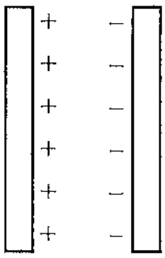
Question 3 84 %

Two large charged plates with equal and opposite charges are placed close together, as shown in the diagram below. A distance of 5.0 mm separates the plates. The electric field between the plates is equal to 1000 N C^{-1}.



$$E = \frac{V}{d}$$

$$V = Ed$$

$$= 1000 \times 0.005$$

$$= 5.0\ V$$

Which one of the following is closest to the voltage difference between the plates?

[✓ **A.**] 5.0 V

B. 200 V

C. 5000 V

D. 5 000 000 V

Use the following information to answer Questions 4 and 5.

Students doing a VCE Physics practical investigation use a step-down transformer with 240 V_{RMS} AC to 12 V_{RMS} AC.

Question 4 84 %

Which one of the following best gives the ratio of the number of turns, $N_{primary}$: $N_{secondary}$?

A. 1:4

B. 1:20

C. 4:1

[✓ **D.**] 20:1

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{240}{12} = 20:1$$

Question 5 51 %

The transformer delivers 48 W_{RMS} to a resistor. Assume that the transformer is ideal.

Which one of the following best gives the peak current in the secondary coil?

A. 0.2 A

B. 4.0 A

[✓ **C.**] 5.7 A

D. 11.3 A

$$P_{RMS} = V_{RMS} I_{RMS}$$

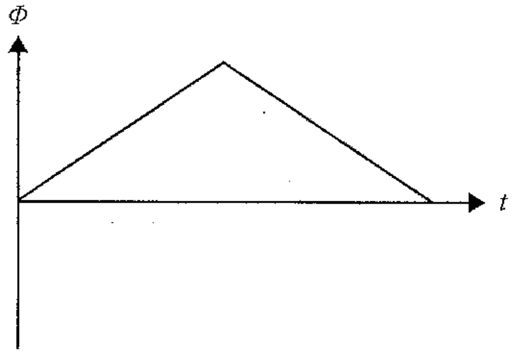
$$I = \frac{P}{V} \quad I_{RMS} = \frac{48}{12} = 4\ A$$

$$I_{peak} = \sqrt{2}\, I_{RMS}$$

$$= 5.7\ A$$

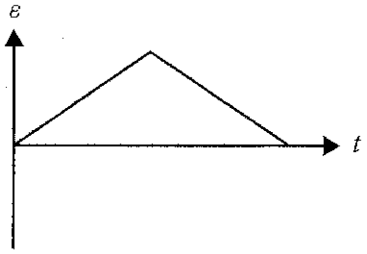
Question 6 60%

The graph below shows the change in magnetic flux (Φ) through a coil of wire as a function of time (t).

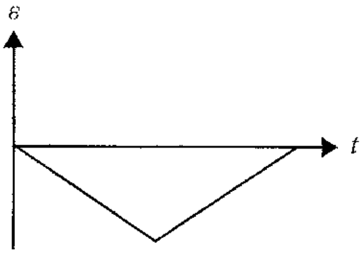


Which one of the following graphs best represents the induced EMF (ε) across the coil of wire as a function of time (t)?

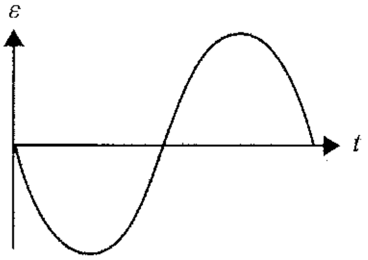
A.



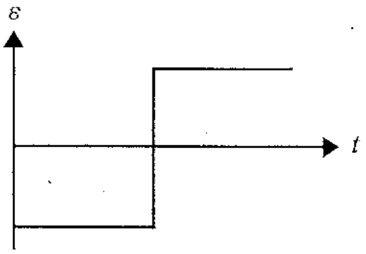
B.



C.



[✓ **D.**]



$$\varepsilon = -\frac{d\Phi}{dt}$$

Question 2 (5 marks) 81 % av. 1.7

According to one model of the atom, the electron in the ground state of a hydrogen atom moves around the stationary proton in a circular orbit with a radius of 53 pm (53×10^{-12} m).

a. Show that the magnitude of the force acting between the proton and the electron at this separation is equal to 8.2×10^{-8} N. Take $k = 9.0 \times 10^9$ N m^2 C^{-2} and the magnitude of the electron and proton charges as 1.6×10^{-19} C. Show all the steps of your working. 2 marks

$$F = K\frac{q_1 q_2}{r^2}$$

$$F = \frac{9\times10^9 \times (1.6\times10^{-19})^2}{(53\times10^{-12})^2} = 8.2\times10^{-8} N$$

b. Using 8.2×10^{-8} N as the value of the magnitude of the force given in **part a.**, calculate the speed of the electron in its circular path. Take the mass of the electron to be 9.1×10^{-31} kg. Show your working. 3 marks

51 % av. 1.7

$$F_c = \frac{mv^2}{r} \qquad v = \sqrt{\frac{Fr}{m}} \qquad v = \sqrt{\frac{8.2\times10^{-8}\times53\times10^{-12}}{9.1\times10^{-31}}}$$

$$v = 2.2\times10^{6}\ ms^{-1}$$

2.2 m s^{-1}

SECTION B – continued

TURN OVER

Question 3 (5 marks) 48 % av. 2.1

Figure 2 shows a schematic diagram of a simple DC motor.

It consists of two magnets, a single 9.0 V DC power supply, a split-ring commutator and a rectangular coil of wire consisting of 10 loops.

The total resistance of the coil of wire is 6.0 Ω.

The length of the side JK is 12 cm and the length of the side KL is 6.0 cm.

The strength of the uniform magnetic field is 0.50 T.

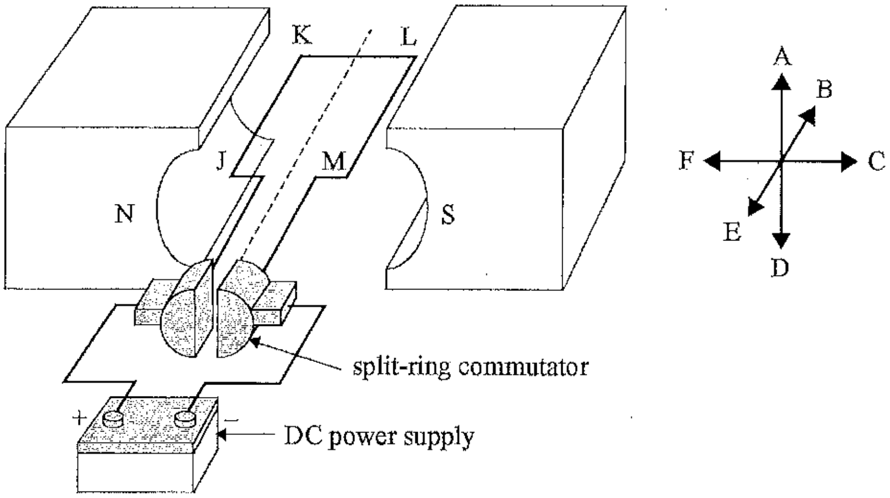


Figure 2

a. Determine the size and the direction (A–F) of the force acting on the side JK. 3 marks

$I = \frac{V}{R} = \frac{9}{6} = 1.5A$

$F = nBIl$

$F = 10 \times 0.5 \times 1.5 \times 0.12$

$F = 0.9\ N$

0.9 N	Direction down

Question 5 (8 marks)

The alternator in Figure 3 has a rectangular coil with sides of 0.30 m × 0.40 m and 10 turns. The coil rotates four times a second in a uniform magnetic field. The magnetic flux through the coil in the position shown is 0.20 Wb.

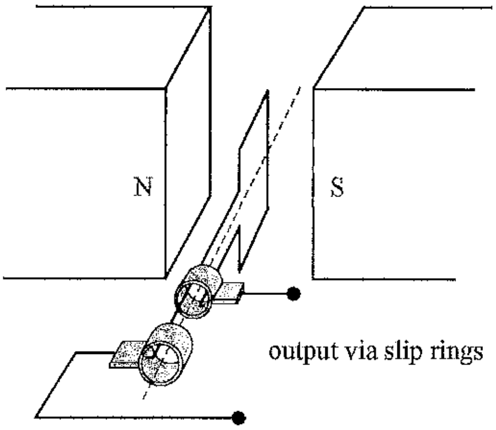


Figure 3

a. Calculate the magnitude of the magnetic field. Include an appropriate unit. 67% av. 2.2 3 marks

$\Phi = BA\cos\theta \quad \theta = 0°$

$B = \frac{\Phi}{A} = \frac{0.2}{0.12} = 1.7\ T$

$\boxed{1.7\ T}$

b. Calculate the magnitude of the average EMF (ε) generated in a quarter of a turn. Show all the steps of your working. 43 % av 1.6 3 marks

$\varepsilon = n\frac{\Delta \Phi}{\Delta t}$

$= 10 \times \frac{0.2}{0.063}$

$\doteq 32 V$

32 V

c. Figure 4 shows the output EMF (ε) versus time graph of the alternator for two complete cycles. 65 % av. 1.4

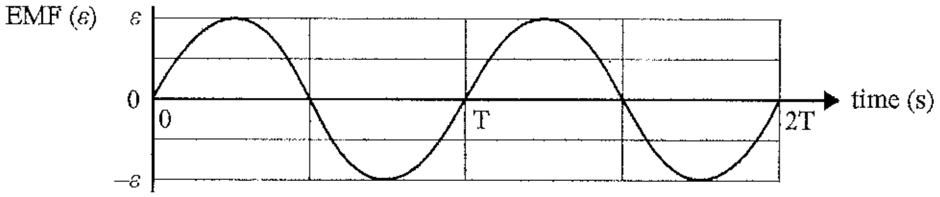
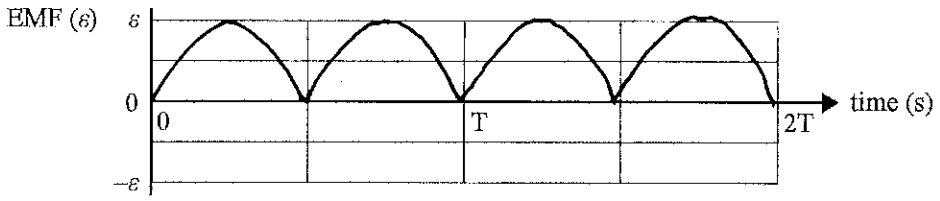


Figure 4

The two slip rings in Figure 3 are now replaced with a split-ring commutator.

On the axes provided below, sketch the EMF (ε) versus time graph of this new arrangement for two complete cycles. 2 marks



Question 6 (4 marks) 70 % av. 1.5

Figure 5 shows a generator at an electrical power station that generates 100 MW_{RMS} of power at 10 kV_{RMS} AC.

Transformer T_1 steps the voltage up to 500 kV_{RMS} AC for transmission through transmission wires that have a total resistance, R_T, of 3.0 Ω. Transformer T_2 steps the voltage down to 50 kV_{RMS} AC at the substation. Assume that both transformers are ideal.

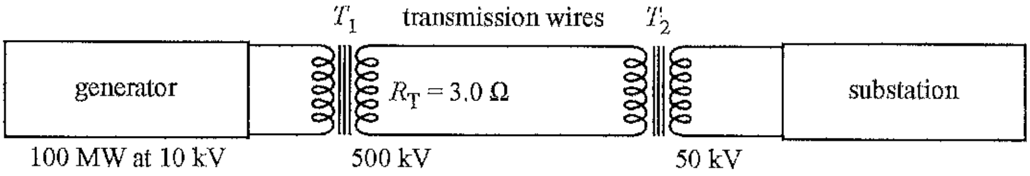


Figure 5

a. The current in the transmission lines is 200 A.

Calculate the total electrical power loss in the transmission wires. 2 marks

$P_{Loss} = I^2 R$

$= 200^2 \times 3$

$= 120000$ W

$\boxed{120}$ kW

b. Transformer T_1 stepped the voltage up to 250 kV_{RMS} AC instead of 500 kV_{RMS} AC. 45 % av. 1

By what factor would the power loss in the transmission lines increase? 2 marks

$V \div 2 \rightarrow \underline{I} \times 2$ as $P = const$

$\underset{\sim}{I}^2 \times 4$

$P \times 4$

Factor of 4

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 (5 marks)

An electric field accelerates a proton between two plates. The proton exits into a region of uniform magnetic field at right angles to its path, directed out of the page, as shown in Figure 1.

Data

mass of proton	1.7×10^{-27} kg
charge on proton	$+1.6 \times 10^{-19}$ C
accelerating voltage	10 kV
distance between plates	20 cm
strength of magnetic field	2.0×10^{-2} T

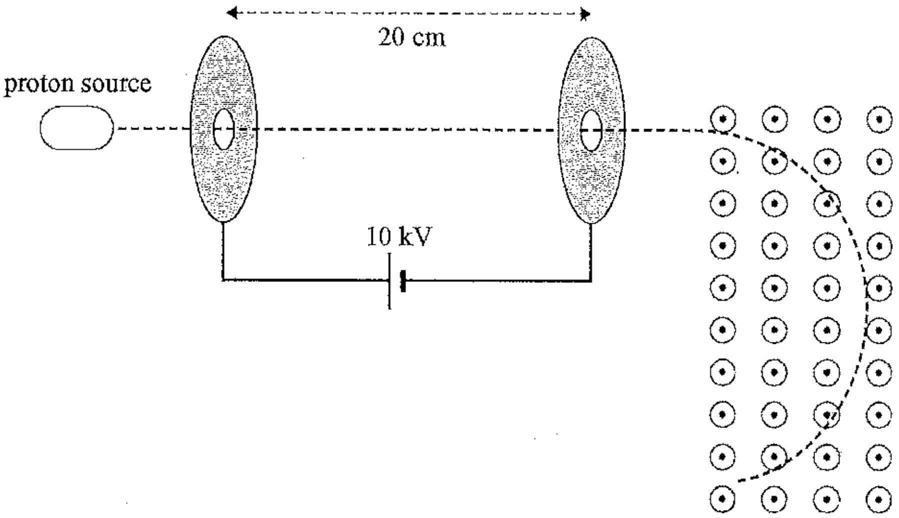


Figure 1

a. Calculate the strength of the electric field between the plates. 82 % 1 mark

$E = \frac{V}{d} = \frac{10000}{0.2} = 50000$

50000 V m^{-1}

b. Calculate the speed of the proton as it exits the electric field. Show your working. 57 % av 1.2 2 marks

$qV = \frac{mv^2}{2}$

$v^2 = \frac{2qV}{m}$ $v = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 10000}{1.7 \times 10^{-27}}} = 1.4 \times 10^6$

1.4×10^6 m s^{-1}

c. With a different accelerating voltage, the proton exits the electric field at a speed of 1.0×10^6 m s^{-1}.

Calculate the radius of the path of this proton in the magnetic field. Show your working. 65 % av 1.4 2 marks

$qvB = \frac{mv^2}{r}$

$r = \frac{mv^{\cancel{2}}}{q\cancel{v}B} = \frac{1.7 \times 10^{-27} \times 1.0 \times 10^6}{2 \times 10^{-2} \times 1.6 \times 10^{-19}} = 0.53$

0.53 m

Question 2 (6 marks)

A square loop of wire of 10 turns with a cross-sectional area of 1.6×10^{-3} m^2 passes at a constant speed into, through and out of a magnetic field of magnitude 2.0×10^{-2} T, as shown in Figure 2.

The loop takes 0.50 s to go from position X to position Y.

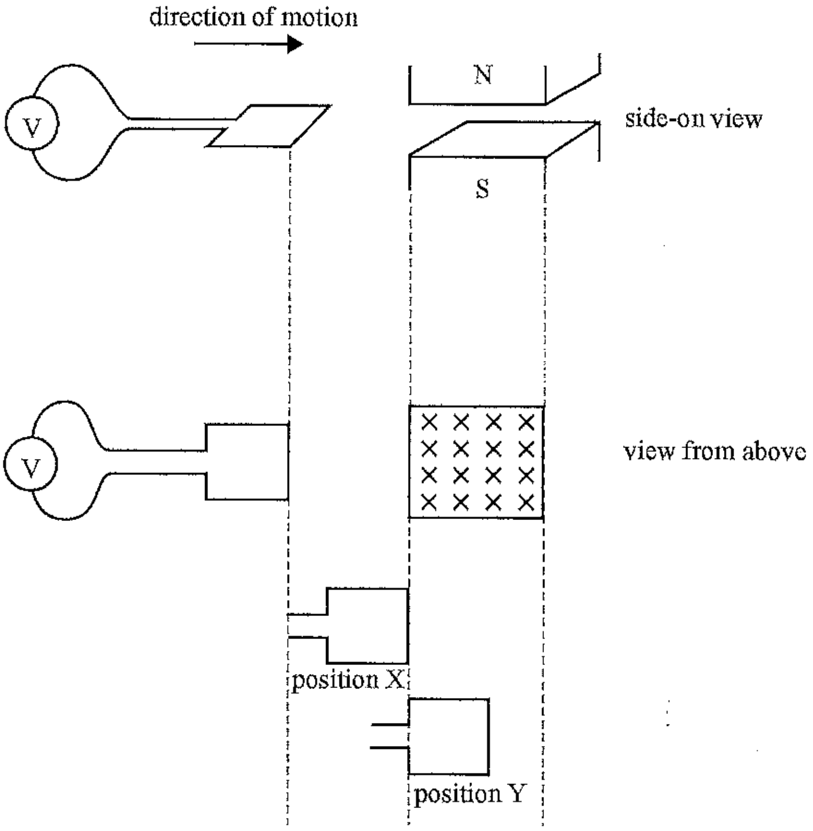


Figure 2

a. Calculate the average EMF induced in the loop as it passes from just outside the magnetic field at position X to just inside the magnetic field at position Y. Show your working. 72 % 3 marks

av 2.4

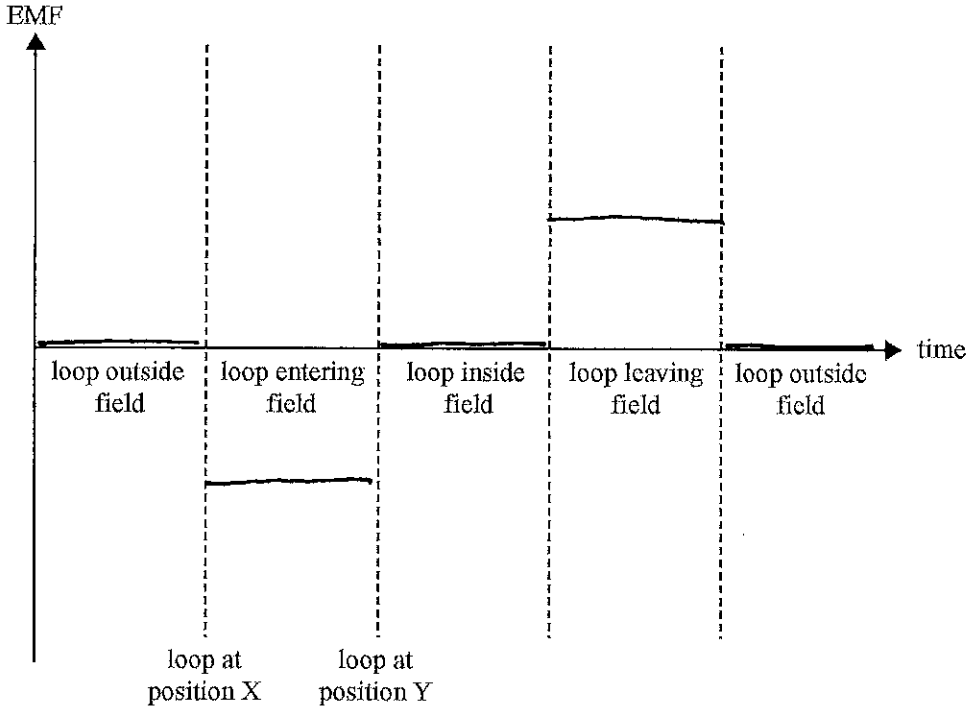
$\mathcal{E} = n \frac{\Delta \Phi}{\Delta t}$

$\mathcal{E} = 10 \times \frac{2 \times 10^{-2} \times 1.6 \times 10^{-3}}{0.5}$

6.4×10^{-4} V

b. Sketch the EMF induced in the loop as it passes into, through and out of the magnetic field. You do not need to include values on the axes. 3 marks

42 % av 1.4



Question 3 (5 marks)

Students build a model of a simple DC motor, as shown in Figure 3.

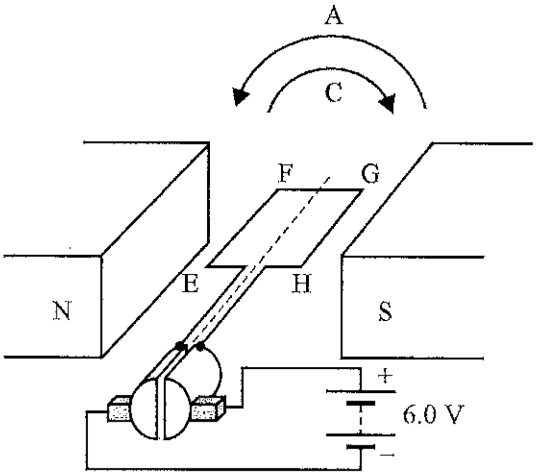


Figure 3

a. The motor is set with the coil horizontal, as shown, and the power source is applied. 47% av. 2

Will the motor rotate in a clockwise (C) or anticlockwise (A) direction? Explain your answer. 3 marks

Clockwise

Current flow from H to G.

RHSR

b. One student suggests that slip rings would be easier to make than a commutator and that they should use slip rings instead.

23% av 0.7

Explain the effect that replacing the commutator with slip rings would have on the operation of the motor, if no other change was made. 2 marks

Coil will rotate 90°

and stops

Question 4 (4 marks)

Figure 4 shows a simple AC alternator with the output connected to an oscilloscope and a light globe.

The oscilloscope can be considered as having a very large resistance. The coil is rotated, as shown in Figure 4.

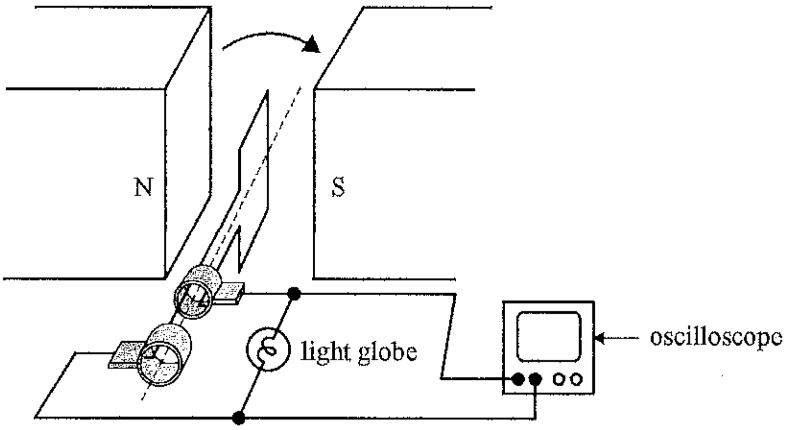


Figure 4

The output on the oscilloscope is shown in Figure 5.

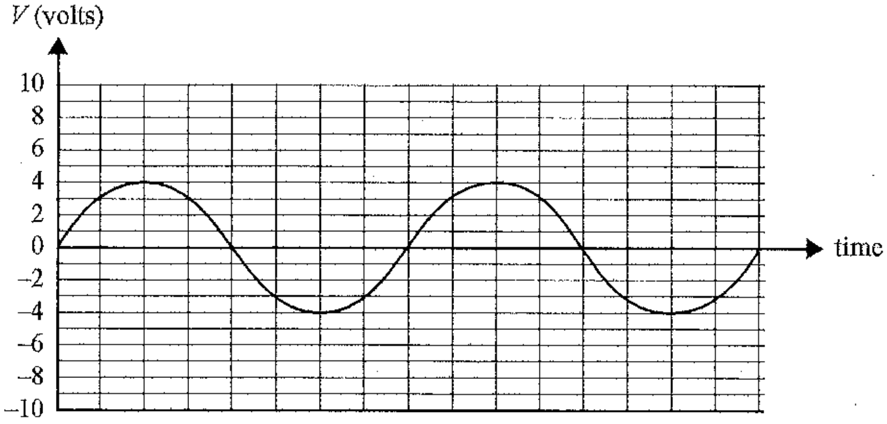


Figure 5

a. The AC alternator is to be replaced with a battery. 55% av 1.1

What voltage should the battery have for the light globe to light up with the same average brightness as it did with the alternator? Show your working. 2 marks

$V_{DC} = \frac{V_P}{\sqrt{2}} = \frac{4}{\sqrt{2}}$

2.8 V

b. The rate of rotation of the loop is doubled. 38% av. 1.2

On Figure 6 below, sketch the output that will now be seen on the oscilloscope. The original waveform is shown as a dashed line on Figure 6. 2 marks

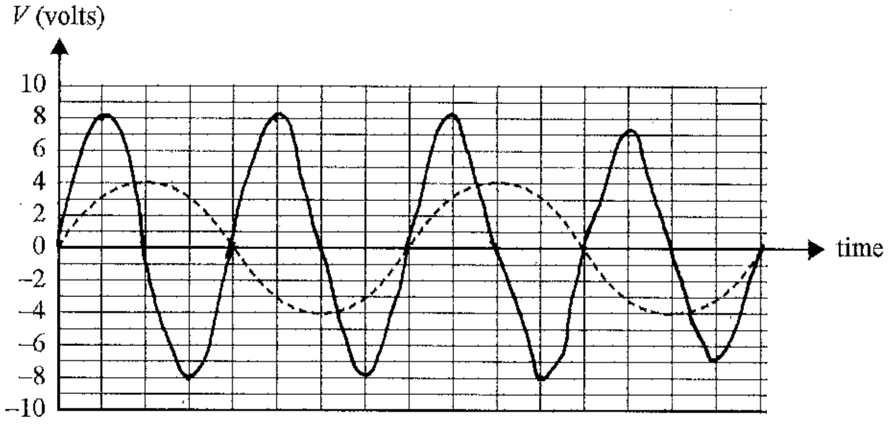


Figure 6

Question 5 (12 marks)

A Physics class is investigating power loss in transmission lines.

The students construct a model of a transmission system. They first set up the model as shown in Figure 7. The model consists of a variable voltage AC power supply, two transmission lines, each of 4.0 Ω (total resistance = 8.0 Ω), a variable ratio transformer, a light globe and meters as needed. The purpose of the model is to operate the 4.0 V light globe.

A variable ratio transformer is one in which the ratio of turns in primary windings to turns in secondary windings can be varied. The resistance of the connecting wires can be ignored.

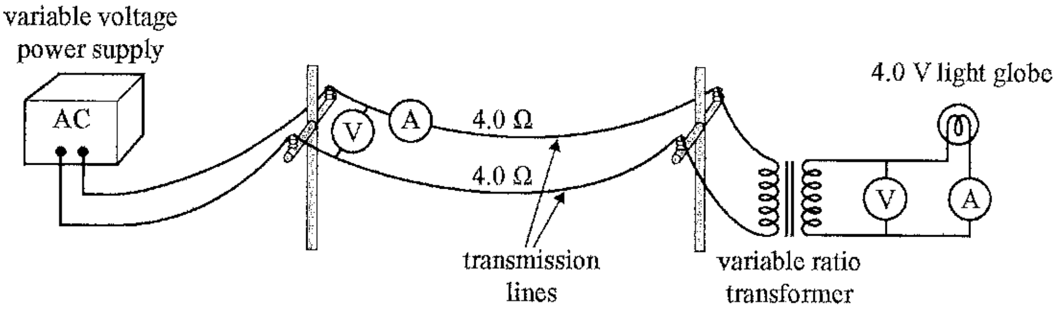


Figure 7

In their first experiment, the transformer is set on a ratio of 4:1 and the current in the transmission lines is measured to be 3.0 A. The light globe is operating correctly, with 4.0 V_{RMS} across it.

a. Calculate the power dissipated in the light globe. Show your working. 44% av 0.9 2 marks

$P = VI \quad I = $ [illegible] $3 \times 4 = 12\ A$

$P = 4 \times 12$

48 W

b. Calculate the voltage output of the power supply. Show your working. 31% av 1.4 3 marks

$V_{line} = IR$

$V_{line} = $ [illegible] $3 \times 8 = 24\ V$

$V_{transformer} = 4 \times 4 = 16\ V \quad V_{out} = 24 + 16 = 40\ V$

[illegible]40 V

c. Calculate the total power loss in the transmission lines. Show your working. 75 % av 1.5 2 marks

$P_{loss} = I^2 R$

$= 3^2 \times 8$

72 W

d. In a second experiment, the students set the variable ratio of the transformer at 8:1 and adjust the variable voltage power supply so that the light globe operates correctly, with 4.0 V_{RMS} across it. 21 % av 0.7

Calculate the total power loss in the transmission lines in this second experiment. Show your working. 3 marks

$I_{globe} = 12$ A (globe operates correctly)

$I_{Line} = \frac{12}{8} = 1.5$ A

$P_{Loss} = I^2 R = 1.5^2 \times 8$

18 W

57 % av 1.4

e. Suggest **two** reasons why high voltages are often used for the transmission of electric power over long distances. 2 marks

Any 2 of: Reduce Current

Reduce power loss

Reduce size of wires

Reduce voltage drop