The following list of formulae may be found useful :

Coulomb's law $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$

Electric field strength due to a point charge $E = \frac{Q}{4\pi\varepsilon_0 r^2}$

Electric field between parallel plates (numerically) $E = \frac{V}{d}$

Use the following data wherever necessary :

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

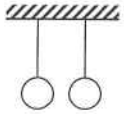
Charge of electron $e = 1.6 \times 10^{-19}\ \text{C}$

Electron rest mass $m_e = 9.11 \times 10^{-31}\ \text{kg}$

Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$

Part A : HKCE examination questions

1. < HKCE 1981 Paper II - 26 >

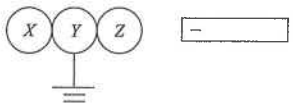


Two light conducting spheres are suspended from two silk threads as shown. If they are found to attract one another, which one of the following conclusions is/are correct ?

(1) They carry similar charges.
(2) They carry opposite charges.
(3) Only one of them is charged.

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

2. < HKCE 1982 Paper II - 35 >

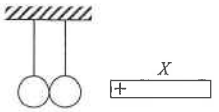


Three metal spheres X, Y and Z are placed in contact as shown. A negatively charged rod is brought near Z. The sphere Y is then earthed while the charged rod is still nearby. Which of the following statements is/are true ?

(1) X is negatively charged.
(2) Y is neutral.
(3) Z is positively charged.

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

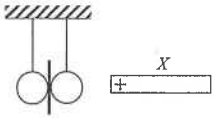
3. < HKCE 1984 Paper II - 24 >



Two uncharged metal spheres in contact are suspended by dry cotton threads. When a positively charged rod X is brought near them as shown above, the distribution of charges on the spheres will be

A. 
B. 
C. 
D. 

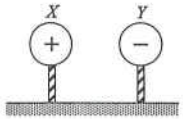
4. < HKCE 1985 Paper II - 33 >



Two uncharged metal spheres are suspended by insulating threads as shown in the diagram. A plastic sheet is put between them. When a positively charged rod X is brought near them as shown, which of the following diagrams shows the resulting charge distribution of the spheres ?

A. 
B. 
C. 
D. 

5. < HKCE 1986 Paper II - 28 >

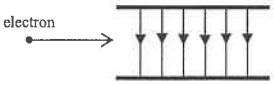


The diagram shows two conducting spheres X and Y mounted on insulating stands. Sphere X carries positive charges and sphere Y carries negative charges. As Y is moved slowly towards X (but without touching X) the total charges on X

A. increase and are positive.
B. remain unchanged.
C. become negative.
D. disappear.

6. < HKCE 1987 Paper II - 37 >

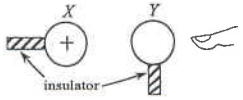
In the figure shown, an electron travels in a horizontal direction and enters a uniform electric field. The direction of the electric field is as shown. What is the direction of the force due to the electric field acting on the electron ?



A. upwards
B. downwards
C. into the page
D. out of the page

7. < HKCE 1988 Paper II - 28 >

A positively charged metal sphere X is brought near an uncharged metal sphere Y as shown. Y is then touched momentarily with a finger. X is then taken away. Y is now



A. positively charged.
B. negatively charged.
C. negatively charged on the left side and positively charged on the right side.
D. positively charged on the left side and negatively charged on the right side.

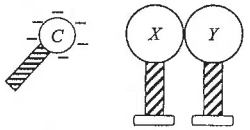
8. **< HKCE 1990 Paper II - 30 >**

A positively-charged metal sphere is mounted on an insulating stand. When the sphere is earthed with a finger,

A. protons will move from the sphere to the earth.
B. protons will move from the earth to the sphere.
C electrons will move from the sphere to the earth.
D. electrons will move from the earth to the sphere.

9. **< HKCE 1991 Paper II - 29 >**

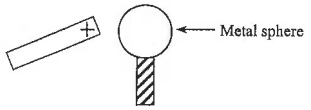
In the figure shown, *X* and *Y* are two insulated metal spheres in contact with each other. A negatively charged object *C* is brought near *X*. *X* is touched momentarily with a finger, and then *X* and *Y* are separated. The charges on *X* and *Y* are



	Sphere *X*	Sphere *Y*
A.	positive	positive
B.	positive	negative
C.	negative	negative
D.	positive	zero

10. **< HKCE 1992 Paper II - 30 >**

A positively charged rod is brought near an insulated uncharged metal sphere as shown in the figure. If the sphere is earthed with a finger,



A. positive charges flow from the earth to the sphere.
B. electrons flow from the earth to the sphere.
C. electrons flow from the sphere to the earth.
D. the sphere is completely discharged.

11. **< HKCE 1993 Paper II - 31 >**

An uncharged light conducting sphere is suspended by an insulating thread. The metal dome of an operating Van de Graaff generator is brought near the sphere. Which of the following statements best describes the motion of the sphere ?

A. The sphere remains stationary.
B. The sphere moves away from the dome.
C. The sphere moves towards the dome, touches it and remains there.
D. The sphere moves towards the dome, touches it and then moves away.

12. **< HKCE 1994 Paper II - 25 >**

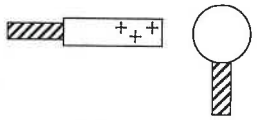
Which of the following involve(s) the application of electrostatics ?

(1) A photocopier
(2) A precipitator in the chimney of a coal-fired power station
(3) A Van de Graaff generator

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

13. **< HKCE 1994 Paper II - 24 >**

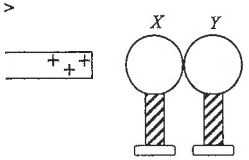
An insulated charged metal rod is brought near an insulated uncharged metal sphere as shown in the figure. Which of the following can charge the sphere ?



(1) Touching the sphere momentarily with a finger.
(2) Touching the sphere momentarily with the rod.
(3) Touching the rod momentarily with a finger and then touching the sphere momentarily with the same finger.

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

14. **< HKCE 1995 Paper II - 29 >**



Two insulated uncharged metal spheres *X* and *Y* are in contact with each other. A positively charged rod is brought near *X* as shown above. Which of the following diagrams correctly shows the distribution of charges on the spheres ?

A.

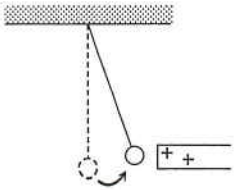

B.


C.


D.


15. **< HKCE 1996 Paper II - 29 >**

A small conducting sphere is suspended by an insulated thread. When a positively charged rod is brought near the sphere, the sphere is attracted as shown. Which of the following is/are reasonable deduction(s) ?



(1) The sphere may carry a positive charge.
(2) The sphere may carry a negative charge.
(3) The sphere may be neutral.

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

16. **< HKCE 1997 Paper II - 27 >**

The following are the steps to charge an isolated metal sphere by induction, but they are in the wrong order.

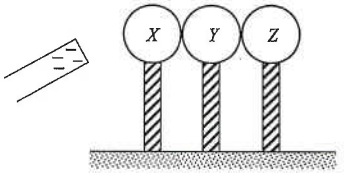
(1) Removing the finger away from the metal sphere.
(2) Touching the metal sphere with a finger.
(3) Bringing a positively charged rod near the metal sphere.
(4) Removing the positively charged rod away from the metal sphere.

Which of the following shows the correct order ?

A. (2), (3), (4), (1)
B. (3), (2), (1), (4)
C. (3), (2), (4), (1)
D. (3), (4), (2), (1)

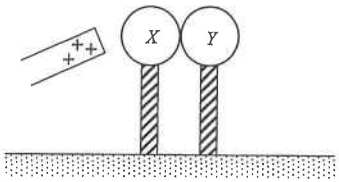
17. **< HKCE 1998 Paper II - 29 >**

Three insulated uncharged metal spheres *X*, *Y* and *Z* are placed in contact as shown. A negatively charged rod is brought near *X* and sphere *Y* is then earthed momentarily. If the charged rod is still near *X*, which of the following describes the charges on *X*, *Y* and *Z* ?



	Sphere *X*	Sphere *Y*	Sphere *Z*
A.	positive	zero	zero
B.	positive	zero	negative
C.	positive	positive	positive
D.	zero	zero	zero

18. < HKCE 2000 Paper II - 28 >



Two insulated uncharged metal spheres X and Y are placed in contact. A positively-charged rod is brought near X as shown above. X is then earthed momentarily. The charged rod is removed and the two spheres are then separated. Which of the following describes the charges on X and Y?

	Sphere X	Sphere Y
A.	negative	negative
B.	negative	uncharged
C.	positive	positive
D.	uncharged	uncharged

19. < HKCE 2001 Paper II - 28 >

Two charged spheres A and B hanging at a point on a ceiling by two identical nylon threads. They remain at rest as shown above. Which of the following statements must be correct ?

(1) Both spheres carry positive charges.

(2) The force acting on B by A is larger than the force acting on A by B.

(3) The mass of A is larger than B.

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

20. < HKCE 2002 Paper II - 31 >

A plastic ruler is placed close to a stream of running water coming from an insulated tap. The stream of water is attracted towards the ruler as shown above. Which of the following statements are correct ?

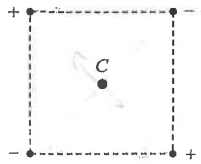
(1) The ruler carries an electric charge.

(2) The ruler and the running water are attracting each other with forces of equal magnitude.

(3) Both positive and negative charges are induced on the running water

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

21. < HKCE 2003 Paper II - 31 >



Four point charges of equal magnitude are placed at the four vertices of a square. The signs of the charges are as shown. A point charge C is placed at the centre of the square. What will be the direction of the resultant electrostatic force, if any, acting on C ?

A. $\rightarrow$
B. $\uparrow$
C. The resultant force acting on C is zero.
D. It cannot be determined since the sign of C is not given.

22. < HKCE 2004 Paper II - 27 >

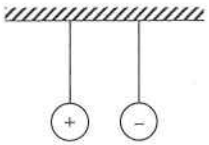
Three conducting spheres are suspended by separate nylon threads. When any two of them are brought near each other, they attract each other. Which of the following deductions is correct ?

A. All three spheres are charged.
B. Only one sphere is charged and the other two are uncharged.
C. One sphere is uncharged and the other two carry like charges.
D. One sphere is uncharged and the other two carry unlike charges.

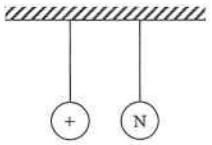
23. < HKCE 2005 Paper II - 17 >

Two conducting spheres are hanging freely in air by insulating threads. In which of the following will the two spheres attract each other ? Note : 'N' denotes that the sphere is uncharged.

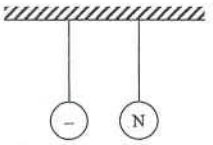
(1)



(2)



(3)



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

24. < HKCE 2006 Paper II - 22 >

A rubbed plastic ruler can attract paper scraps before actually touching them. Which of the following descriptions about the charges on the rubbed ruler and the original charges on the paper scraps are possible ?

(1) The ruler and the paper scraps carry opposite charges.

(2) Both the ruler and the paper scraps are uncharged.

(3) The ruler carries charges and the paper scraps are uncharged.

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

25. **< HKCE 2007 Paper II - 19 >**

In the above figures, P, Q, R and S are identical light conducting spheres and they are hanging freely by insulating threads of the same length. Which of the following deductions is/are correct ?

(1) P and Q must carry like charges.

(2) R and S must carry unlike charges.

(3) P and Q must carry the same amount of net charges.

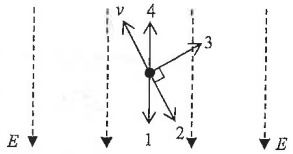
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

Part B : HKAL examination questions

26. **< HKAL 1982 Paper I - 27 >**

The diagram shows a negative charged particle inside a uniform electric field E pointing in downward direction. At the instant shown, the particle is travelling in the direction of the arrow v. Which of the arrows 1 to 4 gives the direction of the acceleration of the particle at this instant ?

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



27. **< HKAL 1983 Paper I - 20 >**

Two parallel metal plates are placed horizontally with a separation of 0.05 m. A voltage of 2000 V is connected across the plates. An oil drop carrying a charge of -1.6×10^{-19} C is found to be at rest between the plates. Find the mass of the drop.

(Take the acceleration due to gravity to be 10 m s^{-2}.)

A. 1.6×10^{-18} kg.
B. 1.6×10^{-16} kg.
C. 6.4×10^{-14} kg.
D. 6.4×10^{-16} kg.

28. **< HKAL 1983 Paper I - 40 >**

Which of the following statements about the coulomb is/are correct ?

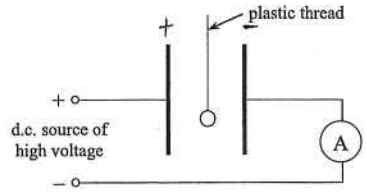
(1) When one coulomb of positive charges flows across a potential difference of one volt from higher to lower potential, one joule of electrical energy is given out.

(2) The force exerted on a charge of 1 coulomb in an electric field of 1 volt per metre is 1 newton.

(3) One coulomb is the total charge of one mole of electrons.

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

29. **< HKAL 1985 Paper I - 45 >**



A light conducting ball is placed between two metal plates connected through an ammeter to a d.c. source of high voltage. The ball shuttles back and forth between the plates, making alternate contacts with each plate. Which of the following statements are correct ?

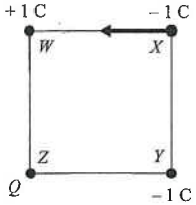
(1) The ball carries charges, sometimes positive, and sometimes negative.

(2) If the separation of the metal plates increases, the frequency of oscillation of the ball decreases.

(3) The galvanometer shows a current flowing always in the same direction.

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

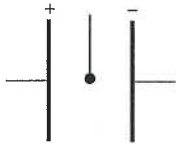
30. **< HKAL 1987 Paper I - 30 >**



Three charge + 1 C, – 1 C and – 1 C are fixed at the corners W, X and Y respectively of a square as shown. A fourth charge, Q, is fixed at Z. If the net electrostatic force acting on the charge at X is indicated by the arrow, what is the magnitude of Q ?

A. $-\sqrt{2}$ C
B. $+\sqrt{2}$ C
C. $-2\sqrt{2}$ C
D. $+2\sqrt{2}$ C

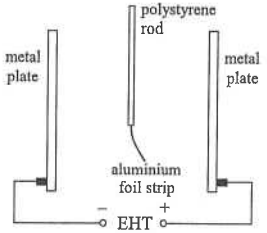
31. **< HKAL 1990 Paper I - 27 >**



A light conducting sphere is hanged from a long insulating thread. It is placed between two oppositely charged metal plates connected to a high voltage supply. If the sphere is given a negative charge, it will

A. move to the positive plate and stick to it.
B. move to the negative plate and stick to it.
C. oscillate, touching each plate in turn, beginning with the positive plate.
D. oscillate, touching each plate in turn, beginning with the negative plate.

32. < HKAL 1993 Paper I - 35 >



Two parallel metal plates are connected to the terminal of an EHT. When a charged aluminium foil strip is placed between the plates, the deflection of the foil is shown in the above figure. Which of the following statements is/are correct ?

(1) The charge on the foil is negative.
(2) If the separation between the two plates decreases, the deflection of the foil increases.
(3) When moving the foil towards the positive plate, the deflection of the foil increases.

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

33. < HKAL 2000 Paper IIA - 26 >

Two parallel plates are connected to an E.H.T. supply giving a d.c. voltage of 4.5 kV. If the separation of the two plates is set at 1.5 mm, calculate the acceleration of an electron placed inside the plates.

A. 1.0×10^{9} m s^{-2}
B. 1.2×10^{12} m s^{-2}
C. 1.6×10^{15} m s^{-2}
D. 5.3×10^{17} m s^{-2}

34. < HKAL 2003 Paper IIA - 23 >

The magnitudes of the charges on two identical small metal spheres are in the ratio 5 : 1. The electrostatic force between them is F_1. If they are brought into contact and then separated to their respective original positions, the electrostatic force between them becomes F_2. Which of the following may be the magnitude of the ratio $F_1 : F_2$?

(1) 5 : 9
(2) 5 : 4
(3) 5 : 2

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

35. < HKAL 2005 Paper IIA - 12 >

X, Y and Z are small identical metal spheres. X and Y are fixed at a certain separation in air and they carry charges of the same magnitude. The attractive force between them is F. Sphere Z is initially uncharged. It first touches X and then it touches Y. What is the electrostatic force between X and Y after Z is taken away ?

A. $\frac{1}{4}F$
B. $\frac{1}{8}F$
C. $\frac{3}{4}F$
D. $\frac{3}{8}F$

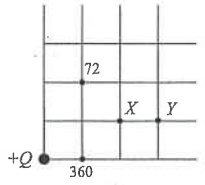
36. < HKAL 2005 Paper IIA - 13 >

A negatively charged oil drop is kept stationary between two horizontal metal plates connected to a d.c. supply as shown. The oil drop then acquires an additional negative charge. Which of the following changes will be able to hold the oil drop stationary ?

(1) Disconnecting the plates from the supply and moving the plates closer
(2) Keeping the separation between the plates unchanged and increasing the p.d. between the plates
(3) Keeping the p.d. between plates unchanged and moving the plates further apart.

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

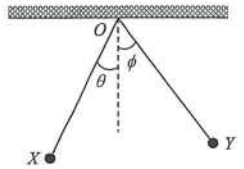
37. < HKAL 2007 Paper IIA - 14 >



The above figure gives the electric field strength (in arbitrary units) at various points near an isolated point charge $+Q$. Which of the following correctly gives the electric field strength (in the same arbitrary units) at X and at Y ?

	electric field strength at X	electric field strength at Y
A.	72	30
B.	72	36
C.	90	30
D.	90	36

38. < HKAL 2007 Paper IIA - 13 >



The figure shows two small charged spheres X and Y suspended by identical nylon threads from a fixed point O. At equilibrium, the threads OX and OY make angles θ and ϕ ($\theta < \phi$) with the vertical. Which of the following conclusions must be correct ?

(1) Both X and Y carry positive charges.
(2) The charge on X is greater than that on Y in magnitude.
(3) The mass of X is greater than that of Y.

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

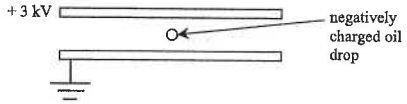
39. **< HKAL 2008 Paper IIA - 14 >**

A point charge $+Q$ is fixed at point X while another point charge $-2Q$ is fixed at point Y as shown. E_X and E_Y denote the magnitude of the electric field due to the point charge at X and Y respectively. For the points on the line passing through X and Y, how many of them has/have $E_X = E_Y$ and how many has/have zero resultant electric field ?
(No need to consider the points at infinity.)

A. There are 3 points with $E_X = E_Y$ and the resultant field is zero at 2 of them.
B. There are 2 points with $E_X = E_Y$ and the resultant field is zero at both of them.
C. There are 2 points with $E_X = E_Y$ and the resultant field is zero at 1 of them.
D. There is 1 point with $E_X = E_Y$ and the resultant field is zero at that point.

40. **< HKAL 2009 Paper IIA - 33 >**

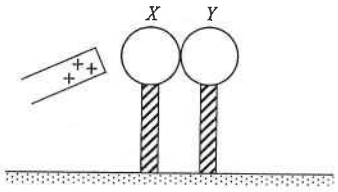
A potential difference of 3 kV is applied across two horizontal metal plates of separation 1.5 cm. A charged oil drop of mass 9.6×10^{-15} kg is kept stationary between the plates as shown. Find the quantity of charge acquired by the oil drop ?
(Take the acceleration due to gravity as 10 m s^{-2}.)



A. 1.6×10^{-19} C
B. 3.2×10^{-19} C
C. 4.8×10^{-19} C
D. 6.4×10^{-19} C

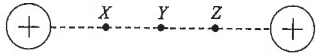
Part C : Supplemental exercise

41. Two insulated uncharged metal spheres X and Y are placed in contact. A positively-charged rod is brought near X as shown. X is then earthed momentarily. The charged rod is then removed. Which of the following describes the charges on X and Y ?



	Sphere X	Sphere Y
A.	negative	negative
B.	negative	uncharged
C.	positive	positive
D.	uncharged	uncharged

42.

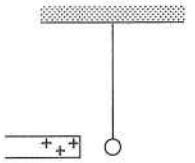


Two identical spheres carrying equal amount of positive charges are placed as shown in the figure above. Which of the following statements are correct ?

(1) At the mid-point Y between the two spheres, it is a neutral point.
(2) If a small negative charge is placed at point X, it experiences a net electric force towards the left.
(3) If a small positive charge is placed at point Z, it experiences a net electric force towards the right.

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

43.

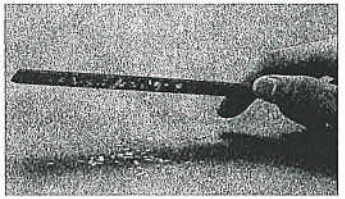


A small neutral conducting sphere is suspended by an insulated thread. When a positively charged metal rod is brought near the sphere, which of the following consequences are correct ?

(1) The sphere is attracted by the charged rod due to the induced charge on the sphere.
(2) The sphere is repelled from the charged rod after touching the charged rod.
(3) The sphere finally carries positive charge.

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

44.

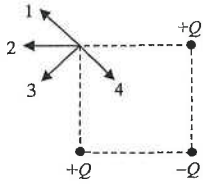


When a plastic ruler is placed close to pieces of small paper, some of them are found to be attracted towards the ruler. Which of the following statements is/are correct ?

(1) The attraction is due to the electric force between the ruler and the pieces of paper.
(2) Those pieces of paper attracted by the ruler remain neutral.
(3) The attraction acting on each piece of paper is greater than the attraction acting on the ruler by that piece of paper.

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

45.



Point charges, each of magnitude Q, are placed at three corners of a square as shown in the diagram. What is the direction of the resultant electric field at the fourth corner ?

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

46.

A, B, C, D are four points on a straight line as shown in the diagram. A point charge $+Q$ is fixed at A. When another point charge $-Q$ is moved from B to C, which of the following statements is/are correct ?

(1) The electrostatic force between the two charges increases.

(2) The magnitude of the electric field strength at the point D increases.

(3) Point B becomes the neutral point.

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

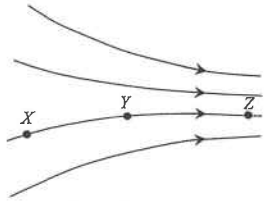
47. The charge on the uranium nucleus is 1.5×10^{-17} C and the charge on the α-particle is 3.2×10^{-19} C. What is the electrostatic force between a uranium nucleus and an α-particle separated by 1.0×10^{-13} m ?

A. 4.32×10^{-33} N
B. 4.32×10^{-20} N
C. 4.32×10^{-13} N
D. 4.32 N

48. What is the magnitude of the electric field strength at a distance r from an isolated stationary nucleus of proton number (atomic number) Z ?

A. $\dfrac{Ze}{4\pi\varepsilon_0 r}$
B. $\dfrac{(Ze)^2}{4\pi\varepsilon_0 r^2}$
C. $\dfrac{Ze}{4\pi\varepsilon_0 r^2}$
D. $\dfrac{Ze^2}{4\pi\varepsilon_0 r}$

49.



The diagram shows a pattern of electric field lines in which X, Y and Z are points marked on one of the field lines. It would be correct to say that

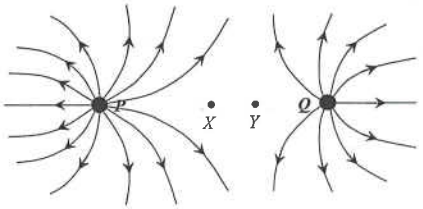
(1) the electric field at X is weaker than that at Z.

(2) a negative charge placed at Z would experience an electric force to the left along the tangent of the field line at Z.

(3) the force exerted on a charge at Y would be greater than if the charge were placed at X.

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

50.



The above figure shows the electric field pattern around two point charges P and Q. X is the mid-point between P and Q. Y is a neutral point. Which of the following deductions is/are correct ?

(1) Both charges P and Q are positive.

(2) The magnitude of charge P is greater than that of Q.

(3) The electrostatic force acting on Q by P is greater than that on P by Q.

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

51. A charged particle is accelerated across the gap between two parallel plates connected to a constant voltage supply. Neglect the effect of gravity, the kinetic energy gained by the particle in crossing the gap depends on

(1) the mass of the charged particle

(2) the separation between the two parallel plates

(3) the voltage across the two parallel plates

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

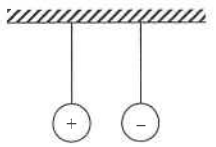
Part D : HKDSE examination questions

52. **< HKDSE Sample Paper IA - 24 >**

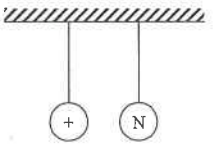
Two conducting spheres are hanging freely in air by insulating threads. In which of the following will the two spheres attract each other ?

Note : 'N' denotes that the sphere is uncharged.

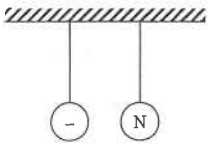
(1)



(2)



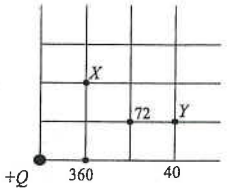
(3)



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

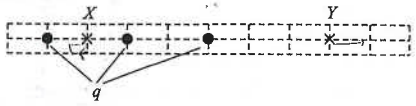
53. **< HKDSE Sample Paper IA - 32 >**

The figure shows the location of an isolated charge of size $+Q$. The magnitude of the electric field strength is marked at certain points. What is the magnitude of the electric field strength at X and Y ?



	electric field strength at X	electric field strength at Y
A.	72	30
B.	72	36
C.	90	30
D.	90	36

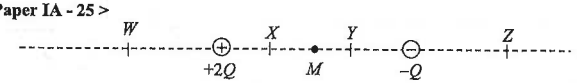
54. **< HKDSE Practice Paper IA - 24 >**



Three identical point charges q (represented by dots) are situated in the space as shown. Which of the following descriptions about the direction and magnitude of the electric field E at X and at Y is correct ?

	Direction	Magnitude
A.	Same	$E_X > E_Y$
B.	Same	$E_X < E_Y$
C.	Opposite	$E_X > E_Y$
D.	Opposite	$E_X < E_Y$

55. **< HKDSE 2012 Paper IA - 25 >**



Two point charges $+2Q$ and $-Q$ are situated at fixed positions as shown. M is the mid-point between the charges. W, X, Y and Z are points marked on the line joining these two charges. At which point could the resultant electric field due to the two charges be zero ?

A. W
B. X
C. Y
D. Z

56. **< HKDSE 2012 Paper IA - 24 >**

P, Q, R, S are charged objects. When two of them are brought close to each other, P and Q repel, R and S also repel while Q and R attract each other. Which of the following descriptions about their charges is/are correct ?

(1) P and R are negatively charged.
(2) Q and S are positively charged.
(3) P is positively charged and S is negatively charged.

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

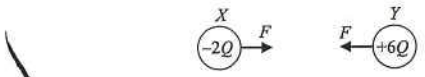
57. **< HKDSE 2013 Paper IA - 25 >**

Lightning flash may occur when the strength of the electric field (assumed uniform) between a thundercloud and the ground reaches 3×10^6 N C^{-1}. A lightning flash on average discharges about 20 C of charge. If a thundercloud is at a height of 500 m above the ground, estimate the order of magnitude of the energy released in a lightning flash.

A. 10^6 J
B. 10^8 J
C. 10^{10} J
D. 10^{12} J

58. **< HKDSE 2013 Paper IA - 24 >**

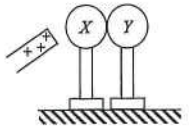
X and Y are two small identical metal spheres carrying charges $-2Q$ and $+6Q$ respectively. When X and Y are separated by a certain distance, the magnitude of the electrostatic force between them is F.



The spheres are brought to touch each other and then placed back to their original positions. The electrostatic force between them becomes

A. $\frac{1}{4}F$, attractive
B. $\frac{1}{4}F$, repulsive
C. $\frac{1}{3}F$, attractive
D. $\frac{1}{3}F$, repulsive

59. **< HKDSE 2014 Paper IA - 20 >**



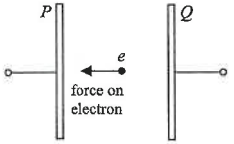
Two insulated uncharged metal spheres X and Y are placed in contact. A positively-charged rod is brought near X as shown. X is then touched by a finger momentarily and the two spheres are then separated by removing Y. The charged rod is removed afterwards. Which of the following describes the charges on X and Y ?

	sphere X	sphere Y
A.	uncharged	uncharged
B.	uncharged	positive
C.	negative	uncharged
D.	negative	negative

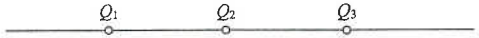
60. **< HKDSE 2014 Paper IA - 22 >**

Two parallel metal plates P and Q are maintained at a certain p.d. by a battery (not shown in the figure). An electron placed between the plates would experience an electrostatic force of 8.0×10^{-18} N towards P. Which of the following descriptions about the electric field E between the plates is correct ?

A. $E = 0.02$ N C^{-1} from Q to P
B. $E = 0.02$ N C^{-1} from P to Q
C. $E = 50$ N C^{-1} from Q to P
D. $E = 50$ N C^{-1} from P to Q



61. **< HKDSE 2014 Paper IA - 21 >**



Three point charges Q_1, Q_2 and Q_3 are fixed on a straight line with Q_2 at the mid-point of Q_1 and Q_3. The resultant electrostatic force on each charge is zero. Which of the following can be the sign and the magnitude (in the same arbitrary units) of Q_1, Q_2 and Q_3 ?

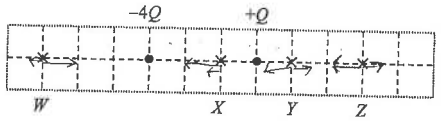
	Q_1	Q_2	Q_3
A.	+2	+1	+2
B.	+2	−1	+2
C.	−4	+1	+4
D.	−4	+1	−4

62. **< HKDSE 2015 Paper IA - 21 >**

Three conducting balls are suspended by insulating threads. Any two of them are found to attract each other if brought close to each other. Which conclusion below is correct ?

A. Only one ball is uncharged while the other two carry like charges.
B. Only one ball is uncharged while the other two carry unlike charges.
C. Only one ball is charged.
D. All three balls are charged.

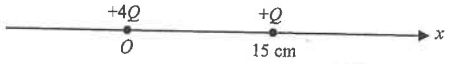
63. **< HKDSE 2015 Paper IA - 22 >**



Two point charges $-4Q$ and $+Q$ are fixed as shown. At which point indicated in the figure is the resultant electric field due to these two charges zero ?

A. *W*
B. *X*
C. *Y*
D. *Z*

64. **< HKDSE 2016 Paper IA - 24 >**

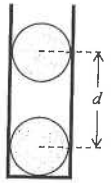


Point charges $+4Q$ and $+Q$ are fixed on the x-axis with $+4Q$ at the origin O and $+Q$ at $x = 15$ cm as shown. The respective electric fields due to the two charges are equal at

A. $x = 10$ cm.
B. $x = 12$ cm.
C. $x = 20$ cm.
D. $x = 30$ cm.

65. **< HKDSE 2017 Paper IA - 22 >**

In the figure, two charged conducting spheres of the same mass m are put in a vertical plastic cylinder. The inner wall of the cylinder is smooth. The spheres are separated by a distance *d* and remain in equilibrium.



Which of the following statements **MUST BE** correct ?

(1) Both spheres carry positive charges.
(2) The amount of charges on the two spheres are the same.
(3) The separation d depends on m.

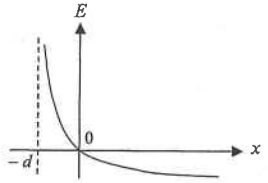
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

66. **< HKDSE 2017 Paper IA - 23 >**

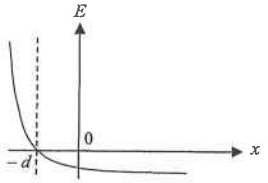
A point charge $+Q$ is fixed at a distance *d* away from the origin *O* as shown.

Which of the following graphs best represents the variation of the electric field strength *E* along the *x*-axis ? (Take the electric field pointing to the right as positive.)

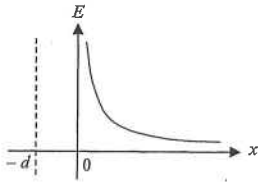
A.



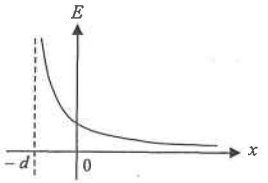
B.



C.



D.



67. <HKDSE 2019 Paper IA-23>

M.C. Answers

1. D	11. D	21. C	31. C	41. A	51. B	61. D
2. C	12. D	22. D	32. C	42. A	52. D	62. B
3. C	13. B	23. D	33. D	43. D	53. B	63. D
4. A	14. C	24. B	34. C	44. C	54. D	64. D
5. B	15. C	25. A	35. B	45. A	55. D	65. B
6. A	16. B	26. D	36. B	46. B	56. B	66. D
7. B	17. A	27. D	37. B	47. D	57. C	67. A
8. D	18. A	28. C	38. B	48. C	58. D	
9. D	19. B	29. D	39. C	49. D	59. C	
10. B	20. D	30. D	40. C	50. B	60. D	

M.C. Solution

1. D

× (1) Repulsion exists between similar charges.

✓ (2) Attraction exists between opposite charges.

✓ (3) Attraction exists between a charged body and an uncharged body.

2. C

Bringing (–) charge towards Z ⇒ (+) charge induced on Z and (–) charge induced on X

Y is earthed ⇒ (–) charge on X moves to the earth but (+) charge on Z is still attracted by the charged rod

Finally, X and Y are neutral and Z is positively charged

3. C

Bringing (+) charged rod towards right ball

⇒ (–) charge induced on right side of the right ball

⇒ (+) charge induced on the left side of the left ball

4. A

Bringing (+) charge towards right ball

⇒ (–) charge induced on right side of the right ball

⇒ (+) charge induced on the left side of the right ball (as plastic sheet does not allow flow of charge)

⇒ (–) charge induced on right side of the left ball

⇒ (+) charge induced on left side of the left ball

5. B

Sphere X is not in contact with other bodies,

thus the total charges on sphere X must remain unchanged.

6. A

Electron carries negative charge, thus the electric force on an electron is opposite to the direction of the E-field.

Therefore, the electron experiences an upwards electric force inside the parallel plates.

7. B

Bringing (+) charged sphere X towards Y and then earthing, negative charges are induced on Y.

When X is removed, Y carries negative charges that would distribute uniformly on the whole surface.

8. D

The (+) charge sphere is earthed

⇒ the sphere becomes neutral

⇒ electrons flow from the earth to the sphere (as proton does not move)

9. D

When the negatively charged object C is brought near X,

(+) charges are induced on the left side of X and (–) charges are induced on the right side of Y.

When X is touched momentarily with a finger,

the (–) charges on Y flows to the earth but the (+) charges on X is still attracted by C.

When X and Y are separated, X carries (+) charges and Y is neutral.

10. B

Bringing (+) charged rod ⇒ (–) charge induced at left side of the sphere and (+) charge at right side of the sphere

Earthed with a finger ⇒ electrons flow from the Earth to the sphere to neutralize the (+) charge at the right side

11. D

When the sphere is brought near, attraction exists between the charged dome and the neutral sphere.

After touching, the sphere shares some like charges and thus repulsion exists to move it away.

12. D

✓ (1) Photocopier makes use of electrostatic charge to give photocopying

✓ (2) Precipitator makes use of electrostatic charge to attract the coal dust

✓ (3) A Van de Graaff generator gives large amount of electrostatic charge for demonstrating

13. B

✓ (1) Bringing positively charged rod near the sphere
⇒ (–) charge induced at the left side and (+) charge induced at the right side of the sphere
⇒ upon earthing, electrons flow to the sphere to neutralize the (+) charge at the right side
∴ the sphere finally carries negative charges.

✓ (2) Touching the sphere with the rod would make the sphere share some positive charges.

× (3) Positive charges of the rod are discharged upon earthing by the finger
but the human body always remains neutral without carrying net charge
∴ no charge is shared with the sphere by the finger, thus the sphere remains neutral

14. C

Due to attraction between unlike charges, negative charge is induced at the left side of X.

Due to repulsion between like charges, positive charge is induced at the right side of Y.

15. C

× (1) If the sphere carries (+) charges, repulsion occurs between the sphere and the rod

✓ (2) Attraction exists between unlike charges.

✓ (3) Attraction exists between a charged body and a neutral body.

16. B

(3) : (–) charges are induced on the sphere at the side near the rod while (+) charges appear at the far side

(2) : electrons flow from the earth to the sphere to neutralize the (+) charges

(1) : the finger must be removed first before the removing of the charged rod

(4) : after the rod is removed, the sphere becomes (–) charged.

17. A

When the charged rod is brought near X, (+) charges are induced on X and (–) charges are induced on Z.

After Y is earthed, only the induced (+) charge remains on the left side of X due to the attraction by the (–) charged rod.

Z would become neutral as the negative induced charges would flow to earth during earthing.

18. A

① presence of positively charged rod ⇒ (–) charge is induced on X while (+) charge is induced on Y

② X is earthed momentarily ⇒ (–) charge on X left but (+) charge on Y is neutralized by electrons from the earth

③ The charged rod is removed ⇒ the (–) charge on X is then shared between X and Y

④ Two spheres are separated ⇒ both X and Y becomes negatively charged

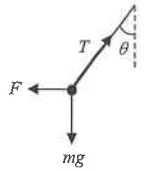
19. B

× (1) Since the two spheres repel, the two spheres may both carry (+) charge or both carry (–) charge

× (2) Since the force acting on B by A and the force acting on A by B are action and reaction pair, they must be equal in magnitude but opposite in direction

✓ (3) Assume the electric force F acting on the sphere is approximately horizontal
Resolving the tension into two components

$T\cos\theta = mg$ and $T\sin\theta = F$ ∴ $\tan\theta = \frac{F}{mg}$



For sphere A, θ is smaller, $\tan\theta$ is smaller, thus m is greater.

20. D

✓ (1) Water is neutral, as the ruler attracts the water, the ruler must carry an electric charge.

✓ (2) The attractive forces between the running water and the ruler are action and reaction pair, so they are of equal magnitude.

✓ (3) The side of the running water near the ruler would induce the opposite type of electric charge while the side of the running water further away from the water would induce the same type of charge

21. C

At the centre, the forces due to the two (+) charges on the point charge C balance each other

while the forces due to the two (–) charges on the point charge C also balance each other, thus resultant force on C is zero.

22. D

Suppose the three spheres are A, B and C such that A is uncharged, B is positively charged and C is negatively charged.

① A and B attract each other since a positively charged body would attract a neutral body.

② A and C attract each other since a negatively charged body would attract a neutral body.

③ B and C attract each other since a positively charged body attracts a negatively charged body.

Thus, one sphere is uncharged and the other two carry unlike charges.

23. D

✓ (1) Two balls carrying unlike charges would attract each other.

✓ (2) A ball carrying positive charge would attract an uncharged ball by induced charge.

✓ (3) A ball carrying negative charge would attract an uncharged ball by induced charge.

24. B

✓ (1) Attraction force exists between two opposite charges.

× (2) No electric force exists between two uncharged objects.

✓ (3) A ruler carrying charge would attract uncharged paper scraps by induced charges on the paper scraps.

25. A

✓ (1) Since repulsion exists between P and Q, they must carry like charges.

× (2) Since attraction exists between R and S,
they may carry unlike charges OR one of them carries charge but the other is neutral.

× (3) Even P and Q carry different amount of charges, same force would exist between them.

26. D

As the E-field is in downward direction

The negatively charged particle experiences an upward electric force $(F = -qE)$

Thus, the particle accelerates in upward direction.

27. D

Downward weight = Upward electric force from electric field

$mg = qE = q\dfrac{V}{d}$

$\therefore\ m(10) = (1.6\times10^{-19})\times\dfrac{(2\times10^{3})}{(0.05)}$ $\therefore\ m = 6.4\times10^{-16}$ kg

28. C

✓ (1) By $U = qV$ $\therefore\ U = (1\text{ C})\times(1\text{ V}) = 1\text{ J}$

✓ (2) By $F = qE$ $\therefore\ F = (1\text{ C})\times(1\text{ V m}^{-1}) = 1\text{ N}$

× (3) Charge on 1 mole of electrons $= 6.02\times10^{23}\times1.6\times10^{-19}\text{ C} = 96320\text{ C} \neq 1\text{ C}$

29. D

✓ (1) After touching (+)-plate, it carries (+) charge. After touching (–)-plate, it carries (–) charge.

✓ (2) $d\uparrow \Rightarrow E\downarrow$ (by $E=\dfrac{V}{d}$) $\Rightarrow F\downarrow$ (by $F=qE$) $\Rightarrow a\downarrow$ (by $a=\dfrac{F}{m}$) $\Rightarrow$ frequency of oscillation $\downarrow$

✓ (3) Carrying (+)-charge to (–)-plate $\Rightarrow$ current flows in clockwise direction
Carrying (–)-charge to (+)-plate $\Rightarrow$ current flows in clockwise direction

30. D

Let the length of the square be r.

Distance between X and Z is $\sqrt{2}\,r$.

$F_W = \dfrac{(1)(1)}{4\pi\varepsilon_o(r)^2} = \dfrac{1}{4\pi\varepsilon_o r^2}$ (to the left) $\quad F_Y = \dfrac{(1)(1)}{4\pi\varepsilon_o(r)^2} = \dfrac{1}{4\pi\varepsilon_o r^2}$ (upward)

Since the net force on X is to the left, thus the upward force by Y is balanced by the downward component of force by Z

$F_Z\cos45° = F_Y$ $\therefore\ \dfrac{Q(1)}{4\pi\varepsilon_o\left(\sqrt{2}r\right)^2}\cdot\left(\dfrac{1}{\sqrt{2}}\right) = \dfrac{1}{4\pi\varepsilon_o r^2}$ $\therefore\ Q = 2\sqrt{2}$ C

Since the electric between X and Z is attractive $\therefore$ Z is (+)

31. C

The sphere carries (–)-charge $\Rightarrow$ moves towards and touches (+) plate first

It then shares some (+) charge and moves towards and touches the opposite (–) plate

$\therefore$ The sphere oscillates.

32. C

✓ (1) Since the strip is deflected towards the positive plates, the strip should carry negative charges.

✓ (2) By $E=\dfrac{V}{d}$ $\therefore\ d\downarrow \Rightarrow E\uparrow$ $\therefore$ deflection $\uparrow$

× (3) E-field is constant within 2 charged plates, thus there is no change in deflection of the strip.

33. D

$E = \dfrac{V}{d} = \dfrac{(4.5\times10^{3})}{(1.5\times10^{-3})} = 3\times10^{6}$ V

$F = qE = (1.60\times10^{-19})(3\times10^{6}) = 4.8\times10^{-13}$ N

$a = \dfrac{F}{m} = \dfrac{4.8\times10^{-13}}{9.11\times10^{-31}} = 5.3\times10^{17}\text{ m s}^{-2}$

34. C

Case 1 : Two charges are of the same sign, i.e. $(+5Q)$ and $(+1Q)$.

After sharing, they become $(+3Q)$ and $(+3Q)$.

$F_1 = \dfrac{(5Q)(1Q)}{4\pi\varepsilon_o r^2}$ $\quad F_2 = \dfrac{(3Q)(3Q)}{4\pi\varepsilon_o r^2}$

$\therefore\ F_1 : F_2 = 5 : 9$

Case 2 : Two charges are of the opposite sign, i.e. $(+5Q)$ and $(-1Q)$.

After sharing, they become $(+2Q)$ and $(+2Q)$.

$F_1 = \dfrac{(5Q)(1Q)}{4\pi\varepsilon_o r^2}$ $\quad F_2 = \dfrac{(2Q)(2Q)}{4\pi\varepsilon_o r^2}$

$\therefore\ F_1 : F_2 = 5 : 4$

35. B

Since the electrostatic force is attractive, X and Y carry unlike charges.

Let the charge carried by X be $+Q$ and the charge carried by Y be $-Q$.

For sharing of charges, $Q_1 + Q_2 = Q + Q$ where Q is the final charge at each of the two spheres.

After Z touches X, X carries $+\frac{1}{2}Q$ and Z carries $+\frac{1}{2}Q$.

After Z touches Y, Y carries $-\frac{1}{4}Q$ and Z carries $-\frac{1}{4}Q$.

Electrostatic force : $F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_o r^2}$ $\therefore\ F \propto Q_1 Q_2$ $\therefore\ F' = \frac{1}{2}\times\frac{1}{4}F = \frac{1}{8}F$

36. B

× (1) After the plates are disconnected from the supply, charges on the plates and thus E-field are unchanged
Thus the electric force is increased by $F = qE$ as q is increased. The oil drop then has a net force.

× (2) Increasing the p.d. between the plates would increase the electric field by $E = V/d$.
Thus the electric force is increased by $F = qE$ as E is increased. The oil drop then has a net force.

✓ (3) Moving the plates further apart decreases the E-field by $E = V/d$.
The electric force may then remain unchanged by $F = qE$ as q is increased but E is decreased.
The unchanged electric force then balances the weight of the oil drop by $qE = mg$.

37. B

Since point X has the same distance as the point of 72, the electric field at X is 72.

Distance of point Y from $+Q$ is $\sqrt{(3)^2+(1)^2} = \sqrt{10}$.

Electric field : $E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$

Thus, electric field obeys inverse-square law, i.e. $E \propto \dfrac{1}{r^2}$ $\therefore$ $\dfrac{E_2}{E_1} = \left(\dfrac{r_1}{r_2}\right)^2$

Electric field at $Y = 360 \times \dfrac{1}{(\sqrt{10})^2} = 36$.

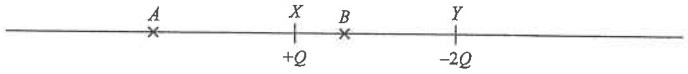
38. B

× (1) They may both carry positive charges OR both carry negative charges.

× (2) The charge on X may be greater OR smaller than that on Y.
However, the forces between them are equal and opposite since they are action and reaction pair.

✓ (3) Since the angle θ is smaller, thus the weight of X is greater.

39. C



By $E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$,

E-field depends on the charge Q and distance r.

At point A, charge at X is smaller and distance is closer, charge at Y is greater but distance is longer, thus $E_X = E_Y$.

At point B, charge at X is smaller and distance is closer, charge at Y is greater but distance is longer, thus $E_X = E_Y$.

There are 2 points with magnitude : $E_X = E_Y$.

At point A, E_X is towards the left but E_Y is towards the right, thus the resultant field is zero.

At point B, E_X is towards the right and E_X is also towards the right, thus the resultant field is not zero.

There is 1 point with zero resultant field.

40. C

$E = \dfrac{V}{d} = \dfrac{(3000)}{(0.015)} = 2\times10^5\ \text{V m}^{-1}$

By $mg = qE$ $\therefore$ $(9.6\times10^{-15})(10) = q(2\times10^5)$ $\therefore$ $q = 4.8\times10^{-19}$ C

To balance the downward weight, the electric force F must be upwards.

Since the direction of E-field is vertically downwards, the charge is negative.

Thus, the charge carried by the oil drop is -4.8×10^{-19} C.

41. A

The positively-charged rod is brought near X	X : negative	Y : positive
X is earthed momentarily	X : negative	Y : uncharged
The charged rod is removed	X : negative	Y : negative

42. A

✓ (1) The mid-point Y is a neutral point, where the electric field due to the two charges balance each other.

✓ (2) Since the left sphere is closer to X, the negative charge is attracted by the left sphere
and thus the net electric force is towards the left

× (3) Since the right sphere is closer to Z, the positive charge is repelled by the right sphere
and thus the net electric force is towards the left

43. D

✓ (1) Some induced negative charges appear at the left side
and induced positive charges appear at the right side of the sphere.
Attraction force then exists between the positive charged rod and the negative induced charges.

✓ (2) After touching the charged rod, the sphere shares some positive charges from the metal rod
and is repelled away.

✓ (3) The sphere is finally positively charged by sharing.

44. C

✓ (1) Electric force exists between the induced charges in the papers and the electric charges in the ruler.

✓ (2) Since both positive and negative charges are induced in the paper, the paper remains neutral.

× (3) Since the two forces are action and reaction pair, they should be equal in magnitude.

45. A

The electric field due to the upper charge is towards the left.

The electric field due to the lower left charge is upwards.

The resultant of these two fields points towards direction 1.

The electric field due to the lower right charge is along direction 4,

however, this field is weaker than the resultant of the other two, thus the overall resultant field is along direction 1.

46. B

× (1) By $F = \frac{(Q)(Q)}{4\pi\varepsilon_0 r^2} \propto \frac{1}{r^2}$ $\therefore$ $r\uparrow \Rightarrow F\downarrow$

✓ (2) At point D, E-field due to the positive charge points to the right
and that due to negative charge points to the left.
As the negative charge is nearer to D, the resultant E-field points to the left.
As the $-Q$ is moved nearer to D, E-field due to $-Q$ further increases, and the resultant E increases.

× (3) At the mid point B, the direction of E-field due to both $+Q$ and $-Q$ are towards the right,
thus, it cannot be a neutral point.
[Note that there is no neutral point in this situation.]

47. D

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2} = \frac{(1.5\times10^{-17})(3.2\times10^{-19})}{4\pi(8.85\times10^{-12})(1.0\times10^{-13})^2} = 4.32\,\text{N}$$

48. C

$$E = \frac{Q}{4\pi\varepsilon_0 r^2} = \frac{Ze}{4\pi\varepsilon_0 r^2}$$

49. D

✓ (1) The density of electric field lines represents the strength of the electric field.
As the field lines at Z is closer, E-field strength at Z is greater.

✓ (2) Negative charged particle experiences an electric force opposite to the E-field
Thus, electric force on the negative charge points towards the left along the tangent of field line.

✓ (3) Electric field lines at Y is closer than that at X, thus the electric field strength at Y is greater,
therefore, a charge would experience a greater force at Y, by $F = qE$.

50. B

✓ (1) Since the field lines are directed away from the charges, the two charges are positive.

✓ (2) As the neutral point is further away from P, the charge P is greater than that of Q.

× (3) The two forces are action and reaction pair, they must be equal in magnitude.

51. B

× (1) Gain of KE does not depend on the mass.
The larger the mass, the smaller the speed, but the same KE.

× (2) For constant voltage between the two parallel plates,
the gain of KE depends on voltage only but not affects by the separation between the two plates.

✓ (3) Gain of KE = loss of electric PE = qV.
The greater the voltage V, the greater the gain of KE.

52. D

✓ (1) Two balls carrying unlike charges would attract each other.

✓ (2) A ball carrying positive charge would attract an uncharged ball by induced charge.

✓ (3) A ball carrying negative charge would attract an uncharged ball by induced charge.

53. B

Since point X has the same distance as the point of 72, the electric field at X is 72.

Distance of point Y from $+Q$ is $\sqrt{(3)^2+(1)^2} = \sqrt{10}$.

Since electric field obeys inverse-square law,

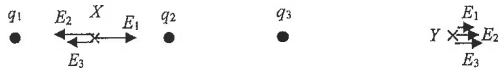
$\therefore$ $E \propto \frac{1}{r^2}$

$\therefore$ $\frac{E_2}{E_1} = \left(\frac{r_1}{r_2}\right)^2$

Electric field at Y = $360 \times \frac{1}{(\sqrt{10})^2} = 36$.

54. D

Assume that the three charges are all positive (it is arbitrary, same result obtained if assumed negative).
The direction of E-field by a positive charge is away from the charge.

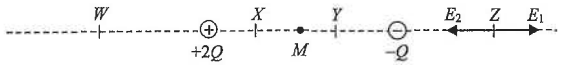


At point X, the electric field due to q_1 and q_2 are in opposite directions and cancel each other,
the net E-field is E_3 and directed towards the left.

At point Y, the electric field due to the three charges are all towards the right,
thus the resultant E-field is rightwards, therefore, the direction of E-field at X and Y are in opposite directions.

The magnitude of E_3 are the same at X and Y, but there are E_1 and E_2 in addition,
thus the resultant E-field at Y is greater than that at X.

55. D



The electric field due to a (+) point charge is away from the charge.

The electric field due to a (−) point charge is towards the charge.

At Z, the field due to $+2Q$ is E_1 while that due to $-Q$ is E_2,

and they are in opposite direction, thus they may be balanced to give zero resultant field, that is, the neutral point.

[Note that W cannot be a neutral point as the E-field due to the greater charge $2Q$ must be greater since it is closer.]

56. B

Since P and Q repel, they must carry like charges.

Since R and S repel, they must carry like charges.

Since Q and R attract, they must carry unlike charges.

× (1) P and R must carry unlike charges, thus they cannot be both negatively charged.

× (2) Q and S must carry unlike charges, thus they cannot be both positively charged.

✓ (3) P and S must carry unlike charges, thus P may be positively charged and S may be negatively charged.

57. C

Potential difference between the thundercloud and the ground (assume that they form 2 parallel plates)

$V = E d = (3 \times 10^6) \times (500) = 1.5 \times 10^9$ V

Energy released :

$U = Q V = (20)(1.5 \times 10^9) = 3 \times 10^{10}$ J

Order of magnitude of the energy released $= 10^{10}$ J

58. D

Before touching, electrostatic force between the two spheres :

$$F = \frac{(2Q)(6Q)}{4\pi\varepsilon_o r^2} = 12\frac{Q^2}{4\pi\varepsilon_o r^2}$$

After touching, the net charges are : $(6Q) + (-2Q) = +4Q$

This charge is then shared between X and Y, each has $+2Q$.

After touching, electrostatic force between the two spheres :

$$F' = \frac{(2Q)(2Q)}{4\pi\varepsilon_o r^2} = 4\frac{Q^2}{4\pi\varepsilon_o r^2} = \frac{1}{3}F$$

The electrostatic forces between X and Y are repulsive as they carry like charges.

59. C

When the positively charged rod is brought near X, X is negatively charged and Y is positively charged.

When X is touched by the finger, X is still negatively charged but Y becomes uncharged.

When Y is removed, X remains negatively charged and Y remains uncharged.

When the charged rod is removed, X remains negatively charged and Y remains uncharged.

60. D

Since the electron carries negative charge, the direction of electric field should be from P to Q.

By $F = q E$

$\therefore (8.0 \times 10^{-18}) = (1.6 \times 10^{-19}) E$

$\therefore E = 50$ N C^{-1}

61. D

Electrostatic force : $F = \frac{Q_1 Q_2}{4\pi\varepsilon_o r^2}$

× A. To give zero resultant force on Q_3, the sign of Q_1 and Q_2 should be opposite.

× B. Distance of Q_1 from Q_3 is two times that of Q_2 from Q_3,
thus the magnitude of the charge of Q_1 should be 4 times as that of Q_2, not 2 times.

× C. To give zero resultant force on Q_1, the sign of Q_2 and Q_3 should be opposite.

✓ D. Forces between Q_1 and Q_3 is repulsive with magnitude : $F_1 = \frac{(4)(4)}{4\pi\varepsilon_o (2r)^2}$

Forces between Q_2 and Q_3 is attractive with magnitude : $F_2 = \frac{(1)(4)}{4\pi\varepsilon_o (r)^2}$

As $F_1 = F_2$, the resultant force on Q_3 is zero.

62. B

Due to the induced charges, a neutral ball and a positive charged ball would attract each other.

Due to induced charges, a neutral ball and a negative charged ball would attract each other.

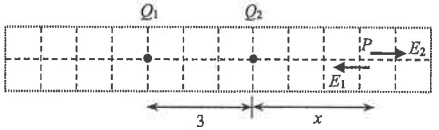
The deduction should be :

① one ball carries positive charge

② one ball carries negative charges

③ one ball is uncharged (neutral).

63. D



Assume the neutral point P is at a distance of x at the right side of Q_2.

Since Q_1 is negative, the electric field E_1 due to Q_1 is towards the left.

Since Q_2 is positive, the electric field E_2 due to Q_2 is towards the right.

To be the neutral point, the two electric fields must be equal and opposite.

$\therefore E_1 = E_2 \quad \therefore \frac{4Q}{4\pi\varepsilon_o \cdot (3+x)^2} = \frac{Q}{4\pi\varepsilon_o \cdot (x)^2} \quad \therefore x = 3$

$\therefore$ The neutral point is at Z.

64. D

There are two points that the magnitude of the electric field due to the two charges are equal.

For the same electric field (both magnitude and direction), the point must be at the right side of $+Q$.

Let the point from O be x.

$\therefore E_1 = E_2 \quad \therefore \frac{4Q}{4\pi\varepsilon_o \cdot x^2} = \frac{Q}{4\pi\varepsilon_o \cdot (x-15)^2} \quad \therefore x = 30$ cm

65. B

× (1) Since the electrostatic forces between the two spheres are repulsive, both spheres carry like charges. However, both spheres may carry positive charges OR both may carry negative charges.

× (2) The amount of charges on the two spheres may NOT be the same.

✓ (3) The electrostatic force F acting on the higher sphere is upwards that balance its downwards weight mg.

$\therefore\ mg = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 d^2}$

Thus, the separation d depends on m.

66. D

By $E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$

Thus, E must be positive and tends to zero as r tends to infinity, therefore, option A and B must be incorrect.

Since the charge Q is placed at $-d$, the electric field must exist starting from $-d$, thus option D is correct.

The following list of formulae may be found useful :

Coulomb's law	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
Electric field strength due to a point charge	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$
Electric field between parallel plates (numerically)	$E = \dfrac{V}{d}$

Use the following data wherever necessary :

Acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)
Charge of electron	$e = 1.6 \times 10^{-19}\ \text{C}$
Electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$

Part A : HKCE examination questions

1. < HKCE 1985 Paper I - 9 >

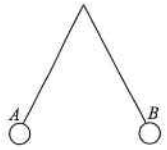
(a) A girl, after combing her hair on a dry day, holds the comb near small pieces of paper. What will be observed if the comb is made of

(i) plastic, and

(ii) aluminium ?

Explain briefly in each case. (4 marks)

(b) Two similar charged metal-coated balls, A and B, are suspended from two insulating threads as shown in the figure.

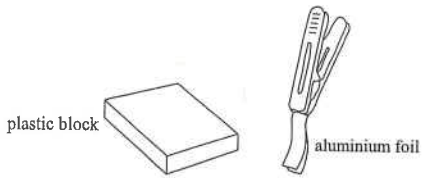


(i) Draw on the diagram all the forces acting on the two balls. (3 marks)

(ii) If the ball A is earthed by touching, what would happen to the two balls ? Explain briefly. (4 marks)

2. **< HKCE 1987 Paper I - 9 >**

The below figure shows two aluminium foils held by plastic clips and a negatively charged plastic block. They are used for charging the aluminium foils by induction.



(a) Describe the steps taken in charging the aluminium foils. (3 marks)

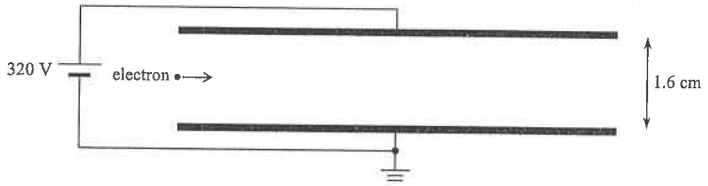
(b) What type of charge is induced on the aluminium foils ? (1 mark)

(c) Explain briefly why the clips should be an insulator but not a conductor in this experiment. (2 marks)

Part B : HKAL examination questions

3. **< HKAL 2006 Paper I - 4 >**

In a vacuum, a beam of electrons with an initial horizontal velocity enters midway into a region of electric field between two horizontal square metal plates as shown in the figure below. A p.d. of 320 V is applied across the plates and the separation between them is 1.6 cm.

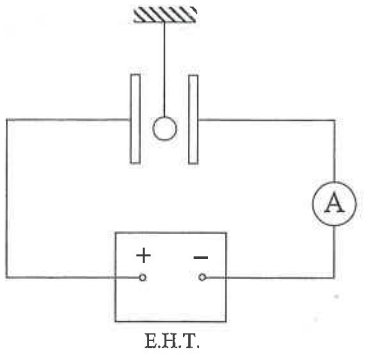


(a) Find the electric field strength between the plates. (2 marks)

(b) The electron beam reaches one of the plates. Sketch in the above figure the path of the electron beam between the two plates. (Neglect the weight of the electron.) (2 marks)

4. **< HKAL 2011 Paper I - 7 >**

A small conducting ball is placed midway between two parallel metal plates connected to an E.H.T. via an ammeter as shown in the Figure.



(a) State how to make the ball acquire positive charges. (1 mark)

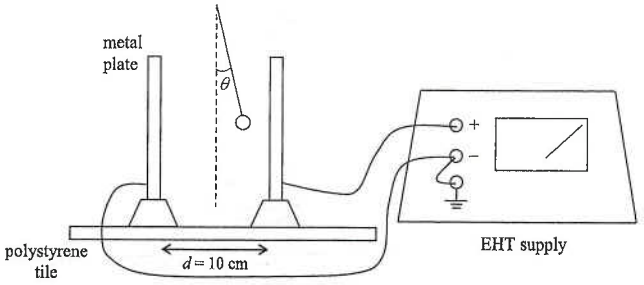
(b) After the ball acquires positive charges, explain why it can shuttle continuously between the two plates. (2 marks)

(c) State and explain how the average current registered by the ammeter is affected if the separation of the two metal plates is decreased. (3 marks)

Part C : HKDSE examination questions

5. < HKDSE Practice Paper IB - 8 >

As shown in the Figure, two large vertical parallel metal plates, each in a slotted base, are placed on a polystyrene tile. The plates are connected to the positive and negative terminals of an EHT supply respectively. The plates' separation $d = 10$ cm.



A small charged ball is suspended by a nylon thread and is placed midway between the plates. The thread makes an angle θ to the vertical when the ball is in equilibrium.

(a) By using a free-body diagram, draw and name all the forces acting on the charged ball. Also indicate in your diagram the direction of the electric field between the plates. (3 marks)

(b) (i) Express $\tan\theta$ in terms of the electric force F acting on the ball and the weight W of the ball. (1 mark)

(ii) Given that the mass of the ball is 0.07 g. When the voltage between the plates is 4000 V, $\theta = 2°$. Estimate the magnitude of the charge carried by the ball. Assume that the electric field between the plates is uniform. (3 marks)

(c) Using the setup in the Figure, suggest a simple method to test whether the electric field between the plates is uniform. (3 marks)

6. < HKDSE 2013 Paper IB - 11 >

Figure (a) shows two identical small metal spheres X and Y suspended by insulating threads of the same length. Each sphere has a mass of 1.0×10^{-5} kg and each carries a positive charge of 3.1 nC (1 nC = 10^{-9} C). The separation d of the spheres is 10 cm. The size of spheres is negligible compared with their separation, therefore they can be treated as point charges.

Take $\frac{1}{4\pi\varepsilon_o} = 9 \times 10^9$ N m^2 C^{-2}.

Figure (a)

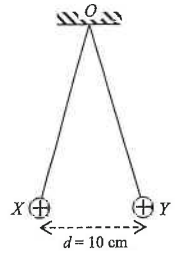


Diagram NOT drawn to scale

(a) Find the angle between the threads. (3 marks)

(b) Point P is vertically below the fixed point O and it is 10 cm from each sphere as shown in Figure (b).

(i) Indicate the direction of the resultant electric field at P due to these two charged spheres. (1 mark)

Figure (b)

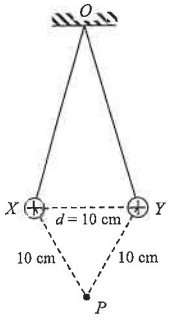


Diagram NOT drawn to scale

(ii) A neutral metal sphere of finite size is now placed at P. State whether the separation d would increase, decrease or remain unchanged due to the presence of this sphere. (1 mark)

Separation d .....

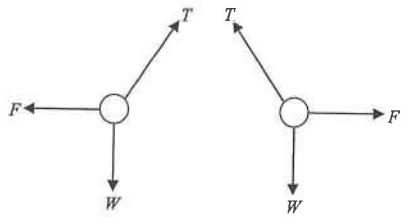
HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) (i) Small pieces of paper are attracted by the comb and are found on the comb [1]
Since the plastic comb is an insulator, charges produced by rubbing remain on the comb [1]

(ii) Small pieces of paper are not affected and stay at the original places [1]
Since aluminium is a conductor, charges produced by rubbing will be conducted away. [1]

(b) (i)



< weight of the two balls marked correctly > [1]
< tension of the strings marked correctly > [1]
< electrostatic force between the two balls marked correctly > [1]

(ii) Both ball A and ball B fall, [1]
touch and then separate again [1]
Since charges in ball A is conducted away, it is attracted by ball B [1]
When it makes contact with ball B, it shares similar charges and repels away. [1]

2. (a) Place the aluminium foils near the plastic block. [1]
Touch the foil momentarily with a finger. [1]
Then remove the block. [1]

(b) positive charge [1]

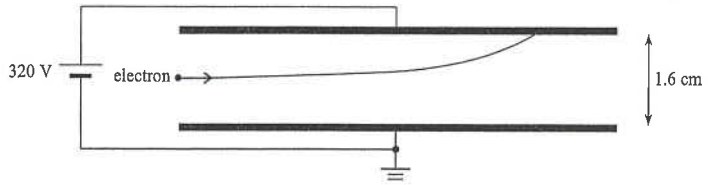
(c) If the clip is a conductor, the induced charge would escape [1]
through the clip and the hand. [1]

3. (a) $E = \dfrac{V}{d}$

$= \dfrac{320}{0.016}$ [1]

$= 2 \times 10^4 \text{ V m}^{-1}$ (**OR** $20\,000 \text{ N C}^{-1}$) [1]

3. (b)



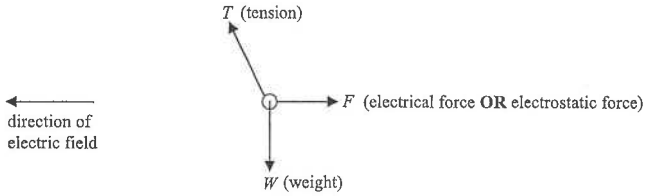
< The path bends upwards > [1]
< The path is a curve > [1]

4. (a) Let the ball touch the left plate to share some positive charges. [1]

(b) The ball is repelled by left plate and attracted to the right plate. [1]
The ball then acquires negative charges when touching the right plate and the process repeats. [1]
Hence, the ball shuttles between the two plates.

(c) As the plate separation d decreases, the electric field between the plate increases ($E = V / d$). [1]
Therefore, electric force on the ball increases. [1]
The acceleration of the ball increases and thus the average current increases. [1]

5. (a)



< Weight and tension correctly drawn with correct name > [1]
< The electrical force correctly drawn with correct name > [1]
< Direction of electric field correct > [1]

(b) (i) $\tan\theta = \dfrac{F}{W}$ [1]

(ii) For parallel plates : $E = \dfrac{V}{d} = \dfrac{4000}{0.1} = 40000 \text{ V m}^{-1}$ [1]

$\tan\theta = \dfrac{F}{W} = \dfrac{qE}{mg}$

$\tan 2° = \dfrac{q \cdot (40000)}{(0.07 \times 10^{-3})(9.81)}$ [1]

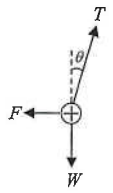
$\therefore\ q = 6.00 \times 10^{-10} \text{ C}$ [1]

5. (c) Fix the plates separation and the output voltage of the EHT Supply. [1]

Move the polystyrene tile so that the ball is placed in different positions in the space between the plates. [1]

The angle θ should remain the same if the electric field between the plates is uniform. [1]

6. (a)



$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2} = (9\times10^9)\times\frac{(3.1\times10^{-9})^2}{(0.10)^2} = 8.65\times10^{-6}$ N [1]

$W = mg = (1.0\times10^{-5})(9.81) = 9.81\times10^{-5}$ N

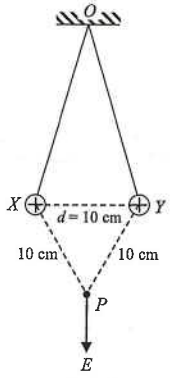
Resolve the tension T: $T\sin\theta = F$ and $T\cos\theta = W$

$\therefore \tan\theta = \frac{F}{W} = \frac{8.65\times10^{-6}}{9.81\times10^{-5}}$ [1]

$\therefore \theta = 5.04°$

Angle between the threads $= 2\theta = 10.1°$ [1]

(b) (i)



< direction of E : vertically downwards > [1]

(ii) Separation d : decreases [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

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

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

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

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

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

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe as 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)