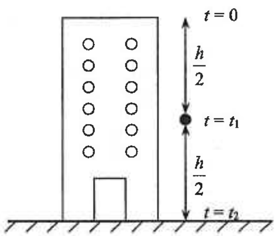
A tram of mass 1500 kg is being pulled by a steel cable. It goes up a 30° slope with a uniform speed. The average resistive force along the tram is 200 N. What is the energy required for the tram to move 100 m up along the slope ?



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.)



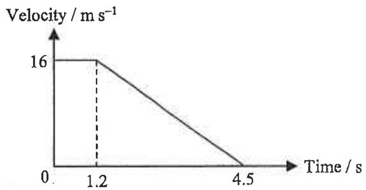
(1) velocity of the object at t_2 = 2 × velocity of the object at t_1

(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 >**

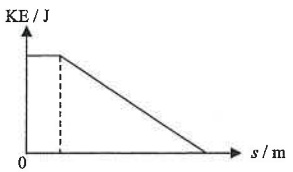
What is the magnitude of the deceleration of the car during braking ?

A. 3.56 m s^{-2}
B. 4.85 m s^{-2}
C. 13.3 m s^{-2}
D. 26.4 m s^{-2}

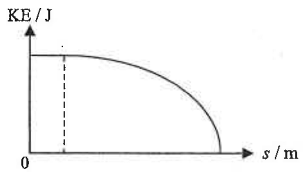
66. **< HKCE 2010 Paper II - 7 >**

Which of the following graphs best represents the variation of the kinetic energy (K.E.) of the car with distance s travelled ?

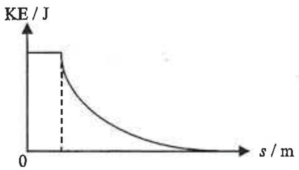
A.



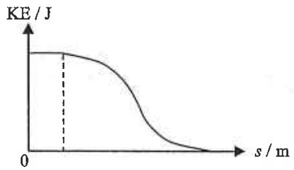
B.



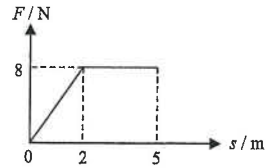
C.



D.



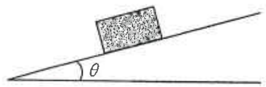
67. **< HKCE 2010 Paper II - 5 >**

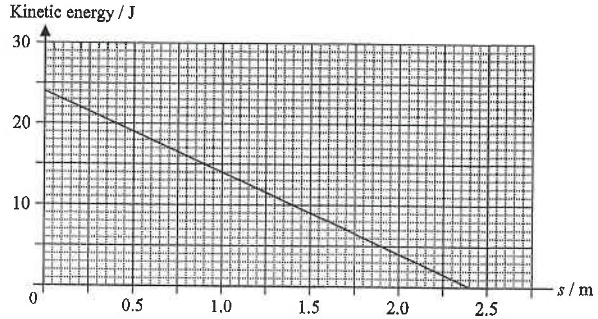


Horizontal force F is applied to a block of mass 4 kg which is initially at rest on a horizontal smooth surface. The variation of the magnitude of F with displacement s is shown in the graph. The direction of F remains unchanged throughout the motion. What is the work done on the block by F from s = 2 m to 5 m ?

A. 16 J
B. 24 J
C. 32 J
D. 40 J

68. **< HKCE 2010 Paper II - 29 >**

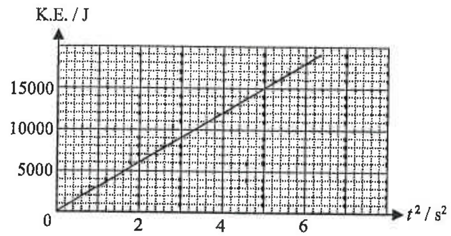




A block of mass 5 kg is projected up along a smooth inclined plane of inclination θ as shown in the figure above. The graph shows the variation of kinetic energy of the block with the distance travelled s up along the plane. Find the angle θ.
Take g to be 10 m s^{-2}.

A. 5.7°
B. 11.5°
C. 23.6°
D. 26.7°

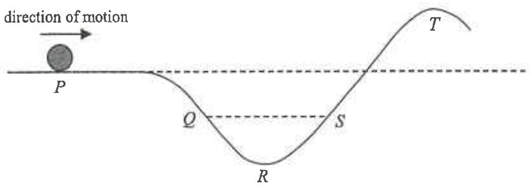
69. **< HKCE 2011 Paper II - 7 >**



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 >**

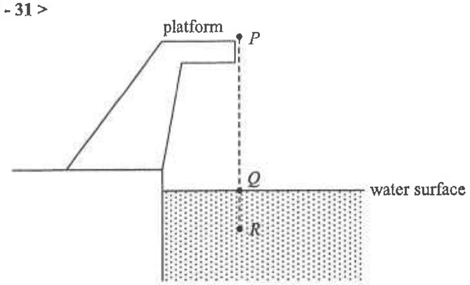


A ball moves along a smooth curved rail and passed P at a certain speed as shown in the figure above. Neglecting air resistance and friction, which of the following statements about the motion of the ball are correct ?

(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

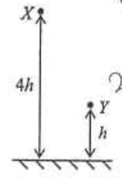
Part B : HKAL examination questions

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 >**



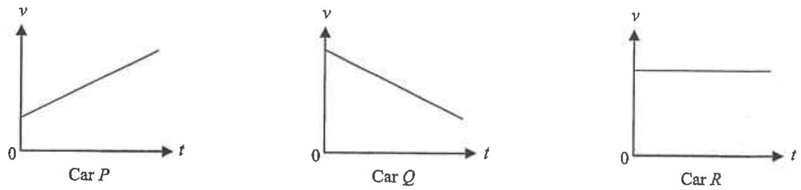
Two small balls X and Y of masses 1 kg and 2 kg respectively are released from rest at heights $4h$ and h above the ground as shown. If air resistance is negligible, which of the following statements is/are correct ?

(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 $g = 10$ m s^{-2}.)
A. 0.375 W
B. 0.9375 W
C. 9.375 W
D. 135 W

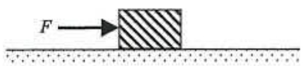
78. David exerts a horizontal force of 500 N on a block placed on a rough horizontal surface. The friction between the block and the surface is 100 N. After the box has moved a horizontal distance of 3 m, what is the gain of kinetic energy of the block ?
A. 300 J
B. 1200 J
C. 1500 J
D. 1800 J

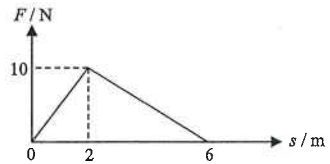
79. Peter pushes a cart along a level road and then lets it go. As the cart is slowing down, the main energy change of the cart is
A. from chemical energy to internal energy.
B. from chemical energy to kinetic energy.
C. from kinetic energy to internal energy.
D. from kinetic energy to potential energy.

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.





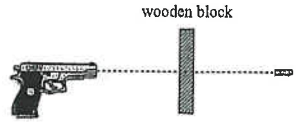
What is the speed of the block after it has been pushed for 6 m ?
A. 12.5 m s^{-1}
B. 15.5 m s^{-1}
C. 17.5 m s^{-1}
D. 25.5 m s^{-1}

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 >**

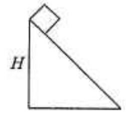


Figure (a)

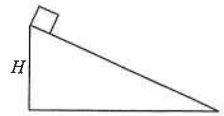


Figure (b)

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 $t_1 < t_2$

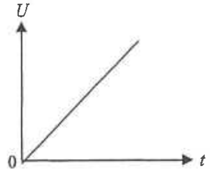
86. **< HKDSE 2015 Paper IA - 8 >**

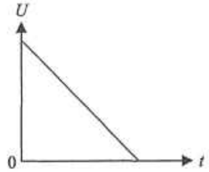
An object is released from rest and falls from P to Q as shown below. Throughout the motion, air resistance increases with the speed of the object. Which of the following description is/are correct ?
(1) The net force acting on the object is constant throughout the motion.
(2) The magnitude of the object's 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.

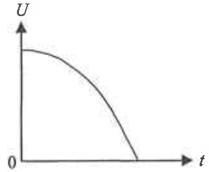
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

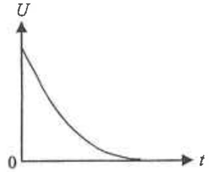
87. **< HKDSE 2016 Paper IA - 8 >**

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.

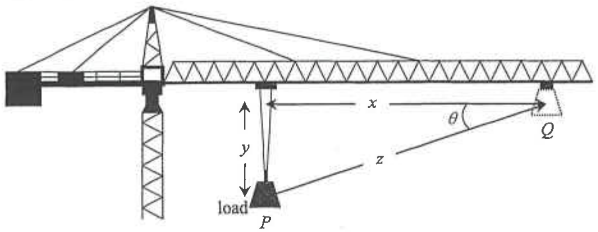
A.


B.


C.


D.


88. **< HKDSE 2016 Paper IA - 9 >**



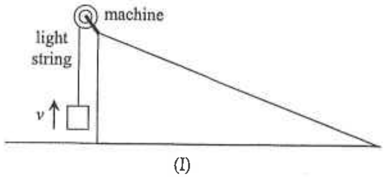
A crane moves a load of weight W steadily from point P to point Q as shown. The work done on the load by the crane is

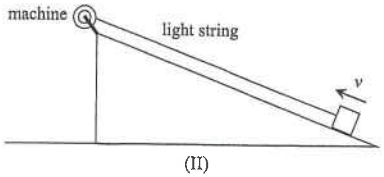
A. Wy.
B. $W(x + y)$.
C. Wz.
D. $Wz \cos \theta$.

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.





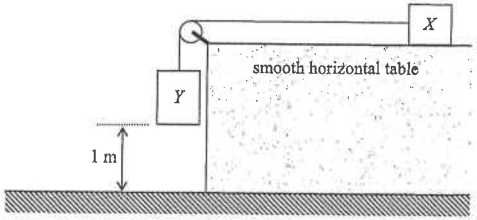
Which of the following statements correctly compare(s) the two methods ?

(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}

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. 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

$\therefore\ m g h = m c \Delta T$ $\quad\therefore\ (9.81)\, h = (4200)(0.2)$ $\quad\therefore\ h = 85.6 \approx 86$ 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

$\therefore\ \frac{1}{2} m v^2 = F s$

$\therefore\ \frac{1}{2}(0.01)(100)^2 = F(0.1)$ $\quad\therefore\ F = 500$ 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 $a = \dfrac{mg}{M+m}$, 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

$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{1}{2}(5)(10)^2 - \frac{1}{2}(5)(6)^2 = 160$ J

25. A

$W_f = Fs = F(vt) = (5) \times (10) \times (4) = 200$ 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) $E = mgh = (10)(9.81)(10) = 981$ J

✓ (2) $E = \frac{1}{2}mv^2 = \frac{1}{2}(2)(10)^2 = 100$ J

✓ (3) $E = Pt = (10)(10) = 100$ 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*

$mgh = \frac{1}{2}mv^2$

$(10)(0.8) = \frac{1}{2}v^2$ $\therefore v = 4$ 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*.

$\therefore W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{1}{2}(0.02)[(450)^2 - (400)^2] = 425$ J

$\therefore \frac{1}{2}mv^2 = nW$

$\therefore \frac{1}{2}(0.02)(450)^2 = n(425)$ $\therefore n = 4.76$

∴ The bullet can pass through 4 identical blocks.

35. C

$P = \frac{KE}{t} = \frac{\frac{1}{2}mv^2}{t} = \frac{\frac{1}{2}(2500)(20)^2}{(5)} = 100\,000$ W $\therefore P = 100$ 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

$P = \frac{E}{t} = \frac{F \cdot s}{t} = \frac{(1200)(1.5)}{2} = 900$ 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}

$$P = \frac{\Delta KE}{t} = \frac{\frac{1}{2}mv^2 - \frac{1}{2}mu^2}{t} = \frac{\frac{1}{2}(2000)(12)^2 - 0}{4} = 36\text{ kW}$$

41. C

✓ (1) As the block rises up, its *PE* increases.

✓ (2) As the tension *T* is greater than the weight mg, 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

$= 100\cos\theta \times 5 = 500\cos\theta$

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 $\frac{1}{2}mu^2 = mgh$

$\therefore \frac{1}{2}mu^2 = m(9.81)(0.5)$

$\therefore u = 3.13\text{ m s}^{-1}$

OR

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

$\therefore (0) = u^2 + 2(-9.81)(0.5)$

$\therefore u = 3.13\text{ m s}^{-1}$

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

$\frac{1}{2}mu^2 = fs$

$\frac{1}{2}(0.5)u^2 = (3)(10)$ $\therefore u = 10.95 \approx 11.0\text{ m s}^{-1}$

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 $F = Fs = 7557.5 \times 100 = 755750\text{ J} \approx 756$ kJ

OR

Energy required = gain of *PE* + work done against air resistance

$= mgh + fs$

$= (1500)(9.81)(100\sin 30°) + (200)(100) = 755750\text{ J} \approx 756$ 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.

$\therefore KE_o = mgh = mgs\sin\theta$

$\therefore$ (24) = (5) (10) (2.4) sin θ $\therefore \theta = 11.5°$

< OR >

Magnitude of the slope of the graph = net force = $mg\sin\theta$

$\frac{24}{2.4} = (5)(10)\sin\theta$ $\therefore \theta = 11.5°$

69. C

K.E. = $\frac{1}{2}mv^2 = \frac{1}{2}m(at)^2 = \frac{1}{2}ma^2t^2$

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 $s = \frac{1}{2}at^2$ $\therefore t \propto \sqrt{h}$ $\therefore$ Time take for ball A is double that for B.

✓ (3) Gain of KE = Loss of PE = $mgh \propto mh$ $\therefore \frac{KE_A}{KE_B} = \frac{(1)(4h)}{(2)(h)} = 2$.

74. A

Since $KE = \frac{1}{2}mv^2$, 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 = Fs = (10) (3) = 30 J

Energy wasted = Energy input − useful energy output = 54 − 30 = 24 J

77. A

Gain of potential energy of water = mgh = (270) (10) (12) = 32400 J

Useful average power = $\frac{E}{t} = \frac{32400}{24\times60\times60}$ = 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 $= \frac{1}{2} m v^2$ $\therefore$ $\frac{1}{2}(10)(6) = \frac{1}{2}(0.25) v^2$ $\therefore$ $v = 15.5 \text{ m s}^{-1}$

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

$\frac{1}{2} m u^2 = \frac{1}{2} m v^2 + F s$

$\frac{1}{2}(0.050)(400)^2 = \frac{1}{2}(0.050)(250)^2 + F(0.06)$ $\therefore$ $F = 4.06 \times 10^4 \text{ N}$

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, $v = u + at = gt$

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

$= mgh$

$= Wy$

89. B

× (1) As the block is moved in uniform velocity, there is no acceleration and forces are balanced.
In method (I), $T_1 = mg$. In method (II), $T_2 = mg \sin \theta$. Thus, the tension is not the same.

× (2) Since the speed is uniform, average power $= Fv$.
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	$P = Fv = \frac{W}{t}$

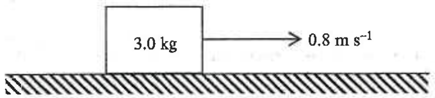
Use the following data wherever necessary :

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.

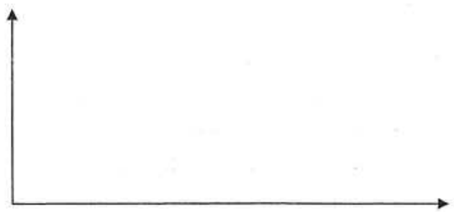


(a) Find the work done by the block in overcoming friction. (3 marks)

(b) What is the frictional force acting on the block ? (3 marks)

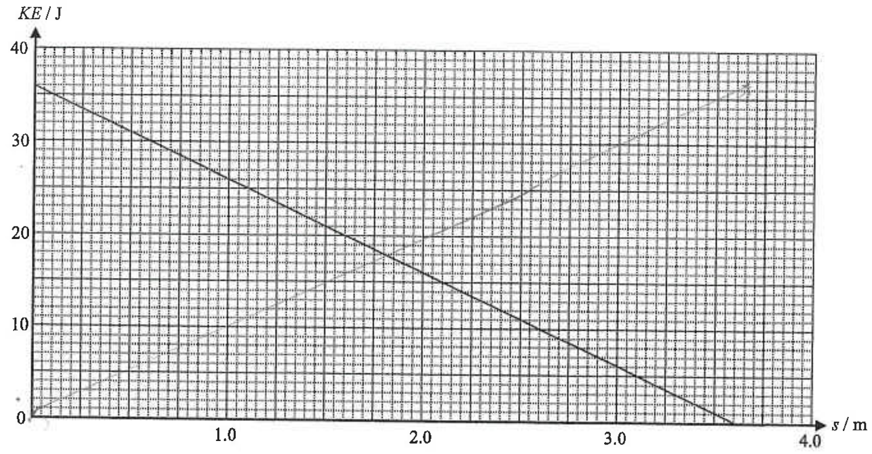
(c) Find the time taken by the block for the journey. (4 marks)

(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)

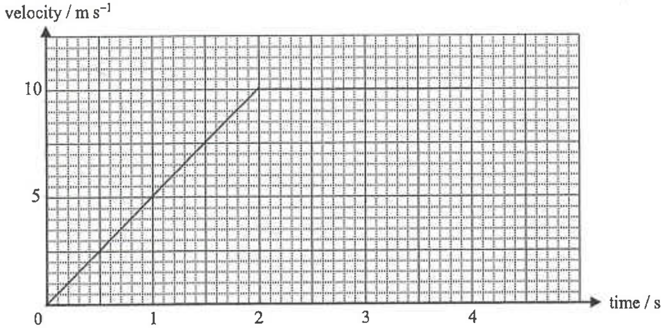
(ii) What physical quantity does the slope of the graph represent ? (1 mark)

(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

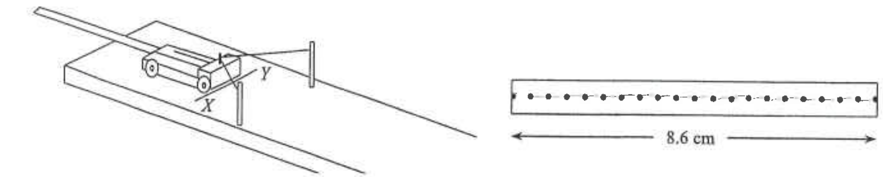
(i) the potential energy lost, and

(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.

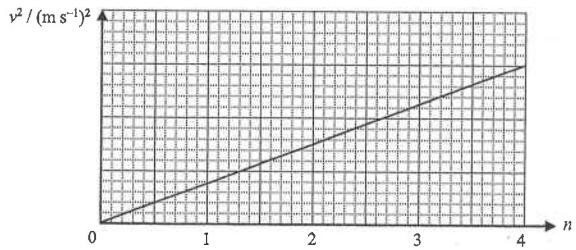
(a) A strip as shown above is selected.

(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)

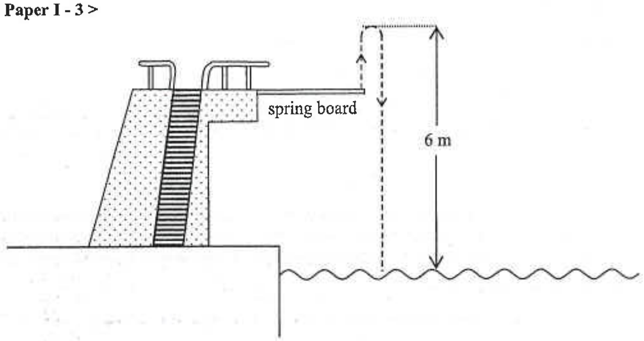
(c) What precaution(s) should be taken in order to

(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)

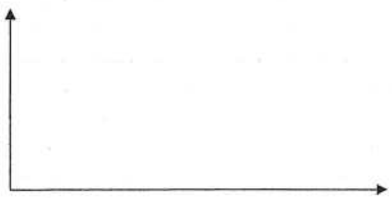
(ii) If the driver takes 10 s to climb up the flight of steps, what is his average power ? (3 marks)

(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.

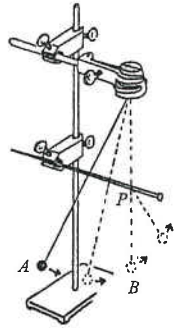
(i) Sketch a graph of the kinetic energy possessed by the diver against time, starting from the moment he leaves the spring board till the moment he reaches the water surface. (3 marks)



(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 >**

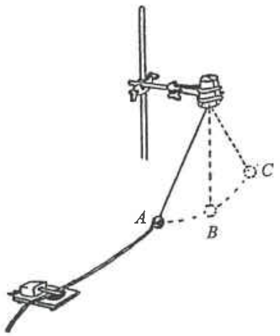


Figure 1

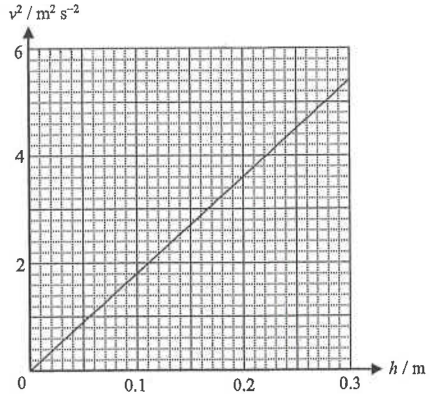


Figure 2

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)

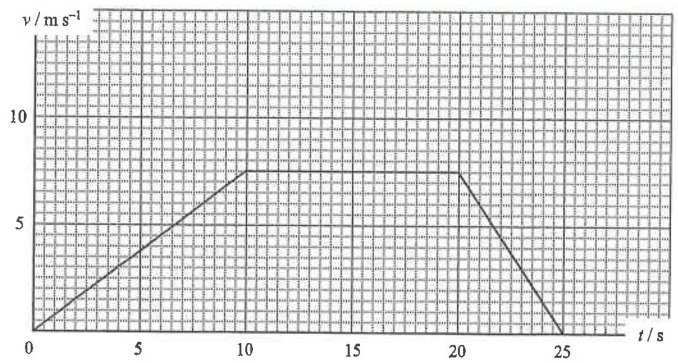
(ii) Write down the equation relating v^2 and h from the graph. (1 mark)

(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)

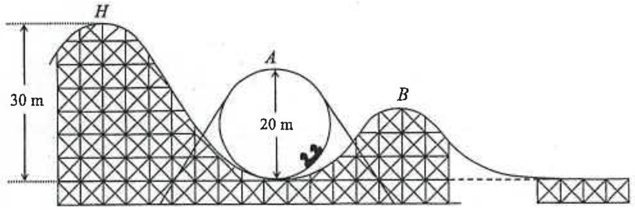
(ii) What is the average power output by the system ? (3 marks)

(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)

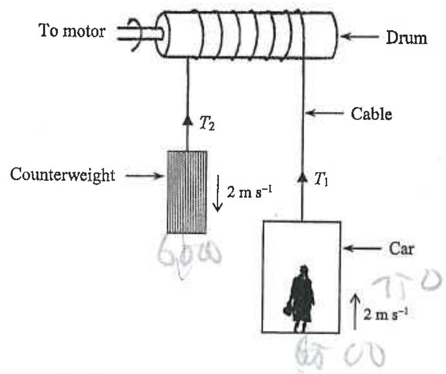
(b) The cart reaches the terminal platform at a speed of 10 m s^{-1}. A braking device at the platform stops the car in 2 seconds. Find the average force on the cart exerted by the device. (3 marks)

(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)

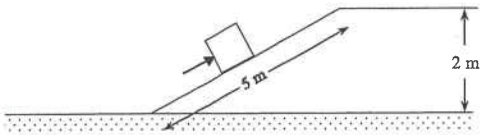


Figure 1

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)

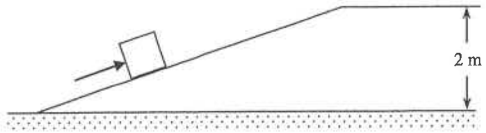


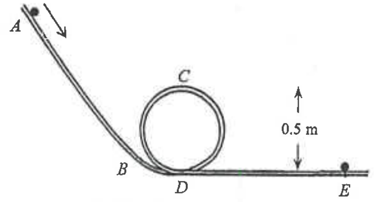
Figure 2

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

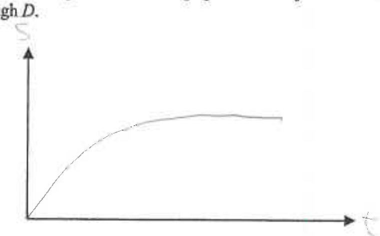
(i) the kinetic energy of the object at *C*, (1 mark)

(ii) the potential energy of the object at *C* (taking the potential energy at *D* as zero), (1 mark)

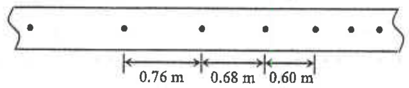
(iii) the work done against friction as the object travels from *C* to *D*. (3 marks)

(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)

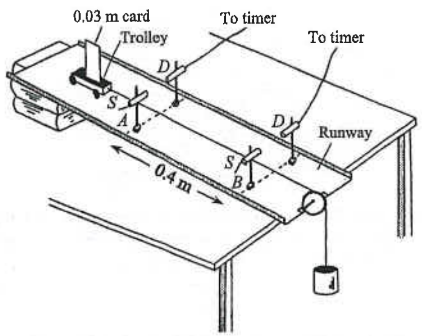


(ii)



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)

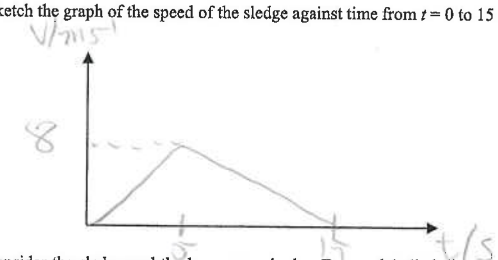
(c) If the string suddenly breaks, describe the subsequent motion of the trolley along the runway. (1 mark)

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

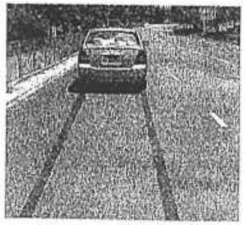
A similar road test is conducted on an inclined road. The car now takes 16.2 s to accelerate from rest to 100 km h^{-1} along the road (see Figure 2). Assume the output power of the car remains unchanged.

(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



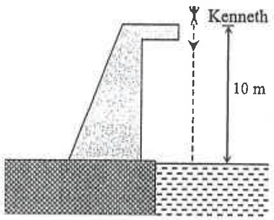
On a certain day, the car was involved in a traffic accident. John braked hard to stop the car and skid marks were left on a horizontal road (see Figure 3). Investigation by the police revealed the following information:

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.

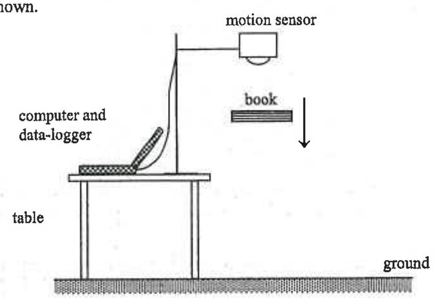
(a) Find the potential energy of Kenneth when he stands on the platform, taking potential energy at the water surface as zero. (1 mark)

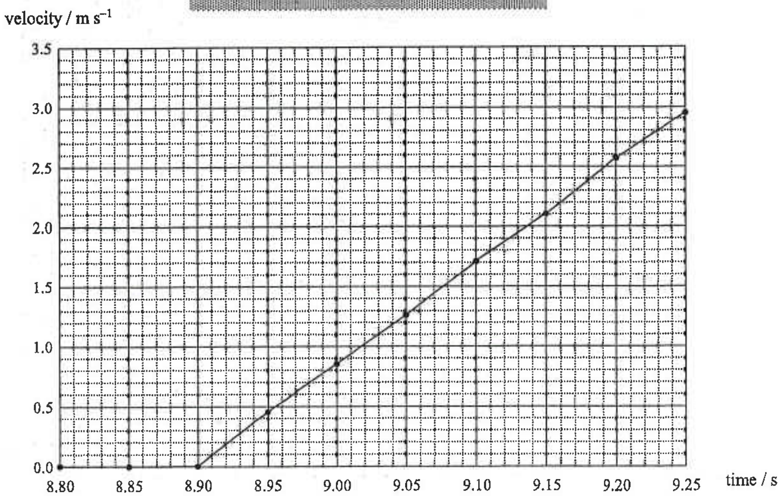
(b) Find the speed of Kenneth at the instant he reaches the water surface. (2 marks)

(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)

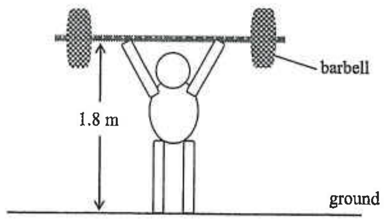
(b) Find the loss in potential energy of the book during the journey in (a). (1 mark)

(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.



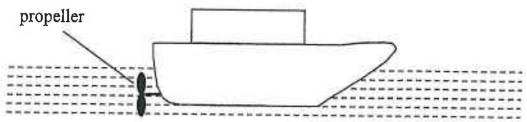
(a) Find the potential energy gained by the barbell after it is lifted up. (1 mark)

(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)

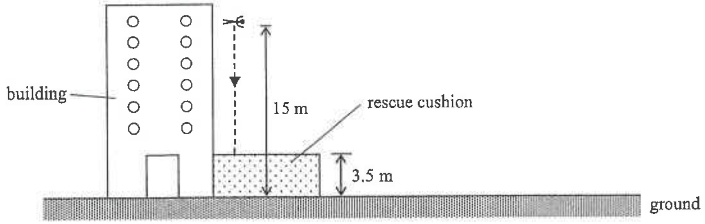
(ii) Find the power developed by this force. (2 marks)

(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.



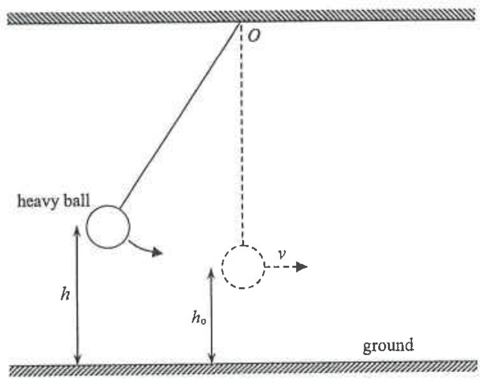
(a) Find the kinetic energy of the man just before reaching the cushion. (2 marks)

(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 >**

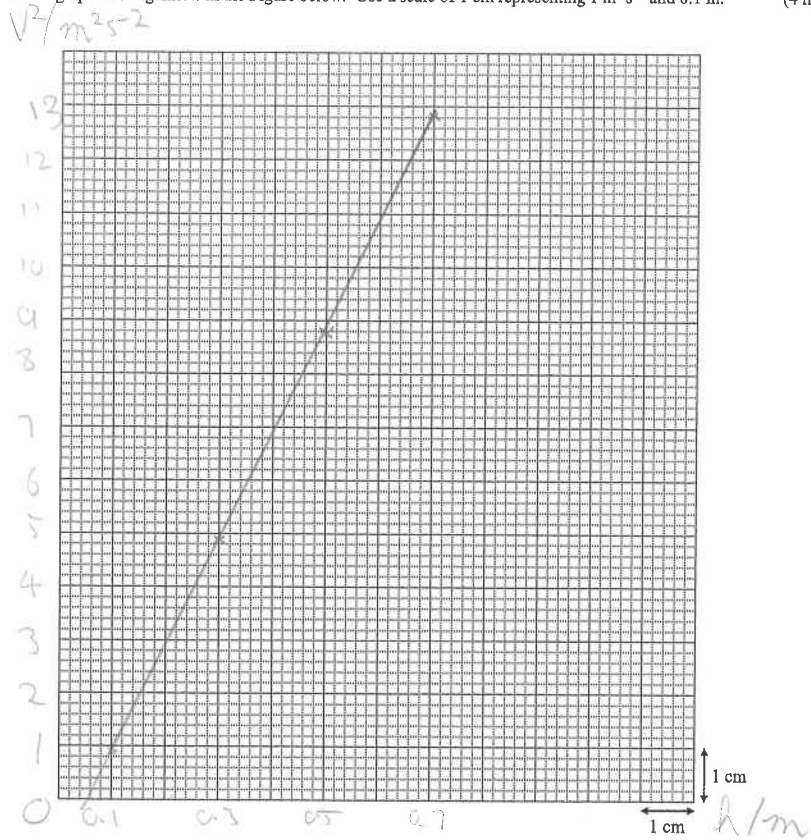
The Figure below shows an experimental setup. The setup is used to find the gravitational acceleration.



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

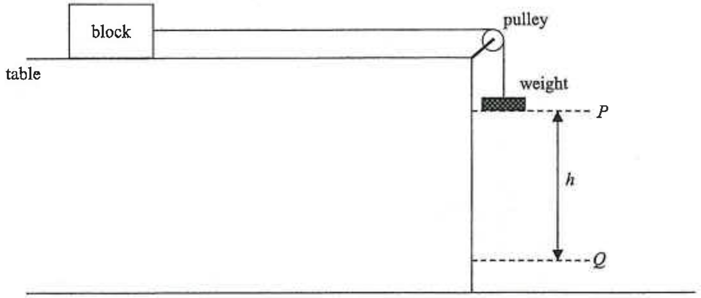
$$v^2 = 2g(h - h_o)$$ (1 mark)

(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.

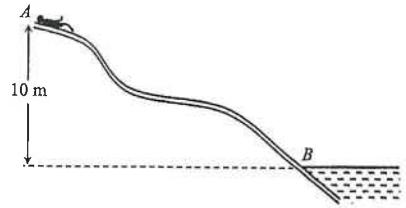
(a) Determine the acceleration of the weight. (2 marks)

(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

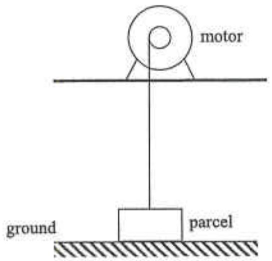
(i) an acceleration of 0.25 m s^{-2} ; and

(ii) a uniform speed of 1 m s^{-1} ? (4 marks)

Part C : HKDSE examination questions

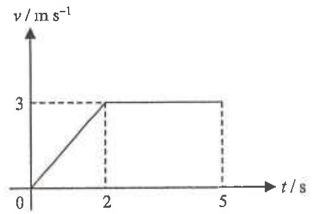
25. **< HKDSE Practice Paper IB - 2 >**

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)



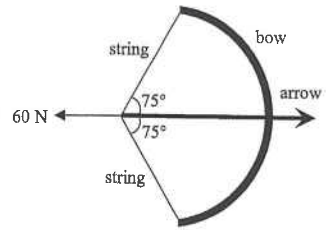
(a) Find the tension in the string at time $t = 1$ s. (3 marks)

(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.

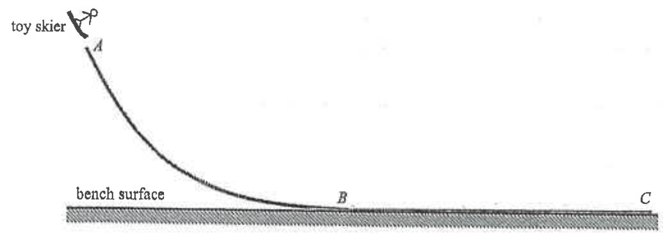


(a) Find the tension of the string. Neglect the weight of the arrow. (2 marks)

(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.

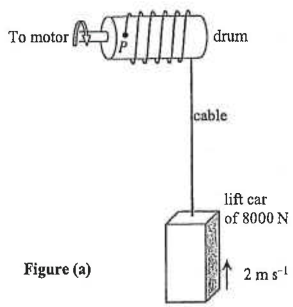


Figure (a)

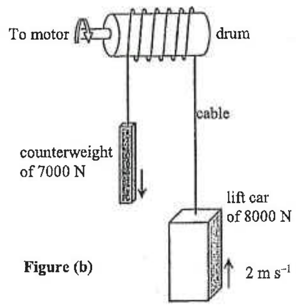


Figure (b)

(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.

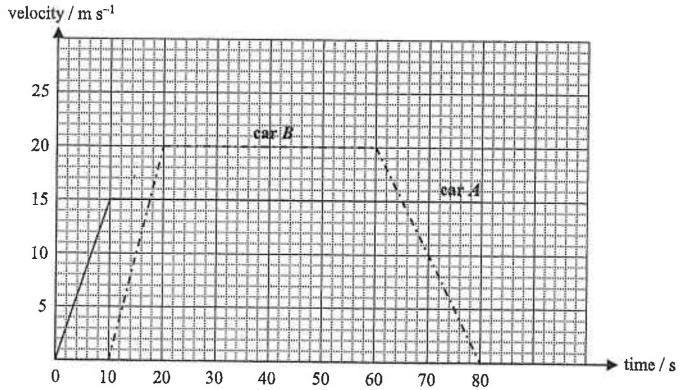
(i) Calculate the total mechanical power output of the motor required in this case, assuming the same power loss in overcoming friction between movable parts as found in (a). (2 marks)

(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 >

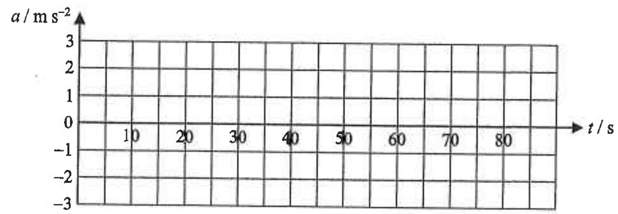
Two cars A and B initially at the same position, start to travel along the same straight horizontal road. The graph below shows how their velocities vary with time.



(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)



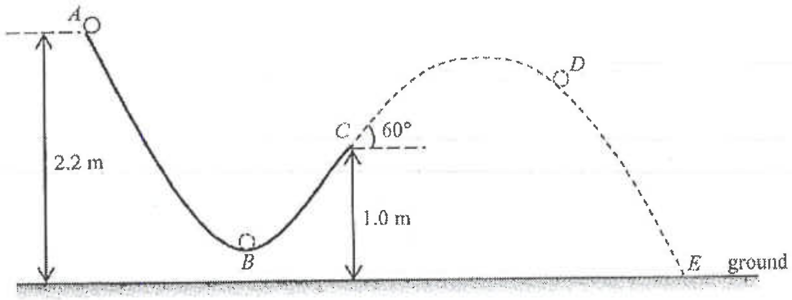
(c) (i) At $t = 20$ s, what is the separation between cars A and B ? (2 marks)

(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.



gure 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)

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]

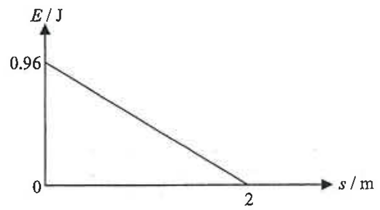
(c) By $f = m a$ $\therefore (-0.48) = (3)\, a$ **OR** $\therefore (0.48) = (3)\, a$ [1]

$\therefore a = -0.16$ 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]

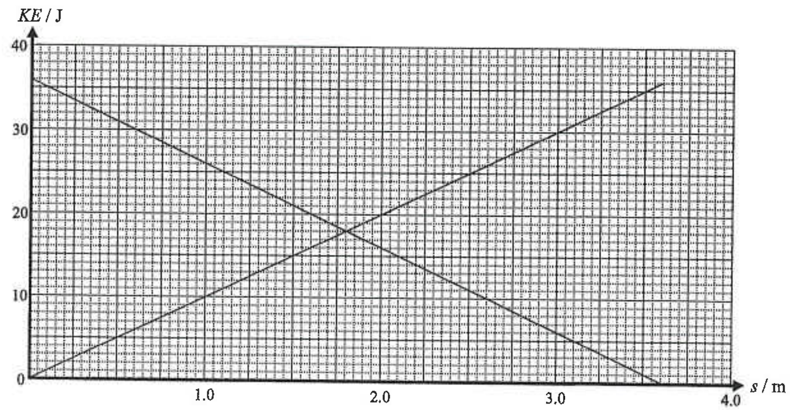
unit of slope = J m^{-1} (or N) [1]

(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)



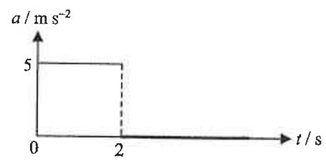
[3]

< 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 $= 20 \times \dfrac{1}{50} = 0.4$ s [2]

(ii) $v = \dfrac{8.6}{0.4} = 21.5$ 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 $= m g h = (50) \times (9.81) \times (30 \times 0.15)$ [1]
$= 2210$ J [1]

(ii) Power $= \dfrac{E}{t}$ [1]

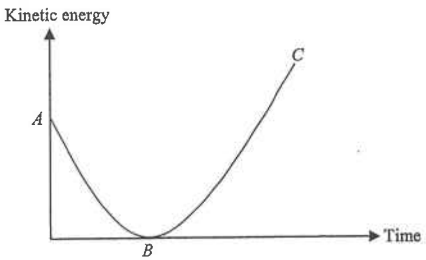
$= \dfrac{2210}{10}$ [1]

$= 221$ 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 $m g h = F s$ [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 $= m g h$
$= (0.1) \times (9.81) \times (0.2)$ [1]
$= 0.1962$ J < accept 0.196 J > [1]

(ii) $m g h = \frac{1}{2} m v^2$ [1]
$(0.1962) = \frac{1}{2}(0.1) \times v^2$
$\therefore$ $v = 1.98$ m s^{-1} [1]

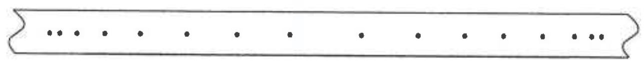
(iii) No work is done [1]
Since the force is always perpendicular to the motion (velocity) [2]

(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 $= \dfrac{5.4}{0.3}$ [1]
$= 18$ m s^{-2} < 17.5 to 18.3 is acceptable > [1]

(ii) $v^2 = 18\, h$ [1]

(iii) $m g h = \frac{1}{2} m v^2$ [1]
$\therefore$ $v^2 = 2 g h$
$\therefore$ Slope of the graph $= 2 g = 18$ [1]
$\therefore$ $g = \dfrac{18}{2} = 9$ 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]

$(72720) = \frac{1}{2} \times (1200) \times v^2$

$\therefore\ v = 11.0$ m s^{-1} [1]

(b) $v = u + a t$

$\therefore\ (0) = (10) + a(2)$ $\therefore\ a = -5$ 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 $= (0.1) \times (9.81) \times (0.5)$

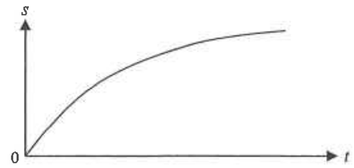
$= 0.4905$ J < accept 0.491 J > [1]

(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]

$u = \dfrac{0.76}{0.2} = 3.8\ \text{m s}^{-1}$

$v = \dfrac{0.60}{0.2} = 3.0\ \text{m s}^{-1}$ [1]

$a = \dfrac{v-u}{t} = \dfrac{3.8-3.0}{2\times 0.2} = -2\ \text{m s}^{-2}$ [1]

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

13. (a) (i) (1) $v_A = \dfrac{0.03}{0.05} = 0.6\ \text{m s}^{-1}$ [2]

(2) $v_B = \dfrac{0.03}{0.025} = 1.2\ \text{m s}^{-1}$ [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]

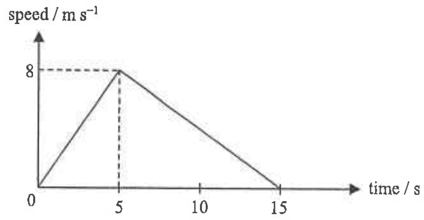
(b) A motion sensor connected to a data-logger is placed on top on the runway. [1]

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)

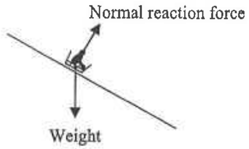


< For the graph from t = 0 to 5 s > [1]

< For the graph from t = 5 to 15 s > [1]

< For labelling the 2 axes with units > [1]

(b)



[1]

[1]

(c) (i) Acceleration $= \dfrac{8}{5} = 1.6\ \text{m s}^{-2}$ [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

$= \dfrac{8}{15-5}$

$= 0.8\ \text{m s}^{-2}$ [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]

<u>OR</u>

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) $100\text{ km h}^{-1} = \dfrac{100\times1000\text{ m}}{3600\text{ s}} = 27.8\text{ m s}^{-1}$ [1]

(b) K.E. $= \frac{1}{2}mv^2 = \frac{1}{2}(1400)(27.8)^2$

$= 541\ 000$ J (OR 540 988 J) (OR 541 kJ) (OR 540 kJ) [1]

$P = \dfrac{E}{t} = \dfrac{541000}{9.3}$ [1]

$= 58\ 200$ W (OR 58.2 kW) (OR 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]

OR

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) $Pt = \frac{1}{2}mv^2 + mgh$ [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) $\frac{1}{2}mv^2 = fs$ [1]

$\frac{1}{2}(1400)v^2 = (11200)(30.5)$ [1]

$v = 22.09\text{ m s}^{-1}$

$= 22.09\times\dfrac{3600}{1000}\text{ km h}^{-1} = 79.5\text{ km h}^{-1}$ [1]

As the speed of the car exceeds 70 km h^{-1}, John was not telling the truth. [1]

16. (a) $PE = mgh = (60)(9.81)(10) = 5886$ J < accept 5890 J > [1]

(b) $mgh = \frac{1}{2}mv^2$ [1]

$(5886) = \frac{1}{2}(60)v^2$

$v = 14.0\text{ m s}^{-1}$ [1]

(c) $mgh = Fs$ < OR > $mgh + \frac{1}{2}mv^2 = Fs$ [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

$= \frac{1}{2}\times2.95\times(9.25-8.90)$ [1]

$= 0.516$ m [1]

(b) $\Delta PE = mgh$

$= (0.154)\times(9.81)\times(0.516)$

$= 0.780$ J [1]

(c) $KE = \frac{1}{2}mv^2$

$= \frac{1}{2}(0.154)\times(2.95)^2$ [1]

$= 0.670$ J [1]

(d) There is air resistance acting on the book. [1]

18. (a) $PE = mgh = (115)(9.81)(1.8) = 2030$ J [1]

(b) $R = (115)(9.81) + (70)(9.81)$ [1]

$= 1810$ N [1]

(c) $s = ut + \frac{1}{2}at^2$ [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) $P = Fv = (0.45)(1.5)$ [1]

$= 0.675$ W [1]

(b) (i) $KE = \frac{1}{2}mv^2 = \frac{1}{2}(1.2)(1.5)^2 = 1.35$ J [1]

(ii) $(1.35) = (0.45)s$ [1]

$\therefore s = 3$ m [1]

20. (a) KE = loss of $PE = mgh$

$= (60)(9.81)(15-3.5)$ [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]

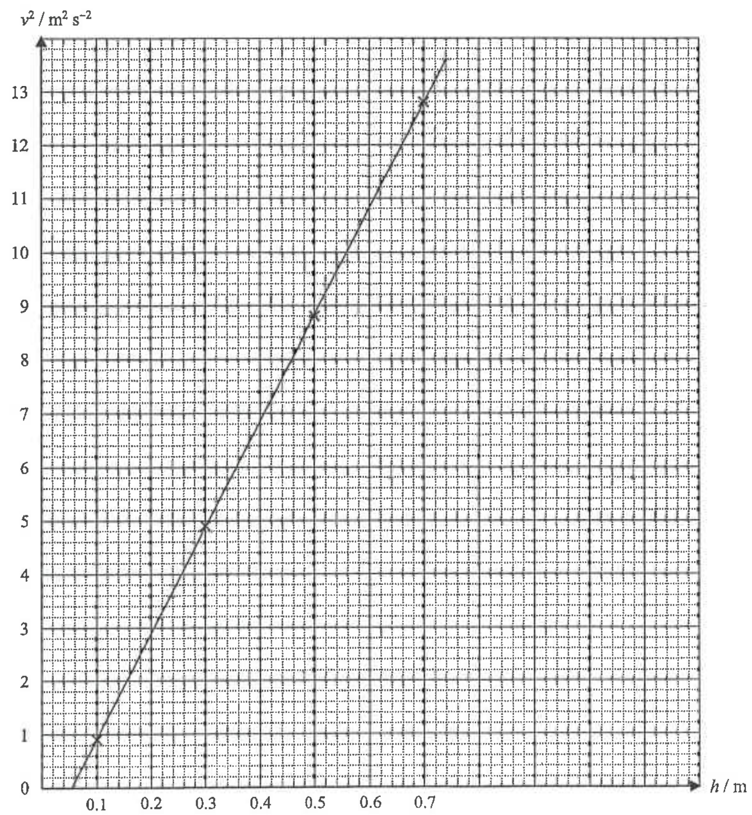
$F = 2850$ N < accept 2840 N > [1]

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 $F = (m\,v - m\,u) / t$, 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 $v^2 = 2 g h - 2 g h_o$

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) $s = u\,t + \frac{1}{2} a t^2$

$(0.7) = 0 + \frac{1}{2} a (2.95)^2$ [1]

$a = 0.161$ m s^{-2} [1]

(b) $v = u + a\,t$

$= (0) + (0.161)(2.95)$ [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

$m g - f = (m + M)\,a$

$(0.02)(9.81) - f = (0.02 + 1)(0.161)$ [3]

$\therefore\ f = 0.0320$ N < accept 0.0316 to 0.0320 N > [1]

23. (a) (i) $PE = m g h = (50) \times (9.81) \times (10) = 4905$ 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 $= Fv = (75 \times 9.81) \times (2)$ [1]
$= 1470$ W [1]

(b) (i) $R - mg = ma$ [1]
$R - (75) \times (9.81) = (75) \times (0.25)$ $\quad \therefore R = 755$ N $\quad$ < accept 754.5 N > [1]

(ii) $R = mg$ [1]
$= (75)(9.81) = 736$ N [1]

25. (a) a = slope $= \frac{3}{2} = 1.5$ m s^{-2} [1]
$T - mg = ma$
$T - (4)(9.81) = (4)(1.5)$ [1]
$T = 45.2$ N $\quad$ < accept 45.24 N > [1]

(b) $P = Fv = (4 \times 9.81)(3)$ $\quad$ < note that at 2 s to 5 s, there is no acceleration, $T = mg$ > [1]
$= 118$ W $\quad$ < 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) $2T\cos 75° = 60$ [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 $\quad$ < 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) $P = Fv = (8000) \times (2)$ [1]
$= 16000$ W $\quad$ < **OR** 16 kW > [1]

(ii) $P_{loss} = 20000 - 16000 = 4000$ W $\quad$ < **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 $\quad$ < **OR** 6 kW > [1]

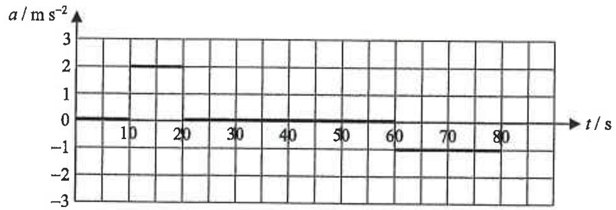
(ii) Output power required from the motor is smaller. **OR** Force exerted by the motor is smaller. [1]

(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 $= \frac{20-0}{20-10} = 2$ 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}.
$\therefore \Delta s = \Delta v \times \Delta t$ $\quad \therefore (125) = (5) \times \Delta t$ [1]
$\therefore \Delta t = 25$ s
The time that car B catches up with car A is at 45 s. [1]

(d) $F \propto v^2$
$P = Fv \propto v^3$ [1]
$\frac{P_A}{P_B} = \left(\frac{v_A}{v_B}\right)^3 = \left(\frac{15}{20}\right)^3 = \frac{27}{64}$ $\quad$ < accept 27 : 64 > [1]