Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

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

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

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

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

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

Physics – Elective part (選修部分)

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

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

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

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

DSE Physics - Section D : M.C. PD - EM5 - M / 01
EM5 : Electromagnetic Induction

The following list of formulae may be found useful :

Induced e.m.f.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$
Force on a current-carrying conductor in a magnetic field	$F = BIl\sin\theta$
Magnetic field due to a long straight wire	$B = \frac{\mu_o I}{2\pi r}$
Magnetic field inside a long solenoid	$B = \frac{\mu_o NI}{l}$

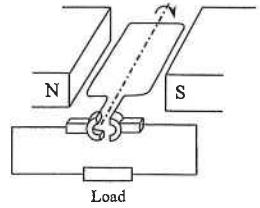
Use the following data wherever necessary :

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 1981 Paper II - 34 >**

Which of the following statements concerning the generator shown in the figure is/are correct ?



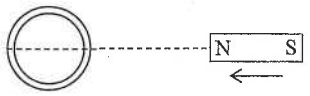
(1) The direction of the current through the load reverses periodically.

(2) The maximum magnitude of the current depends on the speed of rotation of the coil.

(3) The maximum magnitude of the current depends on the resistance of the load.

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

2. **< HKCE 1983 Paper II - 33 >**



The figure shows a bar magnet moving along the diameter of a metal ring. Which of the following will happen ?

A. An induced current will flow in a clockwise direction in the ring.
B. An induced current will flow in an anticlockwise direction in the ring.
C. An alternating current will be produced in the ring.
D. No induced current will be produced.

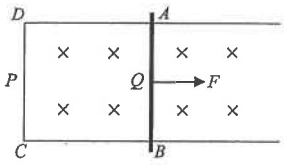
3. **< HKCE 1984 Paper II - 25 >**

Which of the following devices is designed to convert mechanical energy into electrical energy ?

A. dynamo
B. transformer
C. motor
D. electric cell

4. **< HKCE 1985 Paper II - 42 >**

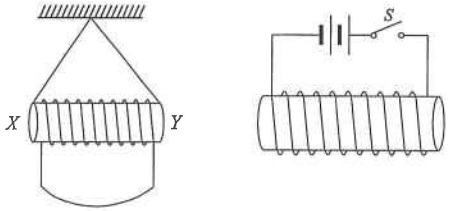
A copper rod AB is free to move on two parallel conducting wires. It is pulled by a force F and moves in the direction shown in the figure. The direction of the magnetic field points into the paper. Which of the following statements is/are true ?



(1) A current will flow from C to D through P.
(2) A current will flow from B to A through Q.
(3) An induced voltage will be set up across AB.

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

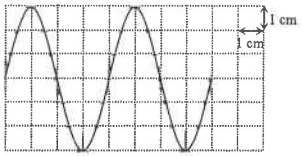
5. **< HKCE 1987 Paper II - 34 >**



A light coil of wire XY is suspended by insulating string such that it can swing freely. A solenoid connected to a cell with a switch S is placed near to the end Y of the coil as shown. What would happen to the coil XY just when the switch S is closed ?

A. The coil moves towards the solenoid.
B. The coil moves away from the solenoid.
C. The coil would move down.
D. The coil would move up.

6. **< HKCE 1989 Paper II - 42 >**



The figure shows the display on a CRO with the time base set at 1 ms cm^{-1} and Y-gain at 0.5 V cm^{-1}. The peak voltage and frequency of the a.c. voltage applied across the Y-plates are

	peak voltage	frequency
A.	1.5 V	500 Hz
B.	1.5 V	250 Hz
C.	3.0 V	50 Hz
D.	3.0 V	250 Hz

7. **< HKCE 1989 Paper II - 35 >**

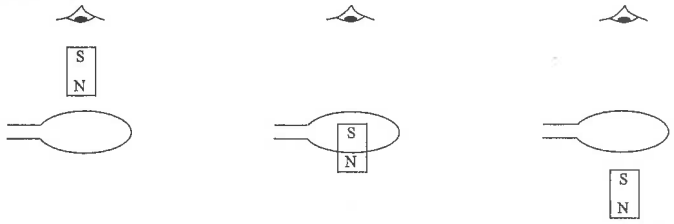


Figure (1) Figure (2) Figure (3)

A magnet is allowed to fall through a copper ring. What is the direction of the induced current (if any) on the ring observed by the eye when the magnet is in the position as shown in Figure (1), (2) and (3) ?

	Figure (1)	Figure (2)	Figure (3)
A.	Clockwise	No current	Anticlockwise
B.	Anticlockwise	No current	Clockwise
C.	Anticlockwise	No current	Anticlockwise
D.	Anticlockwise	Anticlockwise	Clockwise

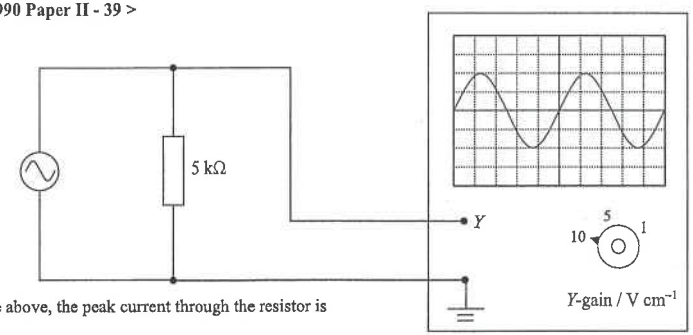
8. **< HKCE 1990 Paper II - 36 >**

Figure 1 Figure 2

In Figure 1, the galvanometer deflects to the left with a reading of 10 μA. The north pole of the same magnet is now pushed towards the coil from the other side at a faster rate as shown in Figure 2. The deflection on the galvanometer will be

A. more than 10 μA to the right.
B. less than 10 μA to the left.
C. more than 10 μA to the left.
D. less than 10 μA to the right.

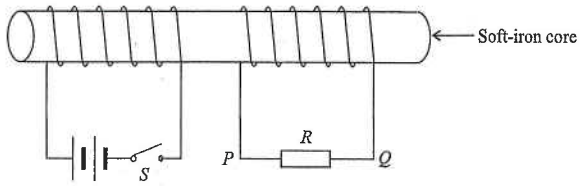
9. **< HKCE 1990 Paper II - 39 >**



In the figure above, the peak current through the resistor is

A. 2 mA
B. 4 mA
C. 8 mA
D. 4 A

10. < HKCE 1993 Paper II - 34 >

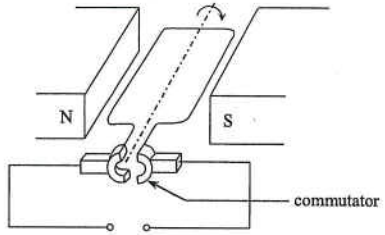


Two coils of conducting wires are wrapped on a soft-iron core as shown in the above figure. Switch S is closed and after a while re-opened. Which of the following statements is/are true ?

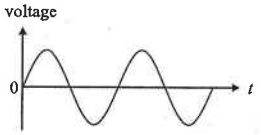
(1) At the moment when S is closed, a current flows through R from P to Q.
(2) When S remains closed, there is no current flowing through R.
(3) At the moment when S is re-opened, a current flows through R from P to Q.

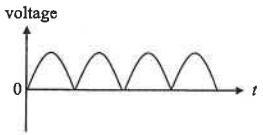
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

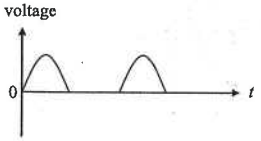
11. < HKCE 1993 Paper II - 37 >

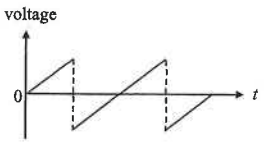


The above diagram shows a simple generator. Which of the following graphs below shows the time variation of the voltage produced by the generator ?

A.


B.


C.


D.


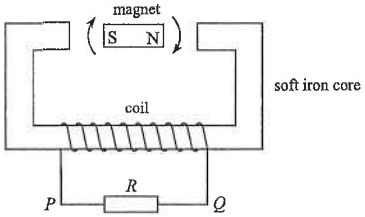
12. < HKCE 1994 Paper II - 31 >

Which of the following statements about direct current (d.c.) and alternating current (a.c.) is/are correct ?

(1) All d.c. sources produce constant voltages.
(2) The direction of current in an a.c. circuit changes with time.
(3) Both d.c. and a.c. produce a heating effect in a resistor.

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

13. < HKCE 1994 Paper II - 36 >



A magnet is initially placed between the ends of a soft iron core as shown above. The magnet is then quickly rotated clockwise through one complete revolution. Which of the following statements correctly describes the induced current flowing through the resistor R ?

A. The current flows through R from P to Q, and then reverses its direction.
B. The current flows through R from Q to P, and then reverses its direction.
C. The current flows through R from P to Q.
D. The current flows through R from Q to P.

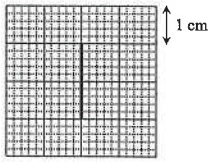
14. < HKCE 1994 Paper II - 32 >

Which of the following correctly shows the major energy change in the device when it is working ?

	Device	From	To
A.	A microphone	electrical	sound
B.	A loudspeaker	sound	electrical
C.	A dynamo	electrical	electrical
D.	A motor	electrical	mechanical

15. < HKCE 1994 Paper II - 37 >

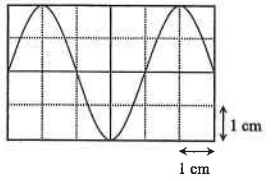
The diagram shows the trace of a signal on a CRO with the time base switched off. The Y-gain is set at 1 V cm^{-1}. Which of the following statements correctly describes the input signal ?



A. It is an a.c. of peak voltage 1 V.
B. It is an a.c. of peak voltage 2 V.
C. It is a d.c. of constant voltage 1 V.
D. It is a d.c. of constant voltage 2 V.

16. < HKCE 1995 Paper II - 37 >

The diagram shows the display on a CRO with the time base at 10 ms cm^{-1} and Y-gain at 0.5 V cm^{-1}. Find the peak voltage and frequency of the signal applied across the Y-plates.



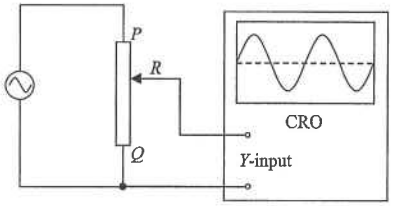
	Peak voltage / V	Frequency / Hz
A.	1	16.7
B.	1	25
C.	1	50
D.	2	25

17. < HKCE 1996 Paper II - 31 >

Which of the following devices is **not** an application of electromagnetic induction ?

A. a bicycle dynamo
B. a magnetic tape playback head
C. a moving coil microphone
D. a moving coil loudspeaker

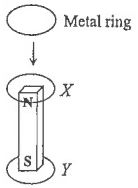
18. **< HKCE 1997 Paper II - 36 >**



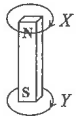
In the above circuit, the terminal Q and the sliding contact R of the variable resistor are connected to the Y-input of a CRO. If R is moved towards P, how would the amplitude and period of the trace displayed on the CRO be affected ?

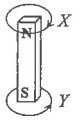
	Amplitude of the trace	Period of the trace
A.	increases	remains unchanged
B.	increases	increases
C.	decreases	remains unchanged
D.	decreases	decreases

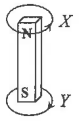
19. **< HKCE 1997 Paper II - 34 >**

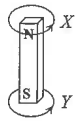


A metal ring is released and falls vertically around a magnet as shown in the above diagram. Which of the following diagrams correctly describes the directions of the induced current, if any, in the ring at positions X and Y ?

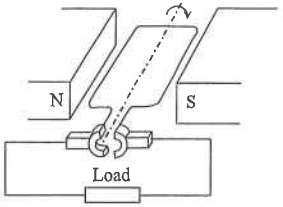
A. 

B. 

C. 

D. 

20. **< HKCE 1997 Paper II - 37 >**

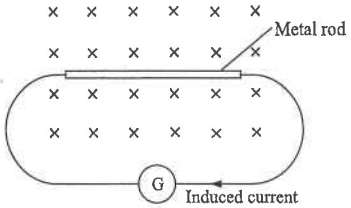


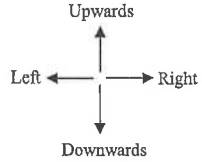
The diagram shows an electricity generator connected to a load. Which of the following can increase the voltage produced by the generator ?

(1) Rotating the coil at a greater speed
(2) Reducing the resistance of the load
(3) Replacing the coil with one of larger area

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

21. **< HKCE 1998 Paper II - 34 >**



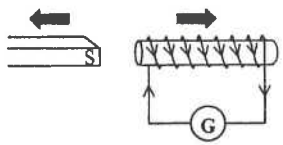


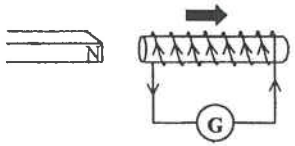
In the above diagram, a metal rod is placed inside a magnetic field pointing into the paper. In which direction should the rod be moved in order to produce an induced current as shown in the diagram ?

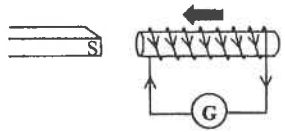
A. into the paper
B. out of the paper
C. upwards
D. downwards

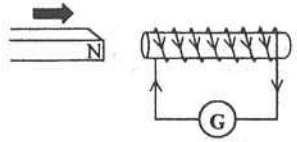
22. **< HKCE 2000 Paper II - 38 >**

A bar magnet is placed near a solenoid. Which of the following correctly shows the direction of the induced current in the solenoid ? (Note : The arrow " → " indicates the direction of motion of the magnet or solenoid.)

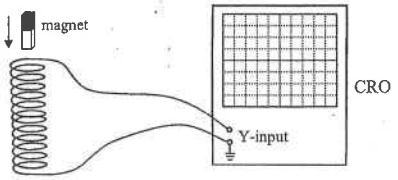
A. 

B. 

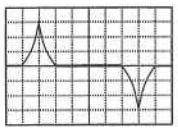
C. 

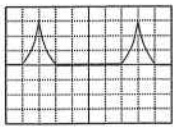
D. 

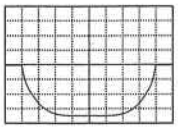
23. **< HKCE 2001 Paper II - 35 >**

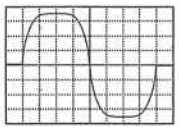


A long solenoid is placed in a vertical position and its two ends are connected to the Y-input of a CRO (with the time base switched on). A bar magnet is released above the solenoid so that it falls through the solenoid. Which of the following figures best represents the trace shown on the CRO ?

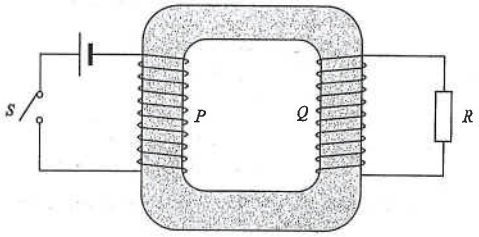
A. 

B. 

C. 

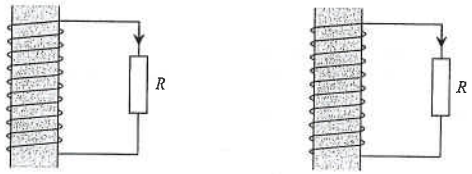
D. 

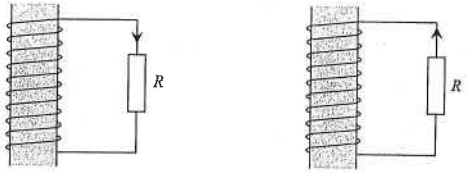
24. < HKCE 2003 Paper II - 37 >

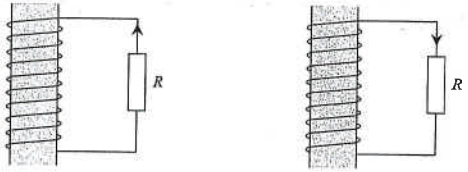


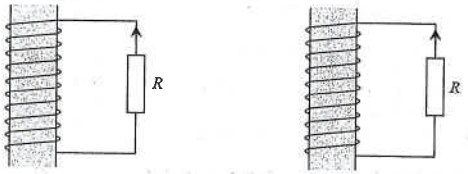
Two coils P and Q are wound on a soft-iron core as shown above. Switches S is closed and then opened again. Which of the following shows the directions of the induced current flowing through the resistor R ?

At the instant S is closed **At the instant S is opened again**

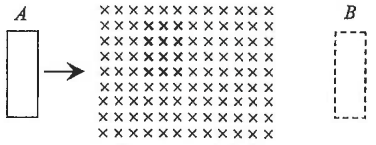
A.


B.


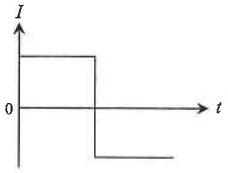
C.


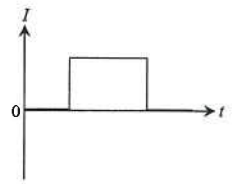
D.


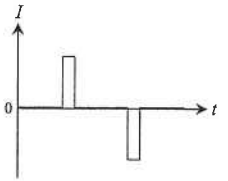
25. < HKCE 2004 Paper II - 35 >

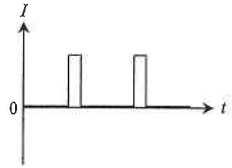


A rectangular coil is moved with a uniform speed from position A to position B as shown above. Which of the following graphs represents the variation of the current induced in the coil with time ?

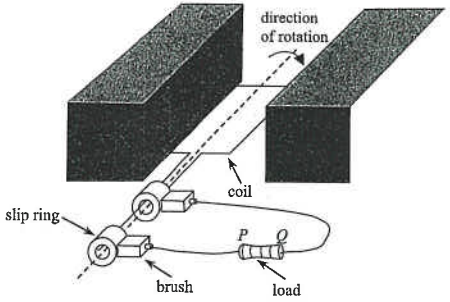
A.


B.


C.


D.


26. < HKCE 2004 Paper II - 36 >

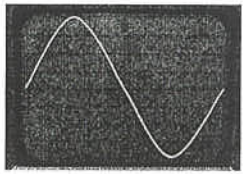


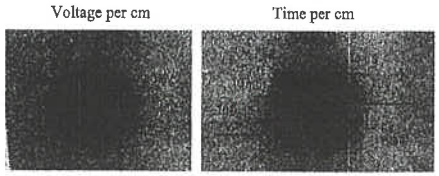
The diagram shows a generator connected to a load. Which of the following statements is/are correct ?

(1) The generator produces an alternating current through the load.
(2) At the instant shown, a current is flowing through the load from P to Q.
(3) The current produced reaches a maximum when the coil is vertical.

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

27. **< HKCE 2004 Paper II - 38 >**

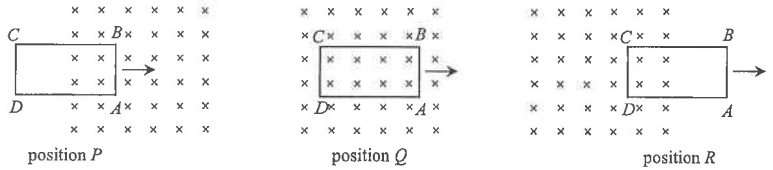




The photographs show the trace of a signal on a CRO and some settings of the CRO. The voltage gain is set at 0.5 V per cm and the time-base is set at 10 ms per cm. Find the frequency and peak voltage of the input signal.

	Frequency / Hz	Peak Voltage / V
A.	10	2
B.	10	4
C.	20	2
D.	20	4

28. **< HKCE 2005 Paper II - 42 >**

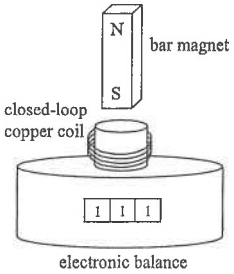


A conducting rectangular coil *ABCD* is moved across a uniform magnetic field pointing into the paper as shown above. Which of the following statements is/are correct ?

(1) The induced current flows from *A* to *C* through *B* when the coil is at *P*.
(2) The magnitude of the induced current is the largest when the coil is at *Q*.
(3) The direction of the induced current when the coil is at *R* is the same as that when it is at *P*.

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

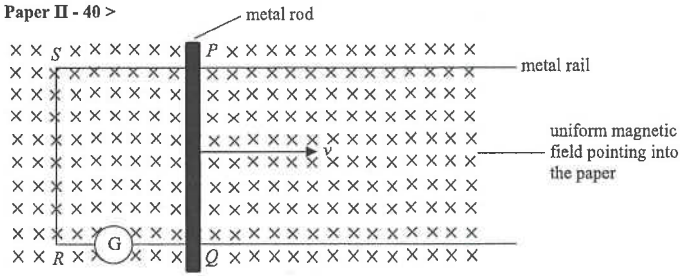
29. **< HKCE 2007 Paper II - 43 >**



An electronic balance reads *X* when a closed-loop copper coil is placed on it as shown above. A bar magnet drops from certain height vertically above. Just before the magnet reaches the coil, the reading of the electronic balance is

A. the same as *X*.
B. first smaller than *X* and then greater than *X*.
C. smaller than *X*.
D. greater than *X*.

30. **< HKCE 2007 Paper II - 40 >**

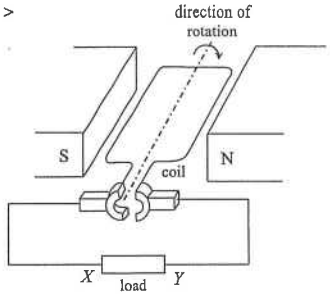


Under an external force, a metal rod *PQ* is moving with a uniform speed *v* on a metal rail placed in a uniform magnetic field as shown above. Which of the following descriptions is/are correct ?

(1) Current flows through the galvanometer from *Q* to *R*.
(2) The metal rod will accelerate to right if the direction of the magnetic field is reversed.
(3) The pointer of the galvanometer will deflect to opposite direction if the direction of the magnetic field is reversed.

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

31. **< HKCE 2007 Paper II - 42 >**



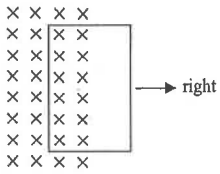
The above figure shows a simple structure of a d.c. generator. Which of the following statements is/are correct ?

(1) The current delivered to the load is constant.
(2) The current generated in the coil is alternating, but the current delivered to the load is unidirectional.
(3) The current flows through the load from *X* to *Y*.

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

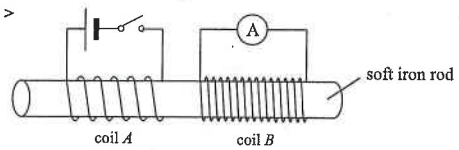
32. **< HKCE 2008 Paper II - 40 >**

In the figure, a rectangular coil is pulled to the right with uniform speed in a uniform magnetic field pointing into the paper. Which of the following descriptions about the current induced in the coil and the magnetic force acting on the coil is correct ?



A. No current is induced in the coil and no magnetic force is acting on the coil.
B. A current is induced in the coil but the resultant magnetic force acting on the coil is zero.
C. A current is induced in the coil and a resultant magnetic force is acting on the coil to the left.
D. A current is induced in the coil and a resultant magnetic force is acting on the coil to the right.

33. **< HKCE 2008 Paper II - 39 >**

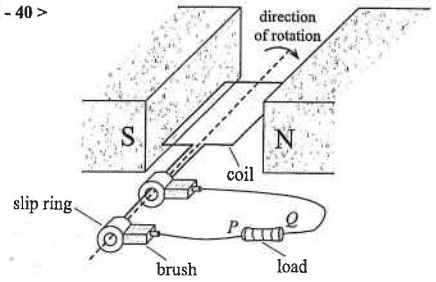


An experiment about electromagnetism is designed as shown above. Coil *B* has a greater number of turns than coil *A*. Coil *B* is connected to a sensitive ammeter. Which of the following statements is/are correct ?

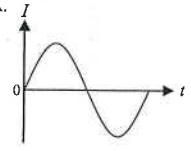
(1) When the switch is closed, a steady current flows through the ammeter.
(2) At the moment the switch is opened, a current flows through the ammeter momentarily.
(3) If the soft iron rod is replaced by a glass rod, the ammeter will have a greater deflection at the moment the switch is opened.

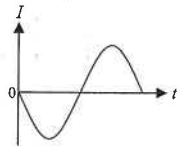
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

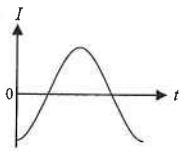
34. **< HKCE 2009 Paper II - 40 >**

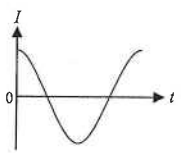


The figure above shows the position of the coil in a generator at time $t = 0$. The current is taken to be positive when it flows from *P* to *Q* through the load. Which of the following graphs best represents the variation of current *I* with time *t* as the coil rotates ?

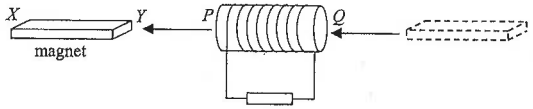
A. 

B. 

C. 

D. 

35. **< HKCE 2009 Paper II - 39 >**

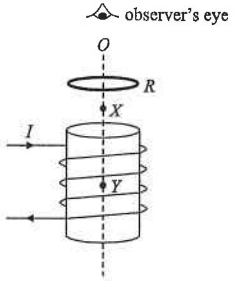


When a magnet is moving towards end *Q* for a solenoid, it is found that a north pole is induced at end *Q*. As shown in the figure above, the magnet passes through and moves away from the solenoid, what are the polarities of end *P* of the solenoid and end *X* of the magnet ?

	polarity of end *P*	polarity of end *X*
A.	S	S
B.	S	N
C.	N	S
D.	N	N

36. **< HKCE 2010 Paper II - 42 >**

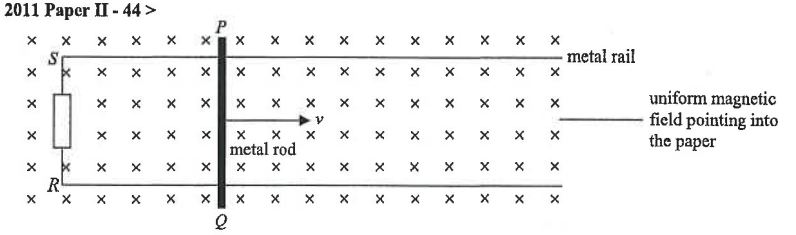
A copper ring *R* is falling through a solenoid along the axis as shown. The plane of the ring is kept horizontal throughout. The solenoid is carrying a steady current *I*. *Y* is the centre of the solenoid.



Which of the following combinations about the directions of the induced current in the ring (if any) at *X* and at *Y* as observed from *O* is correct ?

	at *X*	at *Y*
A.	clockwise	clockwise
B.	clockwise	no current
C.	anticlockwise	anticlockwise
D.	anticlockwise	no current

37. **< HKCE 2011 Paper II - 44 >**



A metal rod *PQ* is moving with a uniform speed *v* on a metal rail placed in a uniform magnetic field as shown in the figure above. A resistor is connected across *RS*. Which of the following descriptions is/are correct ?

(1) Kinetic energy of the rod is converted into electrical energy.
(2) Current flows through the resistor from *S* to *R*.
(3) The induced current will be reversed if the rod moves in the opposite direction.

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

Part B : HKAL examination questions

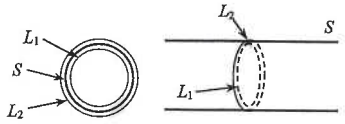
38. **< HKAL 1980 Paper I - 23 >**

The magnetic flux through a coil of *N* turns increases at a uniform rate from zero to Φ in time *t*. What is the magnitude of the e.m.f. induced in the coil ?

A. $N\Phi t$
B. $\Phi t / N$
C. $N\Phi / t$
D. Nt / Φ

39. **< HKAL 1982 Paper I - 25 >**

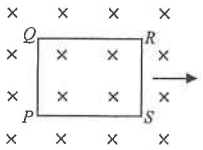
S is a long solenoid. L_1 is a wire loop just inside the solenoid, and L_2 is a wire loop just outside the solenoid. The current in the solenoid is increased at a steady rate, such that the e.m.f. induced in L_1 is 1.2 V. Find the e.m.f. induced in L_2.



A. 0 V.
B. 0.6 V.
C. 1.2 V.
D. 2.4 V.

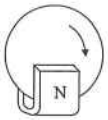
40. **< HKAL 1983 Paper I - 21 >**

Rectangular coil $PQRS$ is driven with constant velocity towards the right in a uniform magnetic field directed perpendicular into paper as shown in the figure. Which of the following statements is correct at the instant shown in the figure ?

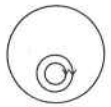


A. The magnitude of the magnetic flux through the coil changes with time.
B. An induced current is flowing in the coil in the anticlockwise direction.
C. An electromagnetic force acts on the side PQ in a direction opposing its motion.
D. There is no induced current flowing in the coil.

41. **< HKAL 1984 Paper I - 27 >**



A large copper disc mounted on a horizontal axle is spun in the clockwise direction between the poles of a horseshoe magnet. Which of the following diagrams correctly shows the eddy currents flowing in the disc ?

A. 
B. 
C. 
D. 

42. **< HKAL 1984 Paper I - 22 >**

A solenoid has a length of 0.30 m and cross-sectional area of 3.2×10^{-4} m^2. There are 1000 turns of wire wound on it. When the solenoid carries a current of 1.5 A, the magnetic flux through the solenoid is

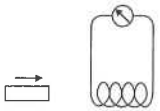
A. 6.0×10^{-7} Wb.
B. 2.0×10^{-6} Wb.
C. 5.7×10^{-4} Wb.
D. 2.0×10^{-3} Wb.

43. **< HKAL 1984 Paper I - 23 >**

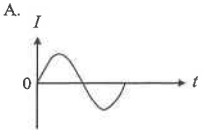
A sinusoidal voltage is generated by an a.c. generator. If the speed of rotation of the coil is increased, what will happen to the frequency and the peak voltage generated ?

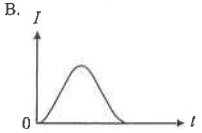
	frequency	**peak voltage**
A.	increase	no change
B.	no change	increase
C.	increase	decrease
D.	increase	increase

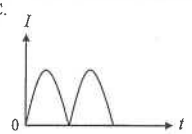
44. **< HKAL 1986 Paper I - 37 >**

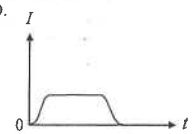


A short bar magnet moving with uniform velocity passes through an air-cored solenoid of connected to a galvanometer as shown. Which of the following graphs best represents the variation of the current I in the solenoid with time t ?

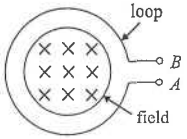
A. 

B. 

C. 

D. 

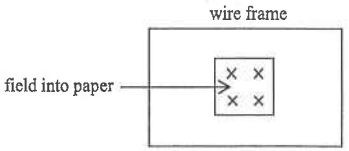
45. **< HKAL 1987 Paper I - 38 >**



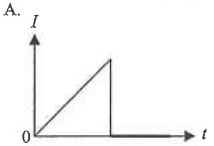
A uniform magnetic field acting perpendicular into paper is inside a circular region of radius 8 cm. A circular loop of radius 10 cm is placed outside the field region as shown in the figure. If the magnetic field is now decreasing at a constant rate of 0.01 T s^{-1}, what will be the magnitude and direction of the induced e.m.f. in the loop ?

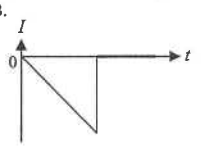
	Magnitude	**Direction**
A.	2.0×10^{-4} V	from A to B via the loop
B.	2.0×10^{-4} V	from B to A via the loop
C.	3.1×10^{-4} V	from A to B via the loop
D.	3.1×10^{-4} V	from B to A via the loop

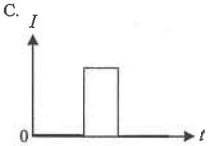
46. **< HKAL 1988 Paper I - 42 >**

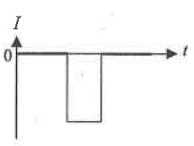


A rectangular wire frame is placed outside a uniform magnetic field which is confined to a square region as shown in the figure. The direction of the magnetic field is perpendicular into paper. If the wire frame moves to the right with a uniform velocity, which of the graphs below best represents the variation of the induced current I with time t ?
(The anti-clockwise direction of the current is taken as positive.)

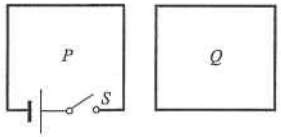
A. 

B. 

C. 

D. 

47. **< HKAL 1989 Paper I - 36 >**



Two rectangular wire loops P and Q are placed in the same plane side by side. Loop P includes a battery and a switch S, which is initially open. If S is suddenly closed, what is the direction of the induced current in loop Q ? Are the magnetic forces between the two loops attractive or repulsive ?

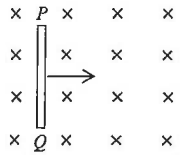
	Direction of induced current	**Nature of force**
A.	clockwise	attractive
B.	clockwise	repulsive
C.	anticlockwise	attractive
D.	anticlockwise	repulsive

48. **< HKAL 1989 Paper I - 35 >**

A certain length of a copper wire is bent to form a circular coil of one turn. The coil is then placed in a uniform magnetic field with its plane normal to the direction of the magnetic field. The flux linkage through the coil is Φ. The same length of wire is now bent to form a double loop of smaller radius. The flux linkage through the coil would become

A. Φ/4.
B. Φ/2.
C. Φ.
D. 2Φ.

49. **< HKAL 1992 Paper I - 38 >**

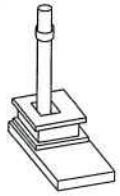


A metal rod *PQ* moves with constant velocity across a uniform magnetic field directed perpendicularly into paper as shown in the above figure. A voltage is induced across the rod. Which of the following statements is/are correct ?

(1) The magnitude of the voltage depends on the length of the rod.
(2) Point *P* is at a lower potential than *Q*.
(3) A magnetic force is acting on the rod to oppose its motion.

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

50. **< HKAL 1992 Paper I - 40 >**



An aluminium ring floats above a coil carrying alternating current. Which of the following will affect the height of the ring ?

(1) the resistivity of the ring
(2) the density of the ring
(3) the frequency of the alternating current

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

51. **< HKAL 1994 Paper IIA - 37 >**

The magnetic flux linkage for a coil placed in a uniform magnetic field depends on

(1) the resistance of the coil
(2) the number of turns of the coil
(3) the angle between the normal of the coil and the direction of the magnetic field

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

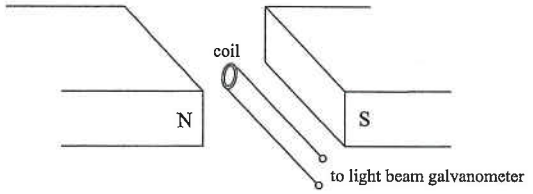
52. **< HKAL 1995 Paper IIA - 35 >**

A bar magnet is moved perpendicularly towards a copper disc. Which of the following statements are correct ?

(1) Eddy current is induced in the copper disc.
(2) Temperature of the copper disc increases.
(3) A repulsive force is experienced by the magnet.

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

53. **< HKAL 1997 Paper IIA - 23 >**

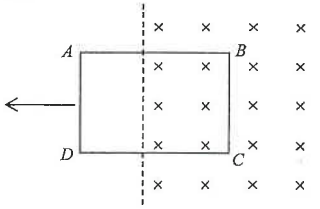


The above figure shows a small coil, connected to a light beam galvanometer, placed in a region of uniform magnetic field between the poles of a magnet. The plane of the coil is parallel to the pole faces. Which of the following actions would produce a deflection of the galvanometer ?

(1) Moving the coil to and fro between the poles.
(2) Moving the coil away from the region between the pole faces.
(3) Rotating the coil about a diameter through an angle of 180°.

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

54. **< HKAL 1997 Paper IIA - 31 >**



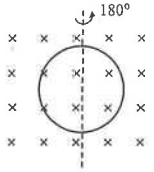
A rectangular metal wire frame *ABCD* moves to the left with a uniform speed across a region of uniform magnetic field acting perpendicularly into paper. Which of the following is/are true at the instant shown in the figure ?

(1) A current is flowing in the clockwise direction.
(2) The electric potential at *B* is higher than that at *C*.
(3) The side *AD* experiences a magnetic force acting to the right.

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

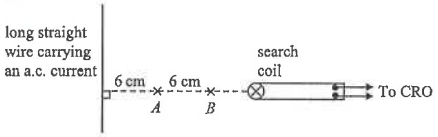
55. **< HKAL 1999 Paper IIA - 36 >**

A coil of metal wire is placed on a plane perpendicular to a uniform magnetic field. The coil is rotated through 180° about a diameter as shown. The induced e.m.f. in the coil is **independent** of



A. the area of the coil.
B. the flux density of the magnetic field.
C. the number of turns of the coil.
D. the resistance of the coil.

56. **< HKAL 1999 Paper IIA - 30 >**

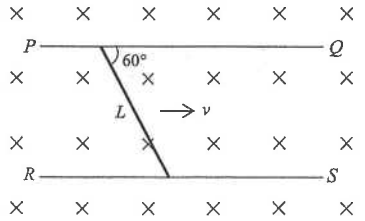


A long straight wire carrying an a.c. current lies on the plane of the paper as shown. A search coil connected to a CRO with the time-base off is used to measure the peak value of the magnetic field produced by the a.c. current. When the search coil is placed at *B*, the length of the trace on the CRO is 2 cm. If the search coil is placed at *A*, the length of the trace would be

A. 0.5 cm.
B. 1 cm.
C. 2 cm.
D. 4 cm.

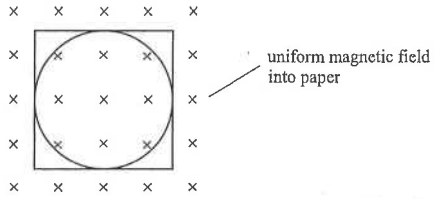
57. **< HKAL 2002 Paper IIA - 27 >**

A metal wire of length *L* is inclined at angle 60° to rail *PQ* as shown. It is moved rightwards with a uniform velocity *v* across a uniform magnetic field directed into paper along the two horizontal rails *PQ* and *RS*. The strength of the magnetic field is *B*. What is the e.m.f. induced in the rod ?



A. $\frac{B v L}{2}$
B. $B v L$
C. $\frac{2B v L}{\sqrt{3}}$
D. $\frac{\sqrt{3}B v L}{2}$

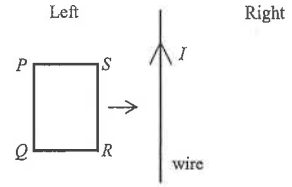
58. **< HKAL 2002 Paper IIA - 28 >**



A circular frame and a square frame, made from the same type of metal wires, are placed in a uniform magnetic field as shown. The length of each side of the square is equal to the diameter of the circle. When the flux density of the magnetic field is increased at a steady rate, find the ratio of the induced current in the circular frame to that in square frame.

A. 1 : 1
B. 1 : π
C. π : 4
D. 2 : π

59. **< HKAL 2003 Paper IIA - 34 >**

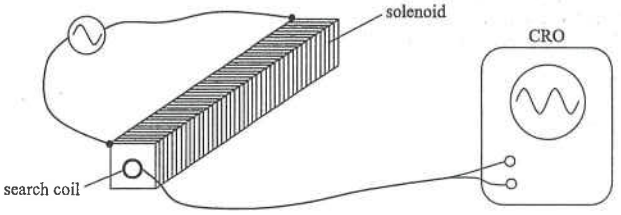


The figure shows a rectangular metal coil *PQRS* moving from left to right with a uniform speed across an insulated metal wire carrying a steady current *I*. Which of the following gives the correct sequence for the direction of the current induced in the coil *PQRS* ?

A. Clockwise and then anticlockwise
B. Anticlockwise and then clockwise
C. Clockwise, then anticlockwise and finally clockwise again
D. Anticlockwise, then clockwise and finally anticlockwise again

60. **< HKAL 2004 Paper IIA - 28 >**

A search coil is placed at one end of a solenoid as shown in the figure. The solenoid is connected to an a.c. source so that an a.c. current is flowing in the solenoid. The induced voltage on the search coil is shown on the CRO connected to the search coil.

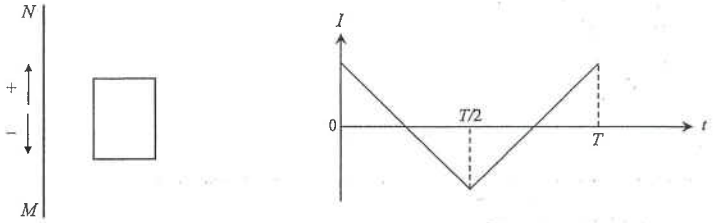


Which of the following changes will **NOT** affect the amplitude of the induced voltage in the search coil ?

A. Increase the frequency of the a.c. current in the solenoid.
B. Increase the number of turns on the search coil.
C. Place the search coil in the middle of solenoid, without changing its orientation.
(D.) Replace the solenoid with one of greater cross-sectional area while keeping the same magnitude of a.c. current.

61. **< HKAL 2005 Paper IIA - 19 >**

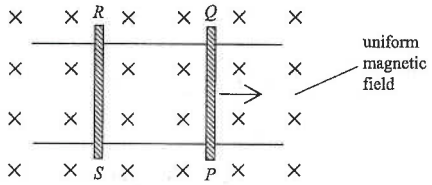
A rectangular coil is placed adjacent to a straight wire *MN* carrying a current *I* which varies with time *t* as shown in the graph. The wire *MN* is in the plane of the coil and the current *I* is positive (+) when it is in the direction from *M* to *N*.



Starting from $t = 0$, how does the direction of the current induced in the coil vary in one period ?

A. Clockwise first and then anticlockwise
B. Anticlockwise first and then clockwise
C. Clockwise → anticlockwise → clockwise → anticlockwise
D. Anticlockwise → clockwise → anticlockwise → clockwise

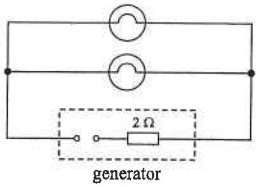
62. < HKAL 2005 Paper IIA - 16 >



Two conducting rods PQ and RS are placed on two smooth, parallel, horizontal conducting rails. A uniform magnetic field is directed into the plane of the paper as shown. If now rod PQ is given an initial velocity to the right, which of the following statements is **NOT** correct ?

A. The induced current is in the direction of $PQRS$.
B. The magnetic force acting on the rod PQ is towards the left.
C. Rod RS starts moving towards the right.
D. Rod PQ would keep on moving with a uniform speed.

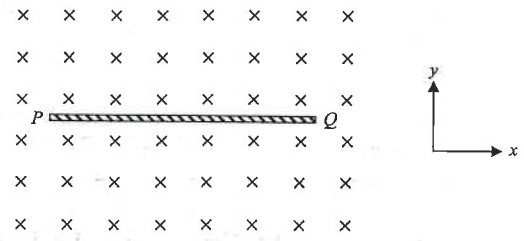
63. < HKAL 2005 Paper IIA - 17 >



Two '12 V, 6 W' lamps are operating at their rated values. The internal resistance of the generator is 2 Ω. What is the percentage of the electrical power generated by the generator dissipated by the two lamps ?

A. 75%
B. 86%
C. 92%
D. 100%

64. < HKAL 2006 Paper IIA - 19 >

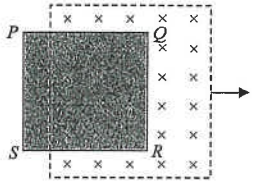


In the figure, a thin metal rod PQ is placed along the x-direction and it is at right angles to a uniform magnetic field pointing into the plane of the paper. In which of the following cases will there be an e.m.f. induced along the length of the metal rod ?

(1) Rotating the rod about an axis through its centre along the y-direction
(2) Moving the rod in the x-direction
(3) Moving the rod in the y-direction

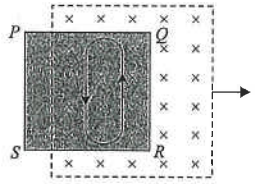
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

65. < HKAL 2008 Paper IIA - 18 >

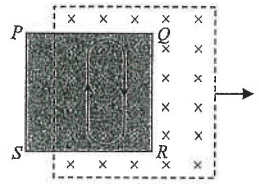


In the figure, $PQRS$ is a metal plate placed perpendicularly to a uniform magnetic field directed into the paper. At the instant shown, the magnetic field is moving to the right and eddy current is induced in the metal plate. Which of the following diagrams best represents a possible path of the eddy current induced in the plate ?

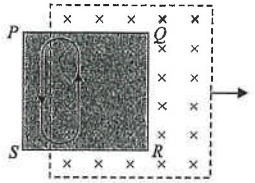
A.



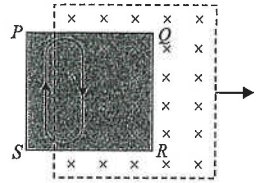
B.



C.

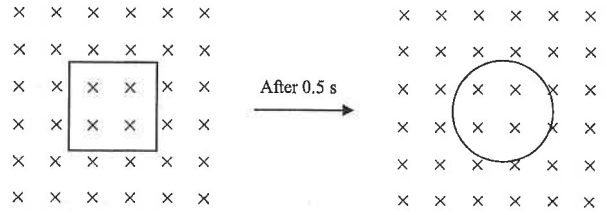


D.



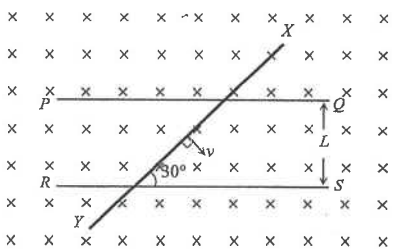
66. < HKAL 2009 Paper IIA - 32 >

A metal wire in shape of a square with each side 15.7 cm is placed in a uniform magnetic field of 0.6 T directed into the paper as shown. Suppose its shape is now changed into a circle within a time of 0.5 s. Find the average induced e.m.f. and the direction of the induced current in the frame during this period.



	average induced e.m.f. / mV	direction of the induced current
A.	8.1	clockwise
B.	8.1	anticlockwise
C.	4.0	clockwise
D.	4.0	anticlockwise

67. < HKAL 2010 Paper IIA - 26 >



In the figure, PQ and RS are two parallel metal rails with separation L. A metal rod XY resting on the rails moves with velocity v perpendicular to its length across a uniform magnetic field B pointing into the paper. If the rod makes an angle of 30° with the rails, what is the potential difference across Q and S ?

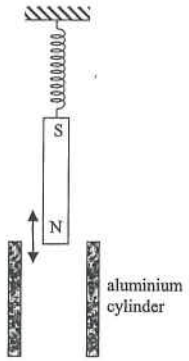
A. $\frac{BLv}{\cos 30°}$

B. $BLv \cos 30°$

C. $\frac{BLv}{\sin 30°}$

D. $BLv \sin 30°$

68. < HKAL 2009 Paper IIA - 12 >



A bar magnet is suspended by a spring from a rigid support. It is oscillating above a hollow aluminium cylinder placed below its lower end. Which of the following statements is/are correct ?
(Neglect air resistance.)

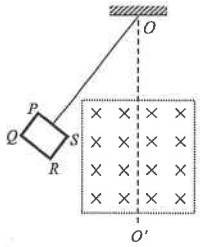
(1) The amplitude of oscillation of the magnet remains unchanged.

(2) The force between the bar magnet and the aluminium cylinder is always attractive.

(3) Eddy currents are induced in the aluminium cylinder.

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

69. < HKAL 2010 Paper IIA - 30 >

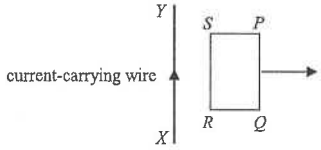


In the above figure, $PQRS$ is a small rectangular metal frame suspended from a fixed point O by a plastic string. The frame is released from the position shown and it swings across a uniform magnetic field pointing into the paper within the dotted rectangle. Neglect air resistance and friction. Which of the following is/are correct ?

(1) A current is induced in the frame in the direction $PQRSP$ when it is entering the field.
(2) The current induced in the frame is at a maximum when it passes OO'.
(3) The direction of the magnetic force experienced by the frame is opposite to its motion when it passes OO'.

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

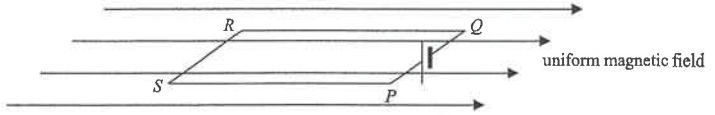
70. < HKAL 2011 Paper IIA - 27 >



A long straight wire XY carrying a steady current lies in the plane of the coil. A rectangular coil $PQRS$ is moving to the right with constant speed. Which of the following gives the correct direction of the induced current in the coil and the resultant magnetic force acting on the coil at the instant shown in the above figure ?

	direction of induced current in the coil	resultant magnetic force acting on the coil
A.	anti-clockwise	to left
B.	anti-clockwise	zero
C.	clockwise	to left
D.	clockwise	zero

71. < HKAL 2011 Paper IIA - 31 >



A rigid rectangular conducting loop $PQRS$ is connected to a cell as shown. It is held at rest horizontally within a uniform magnetic field which is parallel to the plane of the loop and perpendicular to its side RS. Which of the following statements is/are correct ?

(1) The side RS of the loop experiences an upward magnetic force.
(2) The loop experiences a turning moment due to the magnetic field.
(3) The magnetic flux linkage through the loop is zero.

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

72. **< HKAL 2012 Paper IIA - 24 >**

In the above figures, a metal rod PQ making an angle θ with the horizontal moves with speed v across a uniform magnetic field pointing into the paper in two different directions shown. What is the ratio of the e.m.f. induced across the rod in Figure (1) to that in Figure (2) ?

A. $1 : \sin\theta$

B. $1 : \sin^2\theta$

C. $\sin\theta : 1$

D. $\sin^2\theta : 1$

Part C : Supplemental exercise

73. A solenoid has a length of 0.30 m and cross-sectional area of 3.2×10^{-4} m^2. There are 1000 turns of wire wound on it. When the solenoid carries a current of 1.5 A, the magnetic flux linkage through the solenoid is

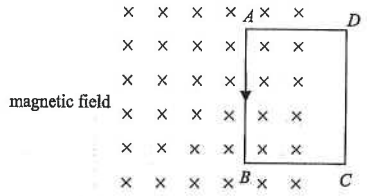
A. 6.0×10^{-7} Wb.

B. 2.0×10^{-6} Wb.

C. 5.7×10^{-4} Wb.

D. 2.0×10^{-3} Wb.

74.



A rectangular coil $ABCD$ is placed in a uniform magnetic field directed perpendicular into paper. When the coil is set into motion, an induced current flows from A to B as shown. Which of the following statements are correct ?

(1) The coil is moving towards the left.

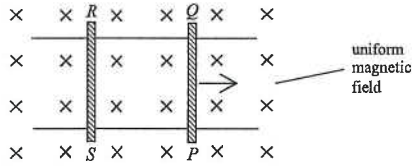
(2) The electric potential at A is higher than that at B.

(3) There is a magnetic force acting on AB towards the right.

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

Part D : HKDSE examination questions

75. **< HKDSE Sample Paper IA - 31 >**



The figure shows conducting rods PQ and RS are placed on two smooth, parallel, horizontal conducting rails. A uniform magnetic field is directed into the plane of the paper as shown. PQ is given an initial velocity to the right and left to roll. Which statement is **INCORRECT** ?

A. The induced current is in the direction $PQRS$.

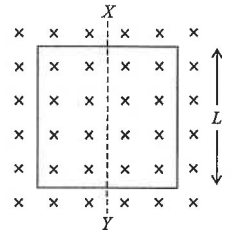
B. The magnetic force acting on the rod PQ is towards the left.

C. Rod RS starts moving towards the right.

D. Rod PQ moves with a uniform speed.

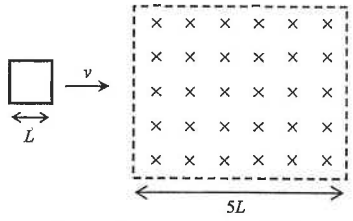
76. **< HKDSE Practice Paper IA - 33 >**

A square metal frame of side length L is placed inside a uniform magnetic field B as shown. What is the change in magnetic flux through the frame when it is rotated about the axis XY by 90° and 180° respectively ?



	90°	180°
A.	0	0
B.	0	$2BL^2$
C.	BL^2	0
D.	BL^2	$2BL^2$

77. **< HKDSE 2012 Paper IA - 31 >**



A square metal frame of length of side L moving with constant velocity v passes through a region of uniform magnetic field of width $5L$ as shown. What is the total time period during which a current is induced in the frame ?

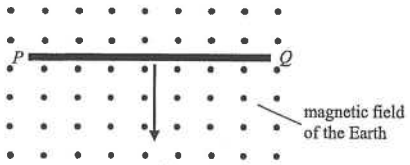
A. $\frac{L}{v}$

B. $\frac{2L}{v}$

C. $\frac{3L}{v}$

D. $\frac{4L}{v}$

78. **< HKDSE 2012 Paper IA - 32 >**



A copper rod PQ is placed horizontally as shown below. It is released and then falls vertically, cutting across the magnetic field of the Earth pointing out of the paper. Neglect air resistance. Which of the following statements is/are correct ?

(1) A voltage is induced across PQ.

(2) A steady induced current is generated in the rod.

(3) Due to the effect of the Earth's magnetic field, the copper rod falls with an acceleration less than the acceleration due to gravity.

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

79. **< HKDSE 2013 Paper IA - 29 >**

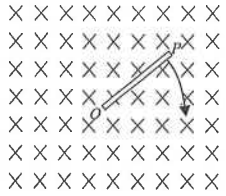
A metal rod OP is rotated about O in a clockwise direction in the plane of the paper with a uniform magnetic field pointing into the paper. Which statement is correct ?

A. An induced current flows in the rod from O to P.

B. An induced current flows in the rod from P to O.

C. E.m.f. is induced in the rod with end O at a higher electric potential.

D. E.m.f. is induced in the rod with end P at a higher electric potential.



80. **< HKDSE 2014 Paper IA - 27 >**

Figure (a)

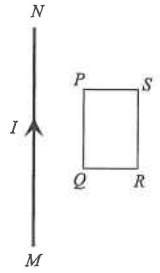
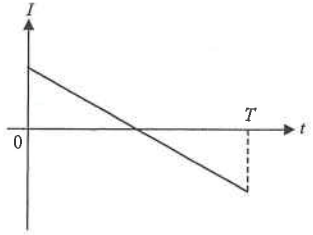


Figure (b)



A long straight current-carrying wire MN and a rectangular coil $PQRS$ are fixed in the same plane as shown in Figure (a). The current I is taken as positive when it flows from M to N and it varies with time t as shown in Figure (b). The direction of the induced current in the coil during the time interval $0 - T$ is

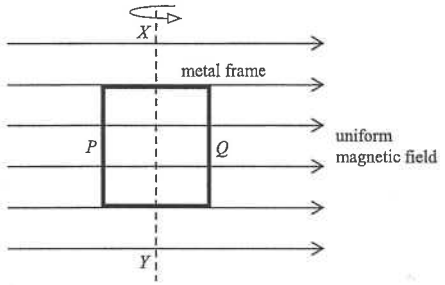
A. first anti-clockwise and then clockwise.

B. first clockwise and then anti-clockwise.

C. anti-clockwise throughout.

D. clockwise throughout.

81. **< HKDSE 2015 Paper IA - 24 >**



A rectangular metal frame is made to rotate steadily about its axis XY in a uniform magnetic field. At the instant shown, the frame is in the plane of the paper and side P is moving out of the paper while side Q is moving into the paper. Which statement is **INCORRECT** at this instant ?

A. The induced e.m.f. in the frame is at a maximum.

B. The induced current produced in the frame is flowing in anti-clockwise direction.

C. The magnetic force acting on side P is in a direction pointing into the paper.

D. The magnetic forces acting on the frame produce a moment opposing the frame's rotation.

82. **< HKDSE 2016 Paper IA - 29 >**

A student uses a search coil to study the strength of the magnetic field inside a long solenoid which is connected to an a.c. signal generator set at a certain frequency. The search coil is connected to a CRO with time-base switched off. When the magnetic field is detected, a vertical trace on the CRO is displayed. Which of the following can improve the accuracy of this experiment ?

(1) Rotate the plane of the search coil until the length of the vertical trace on the CRO is the maximum.

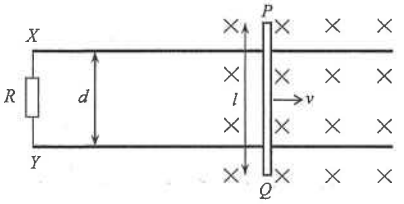
(2) Increase the signal generator's frequency and use the same current as before.

(3) Set the axis of the solenoid along an east-west direction to avoid the effects of the Earth's magnetic field.

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

83. **< HKDSE 2017 Paper IA - 28 >**

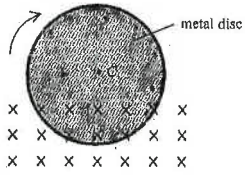
A metal rod PQ of length l is moving along smooth horizontal metal rails X and Y with constant speed v in a uniform magnetic field of magnetic field strength B pointing into the paper. The metal rails X and Y are separated by a distance of d and are connected to a resistor of resistance R as shown. Which of the following descriptions about the induced current is correct ?



	magnitude	direction
A.	$\frac{Blv}{R}$	from X to Y through R
B.	$\frac{Blv}{R}$	from Y to X through R
C.	$\frac{Bdv}{R}$	from X to Y through R
D.	$\frac{Bdv}{R}$	from Y to X through R

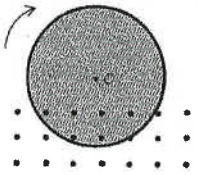
84. **< HKDSE 2017 Paper IA - 27 >**

A metal disc is rotating about its centre *C* with constant speed. Part of the metal disc is inside a uniform magnetic field pointing into the paper as shown. An eddy current flows in the metal disc.

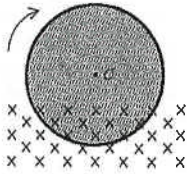


After which of the following changes will the eddy current increase ?

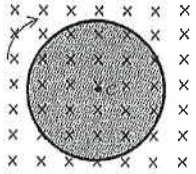
A. Reverse the direction of the magnetic field



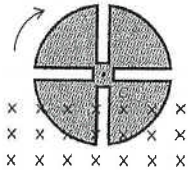
B. Increase the strength of the magnetic field



C. Apply the magnetic field over the whole metal disc

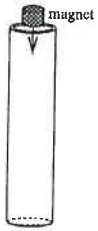


D. Cut several slits from the metal disc



85. **< HKDSE 2018 Paper IA - 29 >**

A stone and a strong magnet of the same size and shape are released from rest into a hollow aluminium tubing respectively. Which of the following is correct ? Neglect air resistance.



	drops slower	reason
A.	stone	the stone is more massive
B.	magnet	the stone is more massive
C.	stone	the magnet induces eddy current in the aluminium tubing
D.	magnet	the magnet induces eddy current in the aluminium tubing

There is question in next page

M.C. Answers

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

M.C. Solution

1. D

× (1) Since commutator is used, it is a d.c. generator, thus the current always flows in the same direction.

✓ (2) The maximum current depends on the induced voltage which depends on the rotational speed of the coil.

✓ (3) By $I = \frac{V}{R}$, maximum magnitude of current depends on the resistance of *R*.

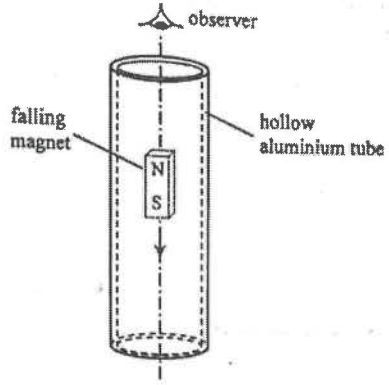
2. D

There is no magnetic flux passing through the coil,

thus there is no induced current in the coil.

86. <HKDSE 2019 Paper IA-28>

87. <HKDSE 2020 Paper IA-28>



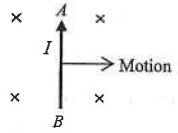
When a small strong magnet falls through a hollow aluminium tube as shown, eddy currents are induced. Which of the following correctly describes the direction of current induced in the tube when viewed by an observer from above ?

A. clockwise both above and below the magnet
B. anti-clockwise both above and below the magnet
C. clockwise above the magnet and anti-clockwise below the magnet
D. anti-clockwise above the magnet and clockwise below the magnet

3. A

Dynamo (generator) changes the mechanical energy of the rotating coil into electrical energy of induced current.

4. D



× (1) By Right-hand rule, current should flow from D to C through P.

✓ (2) By Right-hand rule, induced current flows from B to A through Q.

✓ (3) By Faraday's Law, induced voltage (e.m.f.) is set up across AB where $\varepsilon = B v l$.

5. B

When the switch S is closed, current starts to flow in the solenoid
which produces a magnetic field with N-pole at the left hand side.

An induced current would then flow in coil XY to oppose the change such that the pole at Y is North.

The two solenoids thus experience opposing magnetic forces so the coil would move away from the solenoid.

6. B

Peak voltage : $V_p = 0.5 \text{ V cm}^{-1} \times 3 \text{ cm} = 1.5 \text{ V}$

Period : $T = 1 \text{ ms cm}^{-1} \times 4 \text{ cm} = 4 \text{ ms}$

Frequency : $f = \frac{1}{T} = \frac{1}{4 \times 10^{-3}} = 250 \text{ Hz}$

7. B

Figure (1) : As the N-pole of magnet moves towards the ring, N-pole is induced at the upper end of the ring, thus the induced current is in anticlockwise direction observed by the eye.

Figure (2) : As the magnet is inside the ring, there is no change of magnetic field, thus there is no induced current.

Figure (3) : As the S-pole of magnet moves away from the ring, N-pole is induced at the lower end of the ring, thus the induced current is in clockwise direction.

8. C

In Figure 1, as the S-pole of magnet moves towards the coil (solenoid) from the left,
the left side of the coil is induced to be S-pole,
and the induced current flows through the galvanometer and deflects to the left.

In Figure 2, as the N-pole of magnet moves towards the coil (solenoid) from the right,
the right side of the coil is induced to be N-pole, that means the left side of the coil is induced to be S-pole,
thus the induced current flows in the same direction as Figure 1,
and as the magnet moves at a faster rate, the induced current is greater and is more than 10 μA.

9. B

Peak voltage : $V_o = 2 \text{ cm} \times 10 \text{ V cm}^{-1} = 20 \text{ V}$

Peak current : $I_o = \frac{V_o}{R} = \frac{20}{5 \times 10^3} = 4 \text{ mA}$

10. C

✓ (1) When S is closed, current flows in primary coil to give magnetic field lines directed towards the right.
Current is induced in secondary coil from P to Q through R
to give magnetic field lines directed towards the left to oppose the change.

✓ (2) When S remains closed, there is no change of current, thus there is no change of magnetic field,
therefore, no current is induced in the secondary coil.

× (3) When S is opened, current stops flowing in the primary coil and the magnetic field decreases to zero.
Current is induced in the secondary coil from Q to P through R
to give magnetic field lines directed towards the right to oppose the change.

11. B

As commutator is used, it is a d.c. generator,

d.c. generator gives a varying d.c. voltage (unsteady voltage) as shown in option B.

12. D

× (1) A d.c. generator is a d.c. source but it produces varying d.c. voltages.

✓ (2) All a.c. sources would give out current with changing directions.

✓ (3) Both d.c. and a.c. give heating effect by $P = I^2 R$.

13. A

At the time shown, when N-pole of the magnet moves away from the right hand side of the core,
S-pole is induced on the right hand side of the core, thus induced current flows from P to Q through R.

After half of a cycle, when N-pole of the magnet moves away from the left hand side of the core,
S-pole is induced on the left hand side of the core, thus induced current flows from Q to P through R in reverse direction.

14. D

× A. microphone : sound energy → electrical energy

× B. loudspeaker : electrical energy → sound energy

× C. dynamo : mechanical energy → electrical energy

✓ D. motor : electrical energy → mechanical energy

15. A

As the trace of the signal is a line, it is an a.c. voltage.

Peak voltage : $V_o = 1 \text{ cm} \times 1 \text{ V cm}^{-1} = 1 \text{ V}$

16. B

Peak voltage = 2 cm × 0.5 V cm^{-1} = 1 V

Period : T = 4 cm × 10 ms cm^{-1} = 40 ms

Frequency : $f = \frac{1}{T} = \frac{1}{40\times10^{-3}}$ = 25 Hz

17. D

✓ A. A bicycle dynamo gives induced voltage, which is an application of electromagnetic induction.

✓ B. When a magnetic tape moves across a playback head, a.c. current is induced.

✓ C. When sound wave is incident onto a microphone, the coil is set into vibration inside a magnetic field, thus a.c. current is induced.

× D. Loudspeaker makes use of the magnetic force produced by the current inside a magnetic field.

18. A

When R moves towards P, the resistance of RQ increases,

thus voltage increases, amplitude of the trace increases.

Period (or frequency) depends on the a.c. source, thus it remains unchanged.

19. B

When the ring moves towards the magnet at X, current is induced so that the lower side of the ring is N-pole.

When the ring moves away from the magnet at Y, current is induced so that the upper side of the ring is N-pole.

By using Right hand grip rule, the induced current in both cases can be determined.

20. C

✓ (1) Rotating the coil at a greater speed can increase the rate of change of magnetic flux, thus induced voltage by the generator increases.

× (2) Reducing the resistance can increase the induced current, but the resistance would not affect the induced voltage.

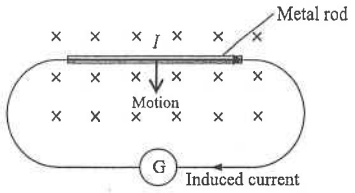
✓ (3) A coil of greater area contains more magnetic flux, thus the induced voltage increases.

21. D

The induced current in the metal rod flows from left to right.

In order to give this induced current,

the rod should move downwards, by using Right-hand rule.



22. C

× A. As they move away from each other, the left side of the solenoid should be induced in N-pole, thus induced current should flow from left to right through the galvanometer.

× B. As the solenoid moves away from the magnet, the left side of the solenoid should be induced in S-pole, thus induced current should flow from right to left through the galvanometer.

✓ C. As the solenoid moves towards the magnet, the left side of the solenoid should be induced with S-pole, thus induced current flows from right to left through the galvanometer.

× D. As the magnet moves towards the solenoid, the left side of the solenoid should be induced with N-pole, thus induced current should flow from left to right through the galvanometer.

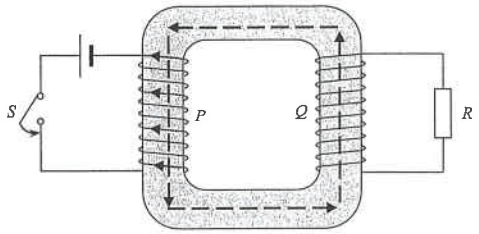
23. A

① When the magnet is approaching, an induced voltage is set up in the solenoid.

② When the magnet is inside the solenoid, no induced voltage is set up.

③ When the magnet is leaving, an induced voltage is set up in the solenoid but in the opposite direction.

24. C



When S is just closed, the current through coil P produces a magnetic field downwards and upwards through Q.

In order to oppose the change of magnetic field, coil Q induces a current which produces a magnetic field in opposite direction (downwards), thus by Right hand grip rule, the current through R is in upward direction.

When S is just opened, current through coil P suddenly stops flowing, thus the magnetic field through Q decreases.

In order to oppose the change of magnetic field, coil Q induces a current which produces a magnetic field in the same direction, thus the induced current should be opposite to that when S is closed.

25. C

When the coil just enters the field region, an induced current flows in anticlockwise direction (+).

When the coil moves inside the field region, there is no induced current.

When the coil just leaves the field region, an induced current flows in clockwise direction (–).

26. A

✓ (1) Since slip rings are used, alternating current is produced.

× (2) By Right-hand-rule, a current is induced in the coil and flows through the resistor from Q to P.

× (3) The current is maximum at the instant shown, but becomes zero when the coil is vertical.

27. A

Since the time base is 10 ms per cm and the time for one cycle is 10 cm

$\therefore$ period T = 10 cm × 10 ms cm^{-1} = 100 ms

$\therefore$ Frequency : $f = \frac{1}{T} = \frac{1}{100 \times 10^{-3}} = 10$ Hz

The amplitude of the trace is 4 cm and the voltage gain is 0.5 V per cm

$\therefore$ Peak voltage = 4 cm × 0.5 V cm^{-1} = 2 V

28. A

✓ (1) By using Right hand rule, induced current flows along AB in anticlockwise direction.

× (2) There is no induced current in this position.

× (3) By using Right hand rule, induced current flows along DC in clockwise direction.

29. D

Since the bar magnet is moving towards the coil, induced current flows to oppose the change.

The top of the coil becomes South-pole due to the induced current.

Action and reaction pair then exists between the magnet and the coil.

For the magnet, an upward force acts on it by the coil.

For the coil, a downward force acts on it by the magnet.

The reading of the balance is then greater due to the downward force on the coil.

30. B

× (1) By Right hand rule, the induced current in the rod is from Q to P,
thus current through the galvanometer is from R to Q.

× (2) If the magnetic field is reversed, the direction of the induced current would reverse.
However, the opposing force is still towards the left, and the rod should still move in uniform speed.

✓ (3) Since the direction of the induced current is reversed,
the pointer of the galvanometer should deflect to the opposite direction.

31. D

× (1) The current delivered to the load by a d.c. generator is an unsteady d.c., thus the current is not constant.

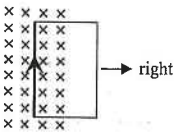
✓ (2) Due to the commutator, current delivered to the load is a d.c., i.e. the current flows in one direction only.

✓ (3) By use of the Right hand rule, the induced current in the coil is in anticlockwise direction,
and thus the current flows from X to Y through the load.

32. C

By Right hand rule :
induced current flows upwards in the left wire.

By Left hand rule :
this current gives a magnetic force towards the left.



33. B

× (1) When the switch is closed, only a pulse of induced current flows momentarily through the ammeter.

✓ (2) At the moment the switch is opened, an induced current flows through the ammeter momentarily.

× (3) Since glass rod is not a magnetic material, the magnetic field will become weaker,
thus the induced current should be smaller.

34. D

At this position, the magnetic field is pointing towards the left from N-pole to S-pole.

The left arm of the coil is moving upwards.

By using Right hand rule, the induced current in the left arm of the coil is flowing out of paper,
and then from P to Q through the load, thus the current is positive and maximum at $t = 0$.

35. D

When the magnet is at the right side and moving towards the solenoid,

as N-pole is induced at Q, thus end X should be N-pole, as opposing forces should exist between them.

When the magnet is at the left side and moving away from the solenoid,

as end Y is S-pole which is leaving, end P should become N-pole as attraction forces should exist between them.

36. D

The top of the solenoid is S-pole and the bottom is N-pole, by Right hand screw rule.

As the ring moves towards the solenoid at X, by Lenz's law, to oppose the change,
a current is induced so that the bottom of the ring is S-pole, and by Right hand screw rule,
the induced current is in anticlockwise direction observed by the eye.

When the ring is at Y, as there is no change of magnetic field, thus no current is induced at Y.

37. D

× (1) Since the rod is moving with uniform speed, its kinetic energy remains unchanged.

✓ (2) By Right hand rule, the induced current flows from Q to P, then flows from S to R through the resistor.

✓ (3) If the rod moves to left, by Right hand rule, the induced current flows from P to Q through the rod.

38. C

$$\varepsilon = \frac{\Delta(N\Phi)}{\Delta t}$$

$$= \frac{N\Phi - 0}{t} = \frac{N\Phi}{t}$$

39. C

The magnetic flux through the coil L_2 is equal to the magnetic flux through the coil L_1,
as both of the contains the same number of magnetic field lines inside the solenoid.

Thus, both of them induce the same e.m.f. of 1.2 V.

40. D

An e.m.f. is induced from P to Q as PQ cuts the magnetic field lines.

Similarly, an e.m.f. is also induced from S to R as SR cut the magnetic field lines.

Since there is no net e.m.f. in the circuit, thus no induced current flows in the loop.

41. D

The magnetic field due to the magnet is perpendicularly into paper.

At the right hand side of the magnet, the disc moves from a region without field to a region with magnetic field, to oppose the change, eddy current is induced in anticlockwise direction to produce magnetic field out of paper.

At the left hand side of the magnet, the disc moves from a region with magnetic field out to a region without field, to oppose the change, eddy current is induced in clockwise direction to produce magnetic field into paper.

42. B

For a solenoid : $B = \dfrac{\mu_o N I}{\ell}$

Magnetic flux through the solenoid : $\Phi = BA$

$\therefore\ \Phi = BA = \dfrac{\mu_o N I}{\ell} \cdot A$

$= \dfrac{(4\pi\times10^{-7})(1000)(1.5)}{(0.3)} \cdot (3.2\times10^{-4})$

$= 2.0 \times 10^{-6}$ Wb

43. D

① Frequency of the voltage is equal to the rotational frequency of the coil, thus the frequency increases.

② Peak voltage is proportional to the rotational speed of the coil, thus the amplitude increases.

44. A

When the bar magnet moves towards the solenoid, induced current in the coil is in one direction.

When the bar magnet moves away from the solenoid, induced current is in the opposite direction.

Only the graph in option A shows that the induced currents are in two directions, thus it is the answer.

45. A

Note that only the small loop contains magnetic field.

Thus, in calculating the magnetic flux : $\Phi = BA$, the area A should be the smaller loop.

By $\varepsilon = \dfrac{\Delta\Phi}{\Delta t} = A\dfrac{\Delta B}{\Delta t}$

$\therefore\ \varepsilon = [\pi \times (0.08)^2] \times (0.01)$

$= 2.0 \times 10^{-4}$ V

As the magnetic field is decreasing, to oppose the change,

the induced current would produce a magnetic field in the same direction, that is, into paper,

thus, the induced current is in clockwise direction.

46. D

In the position shown, there is no cutting of magnetic field lines, thus no induced current.

As the frame moves, during the time interval that the left wire of the frame cuts across the magnetic field, current is induced upwards and flows in the frame in clockwise direction, which is negative, and since the frame moves with uniform velocity, the induced current is constant.

47. D

When the switch S is suddenly closed, current flows in loop P in anticlockwise direction.

As the current in the right wire of loop P is upwards, it then produces a magnetic field into paper at loop Q.

When loop Q suddenly experiences a magnetic field into paper, a current is induced in anticlockwise direction so as to produce a magnetic field out of paper to oppose the change.

As the current in the right wire of loop P is upwards and the current in the left wire of loop Q is downwards, repulsive force occurs between them as currents in opposite directions repel each other.

48. B

For the same length of wire forming the double loop : $2\pi r = 2(2\pi r')\ \ \therefore\ r' = r/2$

The radius of the new loop is halved, thus the area of the new loop becomes one-quarter.

Flux linkage = $NBA \propto NA$

$\therefore$ As $N \to 2N$ and $A \to \frac{1}{4}A$, the flux linkage becomes $\frac{1}{2}\Phi$

49. A

✓ (1) $\varepsilon = \dfrac{\Delta\Phi}{\Delta t} = B\cdot\dfrac{\Delta A}{\Delta t} = Bv L \propto L$

× (2) By Right-hand rule, induced e.m.f. is from Q to P, thus P is at a higher potential.

× (3) As the circuit is not complete, there is induced e.m.f. but no induced current, thus no magnetic force acts on the rod to oppose its motion.

50. D

✓ (1) If the resistivity of the ring is smaller, then the resistance of the ring is smaller, thus greater eddy current can be induced in the ring and the ring would float at a greater height.

✓ (2) If the density of the ring is smaller, then the mass or weight of the ring would be smaller, thus the same upward magnetic force due to eddy current would make the ring float at a greater height

✓ (3) If the frequency of the a.c. increases, then the rate of change of magnetic flux in the coil increases, thus greater eddy current is induced, and the ring would float at a greater height.

51. D

× (1) Resistance would not affect the flux linkage of a coil.

✓ (2) Flux linkage is proportional to the number of turns of the coil.

✓ (3) Since the magnetic flux through a coil depends on the component of the magnetic field through the coil, the angle would affect the flux linkage of the coil.

52. D

✓ (1) When the magnet moves towards copper, the copper experiences a change in magnetic field, thus eddy current is induced in the copper disc.

✓ (2) As eddy current is induced, the current produces a heating effect, thus temperature increases.

✓ (3) The eddy current flows in the direction to give a repulsive force to oppose the motion of the magnet.

53. D

× (1) It gives no change of magnetic flux through the coil, thus no e.m.f. is induced.

✓ (2) The flux through the coil changes to zero, thus e.m.f. is induced.

✓ (3) The flux through the coil changes, thus e.m.f. is induced.

54. A

✓ (1) By Right-hand rule, induced current flows from B to C, and then to D and A in clockwise direction.

× (2) The induced e.m.f. is from B to C, thus C is at a higher potential.

× (3) Side AD is not in the magnetic field, it experiences no magnetic force.

55. D

$$\varepsilon = N\frac{\Delta\Phi}{\Delta t} = \frac{NBA}{t}$$

$\therefore$ ε depends on N, B, A, t only

$\therefore$ ε is independent of the resistance of the coil.

56. D

For a search coil, the length L of the trace on the CRO is proportional to the peak induced voltage in the coil, which is proportional to the peak value of the varying magnetic field.

For a straight wire carrying current, magnetic field produced is :

$$B = \frac{\mu_0 I}{2\pi r} \propto \frac{1}{r}$$

As the distance at A is halved that of B, the magnetic field at A is doubled that of B, thus the length of trace is doubled.

$\therefore$ $L' = \left(\frac{12}{6}\right) \times 2 = 4$ cm

57. D

Since the component of v perpendicular to the wire is $v \sin 60°$

Induced e.m.f. :

$\varepsilon = B(v \sin 60°)L$

$= \frac{\sqrt{3}BvL}{2}$

58. A

① $\varepsilon = A\frac{\Delta B}{\Delta t} \propto A$ ② $R = \frac{\rho \ell}{A} \propto \ell$

$\therefore$ $I = \frac{\varepsilon}{R} \propto \frac{A}{\ell}$

$\therefore$ $\frac{I_C}{I_S} = \frac{A_C}{A_S} \cdot \frac{\ell_S}{\ell_C} = \frac{(\pi r^2)}{(2r)^2} \cdot \frac{(4 \times 2r)}{(2\pi r)} = 1$

59. C

① When the coil is at the left and moves to the right,
the coil experiences an increase of magnetic flux out of paper.
In order to oppose the change, a clockwise current is induced to produce a magnetic field into paper.

② When the coil is just above the wire,
the coil experiences a change of magnetic flux from out of paper to into paper.
In order to oppose the change, an anticlockwise current is induced to produce a magnetic field out of paper.

③ When the coil is at the right and moves to the right,
the coil experiences an decrease of magnetic flux into paper.
In order to oppose the change, a clockwise current is induced to produce a magnetic field into paper.

60. D

The secondary coil is a search coil which gives the peak voltage by $V_o = 2\pi f N B_o A$

✓ A. $f\uparrow \Rightarrow V_o\uparrow$

✓ B. $N\uparrow \Rightarrow V_o\uparrow$

✓ C. B-field in the middle of the solenoid is greater than B-field at the end. $\therefore$ $B_o\uparrow \Rightarrow V_o\uparrow$

× D. By $B = \mu_0 n I$, B is independent of the area A $\therefore$ same $B \Rightarrow$ same V_o

61. A

From $t = 0$ to $T/4$, current flows from M to N and is decreasing, magnetic field through the loop is into paper and is decreasing. Thus, the induced current in the loop flows in clockwise direction to oppose the change.

From $t = T/4$ to $T/2$, current flows from N to M and is increasing, magnetic field through the loop is out of paper and is increasing. Thus, the induced current in the loop flows in clockwise direction to oppose the change.

From $t = T/2$ to $3T/4$, current flows from N to M and is decreasing, magnetic field through the loop is out of paper and is decreasing. Thus, the induced current in the loop flows in anticlockwise direction to oppose the change.

From $t = 3T/4$ to T, current flows from M to N and is increasing, magnetic field through the loop is into paper and is increasing. Thus, the induced current in the loop flows in anticlockwise direction to oppose the change.

62. D

✓ A. By Right-hand rule, induced current flows along PQ and in the anticlockwise direction.

✓ B. By Left-hand rule, magnetic force acting on PQ is towards the left.

✓ C. By Left-hand rule, there is magnetic force acting on RS towards the right.

× D. Due to the opposing magnetic force acting on PQ, the rod PQ would decelerate.

63. B

Total power consumed by the two lamps $= 6 + 6 = 12$ W

Current passing through each lamp $= \frac{6}{12} = 0.5$ A

Power dissipated by the internal resistance of the generator $= I^2 r = (0.5 + 0.5)^2 (2) = 2$ W

Percentage of power dissipated by the lamps $= \frac{12}{12+2} \times 100\% = 85.7\% \approx 86\%$

64. B

× (1) There is no cutting of magnetic flux when the rod rotates about the axis along y.

× (2) By right-hand-rule, the induced e.m.f. is between the top and the bottom of the rod, not along the rod.

✓ (3) By right-hand-rule, there is an induced e.m.f. along the length of the rod.

65. D

When the field moves away, at the left hand side of the field, the metal there experiences the loss of the field.

To oppose the change, current is induced in clockwise direction to produce a magnetic field into paper.

The eddy current should be at the edge of the field, since the change occurs there.

66. B

The circumference of the square and the circle must be equal.

$\therefore \quad 15.7 \times 4 = 2\pi r \qquad \therefore \quad r = 10$ cm

Area of the square $= 15.7 \times 15.7 = 246.5$ cm^2

Area of the circle $= \pi (10)^2 = 314$ cm^2

$$\varepsilon = \frac{\Delta\Phi}{\Delta t} = B\frac{\Delta A}{\Delta t} = (0.6)\frac{(314 - 246.5)\times 10^{-4}}{(0.5)} = 8.1\,\text{mV}$$

As the area is increased, the coil experiences an increase of flux into paper.

By Lenz's law, to oppose the change, the induced current acts to give a magnetic field out of paper.

Thus the induced current flows in anticlockwise direction.

67. C

Potential difference across Q and S = induced e.m.f. along the rod between QS

$$= Bvl = \frac{BvL}{\sin 30^\circ} \qquad (l \text{ is the length of the rod})$$

68. B

× (1) As eddy current is induced in the aluminium cylinder,
the amplitude of oscillation of the magnet gradually decreases
due to the opposing force of the eddy current.

× (2) The force should act always to oppose motion, thus the force may be attractive or repulsive.

✓ (3) The change of magnetic flux experienced by the cylinder induces eddy current in it.

69. A

✓ (1) When the frame enters the field, to oppose the change,
the frame induces a current in anticlockwise direction to produce a magnetic field out of paper,
thus the induced current is in the direction $PQRSP$.

× (2) There is no induced current when it passes OO' as there is no change of magnetic flux.

× (3) As there is no induced current when it passes OO', there is no magnetic force acting on the frame.

70. C

Direction of magnetic field due to the current along XY is into the paper by Right hand grip rule.

As the coil moves away, the strength of B gradually decreases and thus the flux also decreases.

To oppose the change, the coil induces a current in **clockwise** direction to produce a flux into the paper.

Since the induced current along RS is upwards, the magnetic force between XY and RS is attractive,

thus the magnetic force on the coil is **to left**.

71. D

× (1) The current is from S to R, by Left hand rule, the magnetic force should be downwards.

✓ (2) Magnetic force on RS is downwards and force on PQ is upwards, they form a couple to give a moment.

✓ (3) There is no magnetic field lines passing perpendicularly through the loop, thus the flux is zero.

72. A

Figure 1 : $\varepsilon = BvL$ Figure 2 : $\varepsilon = B(v \sin\theta)\, L$

$\therefore$ Ratio $= 1 : \sin\theta$

73. D

$$N\Phi = NBA = N\frac{\mu_0 NI}{\ell} \cdot A = (1000)\times\frac{(4\pi\times 10^{-7})(1000)(1.5)}{(0.3)} \cdot (3.2\times 10^{-4}) = 2.0\times 10^{-3}\ \text{Wb}$$

74. B

✓ (1) By Right hand rule, B is into paper, I is downwards, thus, motion is leftwards.

× (2) By Right hand rule, induced e.m.f. is downwards from low to high potential.
Thus, potential of B is higher than that of A.

✓ (3) By Left hand rule, B is into paper, I is downwards, thus, magnetic force F is rightwards.
OR
For induced current, magnetic force must oppose motion, thus magnetic force is rightwards.

75. D

✓ A. By Right hand rule, induced current along rod PQ is upwards, thus the current is in the direction $PQRS$.

✓ B. The magnetic force must be oppose the motion, thus it is towards the left.

✓ C. Current along rod RS is from R to S. By Left hand rule, the magnetic force on RS is towards the right.

× D. Due to the opposing magnetic force, the rod PQ should decelerate to rest, not uniform speed.

76. D

The flux through the metal frame : $\Phi = B A = B L^2$

When the frame is rotated by 90°, the flux changes from $B L^2$ to zero, thus the change is $B L^2$.

When the frame is rotated by 180°, the flux changes from $B L^2$ to $- B L^2$, thus the change is $2 B L^2$.

77. B

When the square metal frame moves the distance L into the field region, current is induced.

When the square metal frame moves inside the field region, no current is induced.

When the square metal frame moves the distance L away from the field region, current is induced.

Thus the total time that current is induced = $\frac{d}{v} = \frac{2L}{v}$

78. A

✓ (1) By Right hand rule, an e.m.f. or voltage is induced across PQ.

× (2) As the rod is not a complete circuit, there is no current.

× (3) Since there is no current, there is no opposing magnetic force, thus the rod falls with acceleration g.

79. D

Since the rod is isolated, there is no complete circuit, thus there is no induced current.

By Right hand rule, the induced e.m.f. is from O to P, thus the end P is at a higher electric potential,

as induced e.m.f. points from low to high potential.

80. D

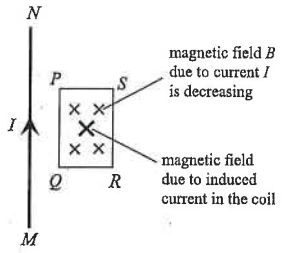
From $t = 0$ to $T/2$, the current is positive and flows from M to N.

By Right hand grip rule, the magnetic field in the coil $PQRS$ due to I is directed into paper.

As current is decreasing, magnetic field B in the coil is decreasing.

By Lenz's law, to oppose the change of magnetic field, the coil induces a current to give a B-field in same direction, thus, the B-field by the induced current is also into the paper.

By Right hand grip rule, the induced current in the coil is in clockwise direction of $PSRQ$.



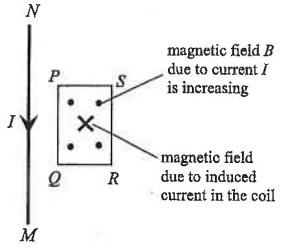
From $t = T/2$ to T, the current is negative and flows from N to M.

The magnetic field in the coil $PQRS$ due to I is directed out of paper.

As current is increasing, magnetic field B in the coil is increasing.

By Lenz's law, to oppose the change, the coil induces a current to give a B-field in opposite direction thus, the B-field due to the induced current is into the paper.

By Right hand grip rule, the induced current in the coil is in clockwise direction of $PSRQ$.



In conclusion, the induced current in the coil is in **clockwise** direction throughout the time interval.

81. B

✓ A. The two sides of the frame P and Q are moving perpendicularly to cut the magnetic field lines, thus the induced e.m.f. is at a maximum at this instant.

× B. Consider the side P, it is moving out of paper. The direction of magnetic field is towards the left. By Right hand rule, the induced current in P is in upward direction. The induced current in Q is in downward direction. Therefore, the induced current in the frame should be in clockwise direction.

✓ C. Whenever there is induced current, there must be a magnetic force opposite to the motion. As P is moving out of paper, the magnetic force on P is into the paper.

✓ D. The magnetic force on P is into the paper and that on Q is out of the paper. These two magnetic forces form a moment to oppose the rotation of the frame.

82. A

✓ (1) Rotate the search coil so that the search coil has different orientation angle with the magnetic field. When the vertical trace on the CRO is maximum, the plane of the search coil is perpendicular to the field. If the vertical trace is not the maximum, the search coil only measures a component of the field.

✓ (2) Since the induced voltage is proportional to the frequency of the a.c., higher frequency gives longer trace, thus, percentage error of the length of the trace is reduced, and accuracy is improved.

× (3) The Earth's magnetic field would not affect the experiment, as search coil cannot detect steady magnetic field such as that of the Earth.

83. C

By using Right hand rule, induced current flows upwards along the rod, thus it flows from X to Y through R.

Since only the length d of the rod can have current flow, induced current is $B d v / R$.

84. B

× A. Reverse the direction of magnetic field can only reverse the direction of eddy current, but cannot increase the magnitude of eddy current.

✓ B. Increase the strength of the magnetic field can increase the rate of change of magnetic flux, thus, the induced eddy current increases.

× C. When the whole disc is inside the magnetic field, there is no change of magnetic flux, thus, no eddy current is induced.

× D. Cut several slits give lamination that will reduce the induced eddy current.

85. D

As the magnet moves down along the aluminium tubing,

the aluminium experiences a change of magnetic flux of the magnet,

thus, eddy current is induced in the aluminium tubing.

As eddy current is induced, there is an opposing magnetic force acting on the magnet.

Thus the net downward force acting on the magnet is less than mg, its downward acceleration is less than g,

therefore, the magnet drops slower.

The following list of formulae may be found useful :

Induced e.m.f.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$
Force on a current-carrying conductor in a magnetic field	$F = BIl\sin\theta$
Magnetic field due to a long straight wire	$B = \frac{\mu_0 I}{2\pi r}$
Magnetic field inside a long solenoid	$B = \frac{\mu_0 NI}{l}$

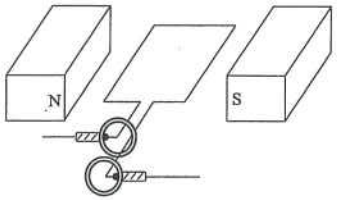
Use the following data wherever necessary :

Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ 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)

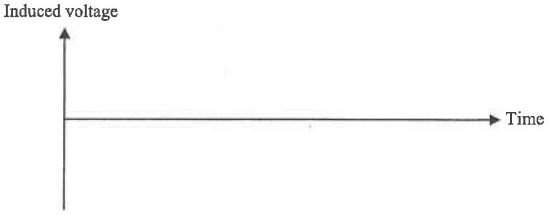
Part A : HKCE examination questions

1. < HKCE 1980 Paper I - 9 >

The figure below shows a simple current generator.



(a) In the figure shown below, sketch a graph to show how the induced voltage varies with time when the coil is turned through one revolution, starting with the plane of the coil lying parallel to the field. (2 marks)



(b) The generator is used to deliver a d.c. current. What modification to the generator is necessary to enable this to be done ? (2 marks)

2. < HKCE 1981 Paper I - 7 >

A light rectangular conducting loop *EFGH* moves from left to right with uniform velocity across a uniform magnetic field pointing into paper. Figure 1, 2 and 3 show three subsequent positions of the loop during its motion.

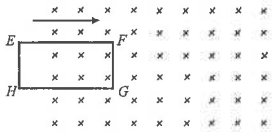


Figure 1

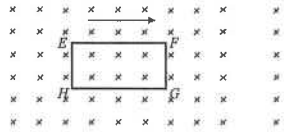


Figure 2

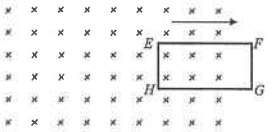


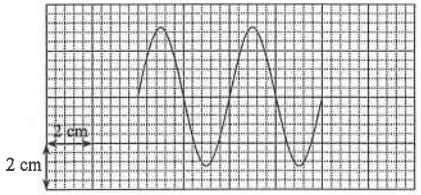
Figure 3

(a) What can you say about the induced current in each of the three cases shown in Figure 1, 2 and 3 ? (3 marks)

(b) State whether an external force is required to maintain the motion of the loop with uniform velocity in each of the above three cases. Explain briefly. (6 marks)

3. < HKCE 1982 Paper I - 7 >

If an a.c. signal is inputted to the CRO with the time-base set at 1 ms cm^{-1} and the voltage sensitivity set at 2.5 V cm^{-1}, the wave pattern displayed is shown in the below figure.



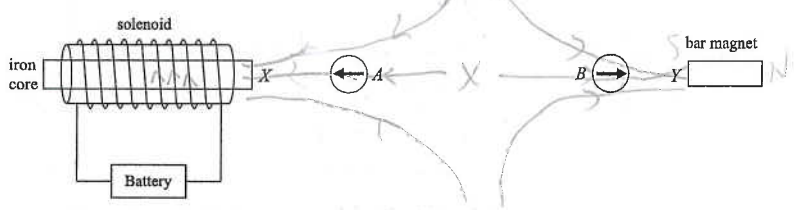
(a) From the wave pattern obtained, estimate the peak voltage of the input signal. (1 mark)

(b) Estimate the time taken for the spot on the screen to produce a complete cycle. (1 mark)

(c) What is the frequency of the input signal ? (2 marks)

4. **< HKCE 1982 Paper I - 9 >**

The diagram below shows a solenoid with an iron core, a bar magnet and compasses *A* and *B* with needles pointing in the directions indicated. Neglect the effect of the Earth's magnetic field.



(a) Sketch on the diagram above, the magnetic field pattern near end *X* and end *Y*.

Indicate

(i) the polarities of *X* and *Y*

(ii) the neutral point, and

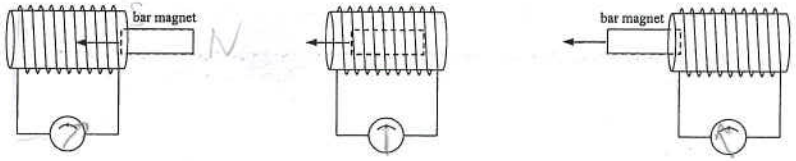
(iii) the direction of the current in the solenoid. (8 marks)

(b) What happens to the neutral point in each of the following cases :

(i) the iron core is taken out of the solenoid at the left hand, and, (1 mark)

(ii) the battery is replaced by a centre-zero galvanometer ? (2 marks)

(c)



After the two changes described in (b) have been made, the bar magnet is moved towards the solenoid and passes through it. Indicate on the given diagrams above the positions of the galvanometer pointer when

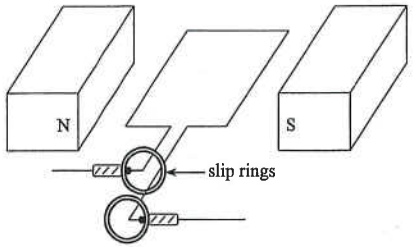
(i) the magnet is just entering the solenoid,

(ii) the magnet is inside the solenoid, and

(iii) the magnet is just leaving the solenoid. (3 marks)

5. **< HKCE 1983 Paper I - 8 >**

The below figure shows an alternating current generator.



(a) Describe briefly with the aid of a diagram how the alternating current generator can be converted into a direct current generator. (4 marks)

(b) Sketch a graph of the output voltage of the a.c. generator against time. Indicate on the time axis of your graph the times at which

(i) the plane of the coil is parallel to the magnetic field (using the letter *H*), and

(ii) the plane of the coil is perpendicular to the magnetic field (using the letter *V*). (5 marks)

(c) Describe what happens to the output voltage if (6 marks)

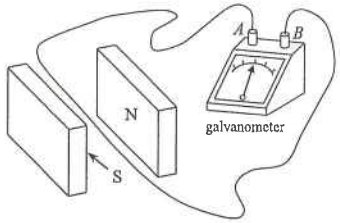
(i) the generator rotates at double its original speed.

(ii) the generator rotates in the opposite direction.

(iii) the number of turns of the coil is doubled.

6. **< HKCE 1985 Paper I - 7 >**

The below figure shows a simple experimental set-up to study the induced current in a wire moving in a magnetic field. The wire is connected to a galvanometer. If current flows through the galvanometer from *A* to *B*, the pointer will deflect to the right.



(a) Draw a diagram to indicate the directions of motion of the wire, of the magnetic field and of the induced current (if any)

(i) if the wire is moving quickly upwards.

(ii) if the wire is moving quickly sideways towards the north pole.

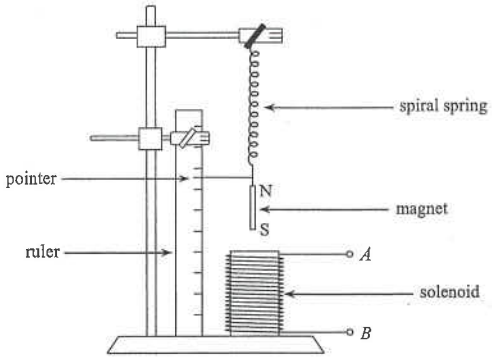
Describe briefly what happens to the galvanometer pointer in each case. (6 marks)

(i)

(ii)

(b) State THREE methods of increasing the induced current in the experiment. (3 marks)

7. **< HKCE 1988 Paper I - 9 >**



A student sets up an apparatus as shown in the above figure and claims that it can be used to measure a current flowing from terminal *A* to *B* through the solenoid.

(a) (i) Explain why this set-up can be used to measure current. (3 marks)

(ii) Suggest TWO methods to increase the sensitivity of the set-up. (2 marks)

(iii) Can this set-up still measure current if the magnet is replaced by a soft iron bar ? Explain briefly. (3 marks)

(b) *A* and *B* are now connected to a centre-zero galvanometer. The magnet is set to vibrate up and down. It is kept out of the solenoid. Is there any current passing through the solenoid when the magnet

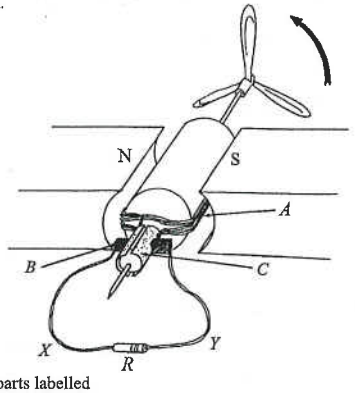
(i) moves towards the solenoid ?

(ii) is at its lowest point ?

If there is a current, state its direction. Explain briefly in each case. (5 marks)

8. **< HKCE 1989 Paper I - 7 >**

A student uses the set-up as shown in the figure to investigate the generation of electrical energy from wind. The blades are turning in the direction shown.



(a) What is the name of the parts labelled

(i) *A*,

(ii) *B*, and

(iii) *C* ? (3 marks)

(b) Sketch the variation of the output current against time and determine the direction of the current passing through the resistor *R* at the moment shown in the figure. (3 marks)

(c) You are given a voltmeter and an ammeter. Draw a circuit diagram to show how they can be used to measure the power output by the generator. (3 marks)

(d) The current output is 0.7 A when the voltage between *XY* is 12 V. Determine the power output by the generator at that moment. (2 marks)

(e) State TWO advantages and TWO disadvantages of using wind to generate electrical energy. (4 marks)

9. **< HKCE 1996 Paper I - 7 >**

(a)

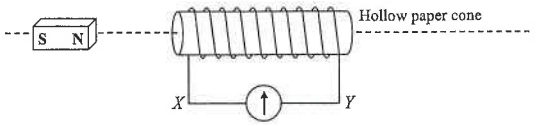


Figure 1

A bar magnet is pushed with constant speed from left to right through a solenoid as shown in Figure 1. Describe the change in the direction of the current passing through the galvanometer during the motion of the magnet. (3 marks)

(b)

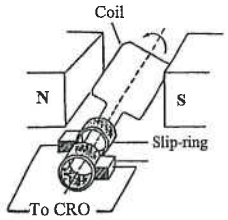


Figure 2

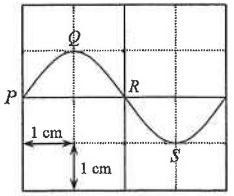


Figure 3

Figure 2 shows the structure of a simple a.c. generator. A voltage is induced when the coil is set into rotation. The output of the generator is displayed on a CRO as shown in Figure 3. The time base of the CRO is set at 20 ms cm^{-1} and *Y*-gain at 50 mV cm^{-1}.

(i) Which points (*P*, *Q*, *R* and *S*) shown in Figure 3 correspond to instants at which the plane of the coil is parallel to the magnetic field ? (2 marks)

(ii) Find the peak voltage and frequency of the output of the generator. (3 marks)

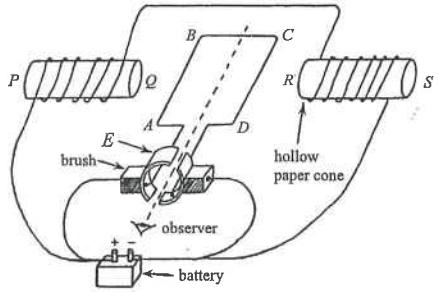
(iii) Describe what happens to the peak voltage and frequency of the output of the generator in each of the following cases :

(1) Increasing the speed of rotation of the coil.

(2) Winding the coil on a soft-iron core. (4 marks)

(iv) Steam is commonly used to drive generators in power stations to generate electricity. Suggest two other practical means of driving generators. (2 marks)

10. < HKCE 1998 Paper I - 5 >



The Figure above shows a type of motor. PQ and RS are solenoids. The solenoids and the coil $ABCD$ are connected in parallel to a battery.

(a) State

(i) the polarity at end Q of the solenoid PQ,

(ii) the direction of rotation of the coil as seen by the observer. (2 marks)

(b) Name the component E and explain its function. (3 marks)

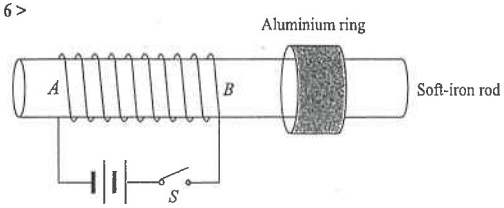
(c) Suggest **two** ways of increasing the rotating speed of the coil. (2 marks)

(d) A student says "If the battery in the above Figure is replaced by a 50 Hz a.c. supply, the coil will only oscillate to and fro. Hence the motor will not function properly."

Explain why the student is incorrect. (4 marks)

(e) Describe, with the help of a diagram, how the motor in the above Figure can be converted to a direct current generator. (3 marks)

11. < HKCE 2002 Paper I - 6 >



A soft-iron rod is inserted into a solenoid AB, which is connected to a battery and a switch S as shown in the above figure. Initially S is open. An aluminium ring is also inserted into the rod and placed beside the solenoid. S is now closed.

(a) State the polarity at end B of the solenoid. (1 mark)

(b) Explain why the aluminium ring will move away from the solenoid. (3 marks)

12. < HKCE 2003 Paper I - 6 >

Figure 1 shows a battery-powered electric fan. Mary wants to construct a simple generator from the fan. She removes the motor of the fan and connects it to a light bulb (see Figure 2). When the blades of the fan are turned rapidly, the bulb lights up.

Figure 1

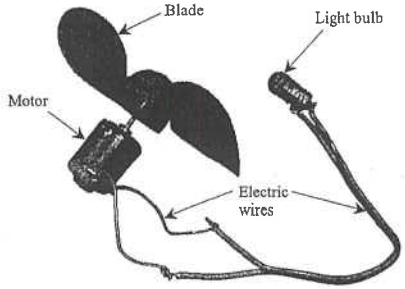


Figure 2

(a) Name **two** essential components of a motor. (2 marks)

(b) Explain why the bulb lights up when the blades are turning. (3 marks)

13. **< HKCE 2008 Paper I - 11 >**

A student uses the setup in Figure 1 to study the current induced in a solenoid when a magnet is falling through it. When a current is passing through the current sensor from *A* to *B*, a positive reading is obtained. Figure 2 shows the result after the magnet is released at a certain height.

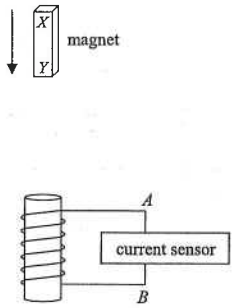


Figure 1

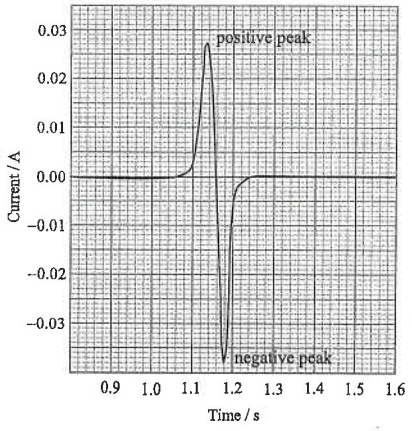


Figure 2

(a) State the polarity of end *Y* of the magnet. (1 mark)

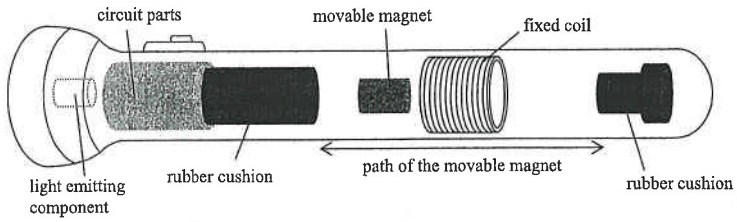
(b) Explain why the reading of the induced current is negative when the magnet leaves the solenoid. (3 marks)

(c) Explain why the magnitude of "negative peak" is greater than that of "positive peak". (2 marks)

14. **< HKCE 2010 Paper I - 13 >**

A hand-shaken torch does not require any battery. Shaking it for a short while will produce a current and give out bright light. Figure 1 shows the structure of the torch.

Figure 1



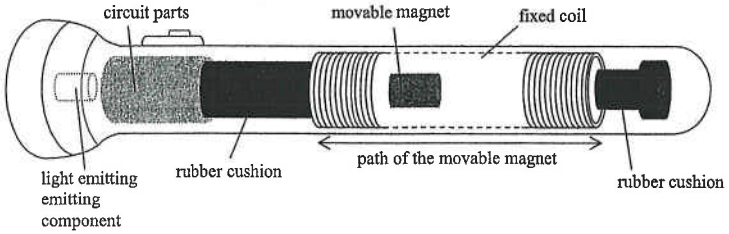
(a) Describe how current is produced in the fixed coil when the torch is shaken. (2 marks)

(b) State **one** method to increase the current without modifying the torch. (1 mark)

(c) Describe the energy conversion when this torch is in operation. (2 marks)

(d) In another design as shown in Figure 2, the fixed coil covers the whole length of the path of the movable magnet. It is found that the torch becomes dimmer than the original design when operating it in the same way. Explain briefly. (The resistance of the fixed coil can be neglected.) (2 marks)

Figure 2



Part B : HKAL examination questions

15. < HKAL 1996 Paper I - 7 >

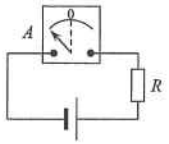


Figure 1

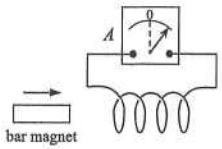


Figure 2

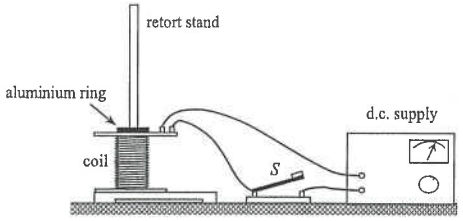
A centre-zero galvanometer *A* is connected in series with a resistor, *R*, and a 1.5 V cell as shown in Figure 1. The pointer of *A* deflects to the left. The galvanometer is now connected to a coil as shown in Figure 2. When a bar magnet is moved with uniform speed by a student towards the coil, the pointer of *A* deflects to the right.

(a) On Figure 2, indicate the direction of the induced current in the coil and also the poles of the bar magnet. (2 marks)

(b) Where does the electrical energy in the circuit come from ? (1 mark)

(c) Suggest THREE ways to increase the deflection of *A*. (2 marks)

16. < HKAL 1996 Paper I - 7 >



A coil and a retort stand made of iron are arranged as shown. The coil is connected to a d.c. supply via a switch *S*. When the switch is pressed on, the aluminium ring placed on top of the coil jumps up momentarily and then falls back to the top of the coil.

(a) Briefly explain this observation. (3 marks)

16. (b) If now the d.c. supply is replaced by an a.c. supply.

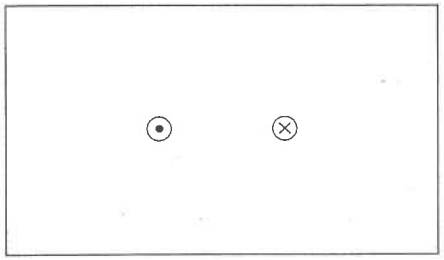
(i) What would be observed if the switch is closed ? (1 mark)

(ii) Suggest a practical use of this experimental result. (1 mark)

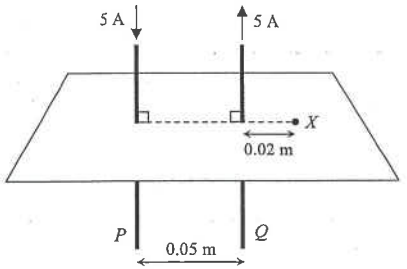
(iii) The heat capacity of the ring is 7.8 J K^{-1} and its temperature is found to rise from 25°C to 40°C during the first 50 s when the a.c. supply is on. Find the average rate of increase in internal energy of the ring. (2 marks)

17. < HKAL 2000 Paper I - 7 >

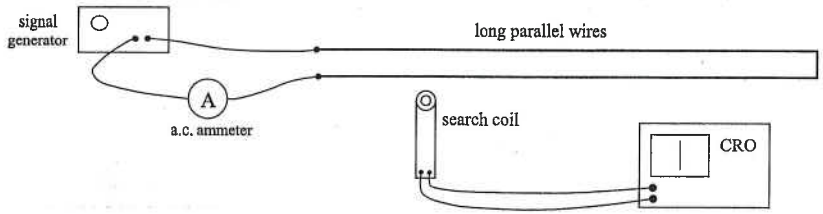
(a) In the figure below, there are two parallel wires carrying currents in opposite directions. The current in the left wire is perpendicularly out of paper while the current in the right wire is perpendicularly into paper. Sketch in the space below the magnetic field pattern around the two wires. (2 marks)



(b) In the figure below, if the current flowing through both wires is 5 A and the separation between them is 0.05 m, find the magnitude of the resultant magnetic field due to these two wires at point *X*, which is 0.02 m from wire *Q*. (2 marks)



17. (c) Two long parallel current-carrying wires are now connected to a signal generator giving out a.c. current. A search coil connected to a CRO is used to investigate the magnetic field around the two wires. With the time base of the CRO switched off, a vertical trace is observed on the screen of the CRO.

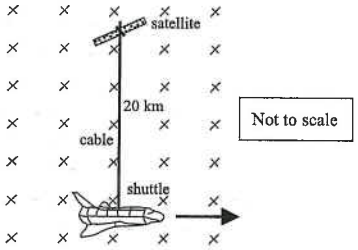


(i) Explain what is represented by the length of the trace observed on the CRO. (2 marks)

(ii) Explain whether the measurement of the magnetic field by the search coil would be affected by the Earth's magnetic field. (2 marks)

18. **< HKAL 2000 Paper I - 8 >**

In the figure below, a space shuttle carries a satellite attached to it by a 20 km long conducting cable. The two move together around the Earth above the equator in orbital motion. In the orbital motion, the cable sweeps through the magnetic field of the Earth.



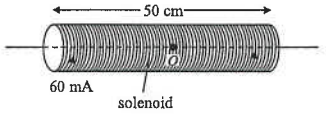
Given : Magnetic field strength in the orbital region = 30×10^{-6} T
Orbital position of the shuttle = 6.8×10^{6} m from the centre of the Earth
Mean radius of the Earth = 6.4×10^{6} m

(a) Calculate the orbital speed of the shuttle at this position. (3 marks)

(b) Find the e.m.f. induced across the cable. State one assumption that you have made in the calculation. (3 marks)

19. **< HKAL 2001 Paper I - 4 >**

The figure below shows a solenoid of diameter 5.0 cm and length 50 cm. The solenoid has 1000 turns and it carries a steady current of 60 mA.

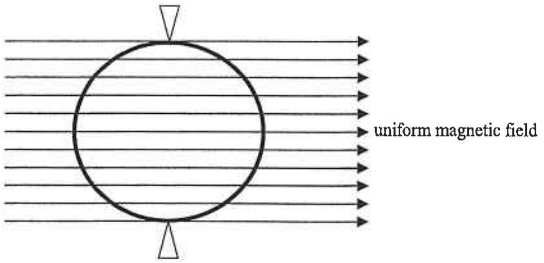


(a) Calculate the magnetic field strength at the centre *O* of the solenoid. (2 marks)

(b) Calculate the magnetic flux linkage through the solenoid. (2 marks)

20. **< HKAL 2003 Paper I - 4 >**

The figure below shows a circular coil of 100 turns and radius 5 cm pivoted by two smooth vertical supports. It is placed in a region with a uniform magnetic field of 0.1 T towards the right. The ends of the coil are joined together and the resistance of the coil is 10 Ω.



The coil is turned through 90° by an external force until its plane is perpendicular to the magnetic field.

(a) Would the coil resist being turned ? Explain briefly. (2 marks)

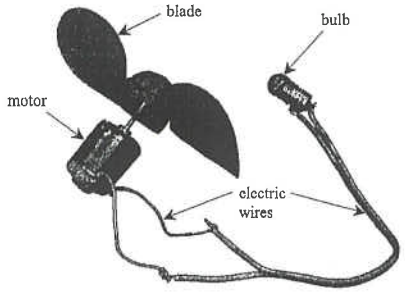
(b) If the coil is released from rest at the new position described above, would it move back to its original position ? Explain briefly. (2 marks)

(c) The coil is now fixed with its plane perpendicular to the magnetic field. The flux density of the field is increased at a uniform rate of 0.3 T s^{-1}. Find the magnitude of the current induced in the coil. (3 marks)

Part C : HKDSE examination questions

21. < HKDSE Sample Paper IB - 7 >

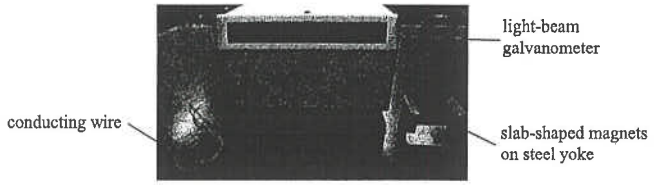
Amy uses the motor of a toy fan as a simple generator. She connects a bulb to the two terminals of the motor. This is shown in the Figure below.



The bulb lights up when the blades are turned rapidly. Explain why and state the energy conversion taking place in this process. (4 marks)

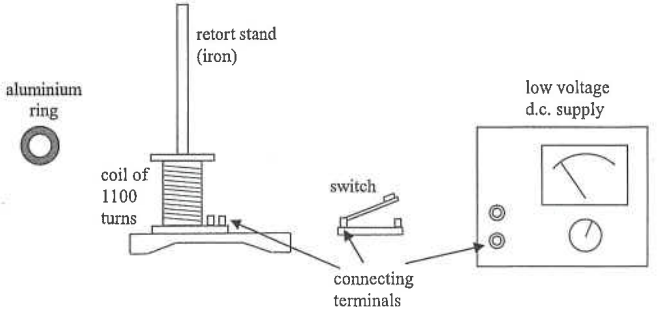
22. < HKDSE 2012 Paper IB - 10 >

You are given a long conducting wire, a pair of slab-shaped magnets on steel yoke and a light-beam galvanometer for detecting small currents. With the aid of a diagram, describe an experiment to investigate TWO factors affecting the e.m.f. induced in a conductor when it moves in a magnetic field. (7 marks)



23. < HKDSE 2014 Paper IB - 9 >

(a) You are given a low voltage d.c. supply, an aluminium ring, a switch, a coil of 1100 turns and a retort stand arranged as shown. Use three connecting leads to complete the connections among the apparatus in the figure and describe how to demonstrate Lenz's law in electromagnetic induction. State and explain the observation. (6 marks)



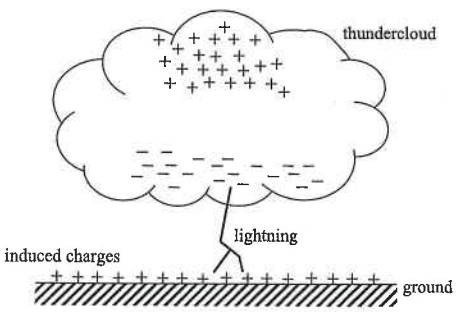
(b) Describe what would be observed if the experiment in part (a) is repeated with

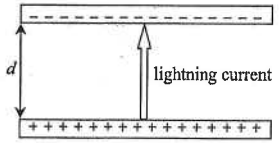
(i) a low voltage a.c. supply ; (1 mark)

(ii) a low voltage a.c. supply and an aluminium ring with a slit cut through it as shown [ ]. (1 mark)

24. **< HKDSE 2016 Paper IB - 8 >**

Read the following passage about **lightning** and answer the question that follow.





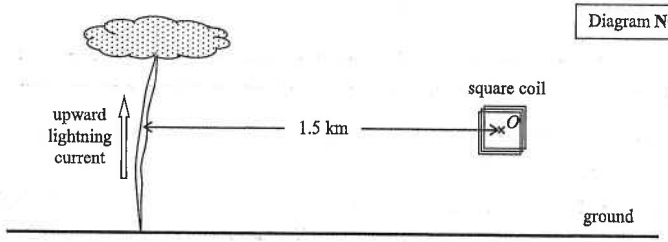
Lightning occurs when charges accumulate in the clouds to such an extent that the electric field in the atmosphere is strong enough to cause the air to lose its insulating properties. The threshold electric field for 'breakdown' to occur is about 3×10^5 V m^{-1} above which electrons or ions in the atmosphere can pass through the air between clouds and the ground or between clouds and clouds. The peak current of a typical lightning bolt can reach about 30 000 A. How the charges are separated and accumulated in the clouds is not fully understood yet. In most cases, negative charges are at the base of the cloud and positive charges are induced on the ground.

(a) (i) What is the meaning of 'breakdown' in the passage ? (1 mark)

(ii) The thundercloud's base and the ground can be modeled as two parallel plates with opposite charges. If the negative charges distributed at the cloud's base are about $d = 2$ km from the ground, find the potential difference between the cloud and the ground when the electric field in the atmosphere just reaches the threshold of 'breakdown'. (2 marks)

A lightning detector having a small square coil inside is placed at point O which is 1.5 km from the lightning bolt. The coil and the lightning's direction are in the same vertical plane as shown. Assume that the lightning current flows vertically upwards to the thundercloud from the ground.

Diagram **NOT** drawn to scale



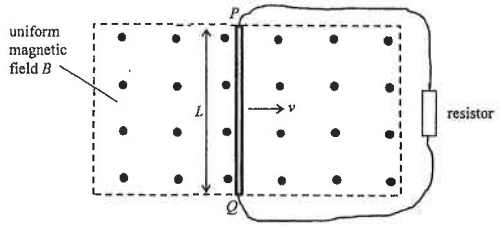
24. (b) (i) State the direction of the magnetic field (to the left / to the right / into paper / out of paper) produced at point O by the lightning current. Estimate the magnetic field strength's peak value at O. (3 marks)

(ii) Explain why within the very short duration of lightning, an induced current first flows in the coil in a certain direction and then reverses. Your answer should include the directions of the induced current in the coil. (3 marks)

(iii) Among the physical quantities related to lightning, **electric field in the atmosphere**, **lightning current** and **magnetic field due to lightning**, suggest which one can be monitored so as to give fore-warning of lightning. Explain your choice. (2 marks)

25. **< HKDSE 2018 Paper IB - 9 >**

(a)



The Figure above shows a metal rod PQ of length L moving with constant velocity v across a uniform magnetic field B pointing out of the paper. An e.m.f. ξ is induced across rod PQ as it cuts the field lines. When the rod is connected to a resistor outside the field, a current I flows in the circuit.

(i) Indicate the direction of I in the above Figure. (1 mark)

(ii) Explain why an external force F is required to maintain the uniform motion of rod PQ. Find F in terms of the physical quantities given. (3 marks)

(iii) This set-up works as a generator. By considering the mechanical power input by external force F to the set-up, show that $\xi = B L v$. (2 marks)

25. (b) At a certain place the Earth's magnetic field runs along the S-N direction such that the field lines make an angle θ with the horizontal as shown in Figure (a).

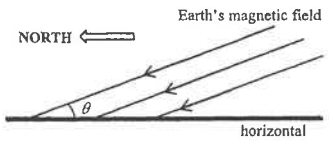


Figure (a)

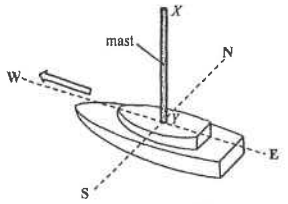


Figure (b)

A ship with a vertical aluminium mast sails at sea along a straight course to the west as shown in Figure (b). As a result, an e.m.f. is induced across the mast XY.

(i) Explain why it is **only the horizontal component** of the Earth's magnetic field that is cut by the mast which gives rise to this induced e.m.f. (1 mark)

(ii) Given : length of mast XY = 20 m
speed of the ship = 6 m s^{-1}
Earth's magnetic field = 50 μT
θ = 30°

Referring to (a)(iii), calculate the e.m.f. induced across XY and state whether the distribution of free electrons along the mast is more at end X, more at end Y or uniform along XY. (3 marks)

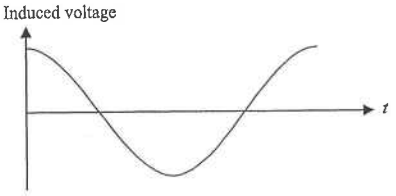
(iii) Suppose X and Y are connected by a cable running side-by-side with the mast so that they form a complete circuit. Explain whether there will be a current passing through it. (2 marks)

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)



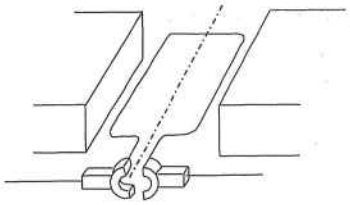
< the induced voltage is maximum at t = 0 > [1]

< a complete cycle shown above is drawn > [1]

(b) Change the slip rings [1]

to a commutator. [1]

< accept the use of diagram to show the commutator >



2. (a) In figure 1, induced current flows in direction of $GFEH$. [1]

OR

In figure 1, induced current flows in anticlockwise direction. [1]

In figure 2, no induced current flows. [1]

In figure 3, induced current flows in the direction of $HEFG$. [1]

OR

In figure 3, induced current flows in clockwise direction. [1]

(b) In figure 1, an applied force along the direction of motion is required to maintain the motion of the loop [1]

since there is an opposite magnetic force acts on the wire GF when current flows in magnetic field. [1]

In figure 2, no force is required [1]

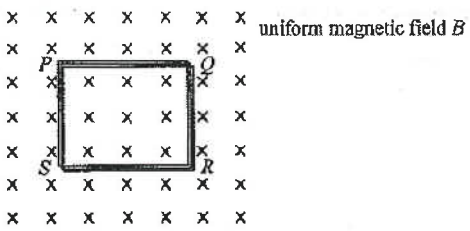
since there is no current flowing in the loop. [1]

In figure 3, an applied force also along the direction of motion is required to maintain the motion of the loop [1]

since there is an opposite magnetic force acts on the wire HE when current flows in magnetic field. [1]

26. <HKDSE 2019 Ppaper-IB-9>

A rectangular coil $PQRS$ of 20 turns, each having an area of 0.005 m^2, is placed in a uniform magnetic field B of strength 0.3 T pointing into the paper as shown in Figure 9.1.



ure 9.1

(a) The strength of the magnetic field decreases uniformly to zero within 0.5 s.

(i) Explain why a current would be induced in the coil. (2 marks)

*(ii) Calculate the change in total magnetic flux linkage through the coil and the value of the induced e.m.f. ξ in the coil. (3 marks)

(b) Now the coil is rotated uniformly about an axis through 180° as shown in Figures 9.2(a) and 9.2(b) within 0.5 s.

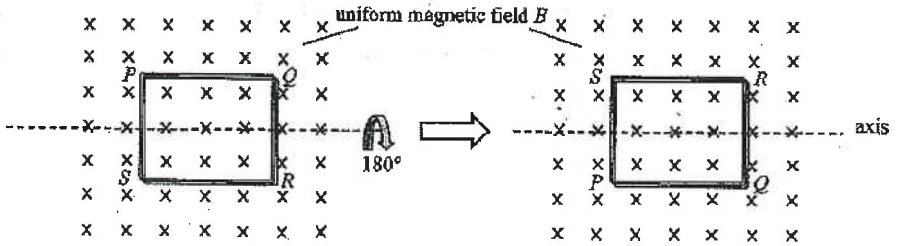


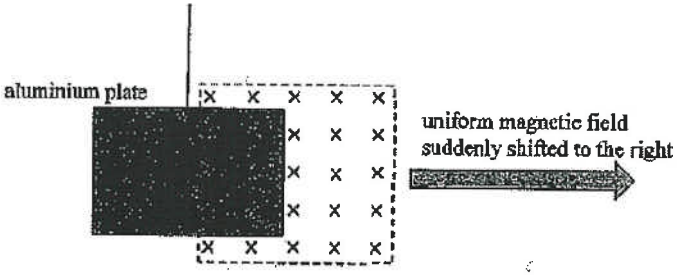
Figure 9.2(a)

Figure 9.2(b)

(i) State the value of the change in total magnetic flux linkage through the coil in this case (1 mark)

(ii) At the moment when the coil rotated through 90°, would the induced current flow in the direction $PQRS$, $PSRQ$ or is there no induced current in the coil ? (1 mark)

(c) Figure 9.3 shows a thin rectangular aluminium plate suspended by a long string. The plate is partly inside a uniform magnetic field provided by a strong magnet.



ure 9.3

The magnet, which is not in contact with the plate, is suddenly shifted to the right.

(i) On Figure 9.3, draw a small circle at the location where eddy currents are induced on the aluminium plate. Use an arrow to indicate the direction of current. (2 marks)

(ii) Describe the subsequent motion of the aluminium plate, if any. (1 mark)

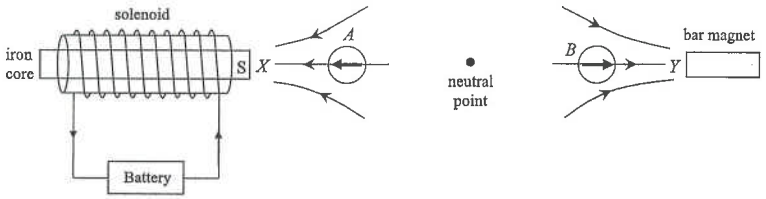
3. (a) Peak voltage = 3 cm × 2.5 V cm^{-1} = 7.5 V [1]

(b) Time taken = 4 cm × 1 ms cm^{-1} = 4 ms [1]

(c) Frequency = $\frac{1}{4\times10^{-3}}$ [1]

= 250 Hz [1]

4. (a)



< Correct pattern > [2]

< Indication of direction of magnetic field > [2]

< Both of the poles are South > [2]

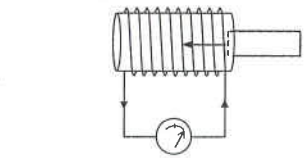
< Neutral point between two compasses > [1]

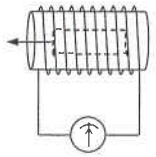
< Correct direction of current > [1]

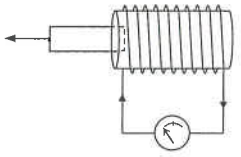
(b) (i) The neutral point moves towards X [1]

(ii) The neutral point disappears [2]

(c)

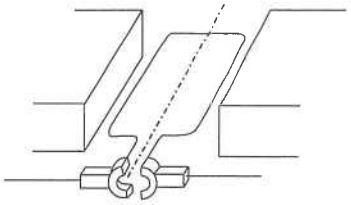

[1]


[1]

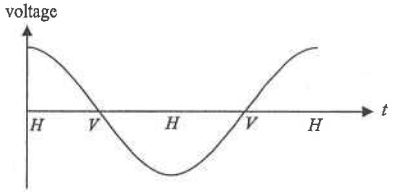

[1]

5. (a) Replace the slip rings by a commutator. [2]

Connect the coil to the commutator via 2 carbon brushes. [1]


[1]

(b)



< Voltage is maximum at $t = 0$ > [1]

< Both positive and negative voltage shown > [1]

< Shape correct > [1]

< Correct H > [1]

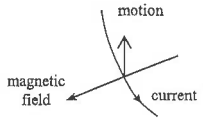
< Correct V > [1]

(c) (i) The output voltage increases and the frequency also increases (**OR** double) [2]

(ii) The amplitude of the voltage is unchanged but the phase is reverse. [2]

(iii) The output voltage increases (**OR** double). [2]

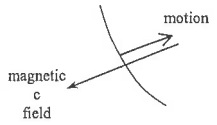
6. (a) (i)



[2]

The pointer deflects to the left. [1]

(ii)



[2]

The pointer does not have any deflection. [1]

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

* Move the wire with a greater speed
* Use a stronger magnet
* Replace the wire with a coil of more number of turns
* Replace the wire with one of lower resistance

7. (a) (i) Current flowing through the solenoid will give a magnetic field to attract the magnet. [1]

The magnet will be pulled down [1]

and the spring will extend. [1]

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

* Increase the number of turns in the solenoid
* Use a stronger magnet
* Use a weaker spring

(iii) The set-up can still work. [1]

Since the soft iron will be magnetized by the magnetic field of the solenoid, [1]

attraction always exists. [1]

(b) (i) Yes ! [1]

From B to A [1]

There is a change of magnetic field and thus has an induced current. [1]

(ii) No ! [1]

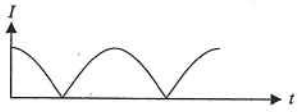
There is no change in magnetic field at the lowest point as the magnet is momentarily at rest. [1]

8. (a) (i) A is coils. [1]

(ii) B is carbon brush [1]

(iii) C is commutator (**OR** two split rings) (**OR** two half-rings) [1]

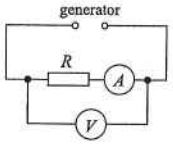
(b)



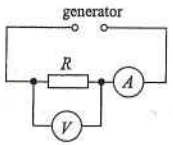
[2]

Current flows from X to Y. [1]

(c)



OR



[3]

(d) Power $= VI = (12) \times (0.7)$ [1]

$= 8.4$ W [1]

8. (e) **Advantages** : (Any TWO) [2]

* Wind is cheaper
* Wind is of unlimited supply
* Wind has no pollution

Disadvantages : (Any TWO) [2]

* Unsteady output (no output when no wind)
* Low power output
* Suitable only for windy places
* Direction of wind always changes

9. (a) When the magnet moves towards the solenoid, a current passes through G from X to Y. [1]

When the magnet is inside the solenoid, there is no current. [1]

When the magnet moves away from the solenoid, a current passes through G from Y to X. [1]

(b) (i) The plane of the coil is parallel to the magnetic field at points Q and S. [2]

(ii) Peak voltage $= 1 \times 50 = 50$ mV (OR 0.05 V) [1]

Period : $T = 4 \times 20 \times 10^{-3} = 0.08$ s [1]

Frequency : $f = \frac{1}{T} = \frac{1}{0.08} = 12.5$ Hz [1]

(iii) (1) Peak voltage increases [1]

Frequency increases [1]

(2) Peak voltage increases [1]

Frequency remains unchanged. [1]

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

* Wind (**OR** moving air)
* Running water
* Sea wave

10. (a) (i) End Q is a south pole. [1]

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

(b) E is a commutator (**OR** 2 half-rings) (**OR** 2 split-rings) [1]

It is used to reverse the direction of current flowing through the coil when the coil has rotated half cycle. [1]

Hence the coil will continue to rotate in the same direction. [1]

10. (c) Any **TWO** of the following : [2]

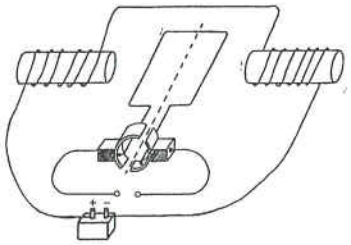
* Increase the voltage of the battery (OR Increase the current passing through the coil)
* Increase the number of turns of the coil
* Increase the area of the coil
* Increase the number of turns of the solenoid
* Insert a soft iron core inside the paper cone
* Wind the coil on a soft-iron core

(d) If the direction of current is reversed, the polarities of the solenoids [1]
and the current flowing through the coil are reversed at the same time. [1]
So the direction of rotation of the coil will remain unchanged. [1]
Hence the motor will still function properly for a.c. supply. [1]

OR

If the direction of current is reversed, the direction of current flowing through the solenoid [1]
and the current flowing through the coil are reversed at the same time. [1]
So the direction of the forces acting on the coil will remain unchanged. [1]
Hence the motor will still function properly for a.c. supply. [1]

(e)



[1]

The wires connecting the commutator are disconnected from the battery. [1]
The other arrangements remain unchanged. [1]

11. (a) *B* is South pole. [1]

(b) When *S* is closed, a magnetic field will be built up in the solenoid.
There will be an induced current flowing in the aluminium ring. [1]
By Lenz's Law, the induced current flows in a direction such that it produces an effect to oppose the change. [1]
So the end of the ring near the solenoid becomes a south pole.
The aluminium ring will move away from the solenoid under the action of the repulsive force acting on it. [1]

12. (a) Any **TWO** of the following : [2]

* coil
* magnet
* commutator
* soft iron core

(b) When the blades are turning, the coil inside the motor will rotate [1]
in the magnetic field of the magnet. [1]
A voltage is induced in the coil [1]
and thus current passes through the light bulb to light it up.

13. (a) North (**OR** N-pole) [1]

(b) By Lenz's law, the induced current flows in a direction to oppose the change of magnetic field. [1]
When the south pole leaves, current is induced so that the lower end of the solenoid becomes north. [1]
By Right hand grip rule, the induced current then flows in an opposite direction through the sensor. [1]

(c) The magnet is accelerating. (**OR** The speed of the magnet is increasing.) [1]
Thus the rate of change of magnetic field is greater. [1]

14. (a) When the torch is shaken, the movable magnet moves across the fixed coil.
The magnetic field through the fixed coil changes (**OR** the coil cuts the magnetic field lines) [1]
and a current is induced. (**OR** by Lenz's law, a current is produced.) [1]

(b) Any **ONE** of the following : [1]

* Shake the torch with a greater speed.
* Shake the torch more times.

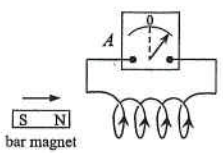
(c) Kinetic energy (**OR** *K.E.*) changes to electrical energy, [1]
and then changes to light (**OR** light and heat) [1]

(d) Because the magnet cannot leave the coil, (**OR** the magnet is always inside the coil) [1]
the coil experiences weaker (**OR** no change) of magnetic field. [1]

< OR >

Only when the magnet is entering or leaving the coil, [1]
there is a change in magnetic field. [1]

15. (a)



< Correct direction of current > [1]

< Correct poles of magnet > [1]

(b) Work done by the student in pushing the magnet. [1]

(c) ✶ Move the magnet more quickly
✶ Use a stronger magnet
✶ Use a coil with more turns
✶ Insert a soft iron in the coil

< any one or two correct > [1]

< the third one correct > [1]

16. (a) When *S* is closed, current starts to flow in the coil and produces magnetic field.

Thus an increase of the magnetic field occurs through the ring. [1]

By Lenz Law, an eddy current is induced in the ring to oppose the change.

Opposing magnetic force acts on the ring to make it jump up momentarily. [1]

However, when the current reaches its steady value, no change of field results and the ring falls back. [1]

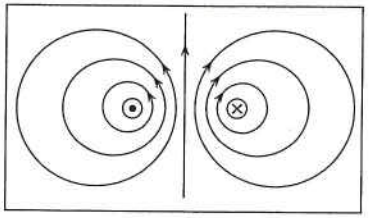
(b) (i) The ring will float steadily above the coil in air. [1]

(ii) Practical use : magnetic levitation of a train [1]

(iii) Rate of increase in internal energy $= \frac{7.8\times(40-25)}{50}$ [1]

$= 2.3\ \text{J s}^{-1}$ [1]

17. (a)



< direction correct > [1]

< pattern correct > [1]

(b) $B = \frac{4\pi\times10^{-7}\times5}{2\pi}\left(\frac{1}{0.02}-\frac{1}{0.07}\right)$ [1]

$= 3.6\times10^{-5}\ \text{T}$ [1]

17. (c) (i) The length of the trace represents the peak-to-peak voltage of the induced voltage in the search coil. [1]

It is proportional to the peak value of the magnetic field produced by the a.c. currents. [1]

(ii) The working of the search coil would not be affected by the Earth's magnetic field. [1]

Since the Earth's magnetic field is steady, no e.m.f. can be induced in the search coil. [1]

18. (a) $g = \frac{GM}{R_E^2}$ $\therefore\ GM = gR_E^2 = (9.81)\times(6.4\times10^6)^2$

By $\frac{GMm}{r^2} = \frac{mv^2}{r}$ [1]

$\therefore\ v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{9.81\times(6.4\times10^6)^2}{6.8\times10^6}}$ [1]

$= 7690\ \text{m s}^{-1}$ [1]

(b) $\varepsilon = BvL$

$= (30\times10^{-6})\times(7690)\times(20\times10^3)$ [1]

$= 4610\ \text{V}$ [1]

Any **ONE** of the followings : [1]

✶ The cable is always perpendicular to the *B*-field

✶ The magnetic field is uniform over this 20 km cable

✶ The satellite and the shuttle move with the same speed

19. (a) $B = \frac{\mu_o NI}{\ell} = \frac{(4\pi\times10^{-7})(1\times10^3)(60\times10^{-3})}{0.5}$ [1]

$= 1.51\times10^{-4}\ \text{T}$ [1]

(b) $N\Phi = NBA$ [1]

$= (1\times10^3)(1.51\times10^{-4})(\pi\times0.025^2)$

$= 2.96\times10^{-4}\ \text{Wb}$ [1]

20. (a) Yes, the coil would resist being turned. [1]

When the coil is turned, a current is induced.

By Lenz's law, magnetic forces acts on the coil to give a moment to oppose its rotation. [1]

(b) No. [1]

Since there is no induced current through the coil, no magnetic forces act to rotate the coil. [1]

20. (c) $\varepsilon = N\frac{\Delta\Phi}{\Delta t} = NA\frac{\Delta B}{\Delta t} = (100)(\pi \times 0.05^2)(0.3) = 0.236\ \text{V}$ [1]

$I = \frac{\varepsilon}{R} = \frac{0.236}{10}$ [1]

$\therefore\ I = 0.0236\ \text{A}$ [1]

21. When the blades are turned, the coil inside the motor will rotate in the magnetic field of the magnet. [1]

An induced e.m.f. will be set up in the coil. [1]

The induced current flows through the bulb and lights up the bulb. [1]

Kinetic energy is converted to electrical energy and then to heat and light energy. [1]

22.

< The conducting wire connected to the light-beam galvanometer > [1]

< The wire placed between the pairs of magnets > [1]

< Two hands holding the wire > [1]

Connect the long wire to the galvanometer and place the wire across the magnetic field.

To investigate the factor affecting the induced e.m.f. : (Any **TWO** of the followings)

* **Rate of movement**

  Move the wire slowly across the field and then quickly across the field. [1]

  The galvanometer would deflect more for a faster rate. [1]

* **Number of turns**

  Move the wire across the field. Then wind the wire into a few number of turns and move it again. [1]

  The galvanometer would deflect more for more number of turns of the wire. [1]

* **Relative movement**

  Move the wire vertically down across the field and then up across the field. [1]

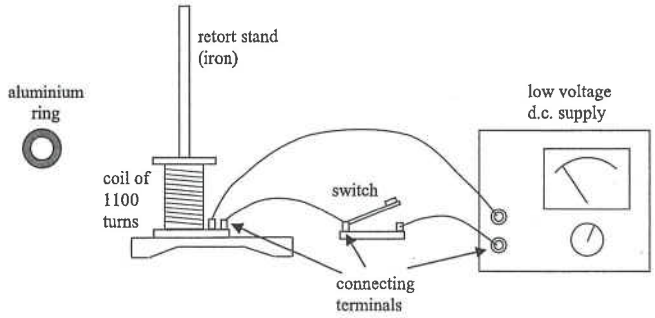
  The galvanometer would deflect to one side and then to the opposite side. [1]

* **Polarities of magnet**

  Move the wire vertically down across the field, the galvanometer would deflect to one side. [1]

  Reverse the polarities of magnets and repeat the experiment, the galvanometer would deflect to the opposite side. [1]

23. (a)



< the connection of the 3 wires is ALL correct > [1]

Place the aluminium ring on the top of the coil through the rod of the retort stand. [1]

When the switch is closed, the ring jumps up momentarily and falls down. [1]

As the aluminium ring experiences a sudden increase of magnetic field produced by the coil at the start, [1]

according to Lenz's Law, eddy currents are induced in the ring to oppose this change. [1]

A repelling upward magnetic force then exerts on the ring to push it up.

When the current and magnetic field becomes constant, the ring falls back as eddy current no longer flows. [1]

(b) (i) The aluminium ring floats above the coil in the air. [1]

(ii) The ring remains at rest on the coil without moving up. [1]

24. (a) (i) Any **ONE** of the followings : [1]

* The air loses its insulating properties.
* The air becomes conducting.
* Charges can pass through the air between the clouds and the Earth.

(ii) $E = \frac{V}{d}$ [1]

$V = Ed = (3 \times 10^5) \times (2000) = 6 \times 10^8\ \text{V}$ [1]

(b) (i) Magnetic field into paper [1]

$B = \frac{\mu_o I}{2\pi r}$ [1]

$= \frac{4\pi \times 10^{-7} \times 30000}{2\pi \times 1500}$

$= 4 \times 10^{-6}\ \text{T}$ [1]

24. (b) (ii) When the lightning current is increasing, the induced current flows in the anticlockwise direction so as to oppose the increase of magnetic field. [1] [1]

After reaching maximum, the lightning current is decreasing, the induced current flows in the clockwise direction (**OR** opposite direction). [1]

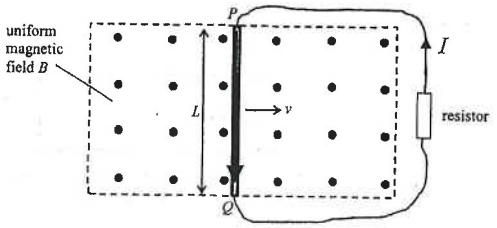
(iii) Electric field [1]

E-field increases (**OR** builds up) before lightning occurs [1]

OR

Lightning current and magnetic field only exist during lightning. [1]

25. (a) (i)



[1]

(ii) By Lenz's law, a magnetic force F_B acts on the rod to oppose its motion. [1]

An applied force F is needed to balance F_B to maintain uniform motion. [1]

$\therefore F = BIL$ [1]

(iii) Mechanical power input : $P = Fv = (BIL)v$ [1]

Power input = electrical power output

$\therefore BILv = \xi I$ [1]

$\therefore \xi = BLv$

(b) (i) The horizontal component is perpendicular to the mast. [1]

OR

The vertical component is parallel to the mast

(ii) $\xi = (B \cos 30°) Lv$ [1]

$= (50 \times 10^{-6} \cos 30°)(20)(6)$

$= 5.12 \times 10^{-3}$ V (accept 5.12 mV) [1]

More electrons at end X [1]

(iii) No current [1]

Both the cable and the mast cut the field lines, both have same e.m.f. induced and the two induced e.m.f. oppose each other. [1]

OR

There is no change of magnetic flux through the loop of the circuit. [1]

Hong Kong Diploma of Secondary Education Examination

26 **Physics – Compulsory part** (必修部分)

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

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

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

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

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

Physics – Elective part (選修部分)

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

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

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

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