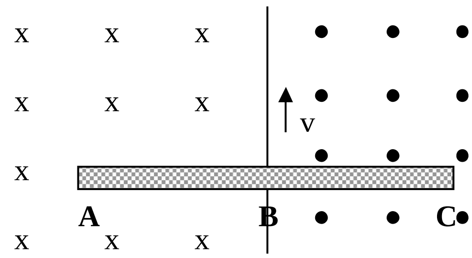
Name: …………………… Class: ………… Marks: ………./ 15 Time: 25 mins

TUTORIAL 15: ELECTROMAGNETIC INDUCTION QUIZ

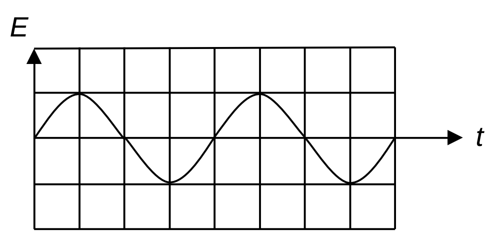
1	2	3	4	5

1 A metal bar lies as shown with its midpoint at the interface between two regions of uniform magnetic fields of opposite directions as shown. The magnitude of the magnetic field is the same in both regions. The bar moves in the indicated direction. Which point or points is/are at the highest potential?



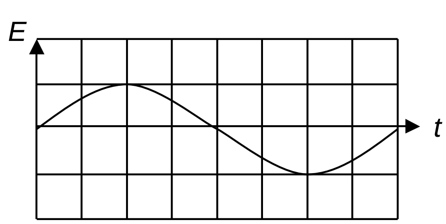
A Point A
B Point B
C Point C
D Points A and C

2 When a coil is rotated in a magnetic field, the induced e.m.f. *E* varies with time as shown below.

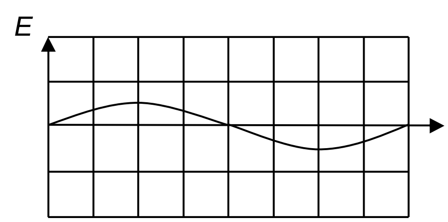


Which of the following graphs, drawn to the same scale, would be obtained if the speed of rotation of the coil is halved?

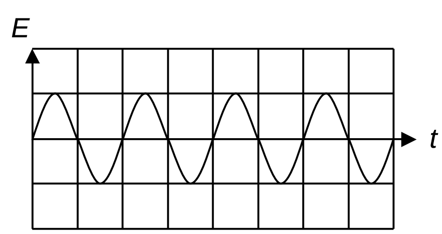
A



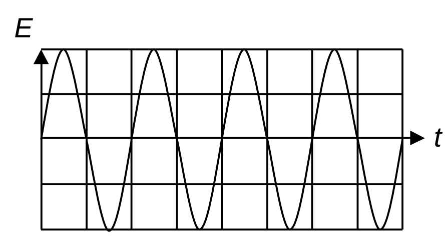
B



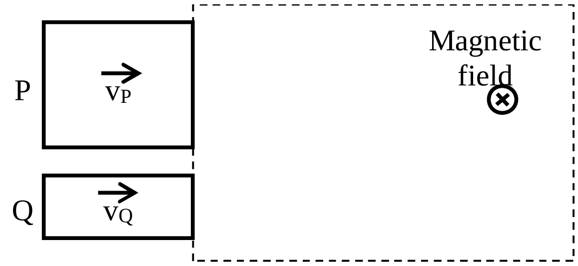
C



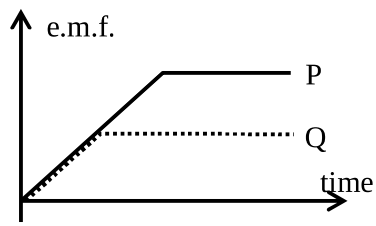
D



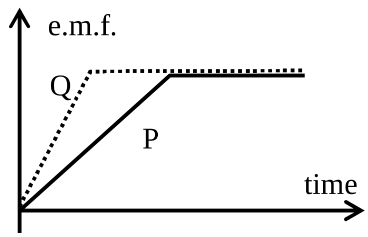
3 Two coils P and Q enter a magnetic field at the same time, as shown. P has the same length but twice the width of Q and is moving with half the speed of Q.



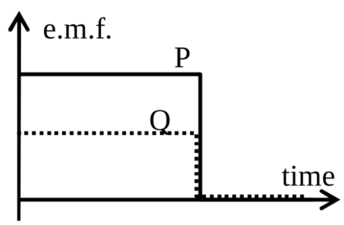
Which of the following correctly shows the e.m.f. induced in the coils as they enter the field?



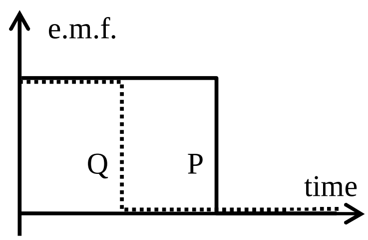
A



B

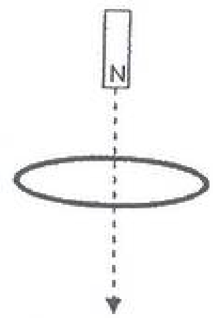


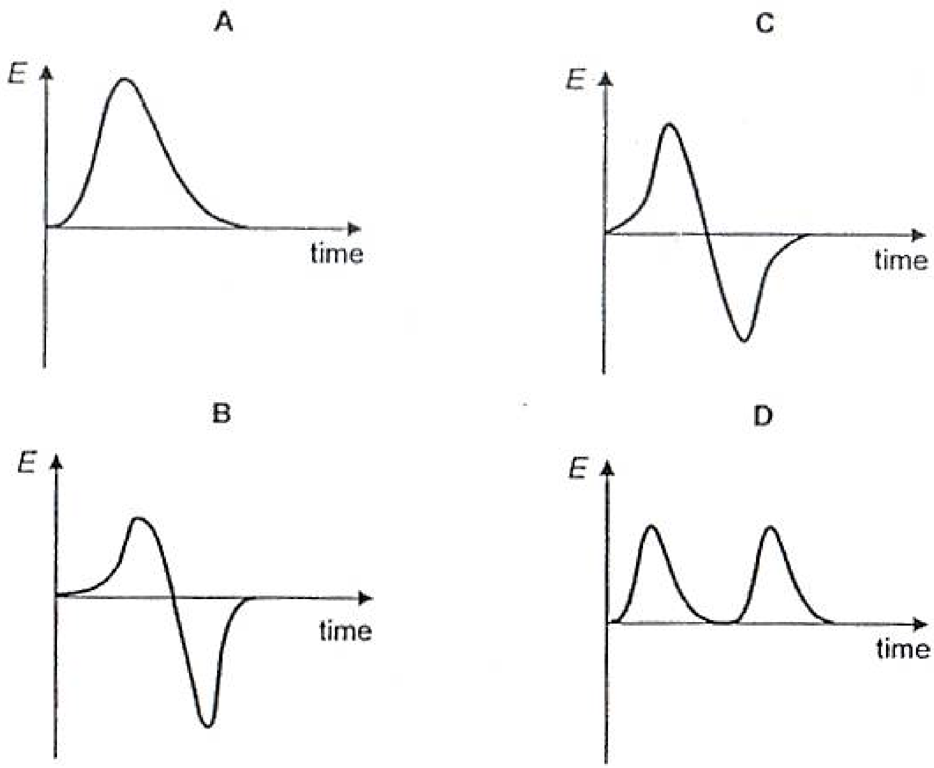
C



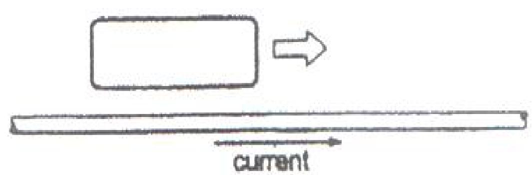
D

4 A circular coil with its plane horizontal is held firmly in a clamp and its terminals are connected to a data-logger. A bar magnet with its axis along the coil axis is released from rest from a position above the coil so that it drops through the coil, as shown below. The data-logger is used to measure the induced e.m.f. produced. Which graph shown below best represents the variation of the induced e.m.f. *E* with time?





5 A closed loop moves with an acceleration parallel to a long straight wire carrying a steady current as shown below. Which of the following statements is true?



A The induced current in the loop will be clockwise.
B The induced current in the loop will be anti-clockwise.
C There will be no induced current in the loop.
D The magnitude of the induced current in the loop will vary with the speed at which the loop moves.

6 A conducting disc of mass m, within a vertical smooth cylinder, is released from height *h* above a strong magnet as shown in Fig. 6.1.

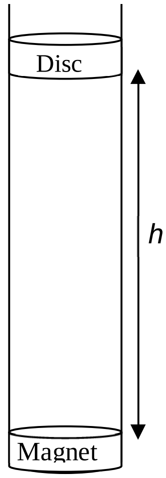


Fig. 6.1

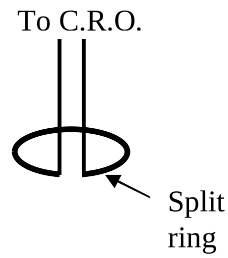


Fig. 6.2

(a) Using the laws of electromagnetic induction, explain the following observation as the disc falls along the cylinder.

(i) The temperature of the disc increases.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) The acceleration of the disc is smaller than the acceleration of free fall.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………… [2]

(b) The disc is replaced with a split ring as shown in Fig. 6.2 and is continuously moved up and down along the cylinder. When connected to a cathode ray oscilloscope (C.R.O.), a trace is obtained as shown in Fig. 6.3.

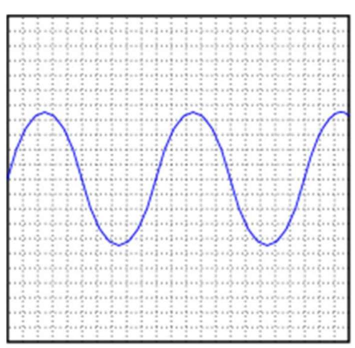


Fig. 6.3

Using the laws of electromagnetic induction, explain the following observations:

(i) The trace shows periodic fluctuation.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………. [2]

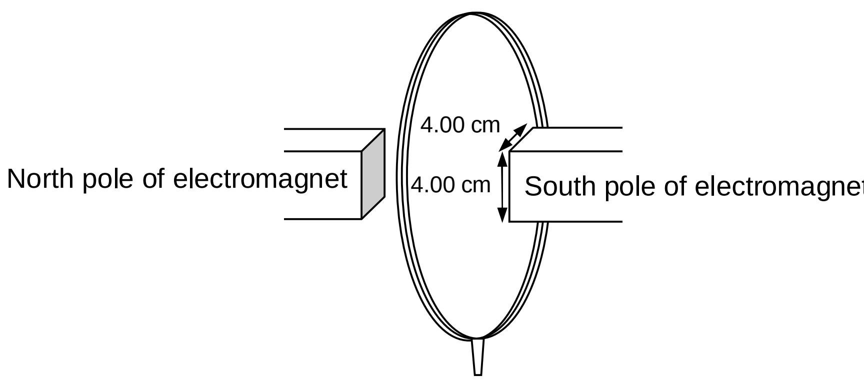
(ii) The amplitude of the trace is dependent on the frequency of oscillation of the split ring.

……………………………………………………………………………………

……………………………………………………………………………………

………………………………………………………………………………..… [2]

7 A powerful electromagnet produces a uniform field in the gap between its poles, each of which measures 4.0 cm × 4.0 cm and are facing each other. There is no field due to the electromagnet outside the gap. A circular coil, of diameter 10.0 cm, is placed between the poles such that its plane is perpendicular to the field lines and encloses all the field lines, as shown below. There are 50 turns in the coil.



The magnetic field produced by the electromagnet is adjusted so that the field strength steadily decreases from 0.40 T to zero in 0.50 s. Calculate the e.m.f. generated in the coil.

e.m.f. = …………………….. V [2]

EMI Quiz Solutions

1	2	3	4	5
D	B	D	B	C

1. Ans: D

Applying FLHR and Lenz's Law (or FRHR), we can see that the induced current would tend to flow in the directions BA and BC.

2. Ans: B

When speed of rotation and hence ω is halved for the a.c. generator, the <u>maximum emf</u> is halved and <u>period</u> is doubled.

Deduce from given emf graph that the equation for emf, $E = NBA\omega \sin(\omega t)$, where $NBA\omega$ would be the amplitude of the emf graph, and is sinusoidal in shape (as per question's diagram).

Period of sin graph = $1/f = 2\pi / \omega$.

3. Ans: D

E.m.f. induced = Rate of change of flux linkage = B w v (where w is width of coil) [recall from lecture notes, page 16-12, emf induced = NBLv]

Q is half the width of P but moving at twice the speed of P. Thus e.m.f. induced in P and Q are the same!

Next, because of its higher speed, Q will enter the field fully in half the time that P takes. Once coil is fully within the B-field, emf induced = 0.

4. Ans: B

When the magnet is dropped and approaches the circular coil at increasing speed, there is an increase in magnetic flux linkage through the coil.

By Faraday's Law, emf is induced in the circular coil. Since speed of magnet increases, the magnitude of the emf increases as well.

When the magnet moves away from the coil at an increasing speed, the magnetic flux through the coil decreases.

By Lenz Law, the induced emf will be negative. Since the speed of the magnet is much greater when leaving than when it is approaching the coil, the magnitude of the induced emf is greater compared to the emf induced when magnet approaches the coil. {i.e. negative peak is 'greater'}

**The <u>total flux change</u> is the same whether the magnet is approaching or leaving the coil. Hence the <u>area</u> under the graph has to be the <u>same</u>.

{this question is similar to lecture eg 5 and tutorial Q5}

5. Ans: C

No induced current in the loop as there is no change in flux linkage through the loop. {similar to page 16-11 of lecture notes}

6(a)(i) As the disc falls towards the magnet, it experiences a change in magnetic flux. Therefore by Faraday's Law, emf is induced and eddy currents flow in the disc.

The eddy current will result in heat dissipation and this is observed as an increase in temperature.

(ii) By Lenz's Law, the induced current will flow in a direction to oppose the increase in magnetic flux.

Hence the disc is subjected to an upward repulsive force which retards its downward motion. This is therefore observed as its acceleration being smaller than acceleration of free fall.

(b)(i) As the split ring is moved up the cylinder, it experienced a change (decrease) in magnetic flux**.** By Faraday's Law, this caused an induced emf ~~and induced current~~ to flow in one direction.

As the split ring is moved down the cylinder, it experienced a change (increase) in magnetic flux, and the induced emf ~~and induced current~~ is in the opposite direction. Thus the trace shows a periodic fluctuation.

(b)(ii) If the ring is moved at a higher frequency, it will experience a greater rate of change of magnetic flux linkage.

Thus by Faraday's Law, a greater emf is induced and is observed as greater amplitude in the trace.

7.

$$|emf| = \frac{d(NBA)}{dt}$$

$$= \frac{50 \times (0.40 - 0) \times (0.0400)^2}{0.5}$$ [1]

= 0.064 V [1]