Jackie and Jim are studying electromagnetic induction. They have a small permanent magnet and a coil of wire wound around a hollow cylinder as shown in Figure 4.

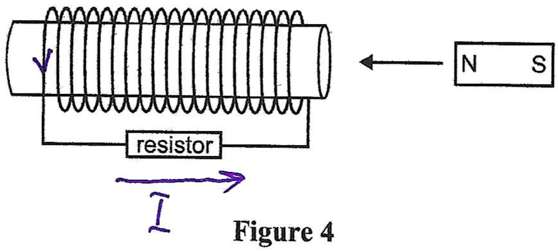


Figure 4

Jackie moves the magnet through the coil in the direction shown at constant speed.

Question 9

Indicate on the diagram the direction of the induced current that flows in the resistor. Explain the physics reason for your choice.

Magnetic field of the magnet is to the left and flux increasing so induced magnetic field is to the right. Using RHGR current through resistor is from left to right

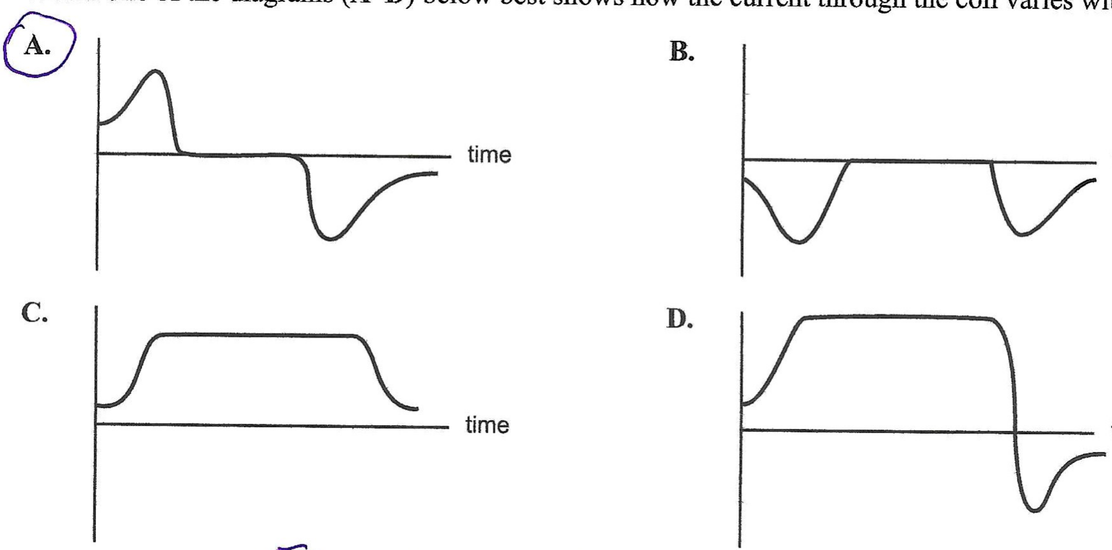
24%

2 marks

They next decide to move the magnet, at a constant speed, all the way through the coil and out the other side.

Question 10

Which **one** of the diagrams (**A–D**) below best shows how the current through the coil varies with time?



A

Flux increasing, then constant while magnet inside coil completely, then decreasing so current will change direction.

45%

2 marks

A transformer as shown in Figure 2 below is being tested. The primary coil is connected to a battery and switch. The switch is initially open and no current is flowing in the primary coil. An ammeter is connected to the secondary coil and initially shows no deflection. When the switch is **first** closed, the ammeter needle is deflected to the right and then returns to its initial position of no deflection.

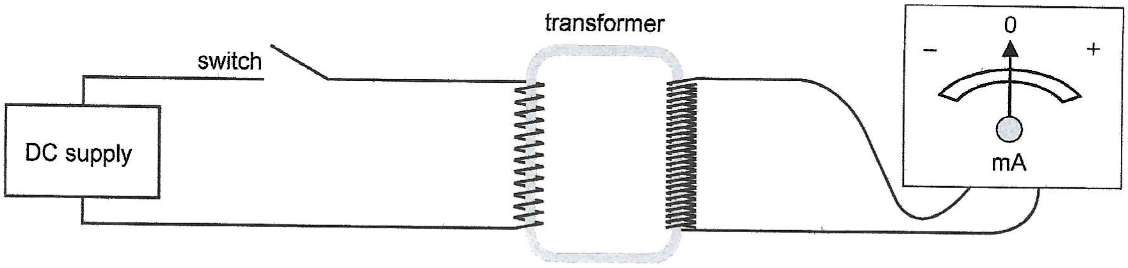


Figure 2

Question 5

Explain why the meter deflects when the switch is closed and then returns to the undeflected position.

Closing switch creates increase in the current and so change in flux so there will be current induced in secondary coil. After that current is constant so no change in flux and no induced current

2 marks

The switch, which has been closed for a short time, is now returned to the open position and remains open.

Question 6

Which one of the following best describes what happens to the reading of the ammeter?

A. it deflects to the left and stays at this position
B. it deflects to the right and stays at this position
C. it deflects to the left and returns to the middle position
D. it deflects to the right and returns to the middle position
E. it does not change

C

There will be brief induced current in the opposite direction compare to question 5 as flux will be decreasing

2 marks

4 marks 42%

Kris is investigating a generator. The magnets are attached to a shaft and are free to rotate around the fixed coil as shown in Figure 3. In this test, the shaft is connected to an electric motor and rotated at a constant speed. Figure 4 below shows the magnetic flux inside the coil. At a speed of 10 revolutions (rotations) per second (rps), the 40-turn coil produces an emf of 2.0 V_{RMS}, and the light globe glows dimly.

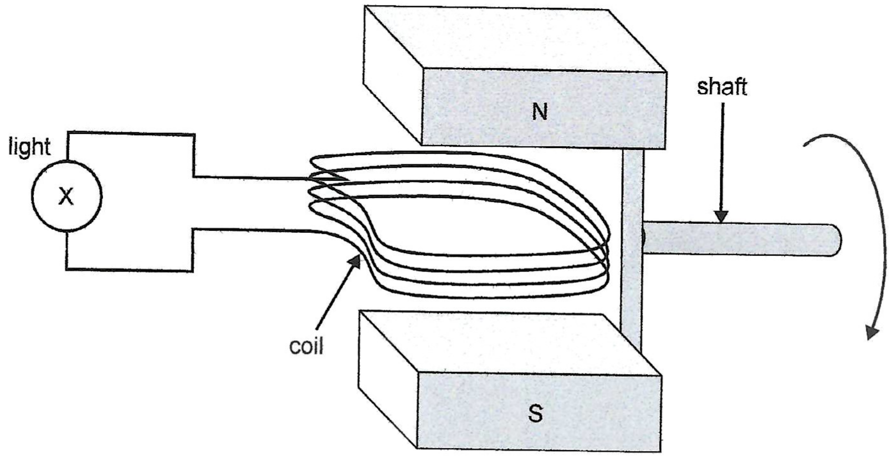


Figure 3

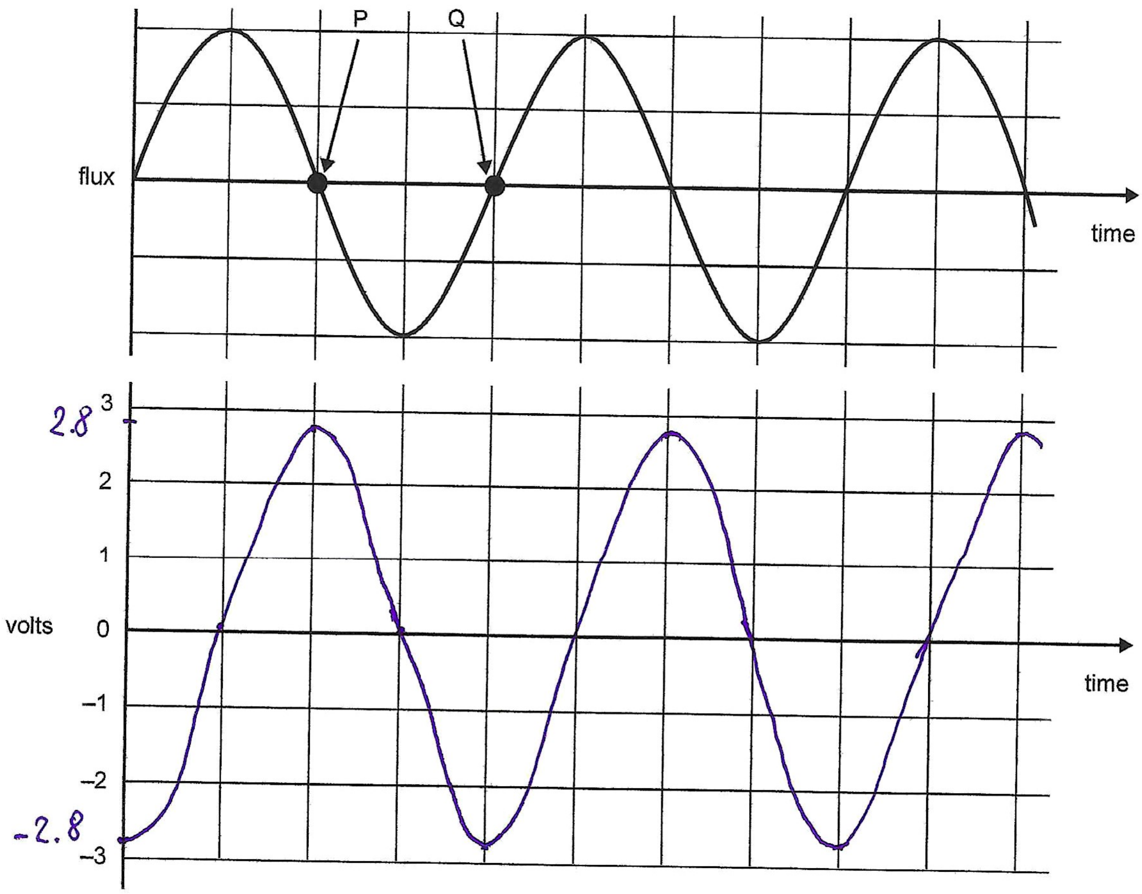


Figure 4

Question 7

What is the time difference between points P and Q in Figure 4?

$T = \frac{1}{f} = \frac{1}{10} = 0.1s$ P ~ Q is a half of a period.

0.05 s

2 marks

Question 8

Complete Figure 4 by sketching the voltage output of the coil. Label your sketch to indicate the maximum and minimum voltages.

$V_p = \sqrt{2} V_{RMS} = 2.8V$ 0 voltage at peak of flux.

4 marks

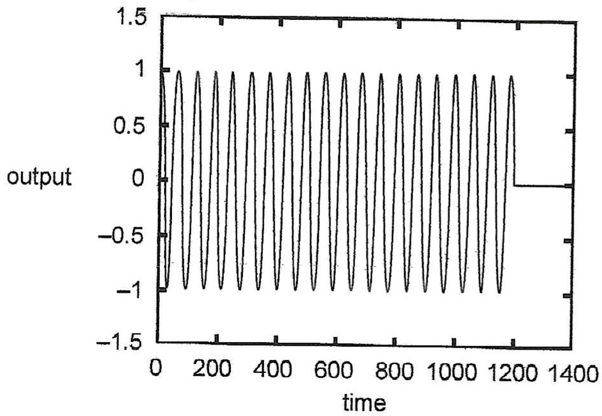
6 marks 29%

Question 9

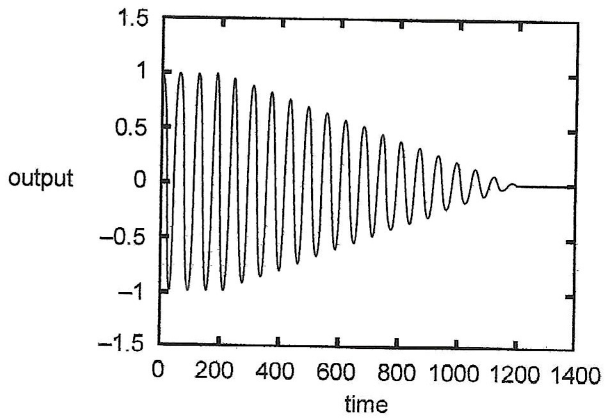
The electric motor is now turned off, and the shaft gradually slows to a halt.

Which one of the following diagrams best describes the voltage output of the generator as it comes to rest?

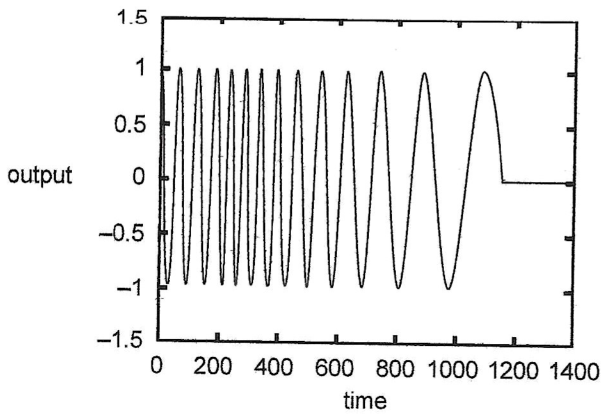
A.



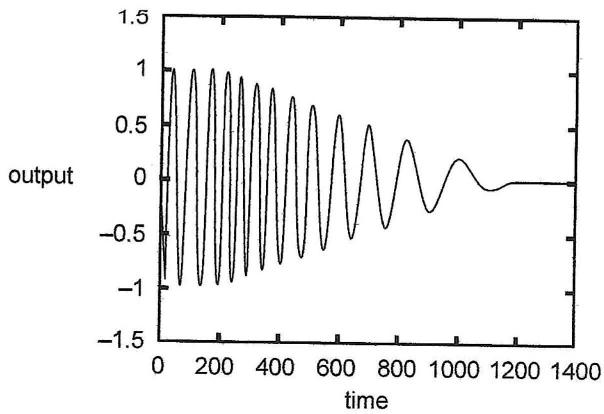
B.



C.



D.



D

Frequency decreasing, so period increasing and output decreasing as rate of change of flux decreasing

68%

2 marks

Question 15

Joan and her grandfather were discussing how a transformer works and this led to a discussion about Faraday's and Lenz's laws. Joan's grandfather stated that the two laws were essentially the same, but Joan disagreed.

Compare and contrast Faraday's law and Lenz's law.

Faraday's law tells that voltage is induced and gives it magnitude. Lenz's law gives direction of induced current.

3 marks

A village has a maximum electrical power requirement of 100 kW. The power is supplied by an alternator, approximately 20.0 km from the village, which generates electricity at 250 V_{RMS} at a frequency of 50 Hz. This is converted by a step-up transformer (T_1) to 22 000 V_{RMS}, transmitted to the edge of the village by power lines with a total resistance of 2.0 Ω, and converted back to 250 V_{RMS} by a step-down transformer (T_2) near the village. A diagram of the system is shown in Figure 5 below.

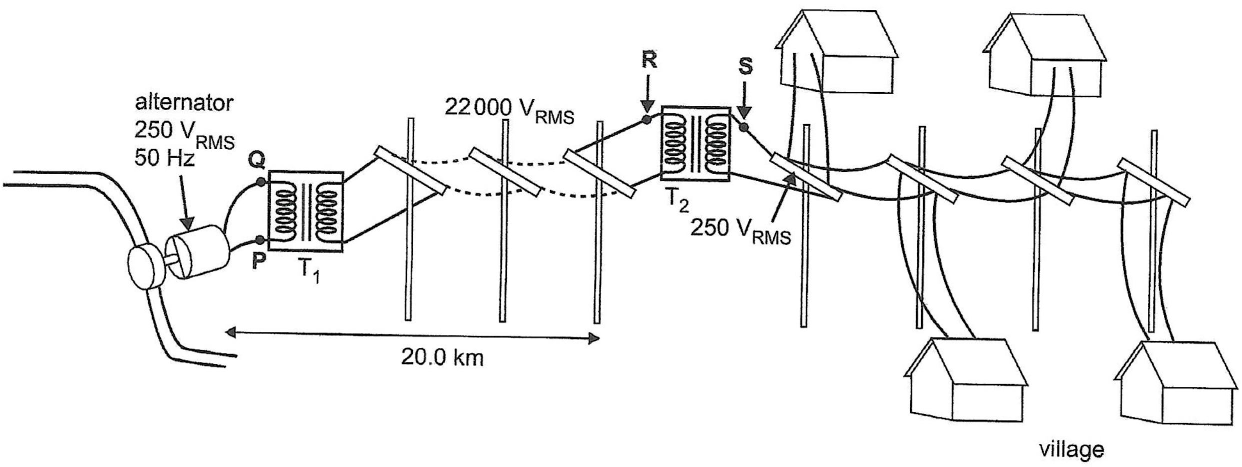


Figure 5

Question 9

What would be the current in the wires at the point marked S when 100 kW of power is being used?

$$I = \frac{P}{V} = \frac{100\,000}{250} = 400$$

400 A

2 marks

Question 10

Show that the current at point R is approximately 4.55 A when 100 kW of power is being used.

$$\frac{V_R}{V_S} = \frac{I_S}{I_R} \quad \frac{22000}{250} = \frac{400}{I_R} \quad I_R = \frac{400 \times 250}{22\,000}$$

$$= 4.55\text{A}$$

2 marks

Question 11

Estimate the power loss in the high voltage transmission lines supplying transformer T_2 when 100 kW of power is being used in the village. Show your working. Include the unit.

$P_{Loss} = I^2 R = 4.55^2 \times 2 = 41$

41 W

3 marks

Question 12

Briefly explain how high-voltage transmission leads to lower power losses in the system.

As power is fixed, increasing voltage decreases current $P = VI$. Smaller current results in smaller power loss. $P_{loss} = I^2 R$

2 marks

A number of different transformers, A–D, are available for use as transformer T_1 in the system. Their characteristics are shown below.

Transformer	Number of turns in primary (input)	Number of turns in secondary (output)
A	62 200	500
B	44 000	500
C	500	44 000
D	500	62 200

Question 13

Which one of the transformers, A–D, would be suitable for use as transformer T_1?

C

$\frac{44000}{500} = \frac{22000}{250}$

2 marks

Question 14

Explain the operation of a transformer in terms of electromagnetic induction.

A changing current in the primary coil produces a changing flux ~~in sec~~ through secondary and so induce a voltage. As flux is the same through the primary and secondary ratio of the voltages will be equal ratio of turns.

3 marks

The alternator fails and the village is without power. One possibility is to replace the alternator with a DC generator but an electrician says this should not be used.

Question 15

Explain why an alternator rather than a DC generator should be used in this system.

The transformer requires AC current as change in flux required to induce EMF in the secondary coil

5marks 23% 2 marks

Normally, the power being used in the village is 40 kW. However, as people come home, the power use increases to 80 kW. The alternator continues to provide 250 V_{RMS} at point P.

Question 16

Which one of the following (A–D below) is the most likely effect on the voltage at point S in Figure 5?

A. The voltage would increase slightly.

B. The voltage would decrease slightly.

C. The voltage would remain the same.

D. The voltage would halve.

B

Increase of power used results in increase in current in transmission line and so to increase in power loss and voltage drop across the line so less voltage at the primary of transformer 2 and so less voltage at the village. As current is smaller in the line, the ~~dro~~ voltage drop across lines is small and even less change due to stepping down in T_2

23%

2 marks

Use the following information to answer Questions 14 and 15.

To study Lenz's law, students set up the following experiment using the circuit shown in Figure 9.

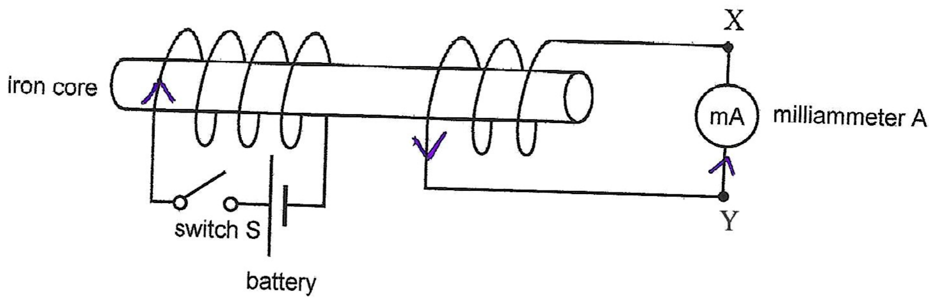


Figure 9

Question 14

Initially switch S is open.

Which one of the following **(A–D)** will best describe the current through the milliammeter A, when the switch S is closed?

A. current flows momentarily in the direction X to Y
B. current flows momentarily in the direction Y to X
C. current flows continuously in the direction X to Y
D. current flows continuously in the direction Y to X

B

44%

2 marks

Question 15

Explain how Lenz's law enables you to determine the direction of the current flow in this experiment.

When switch is closed current in primary coil increase in the direction shown. This increase is for a short time until current becomes constant so change in flux will be momentarily. Using RHGR magnetic field will be to the left, so induced magnetic field will be to the right. Using RHGR current from Y to X.

3 marks

19%

Question 9

The square loop moves from position 1 (just inside the magnetic field) to position 2 (just outside the magnetic field) as shown in Figure 4d (seen from above). What is the average emf (voltage) induced?

Show working.

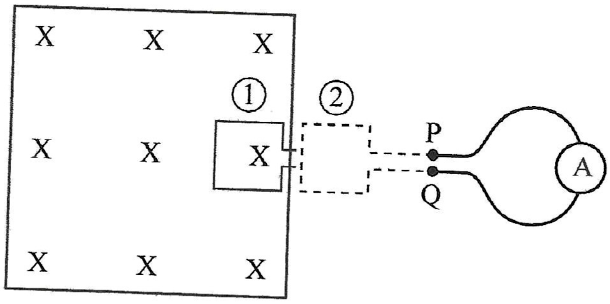


Figure 4d

$$\mathcal{E} = \frac{\Delta \Phi}{\Delta t} = \frac{4\times10^{-3} \times 0.02^2}{1.0} = 1.6\times10^{-6}$$

1.6×10^{-6} V

3 marks

45 %

Question 10

Will the current due to the induced voltage flow from P to Q **or** Q to P **through the square loop** as it moves from position 1 to position 2?

Q to P

Explain your answer in terms of Lenz's law.

Magnetic field is into the page and flux decreasing. So induced field is ~~out of~~ in the page. Using RHGR current from Q to P.

4 marks

13 %

Use the following information to answer Questions 10–12.

A small bar magnet is moved through a circular wire loop, as shown in Figure 5. The magnet moves with **constant** speed through the centre of the loop, in the direction shown by the arrow. An emf is generated in the wire loop. The wire loop is connected to an oscilloscope, as shown in Figure 5.

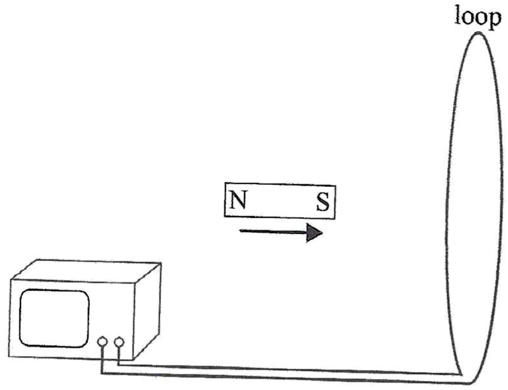


Figure 5

Question 10

Explain why an emf is generated in the wire loop.

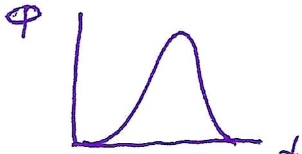
As magnet approaches the loop flux through the loop increasing. Change in flux induces EMF according to Faraday's law.

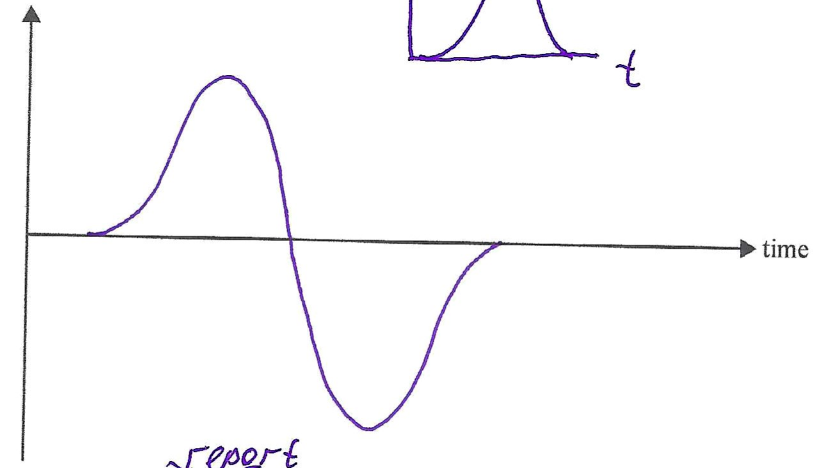
2 marks

63 %

Question 11

On the graph axes below, sketch the variation of the emf with time, from when the magnet is a long way to the left of the loop, through the loop, to when it is a long way to the right of the loop. Note that you can take either upwards or downwards as positive.





In the examiners report there is some flat region at emf = 0 which is wrong. 27%

2 marks

Question 12

After the magnet has passed through the wire loop, and is moving away from the loop, current flows around the loop in an **anticlockwise** direction, as viewed from the left in Figure 5.

Use Lenz's law to explain why the current flows in an **anticlockwise** direction.

Magnetic field of the bar magnet is to the left and flux through the loop decreasing. So induced field is to the left. Using RHGR current is in the anticlockwise direction

3 marks

16 %

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.
Where an answer box is provided, write your final answer in the box.
If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1 (3 marks)

A particle of mass m and charge q travelling at velocity v enters a uniform magnetic field B, as shown in Figure 1.

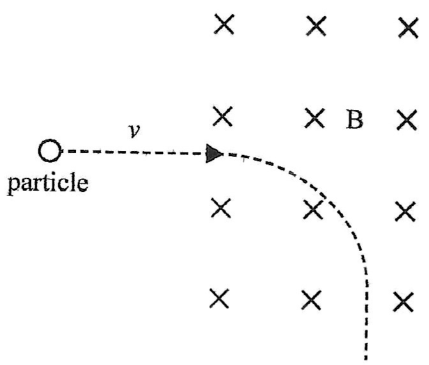


Figure 1

a. Is the charge q positive or negative? Give a reason for your answer.

44%

1 mark

Negative [illegible] to the left due to RHSR, so negative

As force is down at the entry, current has to be

b. Explain why the path of the particle is an arc of a circle while the particle is in the magnetic field.

2 marks

Constant force (1m) acting at the right angle to velocity (1m) results in circular motion

10%