VICTORIAN CERTIFICATE OF EDUCATION

2022

NAME:________________________ **TEACHER:**________________________

PHYSICS

School Assessed Coursework: Test 1

Electric Power

Reading Time: 5 minutes
Writing time: 60 minutes

QUESTION AND ANSWER BOOK

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	26	26	59

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials Supplied
- Question and answer book of 13 pages.

Instructions
- Write your **student name and teacher name** in the space provided above on this page.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

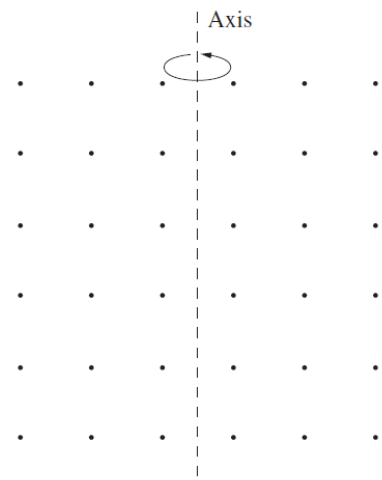
At the end of the examination
- Ensure your name and your teacher's name are written on the space provided.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

Example 1 (NSW 2006 Question 8) 1 mark

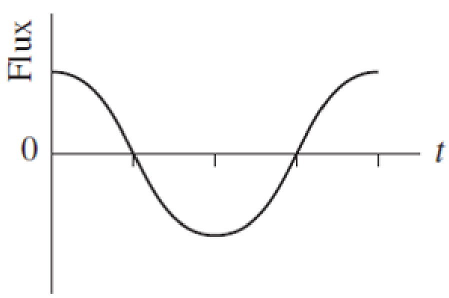
A square loop of wire, in a uniform magnetic field, is rotating at a constant rate about an axis as shown. The magnetic field is directed out of the plane of the page. At time $t = 0$ the plane of the loop is perpendicular to the magnetic field and side *XY* is moving out of the page.

Which graph best represents the variation of the magnetic flux through the loop with time?

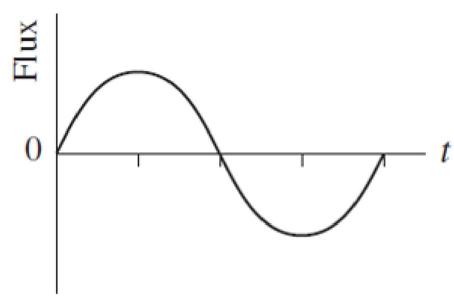


Which graph best represents the variation of the magnetic flux through the loop with time?

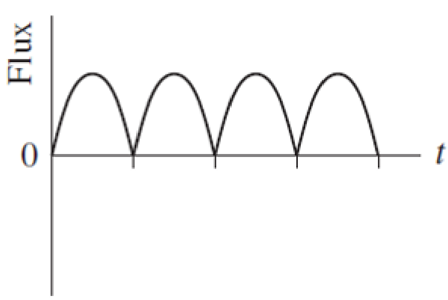
A.



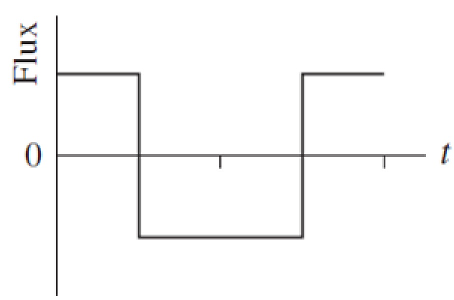
B.



C.



D.



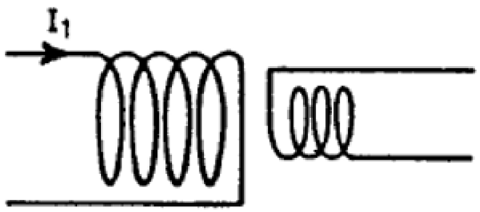


Fig 1

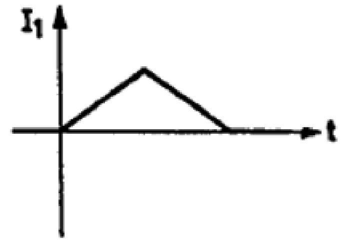
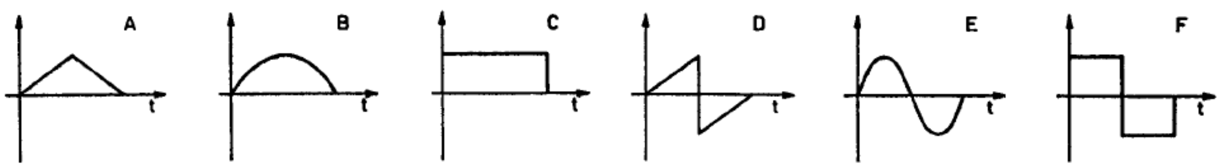


Fig 2

Fig. 1 shows two coils of wire placed in close proximity. The current in the larger coil is made to vary with time in the manner shown in Fig. 2.



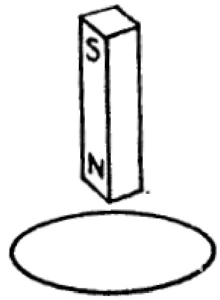
Example 2 1973 Question 83, 1 mark

Which of the graphs above best represents the variation of the magnitude of the magnetic field at the centre of the second coil?

Example 3 1973 Question 84, 1 mark

Which of the graphs above best represents the variation of the EMF induced in the second coil?

A bar magnet is held above a loop of wire in the position shown in the diagram.



In each of the questions 91 to 94 you are asked to indicate which of the graphs **A - F** best represents the variation of the magnitude of the EMF induced in the loop in the circumstances described in the question.

Example 4 1969 Question 91, 1 mark

Both loop and magnet are moved sideways with the same uniform velocity.

Example 5 1969 Question 92, 1 mark

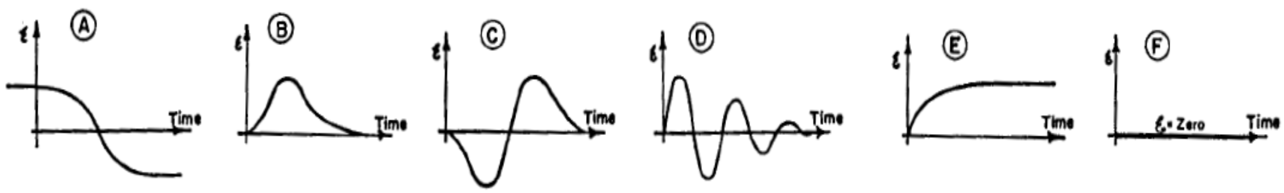
The loop is rotated through 360° about a diameter.

Example 6 1969 Question 93, 1 mark

The loop is released from the position shown and falls away from the magnet.

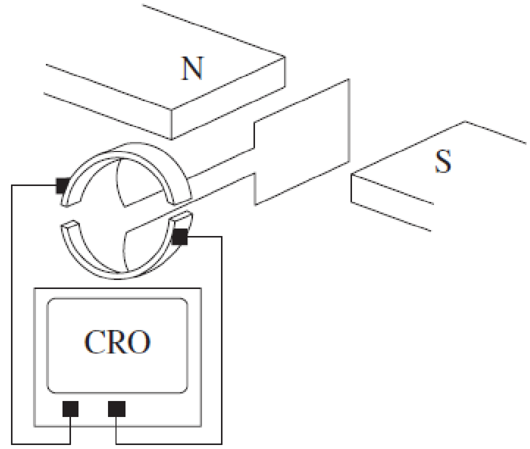
Example 7 1969 Question 94, 1 mark

The magnet is released from the position shown and falls through the loop.



Example 8 NSW 2003 Question 6, 1 mark

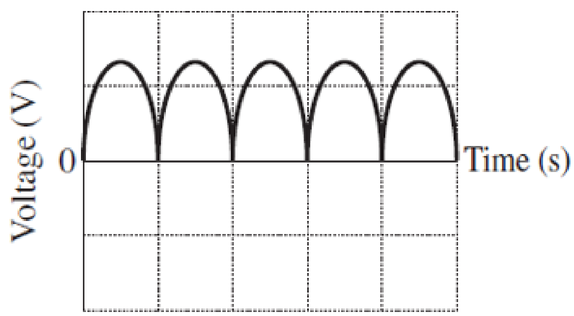
The diagram shows a DC generator connected to a cathode ray oscilloscope (CRO).



What output voltage would be observed for this generator on the CRO?

A.

B.



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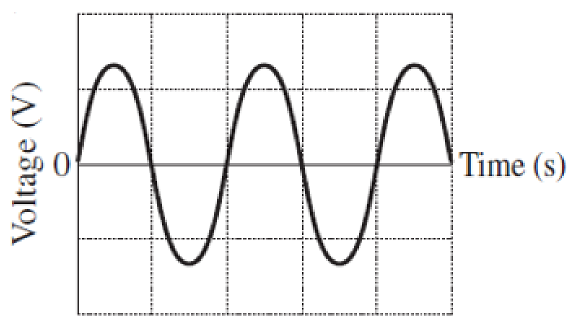

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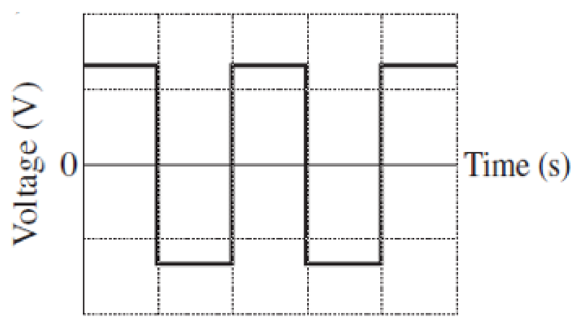
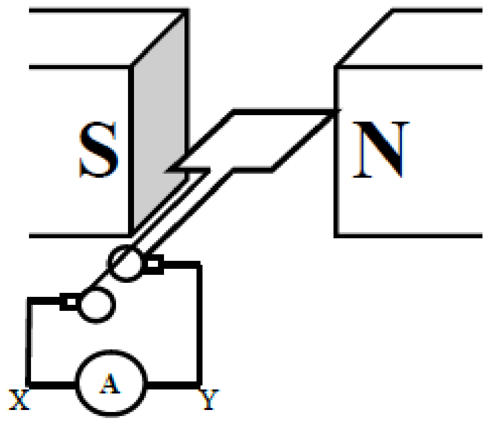


The following information relates to Questions 8 to 13.

The diagram shows a generator with a square coil of side length 8 cm that rotates clockwise at 30 Hz. The magnetic field in which the coil rotates is 40 mT. The coil has 50 turns.



Question 8 (1 mark)

What is the magnetic flux through the coil when the coil is the in position shown in the diagram?

Wb

Question 9 (3 marks)

Calculate the magnitude of the average induced EMF between the 2 slip rings as the coil rotates 90° from the position shown in the diagram.

V

Question 10 (3 marks)

In which direction (X to Y **OR** Y to X) does the induced current flow through the ammeter in the first quarter turn? Explain.

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____

____

Question 11 (3 marks)

Draw the flux vs. time graph for two full rotations of the coil from the position shown in the diagram.

Question 12 (3 marks)

Draw the induced EMF vs. time graph for two full rotations of the coil from the position shown in the diagram. You **do not** need to include a scale on the induced EMF axis.

Question 13 (3 marks)

Describe the changes to induced EMF vs. time graph above if the coil was replaced with one that was the same size but had 75 turns and was rotated 15 Hz. Add the resulting graph to the grid in question 12.

The following information relates to questions 14 – 17.

Farmer Joe uses running water from a river to turn a turbine that is connected to a generator. The generator is used to power his electric tools in the shed that is 4 km away and he has run an electrical cable that has a resistance of 0.002 Ω/m from the generator to the shed and back again. At the generator he measures a potential difference of 250 V but when he returns to test his power tools, the voltage at the shed is only 170 V and his tools do not run properly. Farmer Joe knows he requires at least 240 V in order for the power tools in his shed to run correctly.

Question 14 (3 marks)

Calculate the resistance of the cable and the current in transmission cables.

Ω	A

Question 15 (2 marks)

What is the power provided by the generator?

W

Question 16 (2 marks)

How much power is lost in the transmission between the generator to the shed?

W

Farmer Joe decides to use 2 transformers to reduce the power loss during transmission. He uses a 1:20 step-up transformer and a 20:1 step-down transformer.

Question 17 (2 marks)

Draw a diagram of Farmer Joe's situation. Include the generator, transmission cables, the shed and the two transformers. Clearly indicate which transformer is the step-up and which is the step-down.

Question 18 (4 marks)

With the transformer arrangement, does Farmer Joe's shed run the power tools as expected? Justify with calculations.

The following information relates to Questions 19 and 20.

Imagine you are running a 500 W kettle in Japan, where the mains power supply is 110 V AC.

Question 19 (2 marks)

What is the peak current that passes through the kettle.

A_p

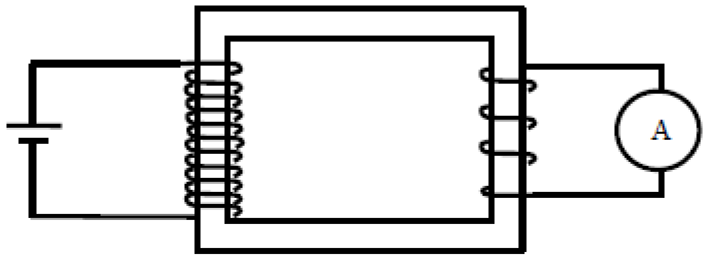
Question 20 (2 marks)

What is the peak to peak voltage across the kettle.

$V_{p\text{-}p}$

The following information relates to Questions 21 and 22.

The diagram below shows a transformer with 2400 turns in the primary coil and 300 turns in the secondary coil.



Question 21 (2 marks)

What material is the core of the transformer usually made from and explain its purpose.

____

____

____

____

The primary coil has a current of 5.0 A.

Question 22 (2 marks)

What is the current in the secondary coil?

Solutions

Example 1 NSW 2006 Question 8

This question must have been a little difficult to answer, as the loop does not appear on the exam paper. Using logic, the initial orientation of the loop is perpendicular to the field, therefore the flux starts at a maximum. The flux will vary sinusoidally.

∴ A (ANS)

Example 2 1973 Question 83, 56%

The magnetic field will be directly proportional to the current.

∴ A (ANS)

Example 3 1973 Question 84, 20%

The induced EMF is the negative gradient of the flux vs time graph. It is constant, then reverses, but remains constant.

∴ F (ANS)

Example 4 1969 Question 91, 96%

As they are both moving sideways, there will not be any change in flux, so the induced EMF is zero.

∴ F (ANS)

Example 5 1969 Question 92, 51%

The flux through the loop will start at a maximum, go to zero and then return to a maximum. The variation of the flux is close to sinusoidal (it would be sinusoidal if the field was uniform, but the field about the end of a bar magnet is not uniform), so the gradient will also be close to sinusoidal, starting at zero and completing one cycle.

The best answer is **C (ANS)**

Example 6 1969 Question 93, 34%

The flux is decreasing, and the loop is accelerating (due to gravity). The induced EMF will create a current to try to replace the field that the loop is losing, since the field is weaker further from the magnet. The induced EMF will always be in the same direction, and will get weaker the further the loop is from the magnet.

∴ B (ANS)

Example 7 1969 Question 94, 31%

(As it doesn't matter if the loop is falling away from the magnet or the magnet is falling away from the loop.) As the magnet approaches the loop the effect should be the opposite to what would happen as it moves away from the loop.

∴ C (ANS)

Example 8 NSW 2003 Question 53

∴ B (ANS)

Short Answers :

Q8 0 Wb as plane of the coil is parallel to the magnetic field

Question 9 (3 marks)

Calculate the magnitude of the average induced EMF between the 2 slip rings as the coil rotates 90° from the position shown in the diagram.

$\Delta t = \frac{1}{4} \times \frac{1}{f} = \frac{1}{120} = 8.33 \times 10^{-3}$ s (1)

$\mathcal{E}_{av} = -N \frac{\Delta \phi_B}{\Delta t} = 50 \times \frac{2.56 \times 10^{-4}}{8.33 \times 10^{-3}} = 1.536$ V.

$\Delta \phi_B = \phi_{Bf} - \phi_{Bi} = (0.08^2 \times 40 \times 10^{-3}) - 0 = 2.56 \times 10^{-4}$ Wb (1)

1.54 V

Question 10 (3 marks)

In which direction (X to Y **OR** Y to X) does the induced current flow through the ammeter in the first quarter turn? Explain.

Traditional Lenz

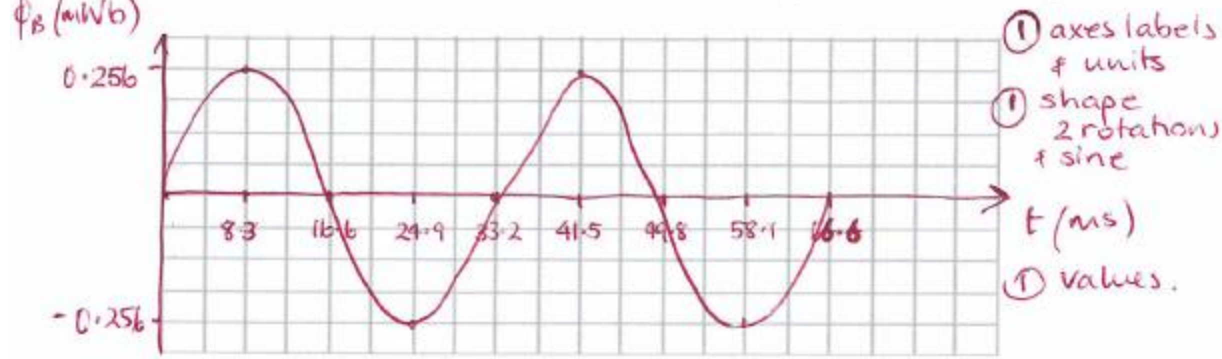
- X - Y (1)
- As the coil rotates clockwise flux increases to the left (1)
- Lenz's Law says that the induced field to oppose the change in flux will be to the right. (1)

Motional EMF

- X - Y (1)
- As AB moves ~~up~~ down in the field a positive charge experiences in AB experiences force from A→B (1)
- Above works / derived from RH slap rule. (1)

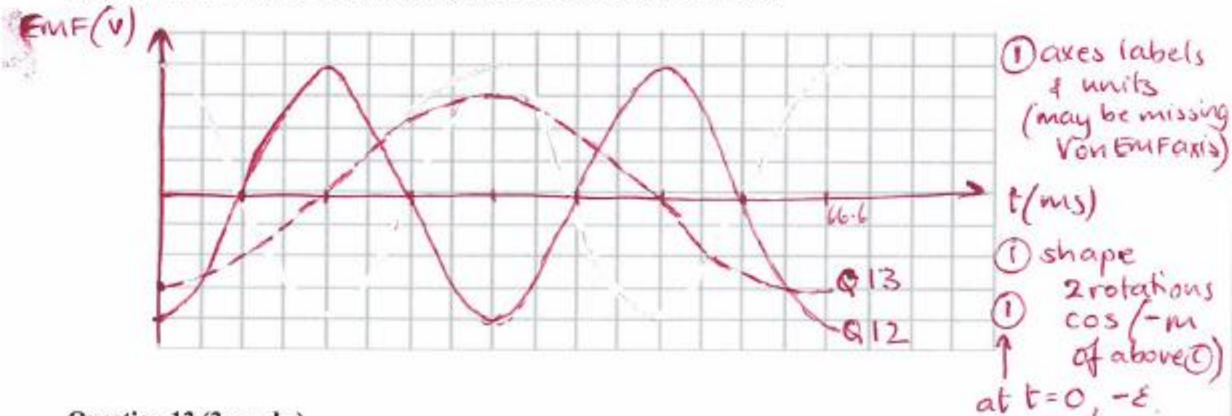
Question 11 (3 marks)

Draw the flux vs. time graph for two full rotations of the coil from the position shown in the diagram.



Question 12 (3 marks)

Draw the induced EMF vs. time graph for two full rotations of the coil from the position shown in the diagram. You **do not** need to include a scale on the induced EMF axis.



Question 13 (3 marks)

Describe the changes to induced EMF vs. time graph above if the coil was replaced with one that was the same size but had 75 turns and was rotated 15 Hz. Add the resulting graph to the grid in question 12.

$\mathcal{E} \times 1.5 \times 0.5$

b/c $N_1 = 1.5 \times N_0$ ① and $f_1 = 0.5 f_0$ ① $\therefore T_1 = 2 T_0$ ① $\therefore \mathcal{E}_1 = 0.75 \times \mathcal{E}_0$ ①

① correct graph

① + ① for any above

(-1) for contradiction

Question 14 (3 marks)

Calculate the resistance of the cable and the current in transmission cables.

$4 \times 2 = 8$ km

$R = 8000 \times 0.002$

$= 16\ \Omega$. (1)

$I = \frac{80}{16}$

$= 5$

16 Ω	5 A

Question 15 (2 marks)

What is the power provided by the generator?

$P = VI$

$= 250 \times 5$ (1)

$= 1250$ W

conseq

1250 W	(1)

Question 16 (2 marks)

How much power is lost in the transmission between the generator to the shed?

conseq.

$P_L = I^2R$

$= 5^2 \times 16$ (1)

$= 400$ W

$\Delta V_L = 250 - 170 = 80$ V (1)

$\therefore P_L = V_L I_L$

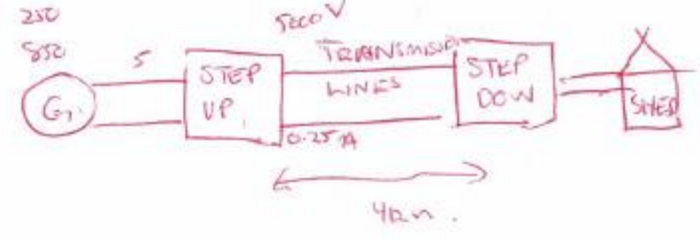
$= 80 \times 5$

$= 400$ W.

400 W	(1)

Question 17 (2 marks)

Draw a diagram of Farmer Joe's situation. Include the generator, transmission cables, the shed and the two transformers. Clearly indicate which transformer is the step-up and which is the step-down.



(1) Correct step-up and step down.

(1) Parts, all.

Question 18 (4 marks)

With the transformer arrangement, does Farmer Joe's shed run the power tools as expected? Justify with calculations.

$V_A = 0.25 \times 16$

$= 4\ V.$ (1)

$V_{P\ step\ down} = 4996$ (1)

$V_{S\ step\ down} = \frac{5996}{20} = 249.8\ V.$ (1)

Yep. (1)

$P_{loss} = I_L^2 R_L$

$= 0.25^2 \times 16$

$= 1\ W.$

Question 19 (2 marks)

What is the peak current that passes through the kettle.

$I_p = \frac{P_p}{}$ $P = VI$ $I_{RMS} = \frac{500}{110} = 4.55A$ (1)

$I_p = 4.55 \times \sqrt{2}$

$= 6.43A.$ (1)

6.4 A_p

Question 20 (2 marks)

What is the peak to peak voltage across the kettle.

$V_{p-p} = 2\sqrt{2}\, V_{RMS}$ (1)

$= 2\sqrt{2} \times 110$

$= 311.13$

311 V_{p-p}

$N_p = 2400$ $N_s = 300$

Question 21 (2 marks) $I_p = 5.0A$

What material is the core of the transformer usually made from and explain its purpose.

Soft iron (1)

Transfers changing magnetic field from primary coil to secondary coil. (1)

The primary coil has a current of 5.0 A.

Question 22 (2 marks)

What is the current in the secondary coil?

0 A