EM4 : Magnetic Field

The following list of formulae may be found useful :

Force on a moving charge in a magnetic field	$F = BQv\sin\theta$
Force on a current-carrying conductor in a magnetic field	$F = BIl\sin\theta$
Magnetic field due to a long straight wire	$B = \dfrac{\mu_0 I}{2\pi r}$
Magnetic field inside a long solenoid	$B = \dfrac{\mu_0 NI}{L}$

Use the following data wherever necessary :

Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\ m^{-1}}$
Charge of electron	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
Electron rest mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
Acceleration due to gravity	$g = 9.81\ \mathrm{m\ s^{-2}}$ (close to the Earth)

Part A : HKCE examination questions

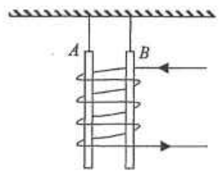
1. < HKCE 1981 Paper II - 33 >

Which of the following will be deflected by a magnetic field ?

(1) Electromagnetic waves
(2) A beam of electrons
(3) A beam of protons

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

2. < HKCE 1981 Paper II - 32 >

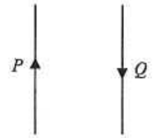


The figure shows two iron rods A and B suspended by two light strings so that they are close together. Their lower ends are inside a solenoid. When a current flows through the solenoid, what will happen to A and B ?

	A	B
A.	moves to the left	moves to the right
B.	moves to the right	moves to the left
C.	moves to the right	moves to the right
D.	moves to the left	moves to the left

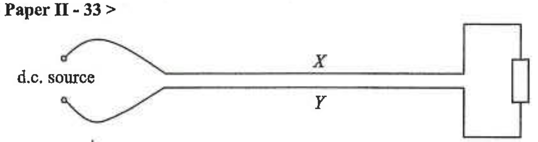
3. **< HKCE 1984 Paper II - 28 >**

P and *Q* are two long parallel straight wires carrying currents as shown.
What is the direction of the force on *Q* ?



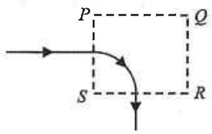
A. to the left
B. to the right
C. out of this page
D. into this page

4. **< HKCE 1986 Paper II - 33 >**



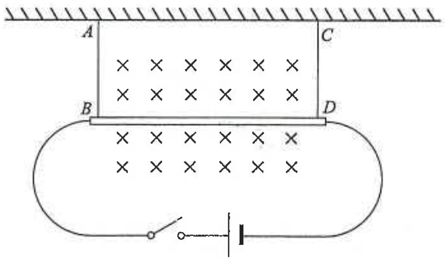
Two close, long, parallel, straight metal wires *X* and *Y* form part of the circuit shown above. *X* and *Y*
A. attract each other.
B. repel each other.
C. first repel and then attract each other.
D. first attract and then repel each other.

5. **< HKCE 1988 Paper II - 32 >**



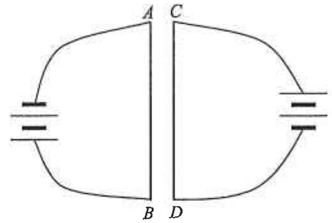
The figure shows the path of an electron in a magnetic field *PQRS*. What should be the direction of the magnetic field ?
A. *PQ*
B. *QR*
C. into the paper
D. out of the paper

6. **< HKCE 1990 Paper II - 31 >**



In the figure shown above, a copper rod is suspended horizontally by two insulating threads *AB* and *CD*, and the direction of the magnetic field is into the paper. What happens when the switch of the circuit is closed ?
A. The copper rod will move into the paper.
B. The copper rod will move out of the paper.
C. The tension in each thread is decreased.
D. The tension in each thread is increased.

7. **< HKCE 1991 Paper II - 32 >**



Two long parallel wires *AB* and *CD* are connected to batteries as shown in the figure. The force acting on *CD* is
A. in a direction to the left.
B. in a direction to the right.
C. in a direction out of the paper.
D. in a direction into the paper.

8. **< HKCE 1992 Paper II - 33 >**

A small compass is placed near a long current carrying wire. In which of the following diagrams is/are the compass needle pointing in the correct direction ?

(1) Compass above the wire

(2) Compass below the wire

(3) Current flowing out of paper

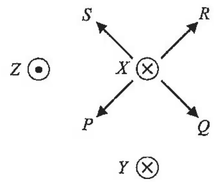
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

9. **< HKCE 1993 Paper II - 35 >**

A motor lifts a load of 40 N vertically upwards at a steady speed of 0.2 m s^{-1}. The voltage applied to the motor is 12 V and the current drawn is 2 A. Find the efficiency of the motor.
A. 12%
B. 16.7%
C. 33.3%
D. 66.7%

10. **< HKCE 1994 Paper II - 33 >**

The diagram shows three long straight wires *X*, *Y* and *Z*. *X* and *Y* carry currents flowing into the paper while *Z* carries a current flowing out of the paper. The currents are all equal in magnitude. What is the direction of the resultant force acting on *X* ?



A. *P*
B. *Q*
C. *R*
D. *S*

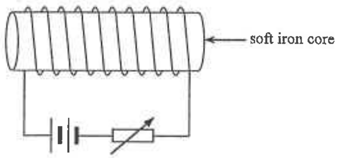
11. **< HKCE 1995 Paper II - 31 >**

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

(1) An electric bell
(2) A telephone receiver
(3) A moving-coil loudspeaker

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

12. **< HKCE 1995 Paper II - 34 >**

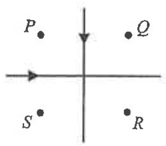


The above diagram shows a simple electromagnet. Which of the following can increase the strength of the electromagnet ?

(1) Decreasing the resistance of the variable resistor.
(2) Replacing the soft iron core with one made of steel.
(3) Replacing the battery with a 50 Hz a.c. source.

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

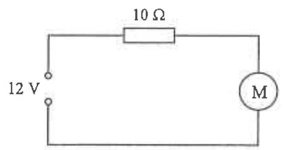
13. **< HKCE 1996 Paper II - 35 >**



Two long insulated wires carrying equal currents are placed perpendicular to each other on a table as shown in the figure. The points P, Q, R and S are all of equal distances from the wires. At which point(s) is the resulting magnetic field pointing out of the paper ?

A. P only
B. Q only
C. R only
D. S only

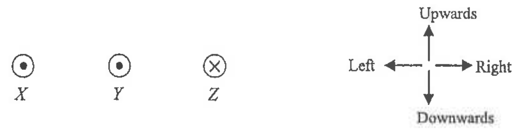
14. **< HKCE 1998 Paper II - 31 >**



A motor is connected in series with a 10 Ω resistor and a 12 V power supply as shown. If the current in the circuit is 0.5 A, find the power consumed by the motor.

A. 3.5 W
B. 5 W
C. 6 W
D. 7 W

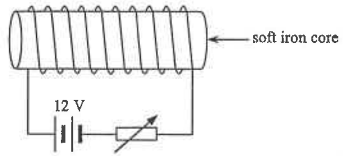
15. **< HKCE 1998 Paper II - 32 >**



The above diagram shows the cross-section of three parallel straight wires X, Y and Z. X and Y carry currents flowing out of the paper and Z carries a current flowing into the paper. What is the direction of the resultant force acting on Y ?

A. towards the left
B. towards the right
C. upwards
D. downwards

16. **< HKCE 2001 Paper II - 36 >**

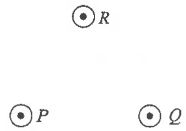


The figure shows an electromagnet which is used to pick up iron objects. Which of the following can increase the strength of the electromagnet ?

(1) increasing the number of turns of the coil
(2) reducing the resistance of the variable resistor
(3) replacing the battery with a 12 V a.c. power supply

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

17. **< HKCE 2002 Paper II - 32 >**



P, Q and R are three parallel straight wires carrying equal currents flowing out of the paper. R is equidistant from P and Q. What is the direction of the resultant force acting on R by P and Q ?

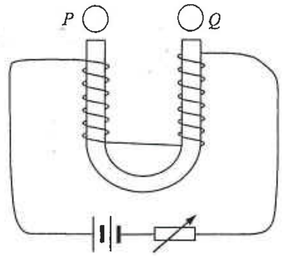
A. 

B. 

C.

D.

18. < HKCE 2003 Paper II - 37 >



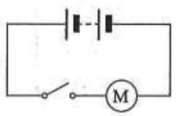
Two compasses P and Q are placed near the poles of an electromagnet as shown above. In which of the following diagrams are the north poles of the compass needles pointing in the correct directions ?

	P	Q
A.	↓	↑
B.	↓	↓
C.	↑	↑
D.	↑	↓

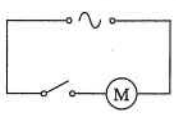
19. < HKCE 2004 Paper II - 30 >

David wants to design a battery-powered toy car. Which of the following circuits should he use ?

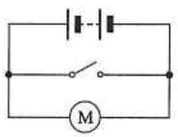
A.



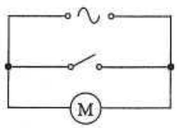
B.



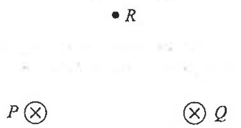
C.



D.



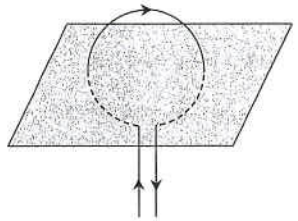
20. < HKCE 2004 Paper II - 34 >



Two parallel straight wires P and Q carry equal currents flowing into the paper. A compass is placed at a point R where $PR = QR$. In which of the following diagrams is the north pole of the compass needle pointing in the correct direction ? The effect of the Earth's magnetic field may be ignored.

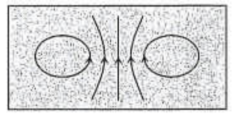
A. ←　　B. →　　C. ↑　　D. ↓

21. < HKCE 2005 Paper II - 22 >

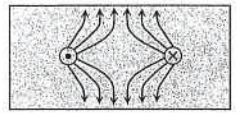


Which of the following diagrams shows the magnetic field pattern formed around a flat circular current-carrying coil, in the plane as shown above ?

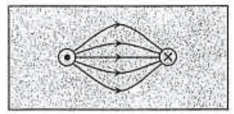
A.



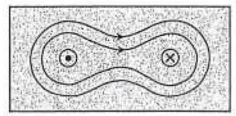
B.



C.



D.

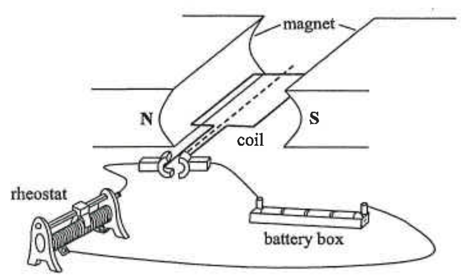


22. < HKCE 2005 Paper II - 23 >

The figure shows a simple motor. Which of the following changes can increase the turning effect of the coil ?

(1) using a stronger magnet
(2) reducing the resistance of the rheostat
(3) using a coil with a smaller number of turns

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

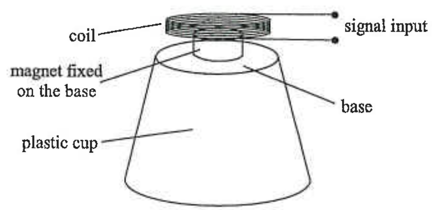


23. < HKCE 2006 Paper II - 36 >

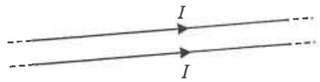
The diagram shows a home-made device which can produce sound. In the device, a magnet is fixed to the base of a plastic cup. When a signal passes through the coil, the base vibrates to produce a sound. Which of the following methods can make the sound louder ?

(1) using a stronger magnet
(2) inserting a copper rod into the coil
(3) increasing the number of turns in the coil

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



24. **< HKCE 2008 Paper II - 19 >**

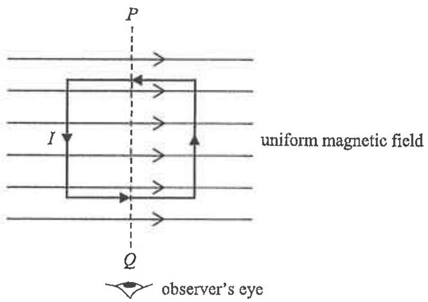


Two parallel wires carry equal currents flowing in the same direction. Which of the following statements are correct ?

(1) The magnetic forces acting on the two wires form an action-reaction pair.
(2) The two wires attract each other.
(3) If the directions of the current in the two wires are both reversed, the wires will repel each other.

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

25. **< HKCE 2008 Paper II - 42 >**



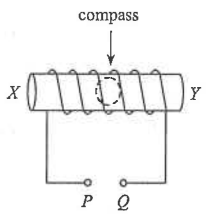
The above figure shows a rectangular loop of wire carrying a steady current *I*. The rectangular loop can rotate freely about *PQ*. If a uniform magnetic field to the right is applied, which of the following is correct ?

	Resultant magnetic force acting on the rectangular loop	Rotation of the rectangular loop about *PQ*
A.	non-zero	clockwise
B.	non-zero	anti-clockwise
C.	zero	clockwise
D.	zero	anti-clockwise

26. **< HKCE 2008 Paper II - 43 >**

A compass is placed inside an air-cored solenoid *XY* which is connected to a d.c. supply with terminals *P*, *Q* as shown. If the end *X* of the solenoid behaves as magnetic north pole, what are the polarity of the terminal *P* and the direction in which the north pole of the compass needle points ?

(The tip of the arrow represents the north pole of the compass needle.)

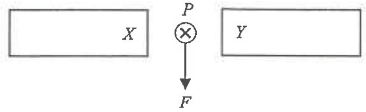


	Polarity of *P*	Compass
A.	+	
B.	+	
C.	–	
D.	–	

27. **< HKCE 2009 Paper II - 22 >**

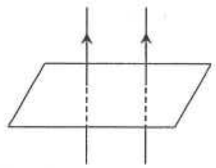
A current carrying wire, perpendicular to the plane of the paper, is located at *P*. *P* is in the midway between two identical bar magnets with unknown polarities *X* and *Y* as shown in the figure. The current in the wire is flowing into the paper. The magnetic force *F* acting on the wire is downward. Which of the following statements are correct ?

(1) *X* is a north pole and *Y* is a south pole.
(2) *F* is reversed if the current direction is reversed.
(3) *F* is larger if stronger bar magnets are used.



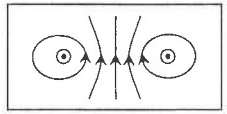
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

28. **< HKCE 2009 Paper II - 21 >**

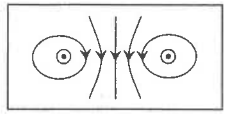


The figure above shows two parallel straight wires carrying equal currents. Which of the following diagrams correctly shows the resultant magnetic field lines ?

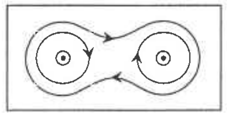
A.



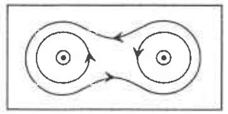
B.



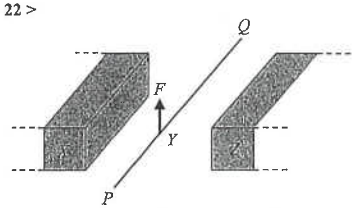
C.



D.



29. **< HKCE 2010 Paper II - 22 >**



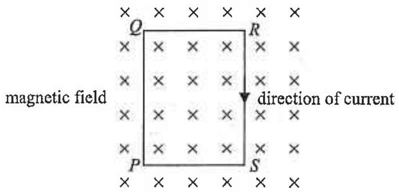
A current carrying wire *Y* is placed between two bar magnets as shown above. The wire experiences an upward force. Which of the following is/are the possible combination(s) of the direction of the current in *Y* and the magnetic poles of *X* and *Z* ?

	pole *X*	current direction in *Y*	pole *Z*
(1)	N	from *P* to *Q*	S
(2)	S	from *P* to *Q*	N
(3)	N	from *Q* to *P*	S

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

30. **< HKCE 2011 Paper II - 21 >**

Rectangular coil *PQRS* is carrying a current flowing in clockwise direction. It is placed inside a uniform magnetic field pointing into the paper as shown in the figure below.



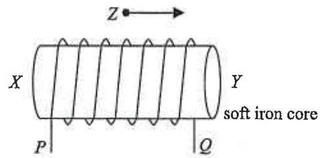
Which of the following statements are correct ?

(1) A magnetic force pointing to the right acts on *RS*.
(2) No magnetic force acts on *QR*.
(3) The resultant magnetic force acting on the coil is zero.

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

31. **< HKCE 2011 Paper II - 41 >**

In the figure below, the arrow shows the direction of the magnetic field at *Z* due to a current-carrying solenoid.



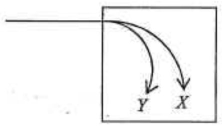
The direction of current through the solenoid and the magnetic north pole of the solenoids are

	Direction of current	Magnetic north pole
A.	from *P* to *Q*	*X*
B.	from *P* to *Q*	*Y*
C.	from *Q* to *P*	*X*
D.	from *Q* to *P*	*Y*

Part B : HKAL examination questions

32. **< HKAL 1980 Paper I - 44 >**

Two charged particles *X* and *Y* enter a region where a magnetic field acts perpendicular to the plane of their motion. The resulting paths shown in the diagram may be affected by the mass, charge and initial speed of the particles. Which of the following quantities alone could cause the observed difference in the paths ?



(1) *X* has a smaller mass than *Y*.
(2) *X* has a smaller charge than *Y*.
(3) *X* has a greater speed than *Y*.

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

33. **< HKAL 1980 Paper I - 46 >**

Which of the following affects the magnetic field strength on the axis of a long solenoid ?

(1) The diameter of the solenoid
(2) The number of turns per unit length of the solenoid
(3) The current flowing through the solenoid

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

34. **< HKAL 1981 Paper I - 44 >**

A free electron travelling horizontally with speed v enters a uniform vertical magnetic field B. Which of the following statements is/are correct ?

(1) The path of the electron is circular on a vertical plane.
(2) The speed of the electron remains constant.
(3) The radius of curvature of the path of the electron is inversely proportional to the magnetic field B.

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

35. **< HKAL 1981 Paper I - 13 >**

A vertical wire of 0.4 m long carries a constant current of 5 A. It is placed in a magnetic field of strength 10^{-3} T, which dips at an angle of 30° to the horizontal. Determine the magnetic force acting on the wire.

A. 5.0×10^{-4} N
B. 8.7×10^{-4} N
C. 1.5×10^{-3} N
D. 1.7×10^{-3} N

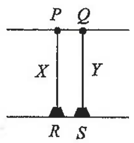
36. **< HKAL 1982 Paper I - 43 >**

A solenoid with a solid core has a diameter d and n turns per length. It carries a current I. The magnetic field B inside is

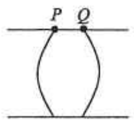
(1) independent of d.
(2) proportional to n.
(3) independent of the material of the core.

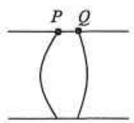
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

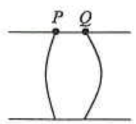
37. **< HKAL 1982 Paper I - 19 >**

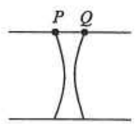


X and *Y* are identical flexible conducting wires, suspended from fixed points *P* and *Q*. The bottom parts of the wires *R* and *S* are also fixed. When a current 2 A is passed from *R* to *P* through *X*, and a current 1 A is passed from *Q* to *S* through *Y*, which of the following diagrams best represents the shapes of the two wires ?

A.


B.


C.


D.


38. < HKAL 1983 Paper I - 18 >

Two parallel wires attract each other with a force F when the same current passes through them. If the current is doubled and the distance between the wires is also doubled, the force of attraction will become

A. $\frac{1}{4}F$.

B. $\frac{1}{2}F$.

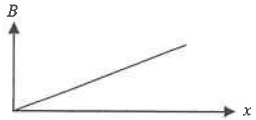
C. F.

D. $2F$.

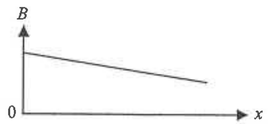
39. < HKAL 1985 Paper I - 25 >

Which of the following graphs best represents the variation of the strength of the magnetic field B along the axis of a long solenoid carrying a constant current, with the distance x from the centre of the solenoid along the axis to one of its end ?

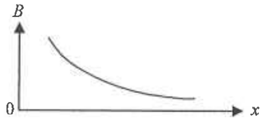
A.



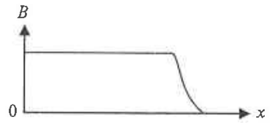
B.



C.



D.



40. < HKAL 1985 Paper I - 27 >

A small particle with mass 3.2×10^{-26} kg and charge -1.6×10^{-19} C enters a uniform magnetic field of flux density 0.08 T at a speed of 10^5 m s^{-1}, as shown in the above figure. It will

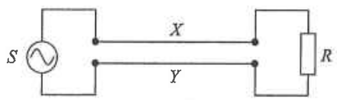
A. pass undeviated through the magnetic field.

B. be deflected upward in a circular arc of radius 0.25 m.

C. be deflected upward in a circular arc of radius 0.50 m.

D. be deflected downward in a circular arc of radius 0.25 m.

41. < HKAL 1987 Paper I - 34 >



As shown in the figure, S is an a.c. supply of frequency 50 Hz connected to a resistor R via two long, parallel, straight metal wires X and Y. The magnetic forces acting on X and Y

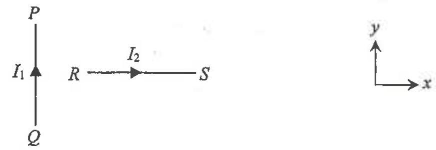
A. are always equal to zero.

B. always attract.

C. always repel.

D. sometimes attract and sometimes repel; the frequency of variation is 50 Hz.

42. < HKAL 1988 Paper I - 38 >



In the above figure, PQ is a fixed long wire carrying a current I_1. RS is another wire perpendicular to PQ. When a current I_2 flows through RS in the direction shown, the magnetic force on the wire RS

A. acts in the $+y$ direction.

B. acts in the $-y$ direction.

C. acts in the $+x$ direction.

D. acts in the $-x$ direction.

43. < HKAL 1988 Paper I - 37 >

A particle of mass m and charge q moves in a circular orbit inside a magnetic field B. The time taken for a single orbit is

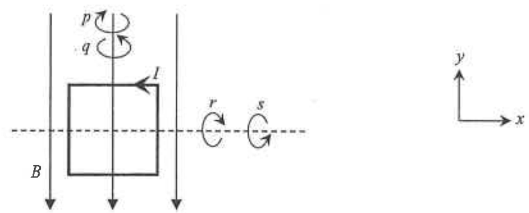
A. $\dfrac{Bq}{2\pi m}$.

B. $\dfrac{2\pi m}{Bq}$.

C. $\dfrac{2mq}{B\pi}$.

D. $\dfrac{Bm}{2\pi q}$.

44. < HKAL 1989 Paper I - 32 >



A square loop carrying a current I is placed in a uniform magnetic field B in the xy plane as shown in the figure. If the loop is free to rotate, the magnetic forces acting on the loop will cause it to

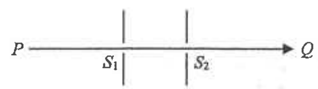
A. rotate about the y-axis as indicated by p.

B. rotate about the y-axis as indicated by q.

C. rotate about the x-axis as indicated by r.

D. rotate about the x-axis as indicated by s.

45. < HKAL 1990 Paper I - 45 >



A beam of particles, of different masses, charges, polarities and speeds, travels long PQ and passes through a narrow slit S_1. In the region between S_1 and S_2, an electric field E and a magnetic field B are directed perpendicularly to each other. The E-field acts vertically upward and the B-field acts out of the plane of the paper. The particles that are undeflected and emerge from slit S_2 must have the same

A. polarity.

B. speed.

C. charge.

D. mass.

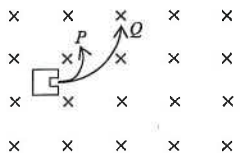
46. **< HKAL 1992 Paper I - 36 >**

Two parallel straight wires separated by a distance r carry currents in the same direction. Which of the following statements is/are correct ?

(1) The two wires attract each other.
(2) The force acting on each wire is inversely proportional to r^2.
(3) The current in two wires produce a magnetic field with maximum flux density midway between them.

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

47. **< HKAL 1993 Paper I - 49 >**

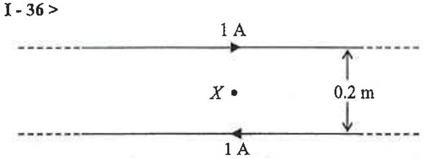


Two particles P and Q of the same charge and mass but moving with different speeds v_P and v_Q respectively enter a region of uniform magnetic field B directed into the plane of the paper. The subsequent circular paths are as shown in the figure. Which of the following statements is/are correct ?

(1) Both particles P and Q are positively charged.
(2) Speed of particle P is smaller than that of Q.
(3) The period of circular motion of P is shorter than that of Q.

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

48. **< HKAL 1993 Paper I - 36 >**



Two long parallel straight wires, each carries a current of 1 A in opposite directions, are separated by a distance of 0.2 m as shown in the figure. The magnetic field at a point X mid-way between the two wires is

A. 2×10^{-6} T out of paper.
B. 2×10^{-6} T into paper.
C. 4×10^{-6} T out of paper.
D. 4×10^{-6} T into paper.

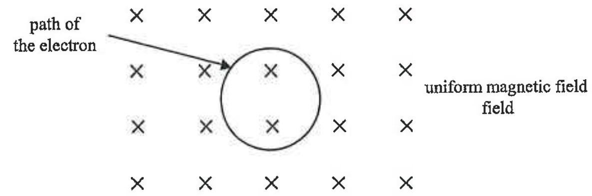
49. **< HKAL 1994 Paper IIA - 31 >**

For two long, straight parallel conducting wires carrying the same current, the magnitude of the magnetic force acting on a section of the wires would be affected by

(1) the distance between the wires
(2) the length of that section of the wires
(3) the directions of current flowing in the wires

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

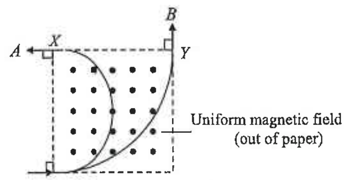
50. **< HKAL 1994 Paper IIA - 32 >**



An electron moves in a circular path of diameter 0.01 m in a plane with a uniform magnetic field of 0.02 T directed perpendicular into the plane as shown in the figure. Find the speed and the direction of circular motion of the electron.

A. 1.76×10^7 m s^{-1} in anticlockwise direction
B. 1.76×10^7 m s^{-1} in clockwise direction
C. 3.52×10^7 m s^{-1} in anticlockwise direction
D. 3.52×10^7 m s^{-1} in clockwise direction

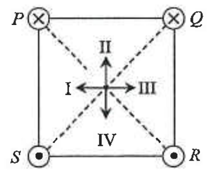
51. **< HKAL 1995 Paper IIA - 34 >**



Particles A and B moving at the same speed enter a square region of uniform magnetic field as shown. Particle A leaves at X while particle B leaves at Y. If the charge to mass ratio of particle A is k, then the charge to mass ratio of particle B would be

A. $\frac{k}{2}$
B. $\frac{k}{4}$
C. $2k$
D. $4k$

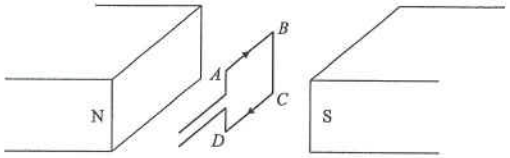
52. **< HKAL 1996 Paper IIA - 26 >**



Four infinitely long straight parallel wires P, Q, R, S carrying equal currents are situated at the four corners of a square as shown. The currents in P, Q are into paper and those in R, S are out of paper. What is the direction of the resultant magnetic field at the centre of the square ?

A. I
B. II
C. III
D. IV

53. **< HKAL 1998 Paper IIA - 30 >**

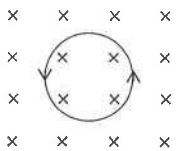


The above diagram shows a rectangular current-carrying coil $ABCD$ in a uniform magnetic field between two pole pieces. The magnetic field is perpendicular to the plane of the coil. Which of the following statements is/are correct ?

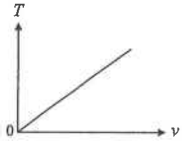
(1) There is a magnetic force acting on the side BC of the coil.
(2) The magnetic forces acting on the coil tend to reduce its area.
(3) There is a resultant force acting on the coil.

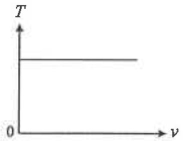
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

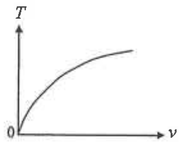
54. **< HKAL 1998 Paper IIA - 26 >**

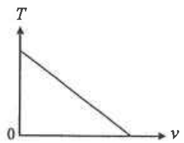


The above figure shows a charged particle moving in a circular orbit with a constant speed v on a plane perpendicular to a uniform magnetic field directed into the paper. Which of the following graphs represents the relation between the time T for the particle to complete a circle and its speed v ?

A.


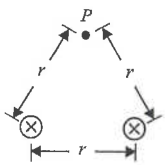
B.


C.


D.


55. **< HKAL 1998 Paper IIA - 27 >**

Two long, straight parallel wires, each carrying a current I into paper, are separated by a distance r as shown in the figure. What is the magnitude and direction of the resultant magnetic field at the point P at the same distance r from both wires ?



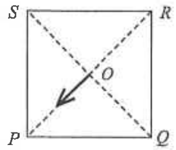
A. $\dfrac{\mu_0 I}{2\pi r}$ to the left

B. $\dfrac{\sqrt{3}\mu_0 I}{2\pi r}$ to the left

C. $\dfrac{\mu_0 I}{\pi r}$ to the left

D. $\dfrac{\sqrt{3}\mu_0 I}{2\pi r}$ to the right

56. **< HKAL 2000 Paper IIA - 25 >**



Four parallel long straight wires carrying currents of equal magnitude pass vertically through the four corners of a square $PQRS$. In one wire, the current is directed into paper. In the other three wires, the currents are directed out of paper. Which of the following can produce a resultant magnetic field with the indicated direction at the centre O ?

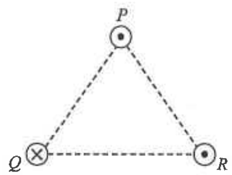
	Current into paper	Current out of paper
A.	P	Q, R, S
B.	Q	P, R, S
C.	R	P, Q, S
D.	S	P, Q, R

57. **< HKAL 2000 Paper IIA - 27 >**

A beam of charged particles passes through a region of crossed uniform electric and magnetic fields without deflection. Which of the following quantities must be the same for the particles making up this beam ?

A. charge to mass ratio
B. velocity
C. mass
D. sign of charge

58. **< HKAL 2002 Paper IIA - 29 >**

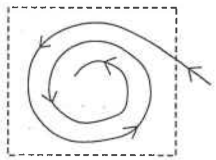


Three long straight parallel wires P, Q and R carrying currents of the same magnitude are situated at the vertices of an equilateral triangle as shown. The currents in wires P and R are directed out of the paper. Which of the following indicates the direction of the resultant magnetic force acting on the wire P ?

A. → B. ↓ C. ↑ D. ↗

59. **< HKAL 2003 Paper IIA - 31 >**

A charged particle enters a region of uniform magnetic field whose direction is normal to the initial velocity of the particle. The subsequent path of the particle is as shown in the figure. Which of the following may be the reason to account for this shape of the path ?

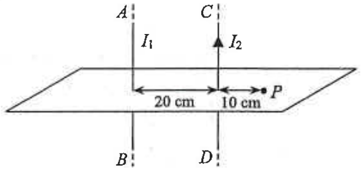


Magnetic field normal to paper

(1) The magnitude of the magnetic field decreases gradually.
(2) The particle loses its charge gradually.
(3) The particle loses its kinetic energy gradually.

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

60. **< HKAL 2003 Paper IIA - 30 >**



In the above figure, AB and CD are two parallel long wires with separation 20 cm carrying currents I_1 and I_2 respectively. The resultant magnetic field at the point P 10 cm from wire CD is zero. If I_2 is equal to 0.6 A, determine the magnitude and direction of the current I_1 in the wire AB.

A. 0.2 A flows in the same direction as I_2

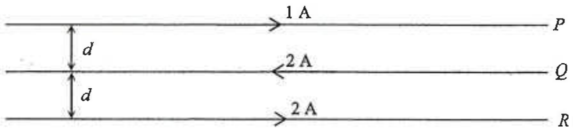
B. 0.2 A flows in the opposite direction as I_2

C. 1.8 A flows in the same direction as I_2

D. 1.8 A flows in the opposite direction as I_2

61. **< HKAL 2004 Paper IIA - 29 >**

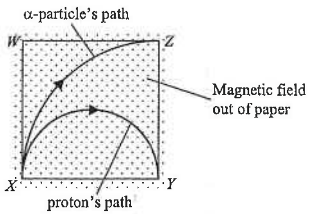
Three long, parallel, straight current-carrying wires P, Q and R are placed in the same plane as shown in the figure.



For two long, parallel, straight wires placed a distance d apart and each carrying a current of 1 A, the magnetic force per unit length is F. What is the resultant magnetic force per unit length acting on the wire R shown in the above figure ?

A. 0
B. F
C. $2F$
D. $3F$

62. **< HKAL 2005 Paper IIA - 18 >**



A proton and an α-particle move in a uniform magnetic field as shown in the above figure. The magnetic field is directed out of the plane of the paper. Within a square region $WXYZ$, the proton takes time t_1 to complete a half circle from X to Y while the α-particle follows a quarter circle from X to Z in time t_2. What is the ratio $t_1 : t_2$?

(Given : mass ratio of an α-particle to a proton is 4 : 1; charge ratio of an α-particle to a proton is 2 : 1.)

A. 1 : 2

B. 1 : 1

C. 2 : 1

D. It cannot be determined as the ratio of their speeds is not given.

63. **< HKAL 2006 Paper IIA - 17 >**

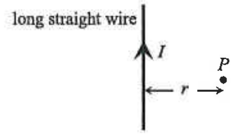
In a vacuum, an electron moves in a circle with speed v in a uniform magnetic field of flux density 1 mT. If an α-particle with speed $\frac{1}{4}v$ is to follow the same path, what magnetic flux density in the opposite direction is required ?

(Given : mass ratio of an α-particle to an electron is 7200 : 1; charge ratio of an α-particle to an electron is 2 : 1.)

A. 0.9 T
B. 1.8 T
C. 3.6 T
D. 7.2 T

64. **< HKAL 2006 Paper IIA - 18 >**

A long straight wire carrying a current I is placed at a distance r from the point P. Both the wire and point P are in the plane of the paper. When the current I increases by 0.5 A, the magnetic flux density B at point P increases by 5.0×10^{-6} T. Find r.



A. 1 cm
B. 2 cm
C. 4 cm
D. 8 cm

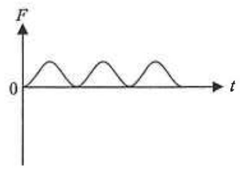
65. **< HKAL 2006 Paper IIA - 16 >**

Two long, parallel wires PQ and RS are connected to a sinusoidal a.c. supply as shown in the figure. Which of the following graph best shows the time variation of the magnetic force F between the two wires ?

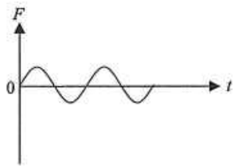
A.

B.

C.



D.



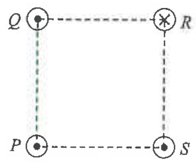
66. **< HKAL 2007 Paper IIA - 20 >**

A beam of charged particles passes through crossed uniform electric and magnetic fields without deflection. If the electric field is removed, the particles will split up into several beams. This splitting may be due to the particles having different

(1) charges
(2) masses
(3) incident velocities

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

67. < HKAL 2007 Paper IIA - 18 >



Four long straight wires perpendicular to the plane of the paper are placed at the four corners of a square *PQRS* as shown in the figure. Same current *I* flows in the wires at *P*, *Q* and *S* directed into the paper while the current flowing along the wire at *R* is in the opposite direction. If the wire at *P* experiences no net magnetic force, find the current flowing in the wire at *R*.

A. $I/\sqrt{2}$

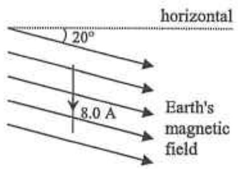
B. $I/2$

C. $\sqrt{2}I$

D. $2I$

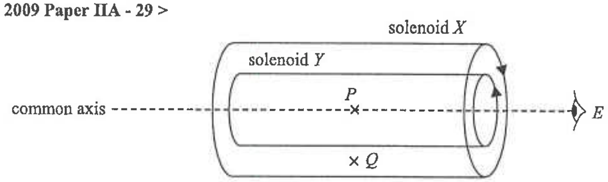
68. < HKAL 2007 Paper IIA - 19 >

A segment of a vertical wire 0.50 m long carrying a current of 8.0 A is placed in the Earth's magnetic field. The direction of the field dips at an angle of 20° to the horizontal. If the magnetic force acting on the wire is 7.5×10^{-5} N, find the magnitude of the Earth's magnetic field.



A. 6.4×10^{-6} T
B. 1.8×10^{-5} T
C. 2.0×10^{-5} T
D. 5.5×10^{-5} T

69. < HKAL 2009 Paper IIA - 29 >



The data about two coaxial long solenoids *X* and *Y* are tabulated below :

	solenoid *X*	solenoid *Y*
radius	5 cm	3 cm
turn density	1200 m^{-1}	2400 m^{-1}
current	1.0 A (clockwise as viewed from *E*)	0.5 A (anticlockwise as viewed from *E*)

Point *P* is on the common axis while point *Q* is 4 cm from the axis. Both *P* and *Q* are well inside the two solenoids. Which of the following statements is/are correct ?

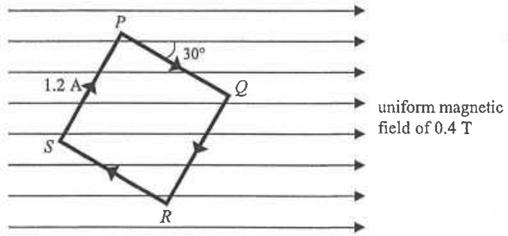
(1) The resultant magnetic field at *P* is zero.

(2) The magnetic field at *Q* is 1.5 mT.

(3) The magnetic field at *Q* points to the left.

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

70. < HKAL 2009 Paper IIA - 30 >



A square coil *PQRS*, each side has a length of 0.15 m is placed in a uniform magnetic field of 0.4 T as shown in the figure. The number of turns in the coil is 20 and the current in the coil is 1.2 A. The magnetic field is parallel to the plane of the coil. The side *PQ* makes an angle of 30° with the magnetic field. Find the magnetic force acting on the side *PQ* of the coil.

A. 0.7 N out of the paper

B. 0.7 N into the paper

C. 1.3 N out of the paper

D. 1.3 N into the paper

71. < HKAL 2010 Paper IIA - 28 >

When moving charged particles enter a uniform magnetic field at right angle, they are deflected. This deflection can be increased by

(1) increasing the mass *m* of the particles

(2) increasing the charge *Q* of the particles

(3) increasing the magnitude *B* of the magnetic field

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

72. < HKAL 2011 Paper IIA - 25 >

Two long straight parallel wires, *X* and *Y*, carry equal currents in the same direction as shown in the figure. Wire *X* experiences a magnetic force of 0.1 N. If now a uniform magnetic field pointing into the paper is applied to both wires (NOT shown in figure), the resultant magnetic force acting on wire *X* becomes 0.5 N. Find the resultant magnetic force acting on the wire *Y*. (Neglect the Earth's magnetic field.)

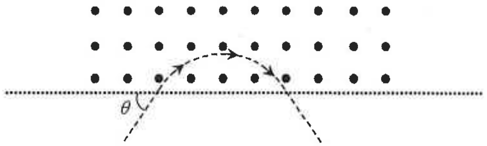
A. 0.3 N m^{-1} to the left

B. 0.3 N m^{-1} to the right

C. 0.6 N m^{-1} to the left

D. 0.6 N m^{-1} to the right

73. < HKAL 2011 Paper IIA - 30 >

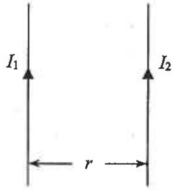


A positively charged particle enters a uniform magnetic field B with a speed v making an angle θ ($0° < \theta \le 90°$) with the boundary of the field. The magnetic field points out of the paper and the particle leaves the field at the same boundary as shown. The time of transit for the particle inside the magnetic field is

(1) proportional to the angle θ.
(2) dependent on the speed v.
(3) inversely proportional to the field strength B.

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

74. < HKAL 2012 Paper IIA - 23 >



Two long straight parallel wires carrying currents I_1 and I_2 (with $I_2 > I_1$) is shown in the figure. The separation between the two wires is r. If now another wire carrying a current I in the same direction is placed midway between the two wires, what would be the magnetic force per unit length experienced by this wire, in both magnitude and direction ?

A. $\dfrac{\mu_0 I (I_2 - I_1)}{\pi r}$ to the right

B. $\dfrac{\mu_0 I (I_2 - I_1)}{\pi r}$ to the left

C. $\dfrac{\mu_0 I (I_1 + I_2)}{\pi r}$ to the right

D. $\dfrac{\mu_0 I (I_1 + I_2)}{\pi r}$ to the left

75. < HKAL 2013 Paper IIA - 28 >

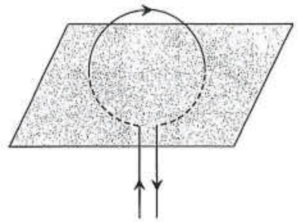
The magnitude of the magnetic field B inside a very long solenoid can be increased by

(1) increasing the current through the solenoid
(2) increasing the number of turns per unit length of the solenoid
(3) decreasing the cross-sectional area of the solenoid

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

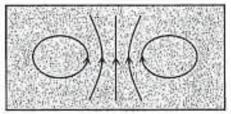
Part C : HKDSE examination questions

76. < HKDSE Sample Paper IA - 29 >

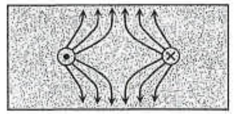


Which diagram shows the magnetic field pattern formed around a flat circular current-carrying coil, in the plane shown ?

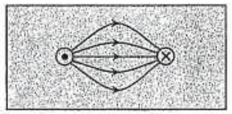
A.



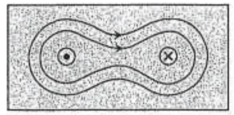
B.



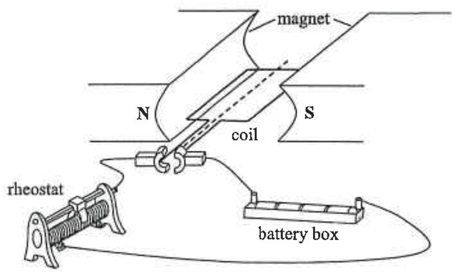
C.



D.



77. < HKDSE Sample Paper IA - 28 >

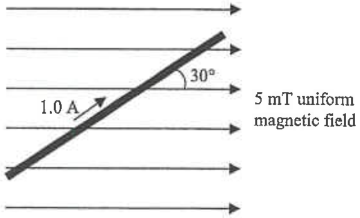


The figure shows a simple motor. Which of the following changes would increase the turning effect of the coil ?

(1) using a stronger magnet
(2) reducing the resistance of the rheostat
(3) using a coil with a smaller number of turns

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

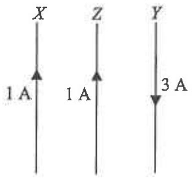
78. < HKDSE Practice Paper IA - 31 >



The figure shows a current of 1.0 A flowing in a metal rod of length 0.5 m. The rod is placed inside a region with a uniform magnetic field of strength 5 mT. What is the direction and the magnitude of magnetic force acting on the rod ?

	Direction	Magnitude
A.	into the paper	1.25×10^{-3} N
B.	out of the paper	1.25×10^{-3} N
C.	into the paper	2.17×10^{-3} N
D.	out of the paper	2.17×10^{-3} N

79. < HKDSE 2012 Paper IA - 29 >



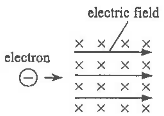
In the above figure shown, X, Y and Z are three long straight parallel wires with Z placed midway between X and Y. X and Z carry currents of 1 A in the same direction while Y carries a current of 3 A in the opposite direction. The magnetic force per unit length experienced by wire X due to wire Z is of magnitude F. The magnetic force per unit length acting on wire Z due to both X and Y is

A. $2F$ to the right.
B. $2F$ to the left.
C. $4F$ to the right.
D. $4F$ to the left.

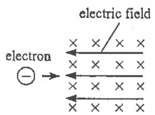
80. < HKDSE 2012 Paper IA - 30 >

An electron enters a region in which both a uniform electric field E and a uniform magnetic field B exist. The magnetic field B is pointing into the paper. In which direction should the electric field be applied so that the electron could be undeflected ?

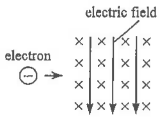
A.



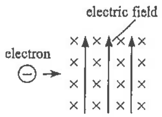
B.



C.

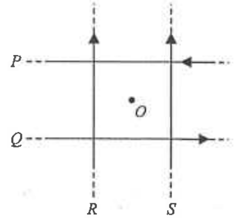


D.



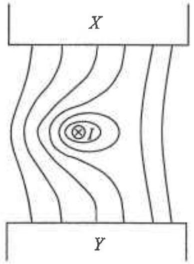
81. < HKDSE 2013 Paper IA - 27 >

In the figure, four long straight wires P, Q, R and S in the same plane carry equal currents in the directions shown. The wires are insulated from each other. O is a point on the same plane and is equidistant from each wire. Removing which wire would increase the magnetic field strength at O ?



A. wire P
B. wire Q
C. wire R
D. wire S

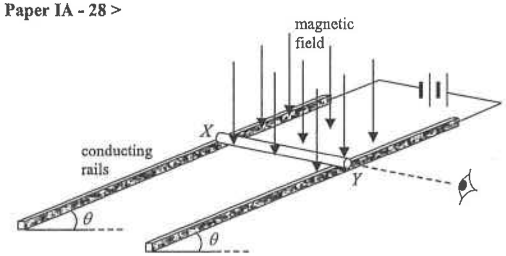
82. < HKDSE 2013 Paper IA - 26 >



A straight wire carrying current I pointing into the paper is placed in a magnetic field between pole pieces X and Y. The figure shows the resultant field line pattern. What is the polarity of pole piece X and in what direction is the magnetic force acting on the wire ? Ignore the effect of the Earth's magnetic field.

	polarity of X	direction of magnetic force
A.	N	to right
B.	N	to left
C.	S	to right
D.	S	to left

83. < HKDSE 2013 Paper IA - 28 >



A copper rod XY is placed on a pair of smooth inclined conducting rails which are located in a magnetic field applied vertically downward. The rails make an angle θ to the horizontal and a battery is connected to the rails as shown above. Which diagram shown below represents the magnetic force F_B acting on the rod when viewed from end Y ?

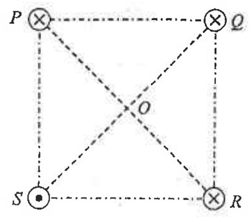
A.

B.

C.

D.

84. < HKDSE 2014 Paper IA - 26 >

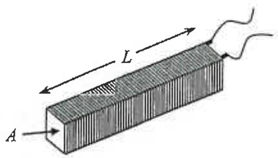


Four long straight parallel wires P, Q, R and S carrying currents of equal magnitude are situated at the vertices of a square as shown. P, Q and R each carries a current directed into the paper while S carries a current directed out of the paper. The direction of the resultant magnetic field at the centre O of the square is along

A. OP.
B. OQ.
C. OR.
D. OS.

85. < HKDSE 2014 Paper IA - 28 >

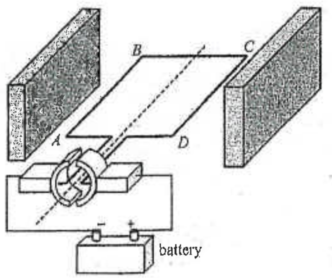
The figure shows a closely packed long solenoid of cross-sectional area A and length L having a total of N turns. If the solenoid carries a constant direct current throughout, which of the following changes can increase the magnetic flux density B at its central cross-section ?



	length	cross-sectional area	total number of turns
A.	$2L$	$2A$	$2N$
B.	L	$2A$	N
C.	$2L$	A	N
D.	L	A	$2N$

86. < HKDSE 2017 Paper IA - 26 >

The figure shows a simple d.c. motor, the coil $ABCD$ is mounted between the poles of two slab-shaped magnets.

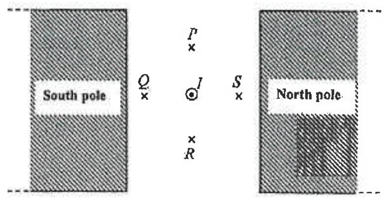


Which of the following statements is correct ?

A. The turning effect is zero when the coil is vertical.
B. The magnetic force acting on BC is the greatest when the coil is horizontal.
C. The direction of the magnetic force acting on AB remains constant.
D. The direction of the current in the coil remains unchanged.

87. < HKDSE 2018 Paper IA - 27 >

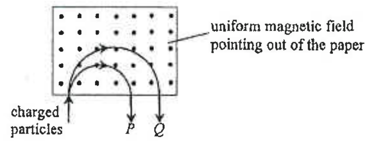
A straight wire carrying a current I pointing out of the paper is placed in a uniform magnetic field between two pole pieces as shown. At which point, P, Q, R or S, can the resultant magnetic field be zero ?



Neglect the effect of the Earth's magnetic field.

A. P
B. Q
C. R
D. S

88. < HKDSE 2018 Paper IA - 28 >



P and Q are two particles carrying the same amount of charge but of different masses. They travel with the same speed and enter a uniform magnetic field pointing out of the paper as shown. Semi-circular paths with different radii are described before they emerge from the field. Which descriptions below are correct ?

(1) Both P and Q are positively charged.
(2) P and Q emerge from the field with the same speed.
(3) The mass of Q is greater than that of P.

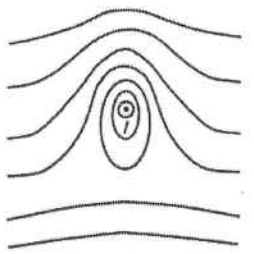
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

89. <HKDSE 2019 Paper IA-26>

90. <HKDSE 2019 Paper IA-27>

91. <HKDSE 2020 Paper IA-26>

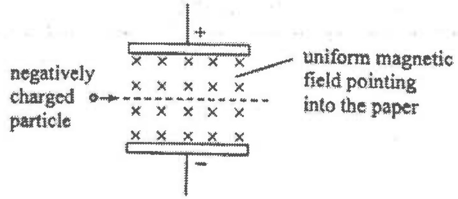
The figure below shows the magnetic field pattern on a horizontal surface around a long vertical straight wire carrying a steady current I pointing out of the paper. The Earth's magnetic field is NOT neglected.



What are the directions of the following ?

	the horizontal component of the Earth's magnetic field	the magnetic force experienced by the current-carrying wire
A.	←	↓
B.	←	↑
C.	→	↓
D.	→	↑

92. <HKDSE 2020 Paper IA-27>



A negatively charged particle goes undeflected through a region in which a uniform electric field and a uniform magnetic field are set up as shown. The electric field is set up by the potential difference across the two parallel metal plates. Which of the following changes may cause the charged particle to deflect downward ? Neglect the effects of gravity.

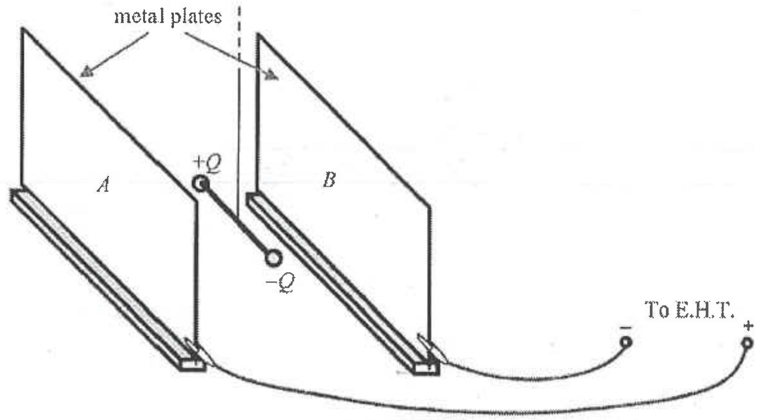
(1) increasing the potential difference across the plates
(2) increasing the magnitude of the charge on the particle
(3) increasing the particle's speed entering the region

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

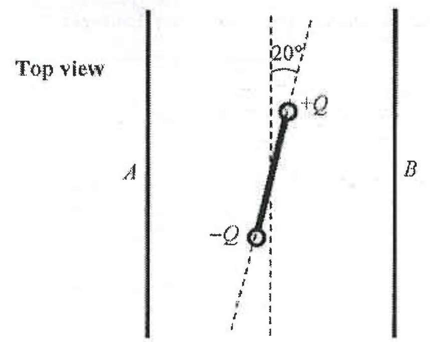
93. < HKDSE 2020 Paper 1B -9 >

Two small metal spheres are attached to the ends of an insulating rod of length 5.0 cm. They carry charges $+Q$ and $-Q$ respectively of equal magnitude as shown in Figure 9.1. The insulating rod is suspended horizontally between two parallel metal plates, A and B, which are connected to an E.H.T. (extra high tension) supply.

ure 9.1



The rod is parallel to the metal plates when the E.H.T. is off. After the E.H.T. is switched on, an electric field is set up between the plates and the rod is twisted by an angle of 20° as shown in Figure 9.2.



gure 9.2

(a) On Figure 9.2, sketch the electric field lines due to the potential difference across the plates. (2 marks)

(b) The potential difference across A and B is 5.0 kV and the separation between the metal plates is 10 cm. The force due to the electric field acting on each sphere is 2.0×10^{-5} N, find

(i) the moment acting on the rod as shown in Figure 9.2 due to the electric forces on the charged spheres. (2 marks)

*(ii)the strength of the electric field E due to the potential difference across the metal plates.

(iii) the magnitude of the charge Q on the spheres.

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

M.C. Solution

1. C

Charged particles will be deflected by a magnetic field.

× (1) Electromagnetic waves : contain no charged particles.

✓ (2) Beam of electrons : negatively charged particles

✓ (3) Beam of protons : positively charged particles

2. A

When current flows through the solenoid, there is magnetic field inside the solenoid.

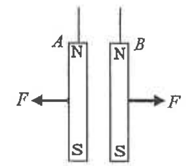
The two iron rods are then magnetized to become electromagnets.

By use of Right hand grip rule, the direction of magnetic field is upwards.

Both the upper ends of the two iron rods are N-pole and lower ends are S-pole.

Since like poles repel, they repel away from each other.

Thus, A moves to the left and B moves to the right.



3. B

There exists repulsive magnetic force between two currents flowing in opposite directions.

$\therefore$ Magnetic force on Q is to the right.

4. B

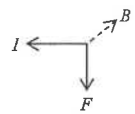
For a d.c. source, there are 2 possible cases.

Case I : Current from wire X to wire Y

Case II : Current from wire Y to wire X.

In both cases, directions of current in the 2 wires are opposite $\Rightarrow$ repulsion

5. C



(1) From the diagram, a downward force is acting on the electron.

(2) Current carried by the electrons is opposite to direction of motion of electrons.

By Left-hand rule, the magnetic field B should be pointing into the paper.

6. C

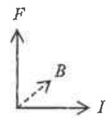
Consider the rod BD,

(1) Direction of current : from B to D,

(2) Direction of B-field : into paper.

By Left-hand rule, an upward force acts on the copper rod

$\therefore$ tension in each thread decreases



7. B

Wire AB : current flows from B to A

Wire CD : current flows from C to D

Since the two currents flow in opposite directions, the forces between them are repulsive.

Thus the force acting on CD is towards the right.

8. B

Direction of needle gives the direction of B-field, which can be found by Right-hand screw rule,

× (1) the needle should point upward

✓ (2) a downward B-field acting on the compass

× (3) the needle should point upward

9. C

$$\eta = \frac{P_{out}}{P_{in}} = \frac{F\cdot v}{V\cdot I} = \frac{(40)(0.2)}{(12)(2)} = 33.3\%$$

10. B

For Z and X, current in opposite direction $\Rightarrow$ repulsion $\Rightarrow$ X experiences a force to the right

For Y and X, current in same direction $\Rightarrow$ attraction $\Rightarrow$ X experiences a downward force

$\therefore$ Resultant force acting on X is the vector sum of the above forces, i.e. Q.

11. B

✓ (1) An electric bell contains a soft iron core.
When current flows through the coil, the soft iron becomes an electromagnet.

✓ (2) A telephone receiver make use of the electromagnet
to give varying magnetic force to make the iron diaphragm vibrate.

× (3) Moving-coil loudspeaker is an application of magnetic force acting on current inside a magnetic field.

12. A

✓ (1) $R\downarrow \Rightarrow I\uparrow \Rightarrow$ strength of magnetic field is increased

× (2) Steel : difficult to magnetize and demagnetize $\Rightarrow$ strength of B-field is decreased.

× (3) a.c. source gives the same strength of B-field but the direction of the magnetic field would vary

13. B

Consider the vertical wire : For a downward current, P and S : B-field into paper ; Q and R : B-field out of paper

Consider the horizontal wire : For a current to the right, R and S : B-field into paper ; P and Q : B-field out of paper

For the resulting field out of paper, B-field from **both** wires should be out of paper, i.e., the case for Q.

14. A

Power given out by the cell $= \varepsilon I = (12)\times(0.5) = 6$ W

Power dissipated by the resistor $= I^2 R = (0.5)^2(10) = 2.5$ W

Power consumed by the motor $= 6 - 2.5 = 3.5$ W

OR

Voltage across the motor $= \varepsilon - IR = (12) - (0.5)(10) = 7$ V

Power consumed by the motor $= VI = (7)\times(0.5) = 3.5$ W

15. A

Consider X and Y, same direction of current $\Rightarrow$ attraction $\Rightarrow$ Y to the left

Consider Y and Z, opposite direction of current $\Rightarrow$ repulsion $\Rightarrow$ Y to the left

$\therefore$ Combining the two results, Y experiences a net force to the left.

16. C

✓ (1) Increase the number of turns $\Rightarrow$ strength of magnetic field is increased

✓ (2) Reduce the resistance $\Rightarrow$ Increase the current $\Rightarrow$ strength of magnetic field is increased.

× (3) a.c. source gives the same strength of B-field but the direction of the magnetic field would vary

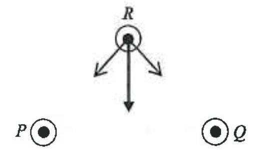
17. D

Currents in wires flowing in the same direction will attract each other

The force acting on R by P will act towards P

The force acting on R by Q will act towards Q

The resultant force acting on R by P and Q is downward.



18. D

By Right hand screw rule,

the magnetic pole at P is North, as the compass needle points away from North, it points upwards ;

the magnetic pole at Q is South, as the compass needle points towards South, it points downwards.

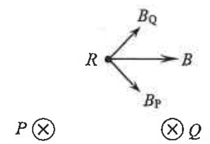
19. A

Since the toy car is battery operated, option B and D are not correct as the supply is a.c.

The switch should be connected in series as shown in A.

Option C is not correct as the battery is shorted when the switch is closed.

20. B



The resultant magnetic field due to B_P and B_Q is the vector sum of them and points towards the right.

Thus the compass needle would point along the B-field direction towards the right.

21. A

By using Right hand screw rule, the magnetic field lines point into the loop.

22. A

✓ (1) Using stronger magnet can increase the strength of the magnetic field, thus increasing the turning effect.

✓ (2) Reducing the resistance of the rheostat can increase the current, thus increasing the turning effect.

× (3) Using a coil with smaller number of turns would decrease the turning effect.

23. B

✓ (1) By using a stronger magnet, a greater magnetic force is produced to give a louder sound.

× (2) Copper is not a magnetic material, it cannot increase the strength of the magnetic field.

✓ (3) By increasing the number of turns, the coil can give a greater magnetic force to have a loud sound.

24. A

✓ (1) These two magnetic forces are equal and opposite and act on each other.

✓ (2) Two currents flowing in the same direction attract each other.

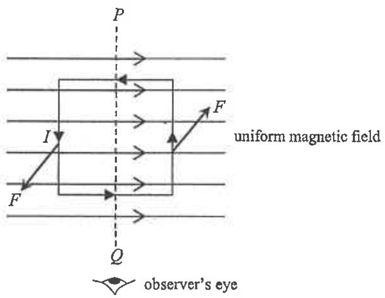
× (3) If the directions of the two currents are both reversed, they are still in the same direction and attract.

25. C

By Left hand rule, the magnetic force acting on the right wire is into the paper and that on the left wire is out of paper.

Since these two forces are equal in magnitude and opposite in direction, their resultant force is zero.

However, these two forces give a clockwise turning effect on the coil to make it rotate.

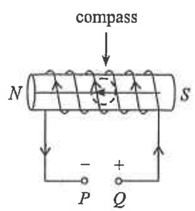


26. C

Since the left hand side of the solenoid is N-pole, by Right hand screw rule, current in solenoid is as shown.

Since the current flows from (+) terminal to (–) terminal of a d.c. supply, Q is (+) and P is (–).

Direction of magnetic field lines inside the solenoid is towards the left, thus the compass needle is towards the left.



27. D

✓ (1) By using Left hand rule, thumb representing magnetic force F points downwards, the middle finger representing current I points into the paper, thus the finger representing magnetic field B should point to the right. Therefore, X is North pole and Y is South pole, to give magnetic field pointing to the right.

✓ (2) If the current direction is pointing out of paper, the magnetic force points upwards, thus reversed.

✓ (3) The magnetic force depends on the strength of the magnetic field, thus stronger magnets can increase the force F.

28. D

Current out of paper should give magnetic field in anticlockwise direction.

Both currents give anticlockwise magnetic field, and give the resultant pattern as shown in option D.

29. D

× (1) If the pole X is N, then magnetic field is towards the right, thus current should be from Q to P.

✓ (2) If the pole X is S, then magnetic field is towards the left, thus current is from P to Q.

✓ (3) If the pole X is N, then magnetic field is towards the right, thus current is from Q to P.

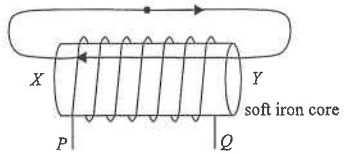
30. B

✓ (1) By Left hand rule, the magnetic force acting on RS is towards the right.

× (2) By Left hand rule, the magnetic force acting on QR is pointing upwards, not zero.

✓ (3) The four magnetic forces acting on the four wires balance each other, thus there is no resultant force.

31. A



The magnetic field line is completed as shown in the figure.

End X is the North pole as magnetic field lines come out here.

By Right hand screw rule, the current is from P to Q through the solenoid.

32. D

From the diagram, the circular path of X has a greater radius, i.e. $r_X > r_Y$

By $F = BQv$ and $F = \dfrac{mv^2}{r}$ $\quad \therefore \; BQv = \dfrac{mv^2}{r}$ $\quad \therefore \; r = \dfrac{mv}{BQ} \propto \dfrac{mv}{Q}$

× (1) $m_X < m_Y \;\Rightarrow\; r_X < r_Y$

✓ (2) $Q_X < Q_Y \;\Rightarrow\; r_X > r_Y$

✓ (3) $v_X > v_Y \;\Rightarrow\; r_X > r_Y$

33. D

For a long solenoid, $B = \mu_0 n I$

× (1) B is independent of the diameter of the solenoid

✓ (2) B is proportional to the number of turns per unit length n

✓ (3) B is proportional to the current I

34. D

× (1) By Left-hand rule, the magnetic force acting on the electron horizontal. $\therefore$ The path of the electron should be circular on a horizontal plane.

✓ (2) Since magnetic force is always perpendicular to the direction of motion $\therefore$ no work done on the electron by the magnetic force $\Rightarrow$ constant speed of electron

✓ (3) By $BQv = \dfrac{mv^2}{r}$ $\quad \therefore \; r = \dfrac{mv}{BQ} \propto \dfrac{1}{B}$

35. D

The horizontal component of the magnetic field $B\cos\theta$ is perpendicular to the vertical current.

$F = B\cos\theta \times I L = (10^{-3}\cos 30°) \times (5) \times (0.4) = 1.7 \times 10^{-3}$ N

36. C

For a long solenoid, $B = \mu_o n I$

✓ (1) B is independent of the diameter d of the solenoid

✓ (2) B is proportional to the number of turns per unit length n

× (3) B depends on the material of the core, μ_o represents the permittivity of air

37. A

Two currents in opposite directions have repulsive forces between them.

These two forces are action and reaction that have the same magnitude,

thus two wires have the same change of shape.

38. D

$$F = \frac{\mu_o I_1 I_2 L}{2\pi r} \propto \frac{I_1 \cdot I_2}{r}$$

$$\therefore\ F' = \frac{(2)(2)}{(2)} \cdot F = 2F$$

39. D

Since the magnetic field inside the solenoid is uniform, B is constant and thus be a horizontal line.

Near the end of the solenoid, the field then decreases gradually to zero outside the solenoid.

40. D

By Left-hand rule, direction of magnetic force on the particle is downward.

$$B Q v = \frac{m v^2}{r}$$

$$\therefore\ (0.08)(1.6\times10^{-19}) = \frac{(3.2\times10^{-26})(10^5)}{r} \qquad \therefore\ r = 0.25\ \text{m}$$

41. C

① When the upper part is at a higher potential,

current flows from left to right along X and flows from right to left along Y

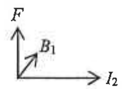
$\Rightarrow$ current flows in opposite direction along the 2 wires $\Rightarrow$ repulsion

② When the lower part is at a higher potential,

current flows from right to left along X and flows from left to right along Y

$\Rightarrow$ current flows in opposite direction along the 2 wires $\Rightarrow$ repulsion

42. A



By Right-hand screw rule, B-field produced by current in wire PQ at position RS is B_1 into the paper.

By Left-hand rule, the magnetic force acting on the wire RS is in $+y$ direction.

43. B

By $B Q v = m r \omega^2$ and $v = r\omega$

$$\therefore\ B Q = m\omega = m\frac{2\pi}{T}$$

$$\therefore\ T = \frac{2\pi m}{B Q}$$

44. D

By Left hand rule, magnetic force acting on the upper wire is out of paper and that on the lower wire is into the paper.

Thus the loop would rotate in anticlockwise direction when viewing from right hand side indicated by s.

45. B

Electric force $= q E$

Magnetic force $= B q v$

For undeflected motion of a charged particle : $q E = B q v \qquad \therefore\ v = \frac{E}{B}$

$\therefore$ Only those particles that have the same speed v equal to E/B can have no deflection in the cross-field region.

46. A

✓ (1) Two currents in the same direction $\Rightarrow$ attraction between the two wires

× (2) $F = \frac{\mu_o I_1 I_2 L}{2\pi r} \propto \frac{1}{r}$

× (3) There should be a neutral point in mid way between them where the magnetic field is zero.

47. C

✓ (1) From the diagram, the magnetic force is upwards.
By Left hand rule, the current is in the same direction as the motion.
$\therefore$ Both P and Q are positively charged.

✓ (2) By $F = B Q v$ and $F = \frac{mv^2}{r}$ $\quad \therefore\ B Q v = \frac{mv^2}{r} \quad \therefore\ r = \frac{m v}{B Q} \propto v \quad \therefore\ r_P < r_Q \Rightarrow v_P < v_Q$

× (3) By $F = B Q v$ and $F = m r \omega^2$ $\quad \therefore\ m\omega\omega = B Q v \quad \therefore\ m \cdot v \cdot \frac{2\pi}{T} = B Q v$

$\therefore\ T = \frac{2\pi m}{B Q}$ which is independent of the speed of the particle

48. D

By Right-hand screw rule :

At X, the B-field by the upper wire is into paper and that by the lower wire is also into paper.

$\therefore$ The resultant B-field is into paper.

$$B = 2 \times \frac{\mu_o I}{2\pi r} = 2 \times \frac{(4\pi\times10^{-7})\cdot(1)}{2\pi(0.1)} = 4 \times 10^{-6}\text{ T}$$

49. C

For two long, straight parallel conducting wires : $F = \dfrac{\mu_o I_1 I_2 L}{2\pi r} = \dfrac{\mu_o I^2 L}{2\pi r} \propto \dfrac{I^2 L}{2\pi r}$

✓ (1) The force is inversely proportional to the distance between the wires r.

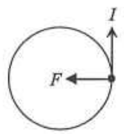
✓ (2) The force is proportional to the length of that section of the wires ℓ.

✗ (3) The directions of current flow only affect the direction of the force but not the magnitude.

50. B

$$B Q v = \frac{m v^2}{r}$$

$$\therefore\ v = \frac{B Q r}{m} = \frac{0.02\times1.6\times10^{-19}\times0.005}{9.1\times10^{-31}} = 1.76\times10^{7}\ \text{m s}^{-1}$$



For the direction, consider the point at the rightmost position

By Left hand rule, since current is upwards, velocity of electron is downwards

$\therefore$ the electron moves in clockwise direction

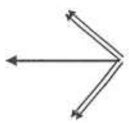
51. A

By $F = B Q v$ and $F = \dfrac{m v^2}{r}$

$$B Q v = \frac{m v^2}{r} \qquad \therefore\ k = \frac{Q}{m} = \frac{v}{B r} \propto \frac{1}{r}$$

$$\therefore\ k' = \frac{r_A}{r_B}\cdot k = \frac{k}{2}$$

52. A



By Right-hand screw rule, the B-field by each wire is given as shown.

Same current carried by the 4 wires $\Rightarrow$ same magnitude of B-field

$\therefore$ The resultant B-field is given by I.

53. C

✓ (1) BC is perpendicular to the magnetic field, thus a magnetic force acts on it.

✓ (2) By Left-hand rule, magnetic force acting on AB is downwards and that on CD is upwards, magnetic force on BC is out of paper and that on AD is into paper.
$\therefore$ The magnetic forces on the four wires tend to reduce the area of the coil.

✗ (3) As the magnetic forces acting on AB and CD balance each other, and that on BC and AD balance, there is no resultant force acting on the coil..

54. B

By $F = B Q v$ and $F = m r \omega^2$

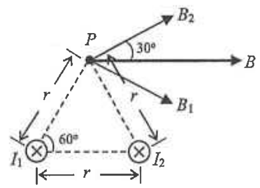
$\therefore\ m r \omega \omega = B Q v$

$\therefore\ m\cdot v\cdot\dfrac{2\pi}{T} = B Q v$

$\therefore\ T = \dfrac{2\pi m}{B Q}$

$\therefore$ T is independent of the speed v and is a constant, thus the graph is a horizontal line.

55. D



By Right-hand screw rule, the B-field by each wire is given as shown.

Current I_1 produces the magnetic field B_1 perpendicular to $P I_1$.

Current I_2 produces the magnetic field B_2 perpendicular to $P I_2$.

The resultant magnetic field B is the sum of the two horizontal components of B_1 and B_2.

$$B = B_1 \cos 30° + B_2 \cos 30°$$

$$= 2B_1 \cos 30° = 2\cdot\frac{\mu_o I}{2\pi r}\cdot\frac{\sqrt{3}}{2} = \frac{\sqrt{3}\mu_o I}{2\pi r}\ \text{(to the right)}$$

56. D

In order to have a B-field along the diagonal RP,

(1) B-field by P and R should be eliminated one another (as B-field produced by P and R at O is along QS),

(2) B-field by Q and S should be from O to P (as B-field produced by Q and S at O is along PR).

To satisfy (1), current of P and R should be in the same direction (either into or out of paper).

To satisfy (2), by Right-hand screw rule, current of S : into paper ; current of Q : out of paper.

57. B

Electric force $= QE$ Magnetic force $= BQv$

Crossed E- and B- fields $\Rightarrow$ both forces in opposite directions $\Rightarrow$ no deflection if the 2 forces equal

$\therefore\ QE = BQv \quad \therefore\ v = \dfrac{E}{B}$

$\therefore$ With same E-field and B-field, the ions should have the same velocity.

58. A

Magnetic force between two parallel currents in same direction is attractive.

Magnetic force between two parallel currents in opposite direction is repulsive.

59. B

Inside the magnetic field, the magnetic force provides the centripetal force

$\therefore\ BQv = \dfrac{mv^2}{r} \quad \therefore\ r = \dfrac{mv}{BQ}$

× (1) If the flux density B has decreased gradually, the radius r should be gradually increased.

× (2) If the charged particle has lost its charge q gradually, the radius r should be gradually increased.

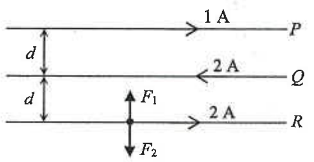
✓ (3) When the charged particle has lost its kinetic energy gradually, its speed v is gradually decreased, thus the radius r would also gradually decrease.

60. D

$B_P = \dfrac{\mu_o I_1}{2\pi(30)} - \dfrac{\mu_o (0.6)}{2\pi(10)} = 0 \quad \therefore\ I_1 = 1.8\ \text{A}$

I_1 is in the opposite direction so that the direction of the magnetic field produced is opposite to that by I_2.

61. D



Force per unit length : $\dfrac{F}{L} = \dfrac{\mu_o \cdot I_1 \cdot I_2}{2\pi \cdot r} \quad \therefore\ F = \dfrac{\mu_o \cdot (1) \cdot (1)}{2\pi \cdot (d)}$

Force acting on R by P : $F_1 = \dfrac{\mu_o \cdot (1) \cdot (2)}{2\pi \cdot (2d)} = F$ (upwards)

Force acting on R by Q : $F_2 = \dfrac{\mu_o \cdot (2) \cdot (2)}{2\pi \cdot (d)} = 4F$ (downwards)

Net force on $R = 4F - F = 3F$

62. B

In a magnetic field, charged particle performs circular motion with period T.

By $BQv = mr\omega^2 \quad \therefore\ BQ = m\omega = m\dfrac{2\pi}{T}$ (as $v = r\omega$)

$\therefore\ T = \dfrac{2\pi \cdot m}{B \cdot Q}$

For the proton ${}^1_1\text{p}$, it performs half of a cycle $\quad \therefore\ t_1 = \dfrac{1}{2}T = \dfrac{1}{2} \times \dfrac{2\pi \cdot m}{B \cdot Q} = \dfrac{\pi \cdot m}{B \cdot Q}$

For the alpha ${}^4_2\alpha$, it performs a quarter of a cycle $\quad \therefore\ t_2 = \dfrac{1}{4}T = \dfrac{1}{4} \times \dfrac{2\pi \cdot (4m)}{B \cdot (2Q)} = \dfrac{\pi \cdot m}{B \cdot Q}$

$\therefore\ t_1 : t_2 = 1 : 1$

63. A

By $BQv = \dfrac{mv^2}{r} \quad \therefore\ B = \dfrac{mv}{Qr} \propto \dfrac{mv}{Q}$ (r is the same)

$\therefore\ \dfrac{B_\alpha}{B_e} = \dfrac{m_\alpha}{m_e} \times \dfrac{v_\alpha}{v_e} \times \dfrac{Q_e}{Q_\alpha}$

$\therefore\ \dfrac{B_\alpha}{(1)} = (\dfrac{7200}{1}) \times (\dfrac{1}{4}) \times (\dfrac{1}{2}) \quad \therefore\ B_\alpha = 900\ \text{mT} = 0.9\ \text{T}$

64. B

By $B = \dfrac{\mu_o \cdot I}{2\pi \cdot r}$

$\therefore\ \Delta B = \dfrac{\mu_o \cdot \Delta I}{2\pi \cdot r}$

$\therefore\ (5.0 \times 10^{-6}) = \dfrac{(4\pi \times 10^{-7}) \cdot (0.5)}{2\pi \cdot r}$

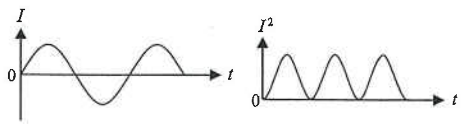
$\therefore\ r = 0.02\ \text{m} = 2\ \text{cm}$

65. C

Since the current through PQ and the current through RS must be always in opposite direction, force between the two wires must always be repulsive.

$F = \dfrac{\mu_o I_1 I_2 L}{2\pi \cdot r} \propto I^2$

The shape of the graph F should be same as the graph I^2.



66. C

If the charged particles passes crossed field without deflection, then $QE = BQv \quad \therefore\ v = \dfrac{E}{B}$

The beam of charged particles must have the same velocity v.

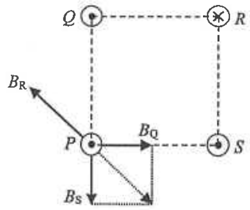
If only the magnetic field is present, $BQv = \dfrac{mv^2}{r} \quad \therefore\ r = \dfrac{mv}{BQ}$

Different masses m or different charges Q can give different radius of curvature r, and thus they split up.

67. D

If the wire P has no net force, then the resultant magnetic field due to Q, R, S must be zero at P.

The magnetic field due to the three wires is shown in the figure.



Let the separation between QR be r, then the separation between PR is $\sqrt{2}\,r$.

$B_Q = B_S = B$

The resultant of B_Q and B_S is $\sqrt{2}\,B$.

$\therefore\ B_R = \sqrt{2}\,B$

$\therefore\ \dfrac{\mu_o I'}{2\pi(\sqrt{2}\,r)} = \sqrt{2} \times \dfrac{\mu_o I}{2\pi r}$

$\therefore\ I' = 2I$

OR

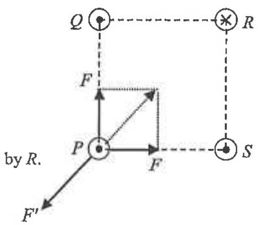
Let the distance of each side of the square be r.

Magnetic forces between any two currents are given by $\dfrac{F}{L} = \dfrac{\mu_o I_1 I_2}{2\pi r}$

For two currents flowing in the same direction, attractive forces exist.

For two currents flowing in the opposite direction, repulsive forces exist.

Consider P, the resultant of attractive forces by Q and by S balances the repulsive force by R.



$\sqrt{2} \times \dfrac{\mu_o I^2}{2\pi r} = \dfrac{\mu_o I \cdot I'}{2\pi \times \sqrt{2}r}$

$\therefore\ I' = 2I$

68. C

Consider the horizontal component of the Earth's magnetic field that is perpendicular to the current.

Horizontal component of the magnetic field is $B\cos\theta$.

By $F = B\cos\theta \cdot I \cdot L$

$\therefore\ (7.5 \times 10^{-5}) = (B\cos 20°)(8.0)(0.5)$

$\therefore\ B = 2.0 \times 10^{-5}$ T

69. D

✓ (1) $B = \mu_o n_X I_X - \mu_o n_Y I_Y = \mu_o(1200 \times 1 - 2400 \times 0.5) = 0$

✓ (2) The magnetic field at Q is due to solenoid X only, as no magnetic field outside a solenoid.
$B = \mu_o n_X I_X = (4\pi \times 10^{-7}) \times (1200) \times (1) = 1.5$ mT

✓ (3) By right hand grip rule, magnetic field due to solenoid X at Q is towards the left.

70. A

$F = BIL\sin\theta \times N$

$= (0.4)(1.2)(0.15)\sin 30° \times (20) = 0.7$ N

By Left hand rule, the magnetic force is out of paper.

71. D

By $BQv = \dfrac{mv^2}{r}$

$\therefore\ r = \dfrac{mv}{BQ}$

For greater deflection, radius r of the circular path should be **decreased**.

× (1) By increasing the mass m, radius r increases, thus deflection decreases.

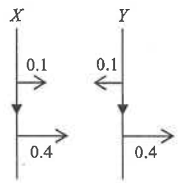
✓ (2) By increasing the charge Q, radius r decreases, thus deflection increases.

✓ (3) By increasing the flux density B, radius r decreases, thus deflection increases.

72. B

The magnetic forces between X and Y are attractive.

Magnetic force on X by Y is 0.1 N rightwards and magnetic force on Y by X is 0.1 N leftwards.



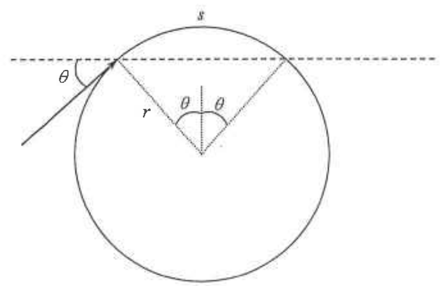
When the magnetic field into the paper is applied, by use of the Left hand rule, the magnetic force is in rightward direction.

Since the resultant magnetic force on X is 0.5 N,
the magnetic force due to the applied magnetic field is 0.4 N rightwards.

The same magnetic force of 0.4 N in rightward direction also acts on Y.

The resultant magnetic force on $Y = 0.4 - 0.1 = 0.3$ N rightwards

73. B



Let r be the radius and s be the arc length of transit.

By $BQv = mr\omega^2$ $\quad\therefore\ BQ = m\omega = m\dfrac{2\pi}{T}$ $\quad$ (as $v = r\omega$)

$\therefore\ T = \dfrac{2\pi \cdot m}{B \cdot Q}$

✓ (1) Time of transit along the arc : $t = T \times \dfrac{2\theta}{360°}$ $\quad\therefore\ t \propto \theta$

× (2) Period T and t should be independent of the speed v.

✓ (3) $t \propto T \propto \dfrac{1}{B}$

74. A

Magnetic force per unit length between two parallel currents : $\dfrac{F}{L} = \dfrac{\mu_o I_1 I_2}{2\pi r}$

Magnetic forces between 2 parallel currents :

same direction are attractive ; opposite direction are repulsive.

Magnetic force per length on the middle wire by I_1 = $\dfrac{\mu_o I_1 I}{2\pi(r/2)} = \dfrac{\mu_o I_1 I}{\pi r}$ (to the left)

Magnetic force per length on the middle wire by I_2 = $\dfrac{\mu_o I_2 I}{2\pi(r/2)} = \dfrac{\mu_o I_2 I}{\pi r}$ (to the right)

Since $I_2 > I_1$, the magnetic force per length by I_2 is greater.

Resultant magnetic force per length on the middle wire = $\dfrac{\mu_o I_2 I}{\pi r} - \dfrac{\mu_o I_1 I}{\pi r} = \dfrac{\mu_o I (I_2 - I_1)}{\pi r}$ (to the right)

75. A

✓ (1) B is proportional to I

✓ (2) B is proportional to n, the number of turns per unit length

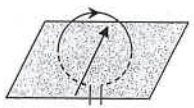
× (3) B is independent of the area A for a long solenoid

76. A

By using Right hand screw rule,

the magnetic field line at the centre of the loop points into the loop

as indicated in A.



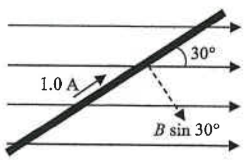
77. A

✓ (1) Using stronger magnet can increase the strength of the magnetic field, thus increasing the turning effect.

✓ (2) Reducing the resistance of the rheostat can increase the current, thus increasing the turning effect.

× (3) Using a coil with smaller number of turns would decrease the turning effect.

78. A



Consider the component of the magnetic field perpendicular to the current, that is, B sin 30°.

The direction of magnetic force is into the paper by use of the Left hand rule.

$F = B \sin 30° \times I \times L$

$= (5 \times 10^{-3}) \sin 30° \times (1.0) \times (0.5) = 1.25 \times 10^{-3}$ N

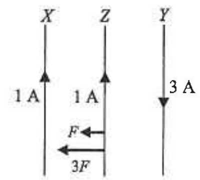
79. D

Magnetic force per unit length between two parallel currents : $F = \dfrac{\mu_o I_1 I_2}{2\pi r}$

Moreover, magnetic forces between 2 parallel currents in the same direction are attractive,

and magnetic forces between 2 parallel currents in the opposite direction are repulsive.

Assume the separation between XZ is r. Separation between YZ is also r.



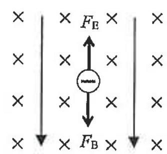
By Newton's third law, the magnetic force per unit length on Z by X is also F.

Magnetic force per unit length on Z by X = $\dfrac{\mu_o (1)(1)}{2\pi(r)} = F$ (to the left)

Magnetic force per unit length on Z by Y = $\dfrac{\mu_o (1)(3)}{2\pi(r)} = 3F$ (to the left)

Resultant force per unit length on Z by X and Y = $F + 3F = 4F$ (to the left)

80. C



When the electron moves towards the right, it represents a current to the left.

Since the magnetic field is pointing into the paper,

by Left hand rule, the magnetic force F_B is downwards.

To make the electron be undeflected, the electric force F_E must be upwards.

As the electron carries negative charge, the electric field should be downwards

so that the electric force is upwards.

81. C

By the use of Right hand screw rule to find the direction of B-field due to a straight wire current :

Direction of B-field at point O due to P : out of paper

Direction of B-field at point O due to Q : out of paper

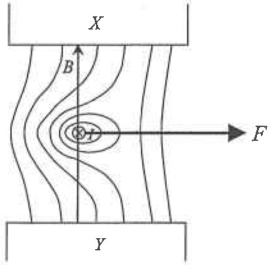
Direction of B-field at point O due to R : into paper

Direction of B-field at point O due to S : out of paper

The B-field given by R is in opposite direction to that of the other wires.

Thus, removing wire R can increase the resultant magnetic field at O.

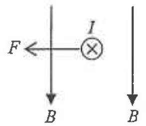
82. C



From the pattern of catapult field, the magnetic force is towards the right.
From the figure shown, the direction of current is into the paper.
By using the Left hand rule, the direction of magnetic field is upwards.
As direction of magnetic field is from N-pole to S-pole, the magnetic pole at X is South.

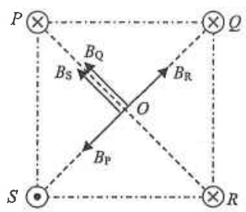
83. C

Direction of current flowing through the rod is from Y to X,
into the paper as seen by the eye.
Direction of magnetic field is downwards.
By using Left hand rule, the magnetic force is towards the left.



84. A

By using Right hand grip rule,
B-field due to P is along OS at O.
B-field due to Q is along OP at O.
B-field due to R is along OQ at O.
B-field due to S is along OP at O.
The B-fields due to P and R are in opposite direction
and they balance each other.



The resultant magnetic field due to Q and S are in the same direction and thus their resultant magnetic field is along OP.

85. D

Magnetic field inside the solenoid is : $B = \frac{\mu_o N I}{L}$

The magnetic field is independent of the area A.

× A. The magnetic field is unchanged as both N and L are doubled.
× B. The magnetic field is unchanged as both N and L are unchanged.
× C. The magnetic field is halved as L is doubled.
✓ D. The magnetic field is doubled as N is doubled.

86. A

✓ A. When the coil is vertical, the magnetic forces on the four wires are either directed away from the centre or towards the centre. Thus, the magnetic forces do not have moment to give turning effect.

× B. The magnitude of magnetic force acting on BC is constant at any position of the coil since $F = B I l$, magnetic field B, current I, and length l are all constant.

× C. The direction of magnetic force acting on AB reverses every half cycle since the direction of current through AB reverses every half cycle due to the commutator.

× D. The direction of current in the coil reversed every half cycle due to the commutator.

87. C

The magnetic field produced by current I is anticlockwise around I. At point R, the B is towards the right.
The magnetic field produced by the poles of magnet is towards the left (from North to South).
Thus, at R, the resultant magnetic field can be zero.

88. D

✓ (1) Consider the charged particles entering the magnetic field.
The magnetic field B is out of paper, magnetic force F is towards the right,
by using Left hand rule, the current is upwards.
As current is the flow of positive charge, the charged particles must be positive.

✓ (2) Since magnetic force is always perpendicular to the motion, no work is done,
thus the kinetic energy and speed must remain unchanged after emerging from the magnetic field.

✓ (3) By $B q v = \frac{m v^2}{r}$, as B, q, v are the same, mass m is proportional to the radius r.
As the radius of Q is greater, the mass of Q must be greater than that of P.

The following list of formulae may be found useful :

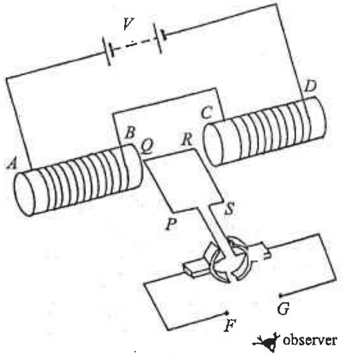
Force on a moving charge in a magnetic field	$F = BQv\sin\theta$
Force on a current-carrying conductor in a magnetic field	$F = BIl\sin\theta$
Magnetic field due to a long straight wire	$B = \dfrac{\mu_o I}{2\pi r}$
Magnetic field inside a long solenoid	$B = \dfrac{\mu_o NI}{l}$

Use the following data wherever necessary :

Permeability of free space	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
Charge of electron	$e = 1.60 \times 10^{-19}$ C
Electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
Acceleration due to gravity	$g = 9.81$ m s^{-2} (close to the Earth)

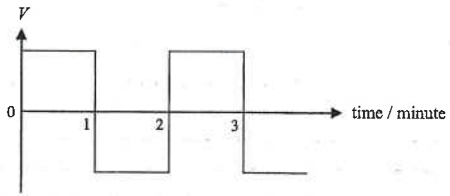
Part A : HKCE examination questions

1. **< HKCE 1984 Paper I - 8 >**



The figure above shows a simple experimental set-up to study the motion of a motor. *AB* and *CD* are solenoids connected to a battery *V*. *F* and *G* are connected to an external voltage supply. Its variation with time is shown in the following figure.

(Positive voltage *V* indicates the current flows from *F* to *G* via the coil.)



1. (a) What is the polarity of the solenoids

(i) at *B*, and

(ii) at *C* ? (2 marks)

(i) ______________________________

(ii) ______________________________

(b) What is the direction of rotation of the coil *PQRS*

(i) in the first minute,

(ii) in the second minute, and

(iii) in the third minute ? (3 marks)

(i) ______________________________

(ii) ______________________________

(iii) ______________________________

(c) What would happen to the rotation of the coil *PQRS* if the input voltage supply reversed at a high frequency (e.g. 50 Hz) ? (2 marks)

____

____

(d) Suppose that instead of being connected to the battery *V*, the terminal of the solenoid at *A* is connected to *F* and the terminal of the solenoids at *D* is connected to *G*. *F* and *G* remain connected to the external voltage supply as indicated in the above voltage-time graph.

(i) What is the direction of rotation of the coil *PQRS*

(1) in the first minute,

(2) in the second minute, and

(3) in the third minute ? (3 marks)

(1) ______________________________

(2) ______________________________

(3) ______________________________

(ii) What would happen to the rotation of the coil *PQRS* if the input voltage reversed at high frequency (e.g. 50 Hz) ? (2 marks)

____

____

(e) State 3 methods to increase the turning speed of this motor. (3 marks)

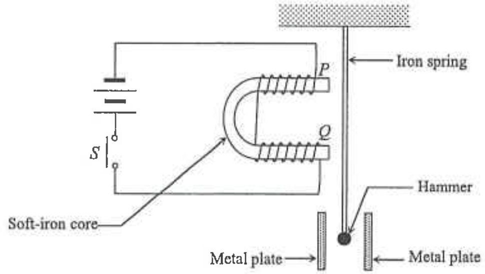
____

____

____

2. < HKCE 1993 Paper I - 5 >

A student designs a simple door bell as shown in the below figure. When switch S is pressed and then released, two notes "ding-ding" are heard.



(a) State the polarities at the two ends of the soft-iron core P and Q. (2 marks)

(b) Explain how the two notes are produced. (4 marks)

(c) Explain why soft iron is used as the core in the above design. (2 marks)

(d) Suggest one way to modify the bell so that two notes of different frequencies "ding-dong" are produced. (2 marks)

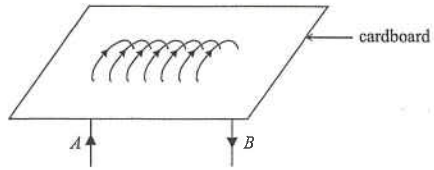
(e) Comment on the following two statements :

Statement 1 : The bell does not work if the spring is made of copper.

Statement 2 : The bell does not work if the polarities of the battery are reversed. (4 marks)

3. < HKCE 1993 Paper I - 5 >

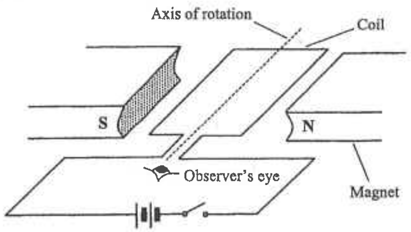
The figure below shows a solenoid passing through a piece of horizontal cardboard. A direct current passes through the solenoid from A to B to produce a magnetic field.



(a) Describe a method to find the magnetic field pattern on the cardboard using iron filings. (3 marks)

(b) Draw a diagram to show the pattern and direction of the magnetic field on the cardboard. (2 marks)

4. < HKCE 2000 Paper I - 6 >



A rectangular coil can rotate in a magnetic field as shown in the above figure. Initially the coil lies horizontally. The switch is now closed.

(a) State the initial direction of rotation of the coil as seen by the observer. (1 mark)

(b) The coil turns, oscillates a few times about the vertical position and then comes to a rest. Explain the motion of the coil. (4 marks)

5. < HKCE 2005 Paper I - 11 >

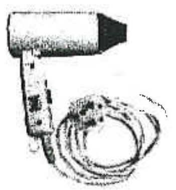


Figure 1

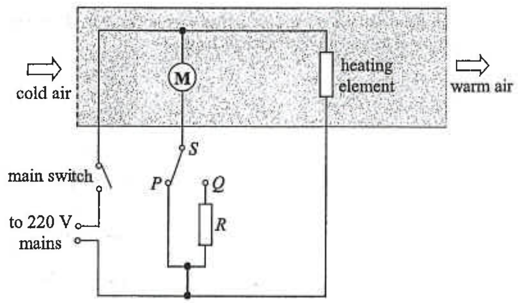


Figure 2

Figure 1 shows a simple hairdryer designed by Joseph. He makes use of a motor-driven fan and a heating element to generate warm air. Figure 2 shows the circuit diagram of the dryer. The motor and the heating element are connected to the 220 V mains. The switch S can be connected to either contact P or Q.

(a) Carmen uses the dryer to dry her wet hair. Explain, in terms of molecular motion, how the dryer can speed up the rate of evaporation of water from wet hair. (2 marks)

(b) Switch S is connected to contact P and the following data are given :

Resistance of the heating element = 50 Ω

Rate of air flowing through the dryer = 0.05 kg s^{-1}

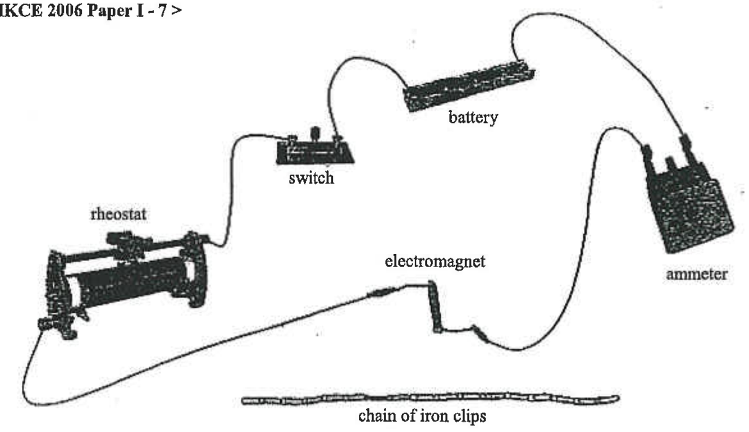
Temperature of air flowing into the dryer = 20°C

Specific heat capacity of air = 1000 J kg^{-1} °C^{-1}

Estimate the temperature of the air flowing out of the dryer, and state one assumption in your calculation. (4 marks)

(c) If switch S is connected to contact Q instead, explain whether the temperature of the air flowing out of the dryer would be higher than when S is connected to contact P. (3 marks)

6. < HKCE 2006 Paper I - 7 >

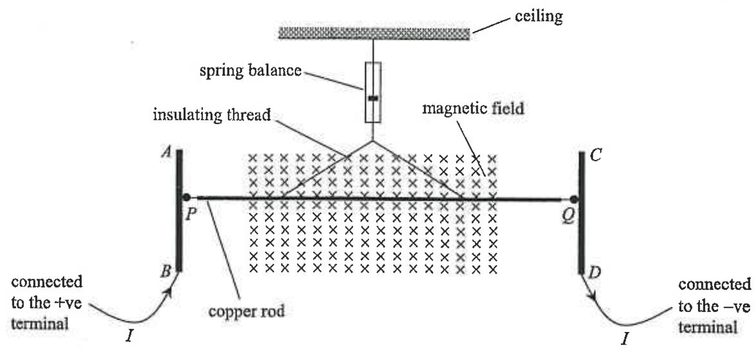


In a physics lesson, you are asked by the teacher to investigate the relationship between the strength of an electromagnet and the number of turns of its coil by using the apparatus shown in the above Figure. Describe the procedure for the experiment you should conduct. State clearly how you can measure the strength of the electromagnet. (5 marks)

7. < HKCE 2007 Paper I - 11 >

A copper rod PQ is hung at rest by insulating threads in a uniform magnetic field pointing into the paper as shown in the below Figure. The other ends of the threads are connected to a spring balance fixed on the ceiling. The two contacts P and Q at the ends of the copper rod can slide smoothly along two fixed vertical conducting rails AB and CD. The rails AB and CD are connected to the positive and the negative terminals of a d.c. power supply respectively. As a result, a current I passes through the copper rod.

Assume that the copper rod always remains horizontal and does not leave the magnetic field throughout the experiment.



7. (a) (i) In the above Figure, indicate the direction of the force F acting on the copper rod due to the current passing from P to Q. (1 mark)

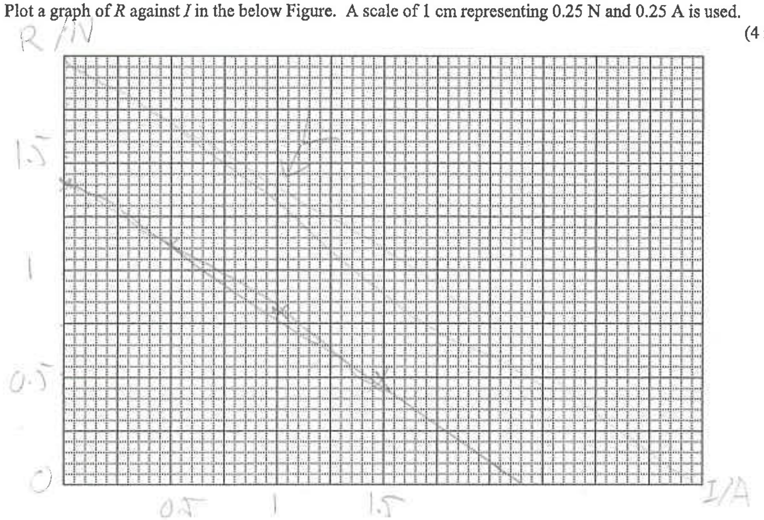
(ii) Suggest THREE methods to increase the force F. (3 marks)

(iii) Express the magnitude of force F in terms of the reading R of the spring balance and the weight W of the copper rod. (1 mark)

(b) A teacher conducts an experiment with the setup in the above Figure to find out how the reading R of the spring balance changes with the current I. The Table below shows the data collected.

R / N	1.4	1.1	0.8	0.5
I / A	0.0	0.5	1.0	1.5

(i) Plot a graph of R against I in the below Figure. A scale of 1 cm representing 0.25 N and 0.25 A is used. (4 marks)



(ii) Find the weight of the copper rod. (1 mark)

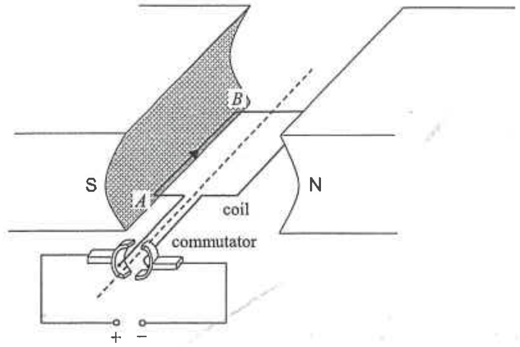
(iii) Find the maximum value of I such that the insulating threads remain taut. (1 mark)

(iv) If the experiment is repeated with a heavier copper rod, sketch a graph of R against I you would expect to obtain in the above Figure, and label it as L. (2 marks)

8. < HKCE 2008 Paper I - 8 >

Figure 1 shows the simplified structure of a motor with the plane of the coil at horizontal position. At this moment, it carries a current in the direction indicated by the arrow.

Figure 1

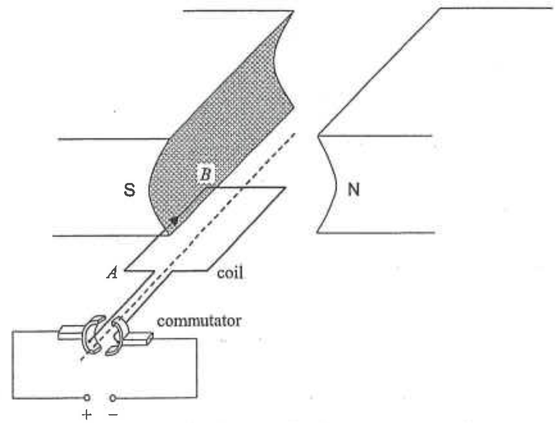


(a) Mark the direction of the magnetic force acting on the side AB in Figure 2. (1 mark)

(b) Explain how the commutator helps to keep the coil rotating in one direction. (2 marks)

(c) When the coil reaches the vertical position, the current is zero. Explain why the coil keeps on turning even no magnetic force is acting on it. (1 mark)

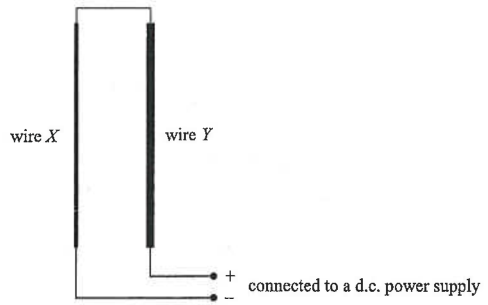
Figure 2



(d) If the coil is not fully inserted between the magnets as shown in Figure 2, describe and explain how this would affect the motion of the coil. Assume the current is the same as before. (3 marks)

9. < HKCE 2009 Paper I - 8 >

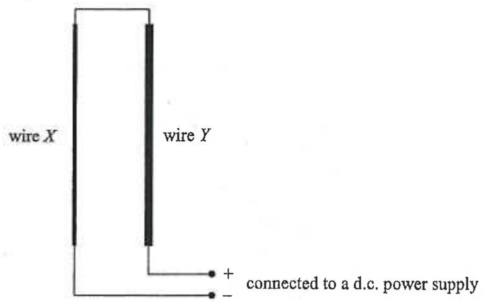
The Figure below shows two long resistance wires X and Y which are connected in series to a d.c. power supply. X and Y are made of the same material but X is thinner than Y.



(a) State the direction of the magnetic field at Y due to the current passing through X. (1 mark)

(b) There are magnetic forces F_X and F_Y acting on X and Y respectively due to the current passing through them.

(i) Indicate the direction of F_Y in the Figure below. (1 mark)



(ii) Compare the magnitudes of F_X and F_Y and explain briefly. (2 marks)

(c) Explain whether X and Y will attract and repel each other alternatively when the d.c. power supply is replaced by an a.c. power supply. (2 marks)

10. < HKCE 2010 Paper I - 12 >

Figure 1 shows a simple motor that contains two electromagnets.

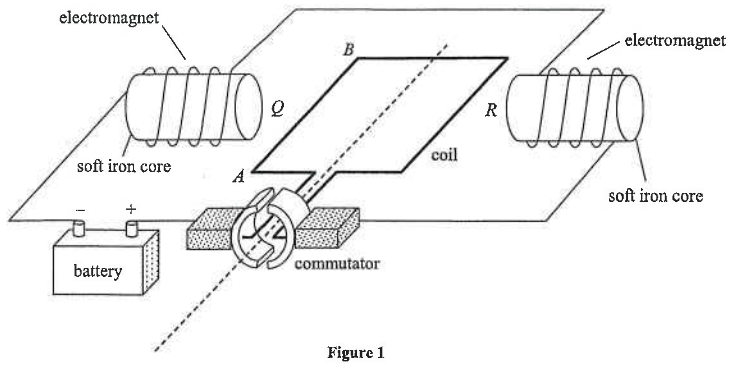


Figure 1

(a) State the polarities (north / south) of the electromagnets at Q and R and the direction (up / down) of the electromagnetic force acting on side AB of the coil at the instant shown. (2 marks)

Q ________ R ________

AB ________

(b) Figure 2 shows the instant when the coil has rotated by 180°. By considering the electromagnetic force acting on side AB, explain why the coil can continue to rotate in the same direction. (4 marks)

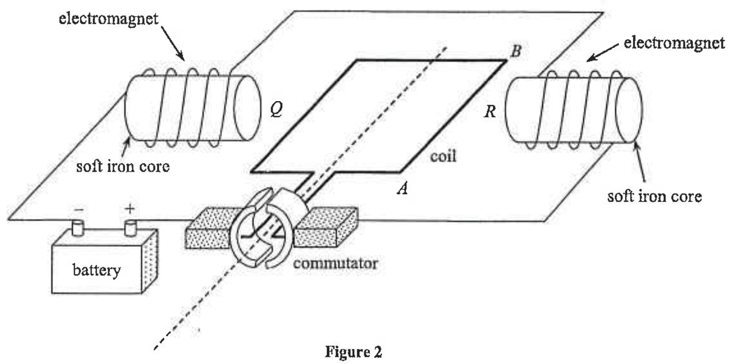
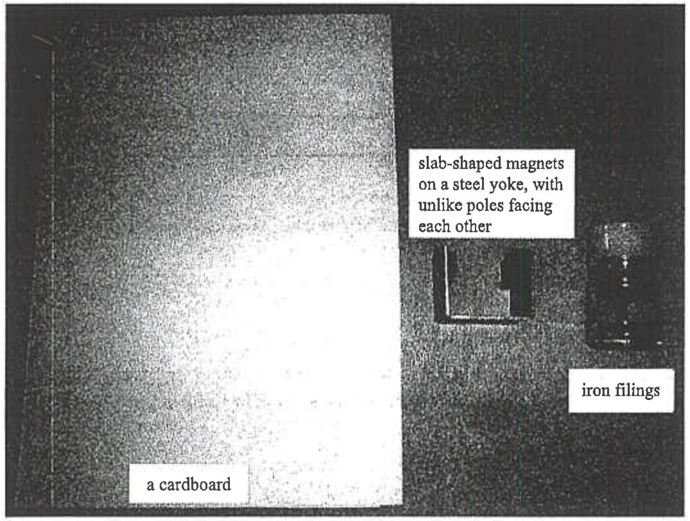


Figure 2

(c) Suggest **two** methods to increase the speed of rotation of the motor. (2 marks)

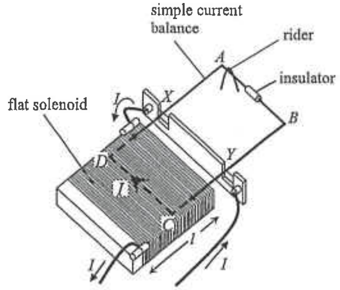
11. **< HKCE 2011 Paper I - 6 >**

The magnetic field between two slab-shaped magnets with unlike poles facing each other is uniform. Describe how to use the apparatus in the Figure below to illustrate this. (4 marks)



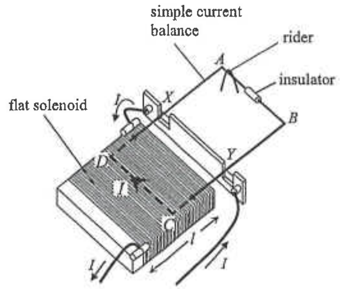
Part B : HKAL examination questions

12. **< HKAL 1996 Paper I - 8 >**



The above figure shows a simple current balance consisting of a horizontal rectangular metal loop $ABCD$ pivoting on the axis XY which is at the middle between AB and CD. Part of the current balance is inside a flat solenoid such that CD is perpendicular to the axis of the solenoid. The length of CD is 20 cm. When current I flows through the current balance $YCDX$ and then to the solenoid, a rider of mass 0.1 g has to be placed on AB to restore equilibrium. The length, l, and the number of turns, N, of the flat solenoid are 50 cm and 600 respectively.

(a) Indicate on the Figure below the direction of the magnetic field inside the solenoid. (1 mark)

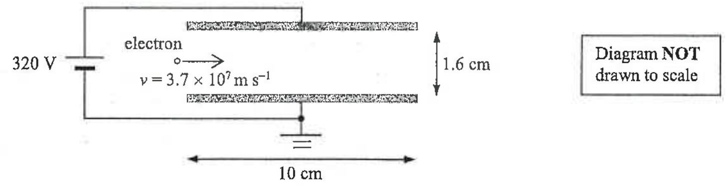


(b) (i) Express, in terms of I, an expression of the magnetic field strength inside the solenoid. Hence, find the magnetic force acting on arm CD in terms of I. (3 marks)

(ii) By considering the equilibrium of the current balance, deduce the value of the current I. (3 marks)

13. < HKAL 2006 Paper I - 4 >

In a vacuum, a beam of electrons with a horizontal velocity 3.7×10^7 m s^{-1} enters midway into a region of electric field between two horizontal square metal plates as shown in the Figure below. The length of the side of the plates is 10 cm. A voltage of 320 V is applied across the plates and the separation between them is 1.6 cm.

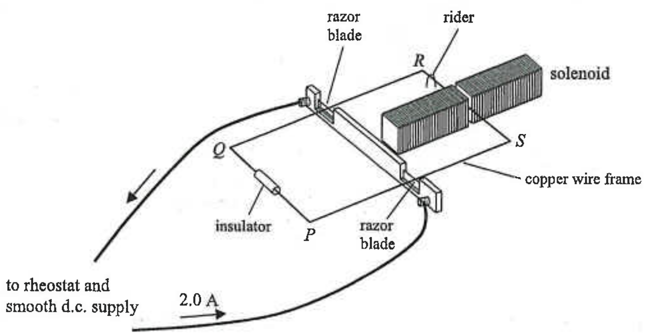


(a) Find the electric field strength between the plates. (2 marks)

(b) A uniform magnetic field normal to the paper is applied between the two plates so as to make the electron beam travel horizontally. Find the magnitude of the magnetic field applied. (Neglect the weight of the electron.) (2 marks)

14. < HKAL 2007 Paper I - 3 >

The Figure below shows a current balance which consists of a copper wire loop *PQRS* balanced on two razor blades. Two identical solenoids, each of 1500 turns, are placed coaxially such that one arm *RS* of the current balance is in the narrow gap between the two solenoids. Each solenoid is 30 cm long and has a square cross-section of 3 cm × 3 cm.



When a current of 2.0 A flows in the arm *RS* of the current balance, and the same current flows in the two solenoids in the same direction (not shown in the figure), placing a rider of mass 72 mg on the arm *RS* can restore the balance.

(a) Indicate in the above Figure the direction of the magnetic force acting on the arm *RS* and the direction of the current in the solenoids. (2 marks)

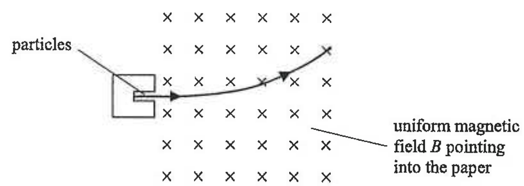
14. (b) (i) By considering the equilibrium of the current balance, find the average magnetic field B in the gap between the two solenoids. (2 marks)

(ii) By considering the current flowing in the two solenoids, calculate the magnitude B' of the magnetic field at the gap produced by the two solenoids. (2 marks)

(iii) State **TWO** possible reasons to account for the discrepancy between the two values of B and B'. (2 marks)

15. < HKAL 2010 Paper I - 4 >

(a) Particles with the speed v of 1.63×10^7 m s^{-1} are directed into an evacuated region with a uniform magnetic field B of 0.5 T perpendicular to the initial velocity of the particles as shown in the Figure below. Given that the charge to mass ratio of a particle is 4.82×10^7 C kg^{-1}, find the radius of the path described by the particles in the field region. (2 marks)

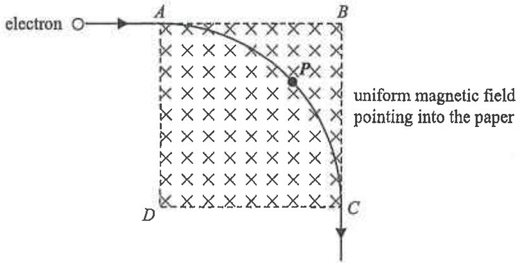


(b) Explain whether the particles would emerge with a greater speed from the region of magnetic field. (2 marks)

Part C : HKDSE examination questions

16. < HKDSE 2013 Paper IB - 4 >

An electron moving with speed 1.2×10^7 m s^{-1} enters a square region *ABCD* with a uniform magnetic field of 0.01 T pointing into the paper as shown in the figure below. The electron describes a quarter circle from *A* to *C* and it emerges from *C* with the same speed. Neglect the effects of gravity.



(a) (i) Find the magnitude of the magnetic force acting on the electron at point *P* on its path. (2 marks)

(ii) Indicate in the above Figure the direction of the electron's acceleration at the point *P*. (1 mark)

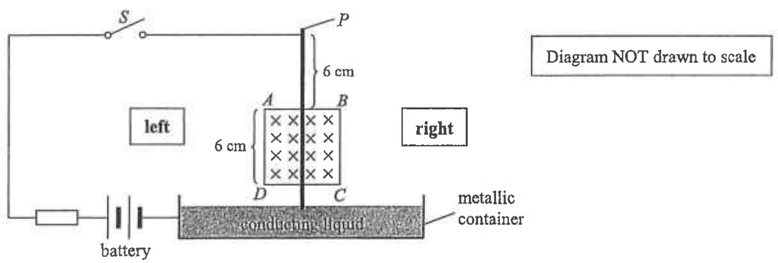
(b) Although the electron accelerates due to the magnetic force, explain why it emerges from the magnetic field with the same speed. (2 marks)

(c) Deduce the speed of the electron when entering the magnetic field such that it would describe a semi-circle from *A* to *D* instead. (2 marks)

17. < HKDSE 2015 Paper IB - 9 >

Figure (a) shows a set-up for demonstrating one of Faraday's discoveries. A light metal rod is free to rotate about point *P* while its lower end just touches some conducting liquid in a metallic container.

Figure (a)



17. A uniform magnetic field pointing into the paper is applied over the region *ABCD* containing part of the rod. When switch *S* is closed, the rod 'kicks' out and leaves the liquid surface.

(a) State the direction (to the left / to the right / out of the paper) that the rod 'kicks' and describe the subsequent motion of the rod. (3 marks)

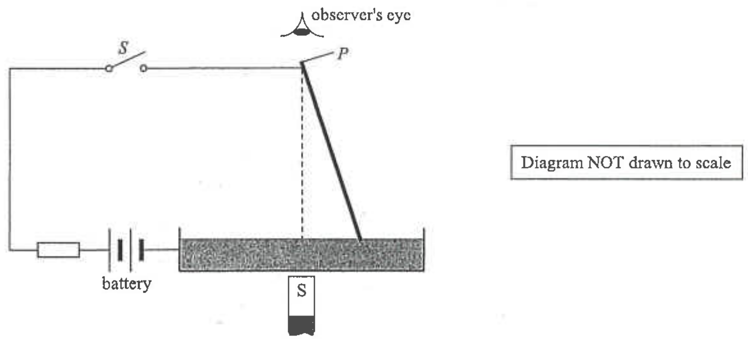
(b) When switch *S* is closed, the initial moment about point *P* that makes the rod 'kick' out is 7.2×10^{-4} N m. Assume that the magnetic force acts at the midpoint of the part of the rod within the magnetic field.

(i) Calculate the magnetic force acting on the rod at that instant. (2 marks)

(ii) Hence, find the strength *B* of the magnetic field if the current flowing through the rod is 3.2 A when the circuit is closed. (2 marks)

(c) Now the uniform magnetic field is removed and a bar magnet is placed underneath the container as shown in Figure (b). The rod is held tilted at an angle to the vertical but with its lower end still in the conducting liquid.

Figure (b)



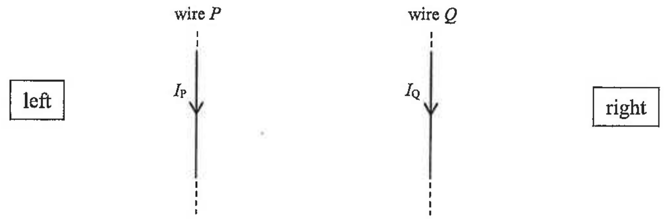
(i) Sketch on Figure (b) the field lines around the rod due to the bar magnet. (1 mark)

(ii) After closing switch *S* and the rod is released from rest, describe its subsequent motion viewed from above. (1 mark)

18. < HKDSE 2017 Paper IB - 9 >

(a) Two long straight current carrying wires, P and Q, are parallel to each other and lie on the plane of the paper as shown in Figure 1. The currents in the wires, I_P and I_Q, flow in the same direction.

Figure 1



(i) State the direction (to the left / to the right / into the paper / out of the paper) of the magnetic field at Q due to P. (1 mark)

(ii) In Figure 1, draw the direction of the magnetic force acting on Q due to P. (1 mark)

(iii) Show that the magnitude of the magnetic force per unit length F_l acting on Q due to P is

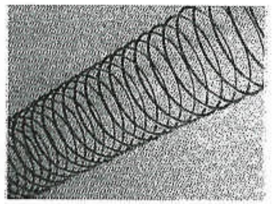
$$F_l = \frac{\mu_o I_P I_Q}{2\pi r}$$

where μ_o is the permeability of free space and r is the separation between the two wires. (3 marks)

(iv) For the magnetic force acting on Q due to P and the magnetic force acting on P due to Q, if $I_P \neq I_Q$, briefly explain whether the two forces are equal in magnitude. (2 marks)

(b) Figure 2 shows a metal slinky spring.

Figure 2



(i) If a direct current passes through the spring, briefly explain whether the spring will be compressed or stretched due to magnetic force. (2 marks)

(ii) A student suggests that the spring will be compressed and stretched alternately due to magnetic force when an alternating current passes through. Briefly explain why he is wrong. (1 mark)

There is question in next page

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

Question Solution

1. (a) (i) S-pole [1]

(ii) N-pole [1]

(b) (i) clockwise [1]

(ii) anticlockwise [1]

(iii) clockwise [1]

(c) No rotation [2]

(d) (i) (1) clockwise [1]

(2) clockwise [1]

(3) clockwise [1]

(ii) The coil would rotate continuously. [2]

(e) Any **THREE** of the following : [3]

* Increase the voltage supply
* Increase the number of turns in $PQRS$
* Increase the number of turns in the solenoids
* Insert iron rods into the two solenoids

2. (a) P is S-pole [1]

Q is N-pole [1]

(b) When S is pressed, current flows through the coil and the soft iron core is magnetized. [1]
It attracts the iron spring towards the left. [1]
The hammer strikes the left metal plate to produce the first note. [1]
When S is released, the iron core is demagnetized.
The hammer then springs back to strike the right metal plate to produce the second note. [1]

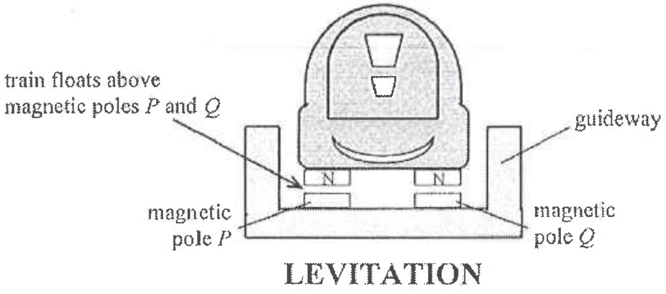
(c) Soft iron is a magnetic material. [1]
It can increase the strength of the magnetic field. [1]

(d) Any **ONE** of the following : [2]

* Replace one metal plate with another made of a different metal
* Change the length of one of the metal plates
* Change of the thickness of one of the metal plates
* Stick a lump of plasticine to one plate

Read the following passage about a **magnetically levitated (maglev) train** and answer the questions that follow.

'A maglev train car is just a box with magnets on the four corners,' says Jesse Powell, the son of the maglev train inventor. The electromagnets employed have superconducting coils (i.e. coils with extremely low resistance). They therefore can generate magnetic fields 10 times stronger than ordinary electromagnets, enough to levitate and propel a train.



Two sets of magnetic fields are set up for different functions. One is to make the train float a few centimetres above magnetic poles *P* and *Q* as shown while the other is a propulsion system run by an alternating current for moving the train car along the guideway by magnetic attraction and repulsion. This floating design enables a smooth movement of the train. Even when the train travels up to 600 km per hour, passengers inside experience less vibration than travelling on traditional trains.

(a) Explain why electromagnets employing superconducting coils can produce much stronger magnetic fields. (2 marks)

(b) State the polarities of the magnetic poles *P* and *Q* and explain how this arrangement enables the train to float. (2 marks)

(c) Referring to the resistive forces experienced by the train, explain why a maglev train ride is (i) smoother and (ii) faster. (2 marks)

2. (e) Statement 1 is correct. [1]

Copper is not a magnetic material, it cannot be attracted by the electromagnet. [1]

Statement 2 is not correct. [1]

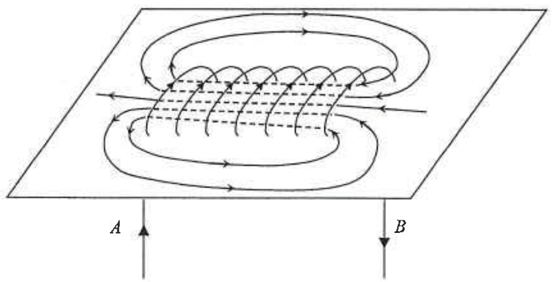
If the polarities of the battery are reversed,
the soft iron core can still be magnetized and attracted by the electromagnet. [1]

3. (a) Sprinkle some iron filings on the board. [1]

Tap the board gently. [1]

The magnetic field pattern is shown by the pattern of the iron filings. [1]

(b)



< Direction magnetic field lines correct > [1]

< Pattern of magnetic field lines correct > [1]

4. (a) The coil rotates in clockwise direction. [1]

(b) When the switch is closed, current flows through the coil. As the coil is placed in a magnetic field, there are magnetic forces acting on the wires to rotate the coil and the coil turns clockwise. [1]

When the coil turns to the vertical position, the turning effect becomes zero.

Due to inertia, the coil shoots through the vertical position to the other side. [1]

The direction of the turning effect acting on the coil reverses
and the coil rotates back in the opposite direction (anticlockwise). This process repeats. [1]

As energy is lost against friction during the motion, the coil will finally stop in the vertical position. [1]

5. (a) More water molecules gain enough energy to escape from the water surface. [1]

The water molecules after escaped from the water surface would be blown away by the wind from the dryer. [1]

5. (b) Power given out by the heating element :

$$P = \frac{V^2}{R}$$

$$= \frac{(220)^2}{(50)}$$

$= 968$ W [1]

Assume no heat lost to the surroundings. [1]

$E = P\,t = m\,c\,\Delta T$ [1]

$\therefore$ $(968)(1) = (0.05)(1000)(\theta - 20)$

$\therefore$ $\theta = 39.4°C$ < accept $\theta = 39.36°C$ > [1]

(c) If S is connected to contact Q, the current flowing through the motor is reduced. [1]

The speed of the rotation of the fan is decreased. [1]

As the rate of air flowing through the dryer is reduced,

the temperature of air flowing out would be higher. [1]

6. Use the electromagnet to attract the iron clips. [1]

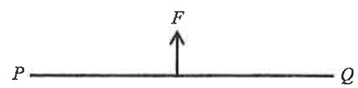
Record the number of iron clips when the chain just falls down. [1]

Change the number of turns of the coil and repeat the above procedure. [1]

Record the change of the number of iron clips when the chain just falls down. [1]

In each trial, the current should be kept constant. [1]

7. (a) (i) [1]



(ii) ① Increase the strength of the magnetic field. [1]

② Increase the current. [1]

③ Widen the magnetic field so that the length of the rod in the magnetic field is increased. [1]

< Do not accept : increase the length of the rod >

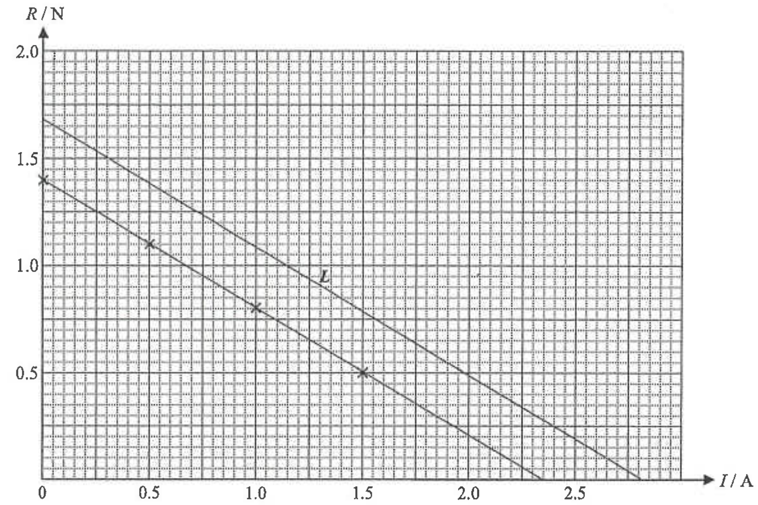
< Do not accept : decrease the resistance of the rod >

< Do not accept : decrease the weight of the rod >

(iii) Balance of forces : $F + R = W$

$\therefore$ $F = W - R$ [1]

7. (b) (i)



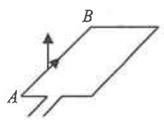
< Correct labelled axes with units > [1]
< Correct scale > [1]
< Correct points plotted > [1]
< Correct straight line through the points > [1]

(ii) W = 1.4 N < accept 1.35 N to 1.45 N > [1]

(iii) When $R = 0$, I = 2.35 A < accept 2.3 A to 2.4 A > [1]

(iv) < The line is above the original line > [1]
< The line is parallel to the original line > [1]

8. (a)



[1]

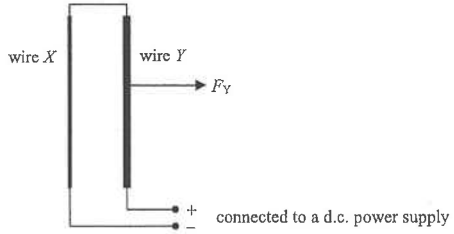
(b) Commutator can reverse the direction of the current through the coil [1]
whenever the coil has rotated half cycle. [1]

(c) due to inertia [1]

(d) Since length of wire inside the magnetic field is decreased, [1]
magnetic force acting on the wire decreases, [1]
thus the rotation speed of the motor decreases. [1]

9. (a) out of paper [1]

(b) (i)



[1]

(ii) The magnitudes of the two forces are equal (**OR** $F_X = F_Y$) [1]
because they are action-reaction pair. [1]

(c) The directions of the current in X and Y are always opposite. [1]
The forces are always repulsive. (**OR** The forces will not attract and repel alternately.) [1]

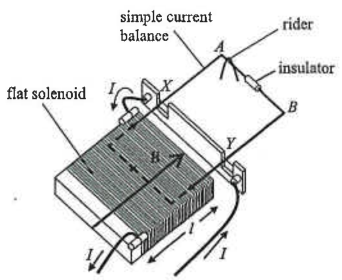
10. (a) Q north < accept N >
R south < accept S > [1]
AB down [1]

(b) The current in the coil is reversed [1]
due to the commutator. [1]
But the direction of magnetic field produced remains unchanged. [1]
So the force acting on side AB points up and the coil continues to rotate. [1]

(c) Any **TWO** of the followings : [2]
* Use a battery of higher voltage. (**OR** Increase the current.)
* Increase the number of turns of the coil.
* Increase the area of coil in the magnetic field.
* Insert a soft iron core in the coil.
* Increase the number of turns of the winding in the solenoid.

11. Put the cardboard on top of the magnets. [1]
Sprinkle some iron filings onto the cardboard. [1]
Tap the cardboard gently to show the magnetic field pattern. [1]
The iron filings will form evenly spaced parallel lines between the magnets. [1]

12. (a)



[1]

(b) (i) $B = \dfrac{4\pi\times10^{-7}\times600\times I}{0.5}$ [1]

$F = B\,I\,L$

$= \dfrac{4\pi\times10^{-7}\times600\times I}{0.5}\times I\times(0.2)$ [1]

$= 3.02\times10^{-4}\,I^2$ < accept $3.0\times10^{-4}\,I^2$ > [1]

(ii) $F = m\,g$ [1]

$\therefore$ $(3.02\times10^{-4}\,I^2) = (0.1\times10^{-3})\,(9.81)$ [1]

$\therefore$ $I = 1.80$ A < accept 1.81 A > [1]

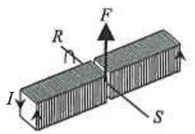
13. (a) $E = \dfrac{V}{d} = \dfrac{320}{0.016}$ [1]

$= 2\times10^{4}\ \text{V m}^{-1}$ [1]

(b) $B\,Q\,v = Q\,E$ [1]

$\therefore$ $B = \dfrac{E}{v} = \dfrac{2\times10^4}{3.7\times10^7} = 5.41\times10^{-4}$ T [1]

14. (a)



< Magnetic force F is upwards > [1]

< Current I is anticlockwise when viewed from left > [1]

(b) (i) $F = m\,g = B\,I\,L$

$(72\times10^{-6})\,(9.81) = B\,(2)\,(0.03)$ [1]

$\therefore$ $B = 0.0118$ T [1]

14. (b) (ii) $B' = \mu_0\,n\,I$

$= (4\pi\times10^{-7})(\dfrac{1500}{0.3})(2)$ [1]

$= 0.0126$ T [1]

(iii) Any **TWO** of the followings : [2]

* The solenoids are not infinitely long.
* There is air gap between the two solenoids.
* The Earth's magnetic field may affect the result.
* The arm RS may not be exactly perpendicular to the magnetic field.
* Since it is difficult to balance, some error may occur for the mass of rider obtained.

15. (a) $B\,Q\,v = \dfrac{m\,v^2}{r}$ $\therefore$ $\dfrac{Q}{m}B\,r = v$ [1]

$\therefore$ $(4.82\times10^7)\,(0.5)\,r = 1.63\times10^7$

$\therefore$ $r = 0.676$ m [1]

(b) No.

Since the magnetic force acting on the particle is always perpendicular to its velocity, [1]

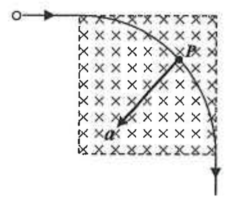
no work is done on the particle by the magnetic force. [1]

16. (a) (i) $F = B\,Q\,v$

$= (0.01)\,(1.6\times10^{-19})\,(1.2\times10^{7})$ [1]

$= 1.92\times10^{-14}$ N [1]

(ii)



< direction of a : towards the centre of the circular arc > [1]

(b) F is always perpendicular to the velocity of the electron, [1]

thus, no work is done and the kinetic energy remains unchanged. [1]

OR

Electron only changes direction while speed remains unchanged, [1]

no work is done and the kinetic energy remains unchanged. [1]

16. (c) $F = BQv = \dfrac{mv^2}{r}$ [1]

$\therefore\ v = \dfrac{BQ}{m} r$

As $\dfrac{BQ}{m}$ is constant, if r is halved, v is also halved.

$\therefore\ v = 0.6 \times 10^7\ \mathrm{m\ s^{-1}}$ < accept $6 \times 10^6\ \mathrm{m\ s^{-1}}$ > [1]

17. (a) The rod 'kicks' to the right. [1]

The rod then leaves the liquid and the circuit is not complete.

Therefore, current stops flowing and the rod swings back to the original position. [1]

The above process then repeats so the rod continually kicks out and then returns. [1]

(b) (i) Moment $= F \times d$

$\therefore\ (7.2 \times 10^{-4}) = F \times (0.06 + 0.03)$ [1]

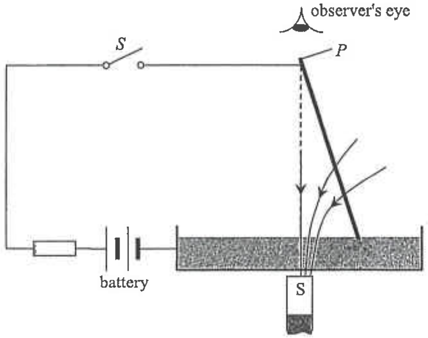
$\therefore\ F = 8 \times 10^{-3}\ \mathrm{N}$ [1]

(ii) By $F = BIL$

$\therefore\ (8 \times 10^{-3}) = B\,(3.2) \times (0.06)$ [1]

$\therefore\ B = 0.0417\ \mathrm{T}$ < accept 0.042 T > [1]

(c) (i)



[1]

(ii) The rod rotates in anticlockwise direction. [1]

18. (a) (i) The magnetic field at Q due to P points out of the paper. [1]

(ii) [1]

18. (a) (iii) The magnetic field at Q due to P :

$B_Q = \dfrac{\mu_o I_P}{2\pi r}$ [1]

Magnetic force on Q with length l :

$F = B_Q I_Q l$ [1]

$= \dfrac{\mu_o I_P}{2\pi r} \cdot I_Q l$

Magnetic force per length :

$F_l = \dfrac{F}{l} = \dfrac{\mu_o I_P I_Q}{2\pi r}$ [1]

(iv) The two forces form an action and reaction pair, [1]

thus they are equal in magnitude. [1]

(b) (i) As current passes in the same direction between two adjacent wires, [1]

the wires attract each other, thus the solenoid is compressed. [1]

(ii) Currents between two adjacent wires always flows in the same direction at any instant, [1]

thus, the solenoid will always be compressed.