PHYSICS 12 – Electricity and Magnetism Topic Test 2 2019
Question/Answer Booklet

NAME: ______________________________

TIME ALLOWED FOR THIS PAPER

Reading time for paper: 5 minutes
Working time for paper: 40 minutes

STRUCTURE OF THE PAPER

Section	No. of questions	No. of questions to be attempted	No. of marks out of 41	
A: Short Answers	7	ALL	21	
B: Problem Solving	3	ALL	20	
C: Comprehension				

Section A: Short Answer
Marks Allocated: 21 marks out of 41 total marks.
This section has 7 questions. Answer the questions in the spaces provided.

Question 1 [3 mark]

A metal aircraft with a wing span of 42 m flies horizontally with a speed of 1000 km h^{-1} in a direction due east in a region where the vertical component of the flux density of the Earth's magnetic field is 4.5×10^{-5} T.

(a) Calculate the flux cut per second by the wings of the aircraft.

(2)

$L = 42m$

$V = 1000 \, kmh^{-1} = \frac{1000 \times 1000}{3600} = 277.8 ms^{-1}$

$B = 4.5 \times 10^{-5} T$

must state that $V = \frac{\Phi}{t}$

$\frac{\Phi}{t} = V = l.v.B = 42 \times 277.8 \times 4.5 \times 10^{-5}$

$= 0.525 \, Wb \, s^{-1}$

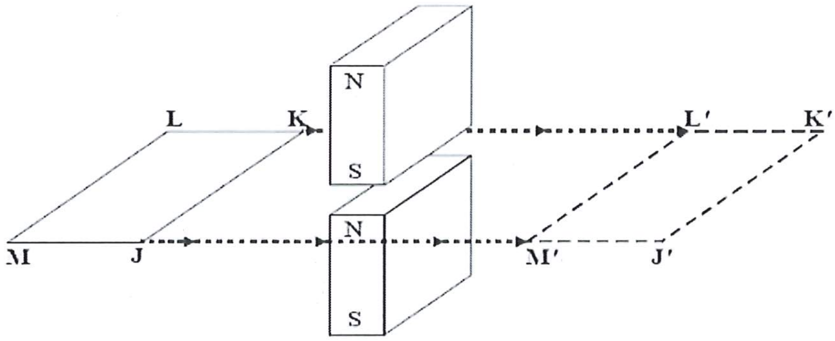
(b) What would be the change in the potential difference, if any, if the aircraft flew due west?

(1)

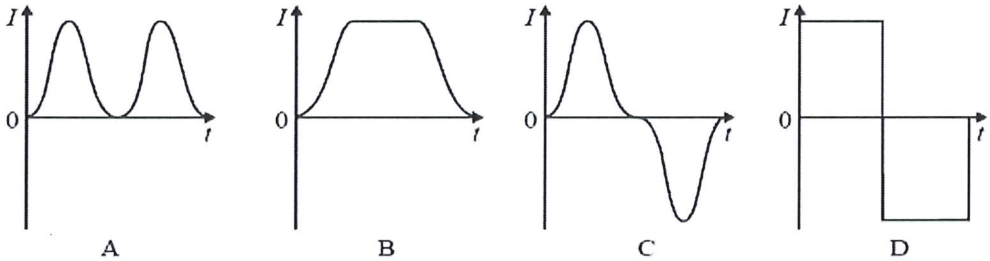
Direction of P.D reversed

Question 2 [1 mark]

A rectangular conducting loop is pulled horizontally through the gap between two vertical magnets as shown in the diagram.



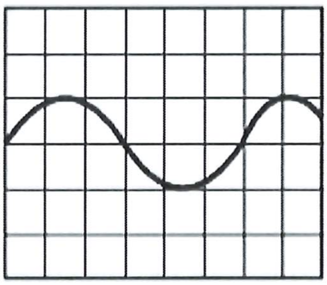
Which one of the graphs best represents the variation of loop current *I* with time *t* as the loop moves at a constant speed from **JKLM** to **J'K'L'M'**?



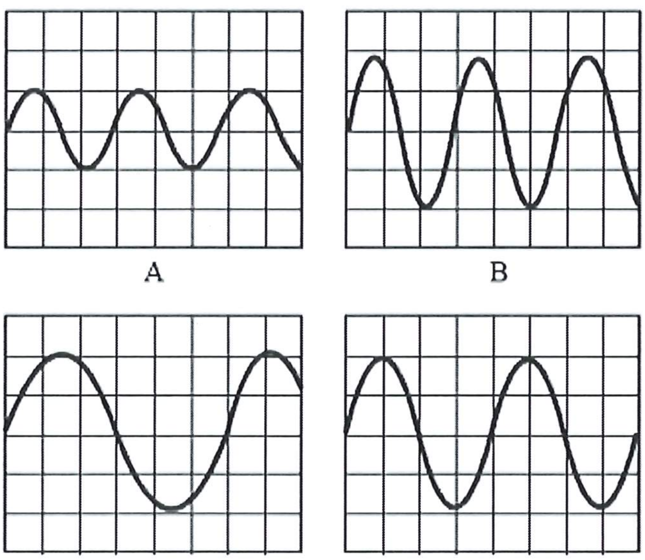
Answer: C

Question 3 [1 marks]

The diagram to the right shows the waveform obtained when the output of a~~n~~ generator is connected to a cathode ray oscilloscope.



Which one of the diagrams below best represents the output when the speed of rotation of the generator is doubled and no adjustment is made to the oscilloscope?

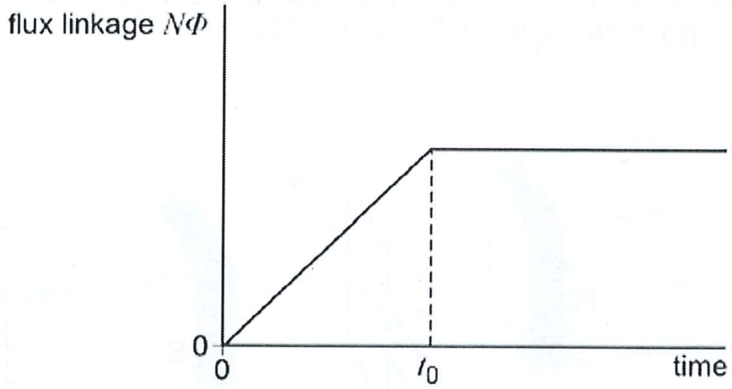


Answer: B

C
B

Question 4 [3 marks]

The graph shows how the flux linkage, $N\Phi$, through a coil changes when the coil is moved into a magnetic field.



(i) The emf induced in the coil

A decreases then becomes zero after time t_0.

B increases then becomes constant after time t_0.

C is constant then becomes zero after time t_0.

D is zero then increases after time t_0.

(1)

(ii) Explain your choice

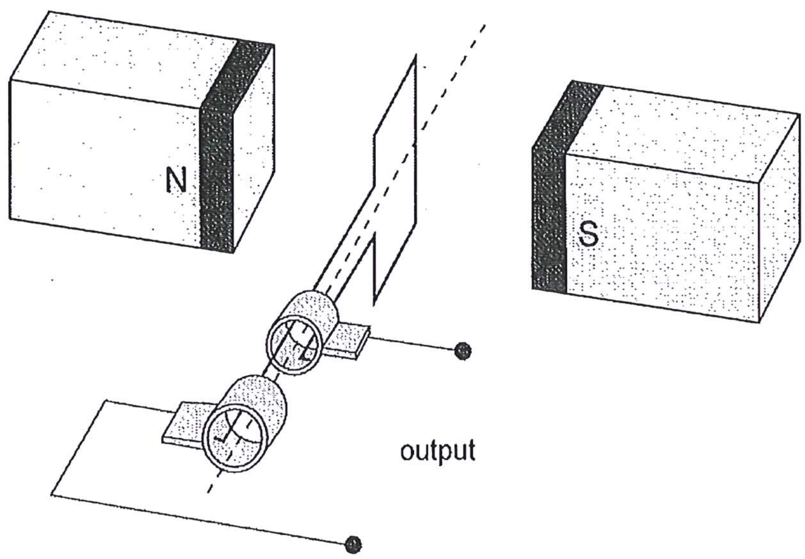
• ~~The~~ From 0 to the flux changes at a constant rate/ linearly. Therefore a constant emf is induced

• After time to there is no change in flux linkage
Therefore no emf is generated
(According the Faraday's Law a change between the conductor and the magnetic field)

(2)

Question 5 [4 marks]

The diagram below shows an AC generator consisting of a rectangular coil with sides 20 cm x 30 cm, and 1000 turns rotating in a uniform magnetic field. The magnetic flux through the coil in the position shown is 3.0×10^{-4} Wb.



a. What is the magnitude of the field? **(2)**

$A = 20 \times 10^{-2} \times 30 \times 10^{-2} = 60 \times 10^{-2}$

$N = 1000$

$\phi = 3.0 \times 10^{-4}$ Wb

$B = ?$

$\phi = NBA$

$B = \frac{\phi}{NA} = \frac{3.0 \times 10^{-4}}{(1000)(0.06)}$ 1

$= 5 \times 10^{-3}$ T 1

b. The coil rotates at 50 Hz. Calculate the magnitude of the induced EMF in the coil. **(2)**

$\cancel{V = \frac{\Delta\phi}{t} = \phi f = (3.0 \times 10^{-4})(50)}$ 1

$\cancel{= 0.015 \text{ V}}$

$\cancel{= 1.5 \times 10^{-2} \text{ V}}$ 1

Either acceptable

$T = \frac{1}{f} = \frac{1}{50} = 0.0200$ s

$\Rightarrow T/4 = 5 \times 10^{-3}$ s

$EMF = \frac{N\Delta\phi}{\Delta t} = \frac{-NB\Delta A}{t} =$

$= \frac{-(1000)(5 \times 10^{-3})[0 - (0.200)(0.300)]}{5 \times 10^{-3}}$

$= 60.0$ V

$EMF = NBA\,2\pi f$

$(1000)(5 \times 10^{-3})(0.200)(0.300)(2\pi)(50)$

$= 94.2$ V

Question 6 [5 mark]

Describe and explain **two** features of the core that improve the efficiency of ~~the~~ a transformer.

1. Laminated core – reduces eddy currents

2. Core made from soft iron – increases flux linkage between the two coils / "transfer" of magnetic field increased

(2)

The primary coil of the transformer is connected to a 230 V_{rms} ac supply. The current in the primary coil is 0.30 A_{rms}. The secondary coil has 300 turns and provides an output of 20 V_{rms} and a power of 65 W.

Calculate the number of turns on the primary coil.

$V_p = 230V$

$I_p = 0.3A$

$V_s = 20V$

$N_s = 300$

$P_s = 65W$

$$\frac{N_p}{V_p} = \frac{N_s}{V_s} \Rightarrow N_p = \frac{(300)(230)}{20} = 3450$$

number of turns on primary = 3450

(1)

Calculate the efficiency of the transformer.

$$P_p = V_p I_p = (230)(0.3) = 69W$$

$$\% \text{ eff} = \frac{\text{Useful Power output} \times 100}{\text{Total Power Input}} = \frac{65 \times 100}{69} = 94\%$$

efficiency 94%

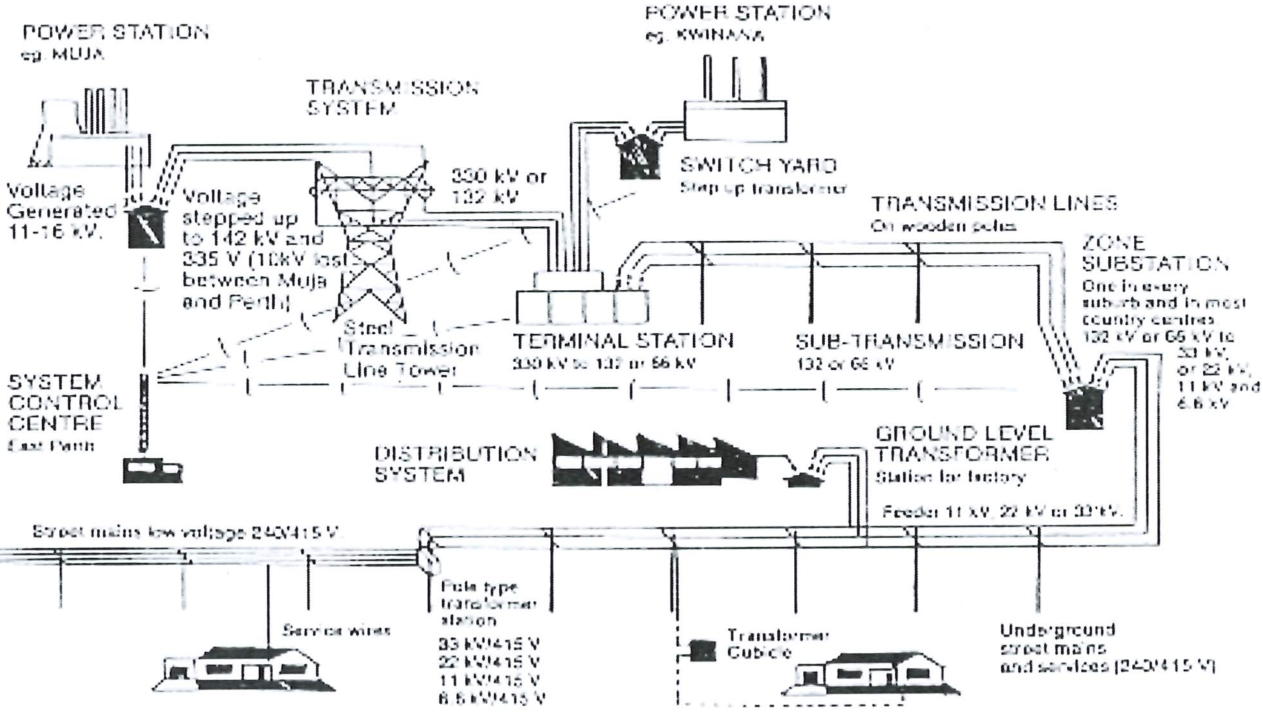
(2)

further down

Question 7 [4 marks]

The diagram ~~above~~ below shows the power transmission grid for the Perth region. The power is generated at a voltage of 11.0 – 16.0 kV (V_{gen}), transmitted at 132 kV (V_{trans}) and supplied to houses and industry at 240 or 415 V (V_{supply}).

The demand for power (P_{req}) in Perth can reach 1.80 x 10^3 MW during peak loadings. Given that the resistance of the power lines from Muja to Perth (2.50 x 10^2 km away) is 5.00 Ω m^{-1}, calculate the ***percentage power loss*** assuming it is transmitted at 330 kV.



— *How electricity is transmitted from power stations to customers.*

$P = 1.80 \times 10^3 \times 10^6 = 1.8 \times 10^9$ W

$R = 5 \times 2.50 \times 10^2 \times 10^3 = 1.25 \times 10^6\ \Omega$

$V = 330 \times 10^3$ V

$P = V.I$ (1)

$I = \dfrac{1.8 \times 10^9}{330 \times 10^3}$

$I = 5.455 \times 10^3$ A (1)

$P_{loss} = I^2R = (5.455 \times 10^3)^2 (1.25 \times 10^6)$

$= 3.72 \times 10^{13}$ W (1)

$\%\text{loss} = \dfrac{3.72 \times 10^{13}}{1.8 \times 10^9} \times 100$ = Non sensical (1)

Error in question

Question should read $R = 5\ \Omega \Rightarrow P_{loss} = I^2R = (5.455 \times 10^3)^2 (5)$

$= 1.488 \times 10^8$ W

$\Rightarrow \%\text{loss} = \dfrac{1.488 \times 10^8}{1.8 \times 10^9} \times 100 = 8.27\%$

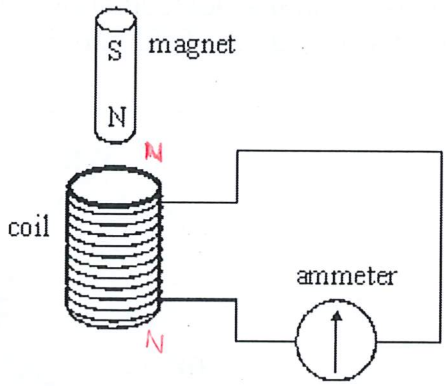
$\Rightarrow$ last 2 marks allocated generously

Common errors: misuse of speed and acceleration → if $a = 8ms^{-2}$, my speed will still increase, even though acceleration has decreased

Section B: Problem Solving
Marks Allocated: 20 marks out of 41 total marks
This section has 3 questions. Answer the questions in the spaces provided.

Question 8 [7 marks]

A coil is connected to a centre zero ammeter, as shown. A student drops a magnet so that it falls vertically and completely through the coil.



(a) Describe what the student would observe on the ammeter as the magnet falls through the coil.

Current noted in one direction as the magnet enters the ~~solenoid~~, coil

Current noted in opposite direction as magnet leaves the ~~solenoid~~ coil

(2)

(b) If the coil were not present the magnet would accelerate downwards at the acceleration due to gravity. State and explain how its acceleration in the student's experiment would be affected, if at all, **as it left the coil**.

Acceleration $< 9.8ms^{-2}$ / gravity. According to Lenz' Law a current is induced in the coil in a direction to oppose the change => force in a direction that opposes the movement of the magnet downwards

(2)

(c) Suppose the student forgot to connect the ammeter to the coil, therefore leaving the circuit incomplete, before carrying out the experiment. Describe and explain what difference this would make to your conclusions in part (b).

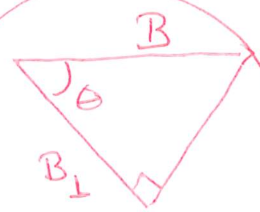
- Magnet falls with an acceleration $= 9.8ms^{-2}$ 1
- A PD will be induced but no current 1 will flow => no opposing force on the magnet 1

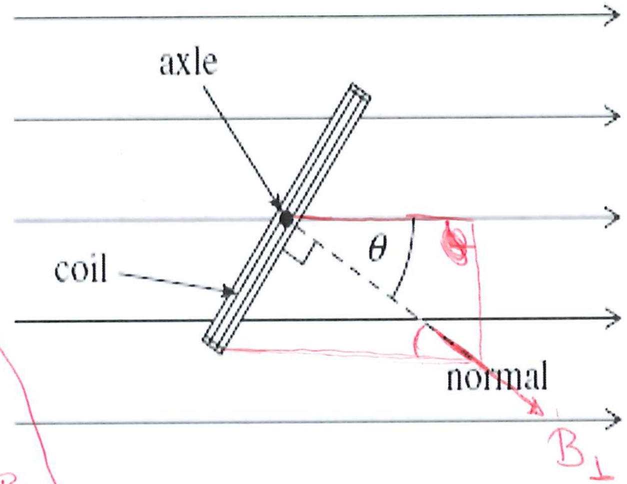
(3)

Question 9 [8marks]

The figure below shows an end view of a simple electrical generator. A rectangular coil is rotated in a uniform magnetic field with the axle at right angles to the field direction. When in the position shown in the figure below the angle between the direction of the magnetic field and the normal to the plane of the coil is θ.

1





$B_\perp = B\cos 35$

$\cos 35 = \frac{B_\perp}{B}$

(a) The coil has 50 turns and an area of 1.9×10^{-3} m^2. The flux density of the magnetic field is 2.8×10^{-2} T. Calculate the flux linkage for the coil when θ is 35°, expressing your answer to an appropriate number of significant figures.

$N = 50$

$A = 1.9 \times 10^{-3}\ m^2$

$B = 2.8 \times 10^{-2}$ T

$\phi = ?$

$\theta = 35°$

$\phi = N \quad A \quad B_\perp$

$\phi = (50)(1.9 \times 10^{-3})(2.8 \times 10^{-2}) \cos 35$

$= 2.18$ Wb

$= 2.2$ Wb 1

answer = ~~2.2~~ 2.2×10^{-3} Wb turns

2 sig fig

further down

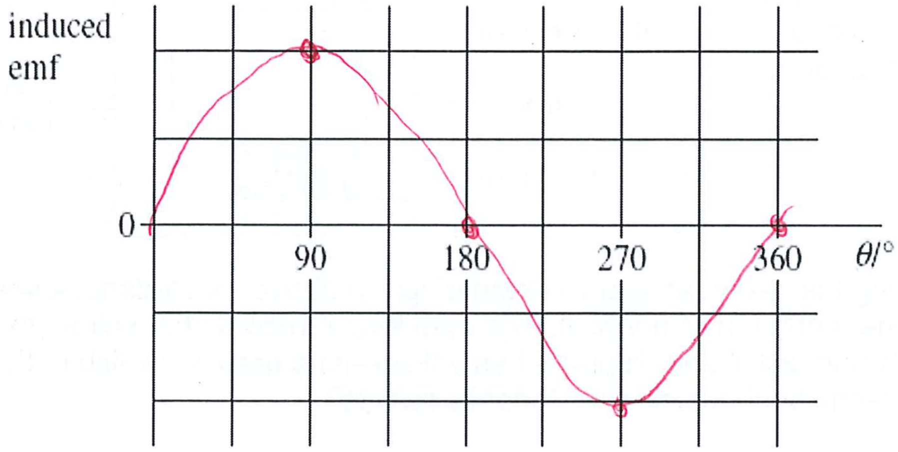
(3)

$2.8 \times 10^{-2} \cos 35 = 2.29 \times 10^{-2}$

1 for sig fig

(b) The coil is rotated at constant speed, causing an emf to be induced.

(i) Sketch a graph on the outline axes to show how the induced emf varies with angle θ during one complete rotation of the coil, starting when $\theta = 0$. Values are not required on the emf axis of the graph.



(1)

(ii) Give the value of the flux for the coil at the positions where the emf has its greatest values.

Answer = 0 Wb

(1)

(iii) Explain why the magnitude of the emf is greatest at the values of θ shown in your answer to part (b)(i).

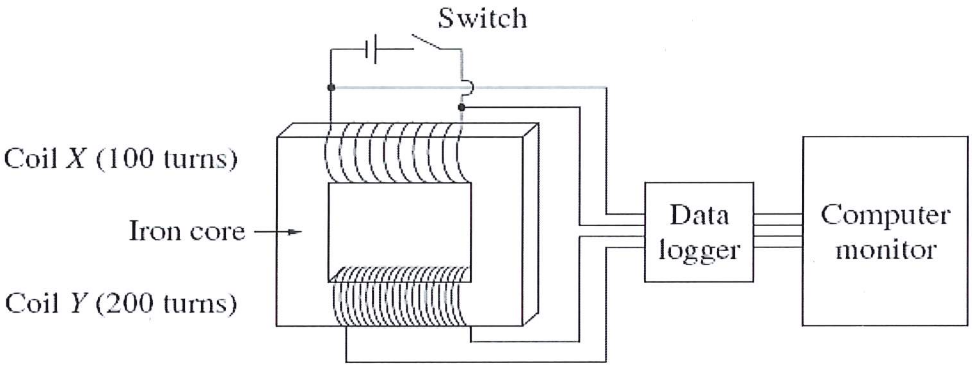
any 3

- Induced emf $\propto$ rate of change of flux
- Flux through the coil changes as it is rotated
- from a maximum at $\theta = 0°$ and $180°$ to zero at $90°$ and $270°$
- Rate of change is greatest when coil is parallel to magnetic field ($\theta = 90°, 270°$)

(3)

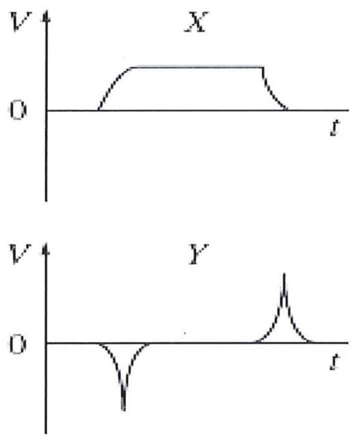
Question 10 ~~[5 marks]~~ 4 marks

In a school experiment students are constructing a transformer. They set up the apparatus as shown in the diagram .

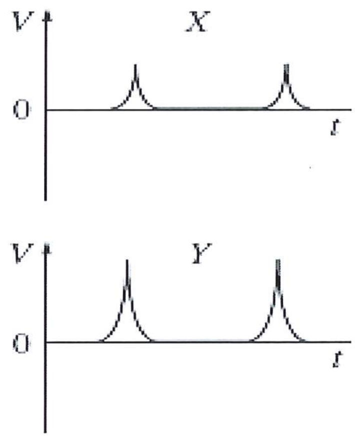


(i) While using the set up as shown in the diagram above - a student closes the switch for a short time, and then re-opens it. The data logger records the values for the voltage of both coil X and coil Y and displays it as voltage-time graphs. Which of the following pairs of graphs best depicts the student's results?

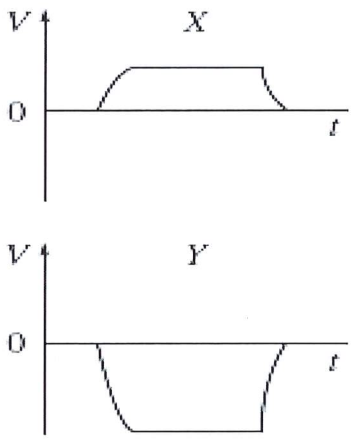
(A)



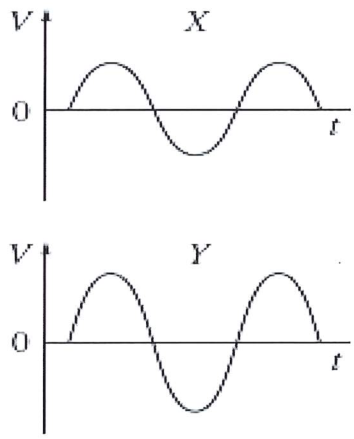
(B)



(C)



(D)



Answer: A

1 (~~2~~ marks)

The students' realise that because their 'transformer' is plugged into a DC power source and doesn't function correctly. The students change the input to an AC source and the transformer functions correctly. Explain why AC is necessary as an input current source for transformers.

(3 marks)

(1) According to Faraday's Law, an emf is induced in the secondary coil if the magnetic field is changing
if it experiences a changing magnetic field

(1) An AC source produces a constantly changing magnetic field as it is constantly changing direction/oscillating

(1) A DC source only produces a change in the magnetic field at the instant/moment it is turned on or turned off

END OF TEST

Extra Working Space