PHYSICS

COMPREHENSIVE HSC REVISION SERIES 2025

Thank you for subscribing to SmarterScience Teacher Edition in 2025.

Key features of the Physics “2025 HSC Comprehensive Revision Series” for include:

- ~17 hours of cherry-picked HSC revision questions by topic
- Targeted at motivated students aiming for a Band 5 or 6 result
- Weighting toward more difficult examples
- Mark allocations given to each topic generally reflect its historical (new syllabus) HSC exam allocation.
- ***Attempt, carefully review and annotate*** this revision set in Term 3
- This question set provides the foundation of a concise and high quality revision resource for the run into the HSC exam.
- This resource should be used to complement (not replace) the critical final stretch preparation for every student - timed full exam practice papers.

Our analysis on each topic, the common question types, past areas of difficulty and recent HSC trends all combine to create this revision set that ensures students cover a wide cross-section of the key areas.

IMPORTANT: If students have been exposed to questions in these worksheets during the year, we say great. Many top performing students attest to the benefits of doing quality questions 2-3 times before the HSC. This type of revision set is aimed at creating confidence and *speed through the exam*, with cherry picked questions that cover all important elements of revision while avoiding low percentage rabbit hole excursions.

HSC Final Study: M6 Electromagnetism

Electromagnetic Induction (~11.5% historical contribution)

Key Areas addressed by this worksheet

- *Electromagnetic Induction* is the most tested subtopic of Module 6, contributing between 1-2 longer answer questions per exam, as well as an average of two multiple-choice questions.
- *Lenz and Faraday* represent the most commonly examined concepts and are a focus of this revision set. Challenging longer answer questions have appeared every year since 2020 in questions worth 7-9 marks.
- *Lenz and Faraday* questions typically require students to analyse situations where induced currents arise and apply relevant physics laws. *2024 HSC 33, 2023 HSC 30, 2021 HSC 31* and *2020 HSC 33* all caused problems and are important revision examples. Students should make it a priority in their revision to provide clear, logical cause and effect explanations in their answers, making the markers job easy.
- *Transformer* calculations have appeared in 5 of the last 6 exams, including longer answer questions in 2023 and 2019. Revision examples look at voltage calculations (typically well-answered) and more importantly, follow up questions looking at efficiency and circuit resistance (not well answered).
- *Electromagnetic Induction* commonly appears in difficult questions towards the end of the multiple-choice section. *2024 HSC 18 MC, 2019 HSC 18 MC* and *2021 HSC 10 MC* represent the upper difficulty level students will encounter and should be closely reviewed.

Finding your resource invaluable and so easy to use in our time poor lives.

~ Neila Darrough, St Charbel’s College

PHYSICS 2025

HSC Revision Series

Module 6 Electromagnetism

Electromagnetic Induction

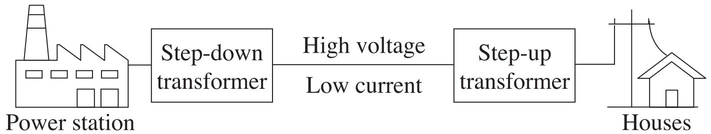
Exam Equivalent Time: 105 minutes *(based on allocation of 1.5 minutes per mark)*

Questions

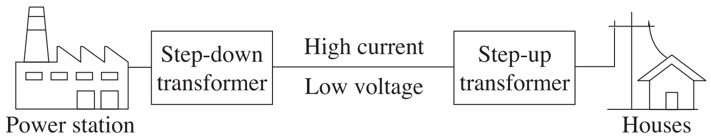
1. PHYSICS, M6 2023 HSC 2 MC

Which diagram best represents the transmission of energy from a power station to people's houses?

A.



B.



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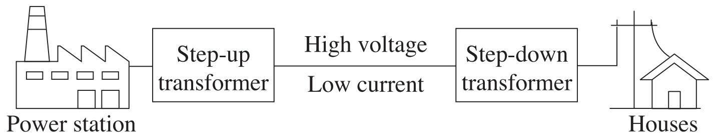

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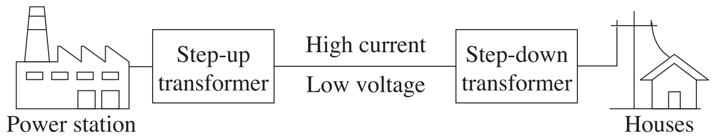

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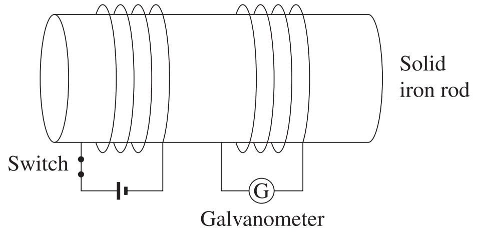
2. PHYSICS, M6 2019 HSC 5 MC

The diagram shows two coils wound around a solid iron rod. Initially the switch is closed.



Opening the switch will cause the galvanometer pointer to

A. remain at a constant reading.

B. move from a non-zero reading to a zero reading.

C. move from a zero reading to a non-zero reading, where it remains.

D. move from a zero reading to a non-zero reading, then back to zero.

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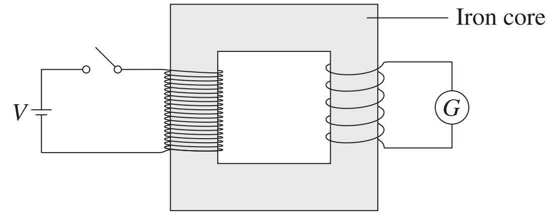
3. PHYSICS, M6 EQ-Bank 10534 MC

The diagram shows an ideal transformer.



When the switch is closed, the pointer on the galvanometer deflects.

How could the size of this deflection be increased?

A. Decrease the number of primary coils.

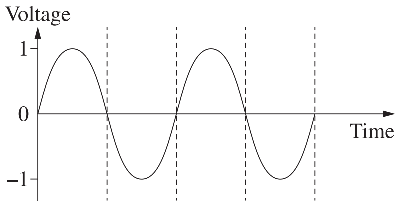
B. Decrease the number of secondary coils.

C. Replace the iron core with a copper core.

D. Place a resistor in series with the galvanometer.

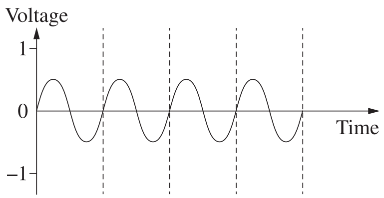
4. PHYSICS, M6 2015 HSC 12 MC

A simple AC generator was connected to a cathode ray oscilloscope and the coil was rotated at a constant rate. The output is shown on this graph.

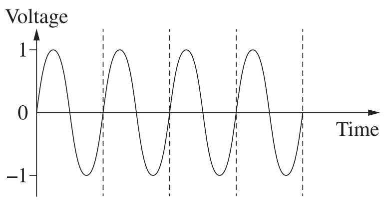


Which of the following graphs best represents the output if the rate of rotation is decreased to half of the original value?

(A)



(B)



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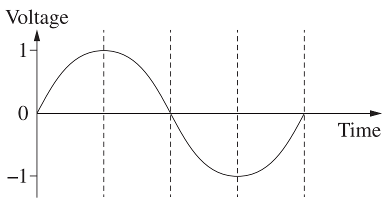
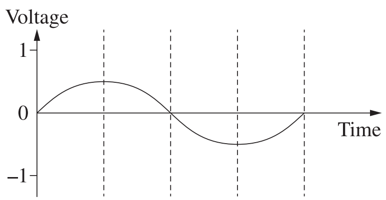


(D)



5. PHYSICS, M6 2021 HSC 7 MC

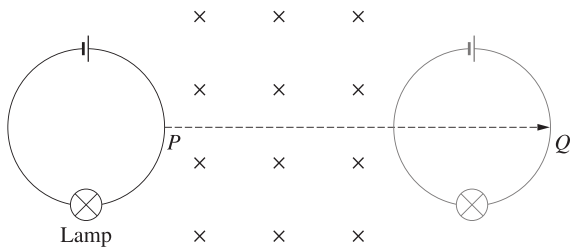
In a certain ideal transformer, the current in the secondary coil is four times as large as the current in the primary coil.

Which row of the table correctly identifies the type of transformer and the ratio of turns?

	Type of transformer	*Ratio of turns in primary coil to turns in secondary coil*
A.	Step up	4 : 1
B.	Step up	1 : 4
C.	Step down	4 : 1
D.	Step down	1 : 4

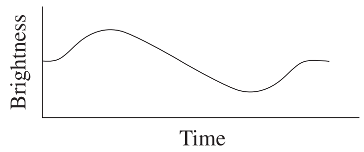
6. PHYSICS, M6 2019 HSC 18 MC

A circular loop of wire is connected to a battery and a lamp. The apparatus is moved from P to Q along the path shown at a constant velocity through a region containing a uniform magnetic field.

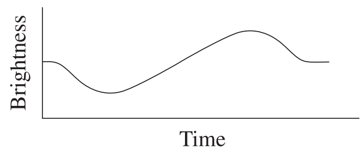


Which graph shows the brightness of the lamp as the apparatus moves between P and Q?

A.



B.



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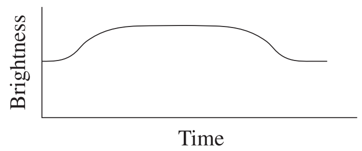

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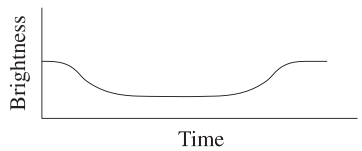
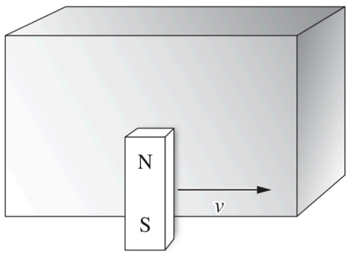


7. PHYSICS, M6 2021 HSC 10 MC

A strong magnet is moved past a copper block at a constant speed as shown.



What is the direction of the force acting on the copper block?

A. To the left

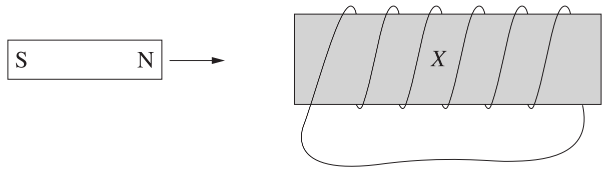
B. To the right

C. Into the page

D. Out of the page

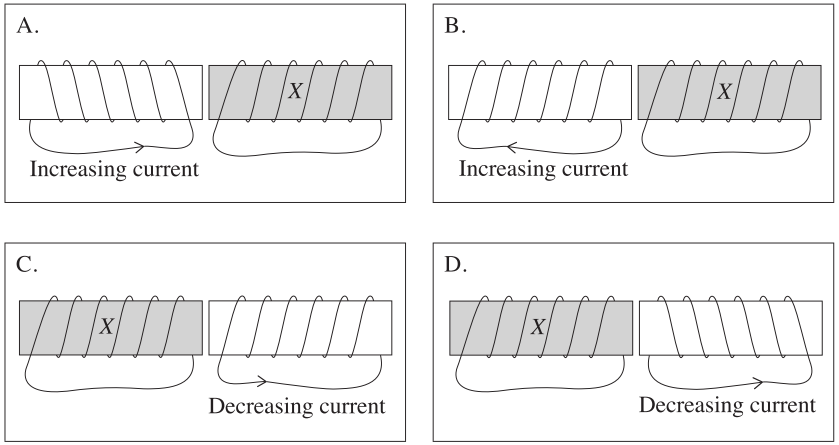
8. PHYSICS, M6 2024 HSC 18 MC

The diagram shows a magnet moving towards a coil X.



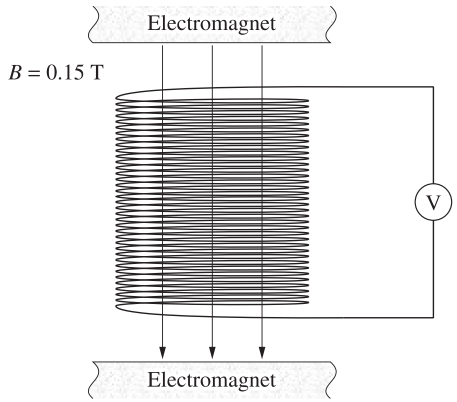
This action causes a current to be induced in the coil.

Which situation will induce a current in coil X that is in the same direction as the current induced by the movement of the magnet?



9. PHYSICS, M6 2021 HSC 24

A stationary coil of 35 turns and cross-sectional area of 0.02 m² is placed between two electromagnets, and connected to a voltmeter as shown. The electromagnets produce a uniform magnetic field of 0.15 T through the coil.

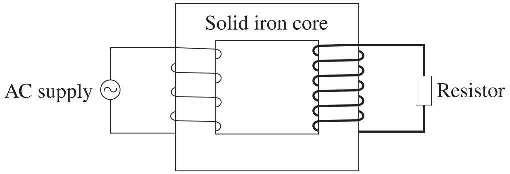


The magnitude of the magnetic field is then reduced to zero at a constant rate over a period of 0.4 s.

Calculate the magnitude of the emf induced in the coil. ***(3 marks)***

10. PHYSICS, M6 2019 HSC 24

A step-up transformer is constructed using a solid iron core. The coils are made using copper wires of different thicknesses as shown.



The table shows electrical data for this transformer.

V_s	I_s	V_pI_p
50 V	9 A	500 J s^{-1}

a. Explain how the operation of this transformer remains consistent with the law of conservation of energy. Include a relevant calculation in your answer. *(3 marks)*

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b. Explain how TWO modifications to this transformer would improve its efficiency. *(4 marks)*

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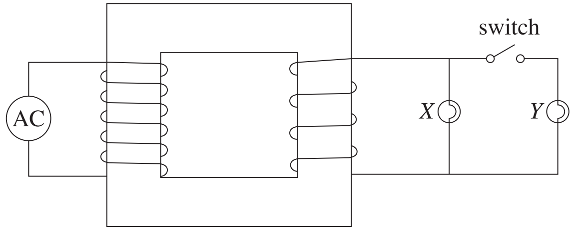
11. PHYSICS, M6 2023 HSC 28

An ideal transformer is connected to a 240 V AC supply. It has 300 turns on the primary coil and 50 turns on the secondary coil.

It is connected in the circuit with two identical light globes, X and Y, as shown.



a. Calculate the voltage across light globe X when the switch is open. *(2 marks)*

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b. Explain why, after the switch has been closed, the current in the primary coil is different from when the switch is open. *(3 marks)*

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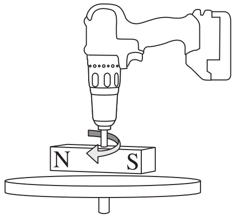
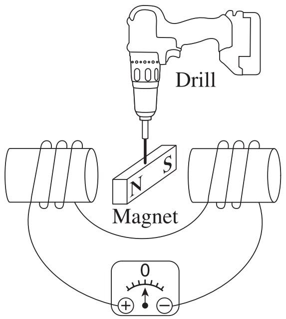
12. PHYSICS, M6 2018 HSC 22

a. A drill spins a magnet above a non-magnetic metal disc which is free to rotate.



Explain the effect of the rotating magnet on the disc. *(3 marks)*

b. The diagram shows a magnet attached to an electric drill so that it can be rotated between two coils connected to a voltmeter.



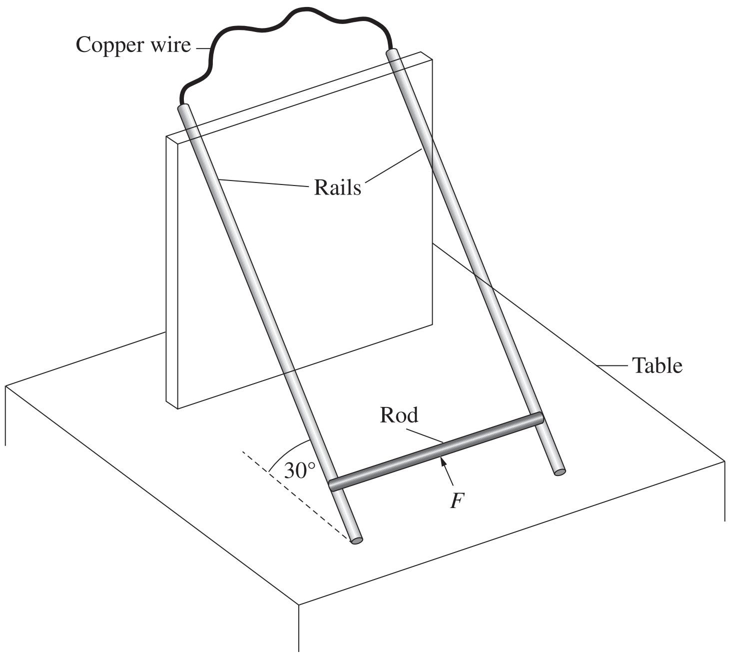
The drill starts from rest and gradually speeds up, reaching its full speed after three revolutions.

Sketch a graph showing the induced emf across the coils during the time that it takes the magnet to reach its full speed. *(3 marks)*

13. PHYSICS, M6 2020 HSC 28

A metal rod sits on a pair of parallel metal rails, 20 cm apart, that are connected by a copper wire. The rails are at 30° to the horizontal.

The apparatus is in a uniform magnetic field of 1 T which is upward, perpendicular to the table.



A force, F, is applied parallel to the rails to move the rod at a constant speed along the rails. The rod is moved a distance of 30 cm in 2.5 s.

a. Show that the change in magnetic flux through the circuit while the rod is moving is approximately 5.2×10^{-2} Wb. *(2 marks)*

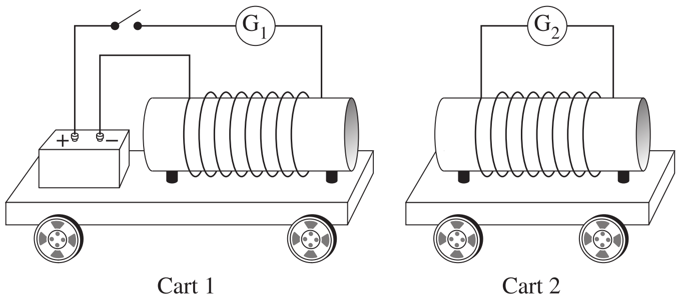
b. Calculate the emf induced between the ends of the rod while it is moving, and state the direction of flow of the current in the circuit. *(2 marks)*

c. The experiment is repeated without the magnetic field.

Explain why the force required to move the rod is different without the magnetic field. *(3 marks)*

14. PHYSICS, M6 2021 HSC 31

Two identical solenoids are mounted on carts as shown. Each solenoid is connected to a galvanometer, and the solenoid on cart 1 is also connected to an open switch and a battery. The total mass of cart 1 is twice that of cart 2.



Explain what would be observed when the switch on cart 1 is closed. In your answer, refer to the current in each galvanometer and the initial movement of the carts. ***(7 marks)***

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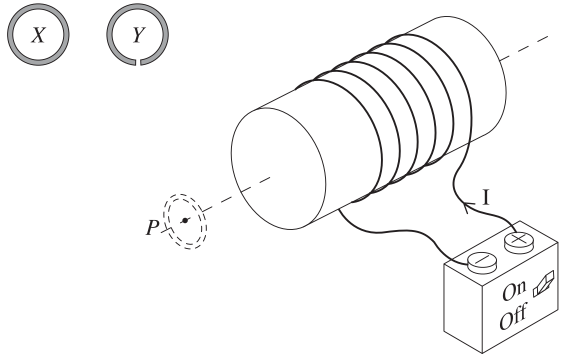
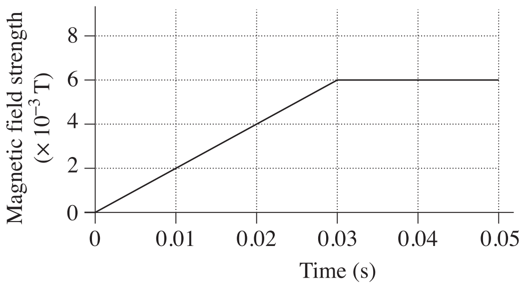
15. PHYSICS, M6 2023 HSC 30

The diagram shows apparatus that is used to investigate the interaction between the magnetic field produced by a coil and two copper rings X and Y, when each is placed at position P, as shown.



Ring X is a complete circular ring, and a small gap has been cut in ring Y. Each of the rings has a cross-sectional area of 4×10^{-4} m².

The power supply connected to the coil produces an increasing current through the coil in the direction shown, when the switch is turned on. This produces a magnetic field at P that varies as shown in the graph.



a. In the first part of the investigation, ring X is held near the end of the electromagnet at position P.

Account for the force acting on the ring from 0 to 0.05 seconds after the power supply is turned on. *(4 marks)*

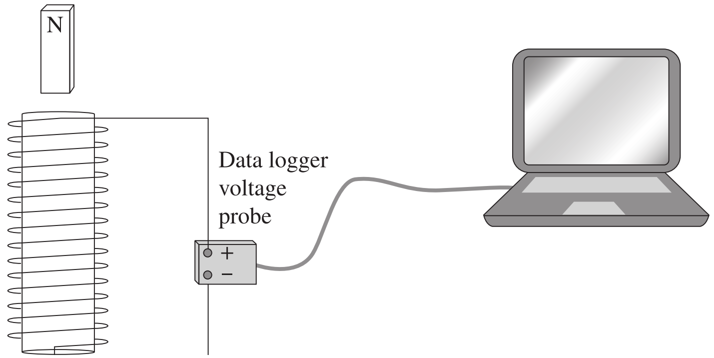
b. **i.** In the second part of the investigation, ring Y is placed at P, and the power supply is turned on. *(2 marks)*

ii. Explain the behaviour of the ring.

Calculate the maximum induced emf in ring Y. *(2 marks)*

16. PHYSICS, M6 EQ-Bank 12314

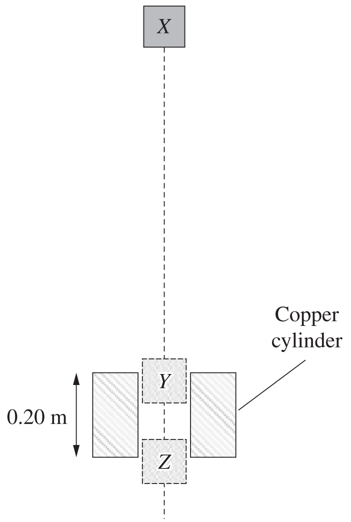
A solenoid was connected to a data logger to measure voltage. A magnet was dropped through the solenoid from above as shown.



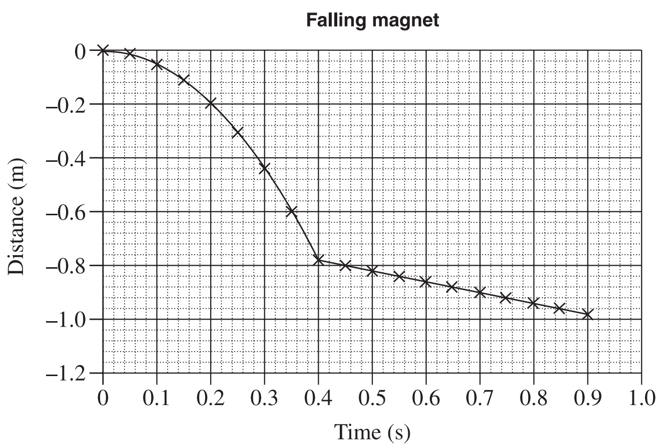
On the axes provided, sketch a graph showing the change in voltage as the magnet falls completely through the solenoid. *(3 marks)*

17. PHYSICS, M6 2020 HSC 33

A strong magnet of mass 0.04 kg falls 0.78 m under the action of gravity from position X above a hollow copper cylinder. It then travels a distance of 0.20 m through the cylinder from Y to Z before falling freely again.



The magnet takes 0.5 seconds to pass through the cylinder. The displacement-time graph of the magnet is shown.

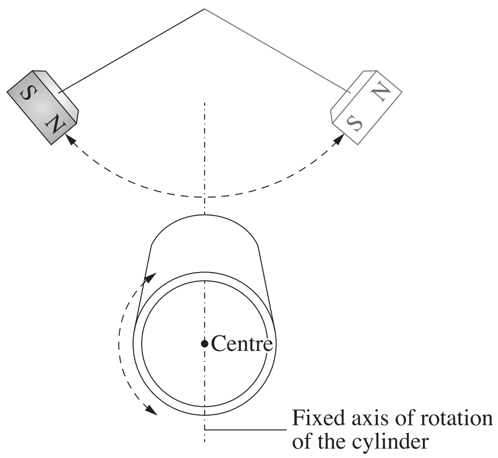


Analyse the motion of the magnet by applying the law of conservation of energy.

Your analysis should refer to gravity and the copper cylinder, and include both qualitative and quantitative information. *(9 marks)*

18. PHYSICS, M6 2024 HSC 33

A magnet is swinging as a pendulum. Close below it is an aluminium (non-ferromagnetic) can. The can is free to spin around a fixed axis as shown.



Analyse the motion and energy transformations of both the can and the magnet. *(7 marks)*

Worked Solutions

1. PHYSICS, M6 2023 HSC 2 MC

→ Energy from power stations passes through a step-up transformer to increase the voltage and decrease the current.

→ This energy then passes through a step-down transformer to be used in homes.

$\Rightarrow C$

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2. PHYSICS, M6 2019 HSC 5 MC

Originally, there is a constant magnetic field passing through the coil on the right due to the current through the coil on the left.

As there is no change in flux through the coil on the right initially the galvanometer shows a zero reading.

When the switch is opened, the decrease in magnetic flux through the coil on the right causes a deflection of the galvanometer to a non-zero reading.

The galvanometer will return to a reading of zero when the magnetic flux passing through it drops to zero.

$\Rightarrow D$

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3. PHYSICS, M6 EQ-Bank 10534 MC

→ In order to increase the deflection of the galvanometer, the current through the secondary coil must increase.

→ The input power (V_pI_p) is fixed.

→ Since $V_pI_p = V_sI_s$, the voltage of the secondary coil (V_s) must decrease if I_s increases.

$$\rightarrow \frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$V_s = \frac{V_pN_s}{N_p}$$

→ Reducing the number of secondary coils (N_s) will therefore decrease the secondary voltage (V_s) and consequently increase the current through the secondary coil.

$\Rightarrow B$

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4. PHYSICS, M6 2015 HSC 12 MC

Halving the rate of rotation of the bar magnet:

→ Doubles the period of the output graph (eliminate A and B).

♦ Mean mark 52%.

→ Halves the rate of change of flux through the coil of the generator.

→ Halves of the maximum output voltage.

$\Rightarrow D$

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5. PHYSICS, M6 2021 HSC 7 MC

Larger current in secondary coil → Lower voltage in secondary coil

♦ Mean mark 42%.

→ Step down transformer → Primary coil has more turns

$\Rightarrow C$

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6. PHYSICS, M6 2019 HSC 18 MC

→ Initially, the current travels clockwise through the loop of wire. As it enters the magnetic field, an anticlockwise current is induced in the loop in order to induce a magnetic field out of page, opposing the external magnetic field (Lenz's Law).

♦♦♦ Mean mark 25%.

→ This decreases the net current through the loop, causing a decrease in brightness.

→ As the loop exits the magnetic field, a clockwise current is induced to create a magnetic field into the page, opposing the decrease in magnetic flux passing through it (Lenz's Law).

→ This increases the net current in the loop, causing an increase in brightness.

$\Rightarrow B$

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7. PHYSICS, M6 2021 HSC 10 MC

→ Eddy currents will be induced in the copper block. According to Lenz's Law, this will produce a force that opposes the motion of the magnet.

♦♦♦ Mean mark 18%.

→ This is done by minimising the relative motion between the block and the magnet, producing a force on the copper block to the right.

$\Rightarrow B$

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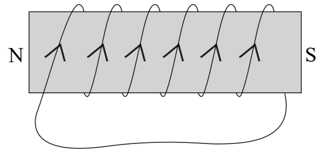
8. PHYSICS, M6 2024 HSC 18 MC

→ As the north pole of the magnet moves towards coil X, the magnetic flux through X is increased. By Lenz's law, a current will be generated in the coil that produces a magnetic field to oppose the increase the flux. Using Lenz's law, the current in X will generate a north pole to the left to repel the approaching magnet. The induced current will run up the coils as viewed from the front.

♦♦♦ Mean mark 28%.



→ The current will be induced in the same direction in D. Using the right hand grip rule, the current though the white coil will produce magnetic field lines gong to the left. As the current is decreasing, the change of flux through X is decreasing. Therefore by Lenz's law, the current induced in X will strengthen the magnetic field to oppose the decreasing magnetic flux.

→ Therefore, the magnetic field lines produced by the current in X will also be to the left, and using the right hand grip rule, the current through X will run up the coils (front view).

→ In all the other options, the current will run down the coils (front view).

$\Rightarrow D$

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9. PHYSICS, M6 2021 HSC 24

$$\begin{aligned}\Phi &= BA \\ &= 0.15 \times 0.02 \\ &= 0.003\text{ Wb}\end{aligned}$$

$$\begin{aligned}\varepsilon &= -N\frac{\Delta\Phi}{\Delta t} \\ &= -35\frac{(0-0.003)}{0.4} \\ &= 0.3\text{ V}\end{aligned}$$

10. PHYSICS, M6 2019 HSC 24

a. The energy input into this transformer is $500\ \text{J s}^{-1}$

The energy output is given by:

$$\begin{aligned}P &= V_s I_s \\ &= 50 \times 9 \\ &= 450\ \text{J s}^{-1}\end{aligned}$$

This is consistent with the law of conservation of energy as 500 J s^{-1} of energy is converted into other energy forms such as heat.

b. Modification 1:

♦ Mean mark part 48%.

→ Laminating the iron core prevents large eddy currents from being induced in it.

→ This reduces energy loss in the form of heat, increasing efficiency.

Modification 2:

→ Increasing the thickness of the wire in the primary coil.

→ This reduces its resistance, increasing the transformer's efficiency.

11. PHYSICS, M6 2023 HSC 28

a. $\dfrac{V_p}{V_s} = \dfrac{N_p}{N_s}$

$$\begin{aligned}V_s &= V_p \times \frac{N_s}{N_p} \\ &= 240 \times \frac{50}{300} \\ &= 40\text{ V}\end{aligned}$$

→ The voltage across light globe X is 40 V.

b. Closed switch $\Rightarrow$ globe X and Y are connected in a parallel circuit.

♦ Mean mark (b) 39%.

→ Once the switch is closed, the total resistance through the circuit is less than when only light globe X is in the circuit.

→ Since $V = IR \ \Rightarrow\ R \propto \dfrac{1}{I}$. Therefore, a decrease in resistance through the circuit leads to an increase in the current.

→ Transformer is ideal, so Power in = Power out ($V_p I_p = V_s I_s$). Hence, an increase in I_s corresponds to an increase in I_p.

→ Therefore, the current in the primary coil is greater when the switch is closed.

12. PHYSICS, M6 2018 HSC 22

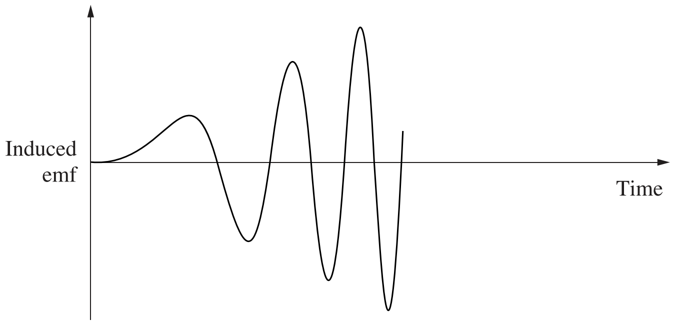
a. → The rotating magnet causes a changing magnetic flux in the metal disc.

→ This induces eddy currents (Faraday's Law). By Lenz's Law, these produce a magnetic field which opposes the change in flux by minimising the relative motion between the disc and the magnet.

→ This will have the effect of the disc rotating in the same direction as the magnet.

b.

♦ Mean mark (b) 50%.



13. PHYSICS, M6 2020 HSC 28

a.

$$\begin{aligned}\phi &= BA\cos\theta \\ &= 1 \times (0.3 \times 0.2) \times \cos 30^\circ \\ &= 0.05196\ldots \\ &\approx 5.2 \times 10^{-2}\ \text{Wb}\end{aligned}$$

b.

♦ Mean mark (b) 51%.

$$\begin{aligned}\varepsilon &= -N\frac{\Delta\phi}{t} \\ &= -1 \times \frac{5.2 \times 10^{-2}}{2.5} \\ &= 0.208\ldots \\ &= 2.1 \times 10^{-2}\ \text{V (V>0)}\end{aligned}$$

The direction of the induced current is anticlockwise as viewed from above (Lenz's Law).

c. Explanation:

♦ Mean mark (c) 50%.

→ When the magnetic field is present, the induced current results in a force acting on the rod which opposes its motion (Lenz's Law).

→ Additionally, the force required to move the rod must also overcome the downwards gravitational force.

→ Without the magnetic field, there is no opposing force due to the induced current so the force applied only needs to overcome gravity.

→ Hence, the force required to move the rod is less without the magnetic field.

14. PHYSICS, M6 2021 HSC 31

When the switch on cart one is closed, a direct current will flow through the cart 1 solenoid causing a deflection on G_1.

♦ Mean mark 45%.

Using the right hand grip rule, this will create a magnetic field with a south pole on the right hand side of this solenoid. As this magnetic field is generated, the solenoid on cart two experiences a change in magnetic flux.

According to Faraday's law, an induced emf and current will be generated in the cart 2 solenoid.

By Lenz's law, this current will flow in a direction that opposes the original change in flux, causing a magnetic south pole on the left hand side of this solenoid, and a momentary deflection of G_2 in the opposite direction to G_1.

As the two solenoids produce south poles facing each other, they will repel causing the carts to move away from each other. The law of conservation of momentum dictates that since cart 1 is double the mass of cart 2, it will have half the velocity of cart 2.

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15. PHYSICS, M6 2023 HSC 30

a. Between 0 – 0.03 seconds:

♦ Mean mark (a) 44%.

→ The magnetic field strength at point P is increasing at a constant rate.

→ Thus, ring X experiences a change in flux, which causes an EMF to be induced across the ring (Faraday's Law)

→ This induced EMF causes a current to flow through ring X that will interact in the external magnetic field to reduce the change in flux that created it (Lenz's Law).

→ Thus, a clockwise current will run through the ring, creating a north pole towards the solenoid, causing the ring to have a repulsive force away from the solenoid acting on it.

Between 0.03 – 0.05 seconds:

→ There is no change in flux through the ring due to there being a constant magnetic field.

→ Therefore, there is no induced EMF or induced current.

→ Therefore, there is no force acting on the ring.

b.i. Ring Y behaviour when placed at P:

♦♦ Mean mark (b)(i) 38%.
♦ Mean mark (b)(ii) 49%.

→ Ring Y will experience the same change in flux and hence the same induced EMF as ring X within 0 – 0.03 seconds.

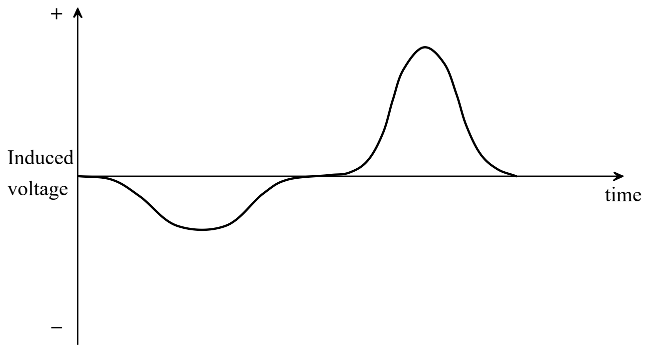
→ However, due to the gap in ring Y (i.e. there is no closed circuit), no induced current will be able to flow through the ring.

→ Hence, there is no force exerted on ring Y.

b.ii.

$$\begin{aligned}\varepsilon &= N\frac{\Delta\phi}{\Delta t}\\ &= N\frac{A\Delta B}{\Delta t}\\ &= 1\times\frac{4\times10^{-4}\times(6\times10^{-3}-0)}{0.03-0}\\ &= 8\times10^{-5}\ \text{V}\end{aligned}$$

16. PHYSICS, M6 EQ-Bank 12314



Points to note on graph:

→ First peak negative, longer wavelength and shorter amplitude.

→ Second peak positive, shorter wavelength and higher amplitude.

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17. PHYSICS, M6 2020 HSC 33

♦ Mean mark 51%.

During the first 0.4 seconds:

→ The magnet is accelerating downwards at 9.8 m s^{-2} due to gravity.

→ The magnet's gravitational potential energy is being converted into kinetic energy consistent with the law of conservation of energy.

→ Quantitatively:

$$\begin{aligned} \Delta E_k &= \Delta U \\ &= mg\Delta h \\ &= 0.04 \times 9.8 \times 0.78 \\ &= 0.30576 \text{ J} \end{aligned}$$

→ Hence 0.30576 J of the magnet's gravitational potential energy is converted into kinetic energy as it falls under gravity.

As magnet reaches the copper cylinder:

→ Its downwards motion causes the formation of induced currents in the cylinder which produce a magnetic field that opposes the magnet's motion (Lenz's law).

→ This causes the magnet to decelerate to 0.4 m s^{-1} and lose kinetic energy.

→ Finding the magnets speed before entering the copper cylinder:

$$\begin{aligned} E_k &= \frac{1}{2}mv^2 \\ 0.30576 &= \frac{1}{2} \times 0.04 \times v^2 \\ v &= 3.91 \text{ m s}^{-1} \end{aligned}$$

→ Quantifying the kinetic energy loss:

$$\begin{aligned} \Delta E_k &= \frac{1}{2}mv^2 - \frac{1}{2}mu^2 \\ &= \frac{1}{2} \times 0.04 \times 3.91^2 - \frac{1}{2} \times 0.04 \times 0.4^2 \\ &= 0.30256 \text{ J} \end{aligned}$$

→ Applying the law of conservation of energy shows that 0.30256 J of the magnet's kinetic energy is being converted to heat energy within the cylinder as the magnet decelerates.

→ Finally, as the magnet passes through the copper cylinder, its gravitational potential energy decreases while its velocity remains constant.

→ Quantifying the decrease in gravitational potential energy:

$$\begin{aligned}\Delta U &= mg\Delta h \\ &= 0.04 \times 9.8 \times 0.2 \\ &= 0.0784\end{aligned}$$

→ Hence, 0.0784 J of the magnet's gravitational potential energy is converted into heat energy in the cylinder, consistent with the law of conservation of energy.

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18. PHYSICS, M6 2024 HSC 33

♦♦ Mean mark 47%.

→ When the magnet swings down from its high position toward the can, its gravitational potential energy transforms into kinetic energy.

→ As the magnet moves, it creates changing magnetic flux through the aluminium can. This flux change is strongest when there's the fastest relative motion between the magnet and can.

→ The induced emf is described in the equation $\varepsilon = -N\dfrac{\Delta\phi}{\Delta t}$.

→ This emf creates eddy currents in the can, which produce both heat and a magnetic field. Following Lenz's law, this magnetic field opposes the magnet's motion.

→ The magnetic fields from both the magnet and the eddy currents interact, causing the can to initially rotate clockwise.

→ Eventually, this interaction dampens the magnet's swing. The magnetic interaction between the eddy currents and the magnet causes the can to rotate back and forth with decreasing amplitude, as the system's energy gradually converts to heat.