ALTERNATING CURRENT

Challenging **MCQ** questions by The Physics Cafe

Compiled and selected by The Physics Cafe

1 **(a)** Fig. 5.1 below shows an alternating voltage supply given by $V = V_0 \cos\left(\frac{2\pi}{T}t\right)$ connected to four diodes numbered 1, 2, 3 and 4 and a resistor *R*.

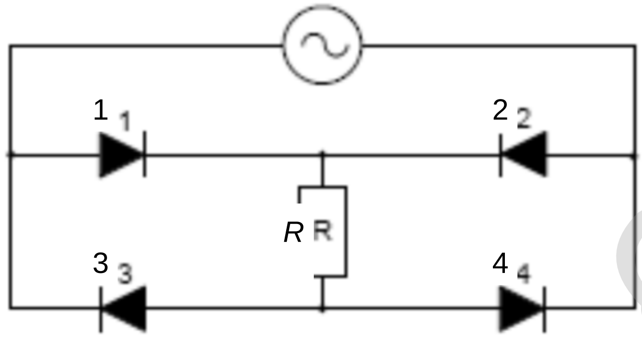
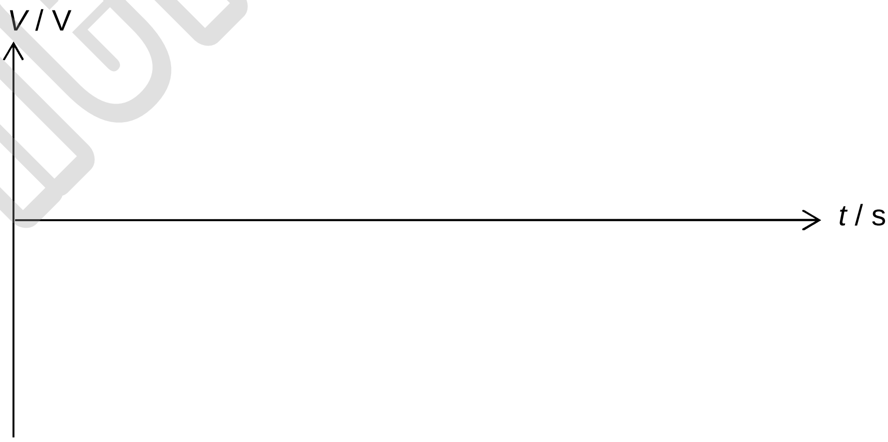


Fig 5.1

(i) On the axes given below, sketch and label the voltage-time graph of the resistor for at least two cycles when all four diodes are in use. Clearly label the period of each cycle. [2]

(ii) If diode 4 is removed, leaving a break in the circuit, sketch and label the new voltage-time graph of the resistor for at least two cycles. [2]



(b) A power station produces **20.0 MW** of power for delivery to a town some distance away. This power is generated at **32.0 kV** and then stepped up to **240 kV** using an ideal transformer before transmission. The total resistance of the transmission cables is **5.0 Ω**.

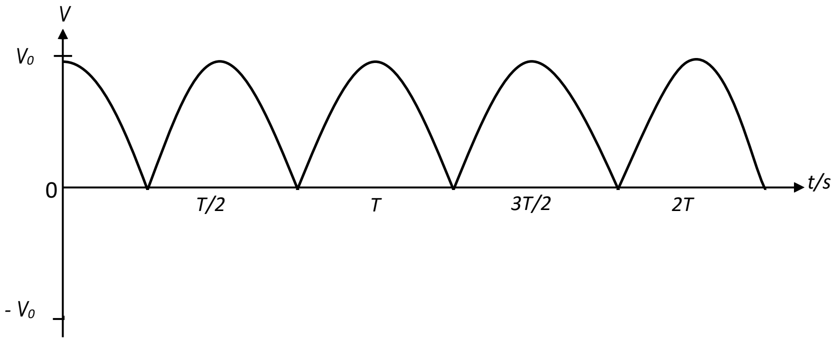
(i) State the turns ratio of the secondary coil to the primary coil in this transformer.

turns ratio = ... [1]

(ii) Explain why it is more economical to step up to **240 kV** before transmitting electrical power to the town. Justify your answer in terms of power loss in the transmission cables.

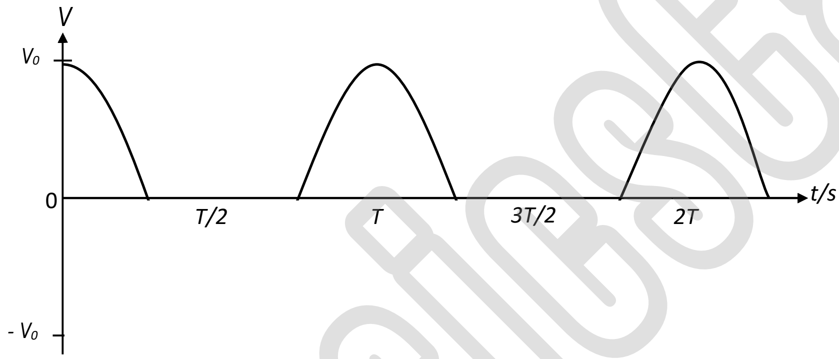
.... …..
.... …..
.... … [3]

Ans **(a)** **(i)**



[M1] for correct shape
V = 0 when t = 0
sharp edges at T/4
at least 2 cycles should be drawn
[A1] for correct label of V_o and T

(ii)



[M1] for correct shape (ecf is given if student show understanding that only half of the cycle exists and the graph can only be in either the positive or negative axis).
[A1] for correct label of V_o and T

(b) **(i)** Turns ratio $\frac{N_s}{N_p} = \frac{240}{32}$ =15:2 [A1]

(ii) Since power in the primary coil = power in secondary coil
At 240 kV,

$P_{in} = P_{out} = 20 \times 10^6$ W

$I_{out} \times V_{out} = 20 \times 10^6$ W

$I_{out} = \frac{20 \times 10^6}{240 \times 10^3} = 83.3$ A

$P_{cables} = I^2 R = 83.3^2 \times 5.0$ =34.7 kW

[M1]

At 32.0 kV, $I_{out} = \frac{20 \times 10^6}{32.0 \times 10^3} = 625$ A

$P_{loss} = I^2 R = 625^2 \times 5.0 = 1.95$ MW [M1]

Since less power is lost transmitting at 240 kV, it is more economical to transmit at 240 kV. [A1]

2 **(a)** An electric kettle, designed for travellers, can be used with different voltages. It is rated **700 W** for a **240 V** alternating supply. Determine its power output when used on a **120 V** direct supply.

[1]

(b) A simple transformer connected with a circuit is illustrated in **Fig. 5.1**

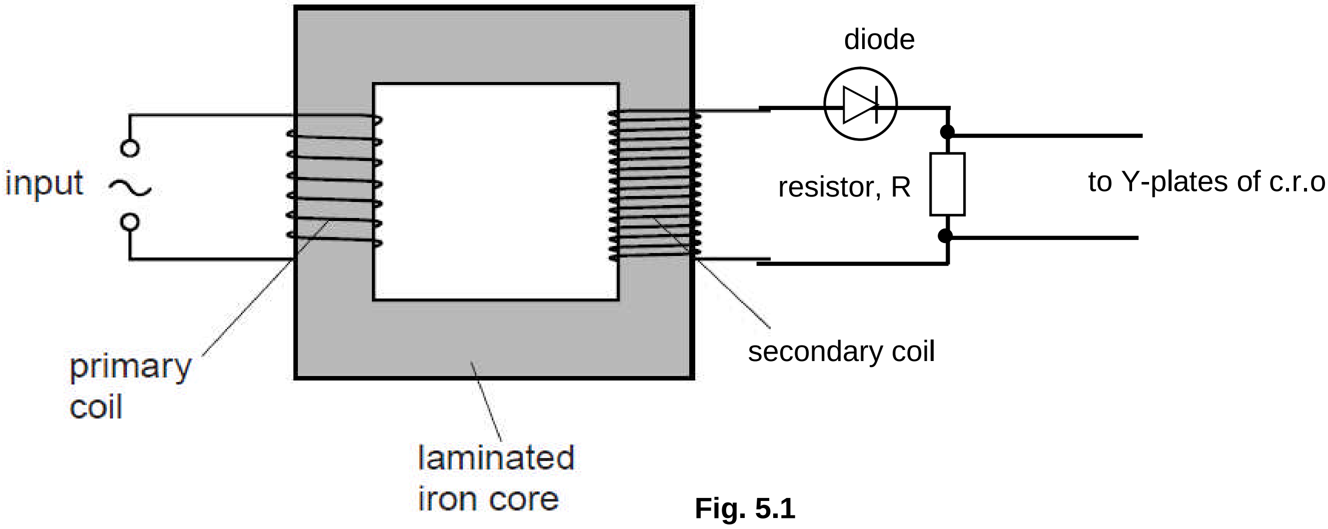


Fig. 5.1

(i) An ideal transformer has **300 turns** on the primary coil and **8100 turns** on the secondary coil. The root-mean-square input voltage to the primary coil is **9.0 V** of frequency **50 Hz**. Calculate the peak voltage in the secondary coil.

[1]

(ii) A cathode-ray oscilloscope (c.r.o) Y-plates connected across the load resistor R and the trace in **Fig. 5.2** is seen. Calculate the Y-plate sensitivity of the c.r.o.

[2]

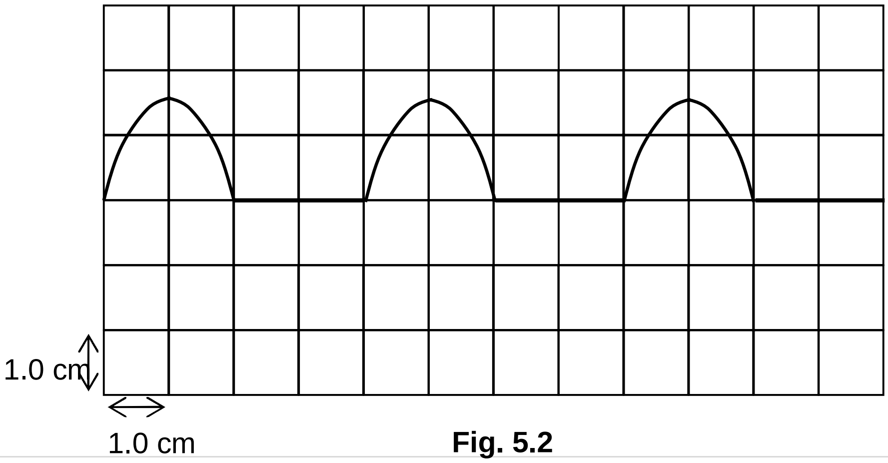


Fig. 5.2

(iii) The diode is now removed from the circuit in **Fig. 5.1**. On **Fig. 5.3**, sketch a graph which shows how the power of the load resistor, R, of resistance **5.0 Ω** varies with time. [3]

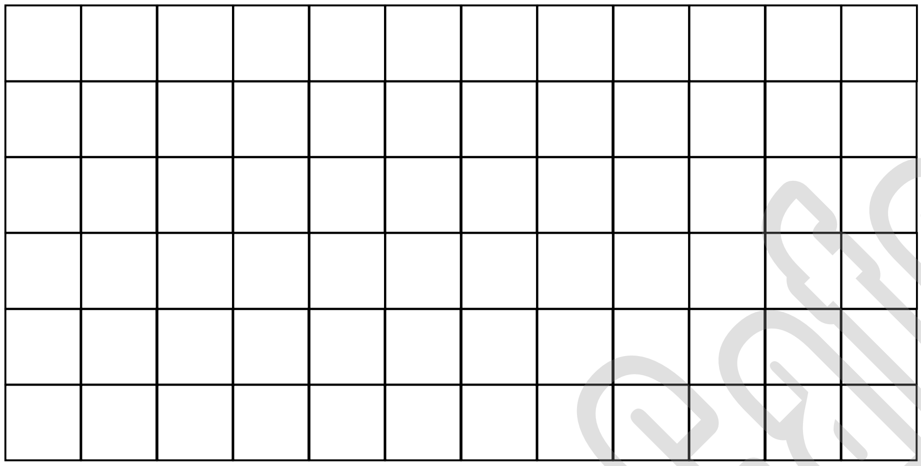


Fig. 5.3

Ans **a.** Using Power, $P=V^2/R$

$R = V^2/P = 240^2/700 = 82.3\ \Omega$

New power dissipated $P' = V^{2'}/R = 120^2/82.3 = 175$ W

bi. Using Np/Ns = Vp/Vs

300/8100 = 9/Vs

Vs = 243 V (rms)

Peak voltage, $V_o = 243 \times \sqrt{2} = 343$ V

bii 1.5 cm represents 343 V

1 cm represents 229 V

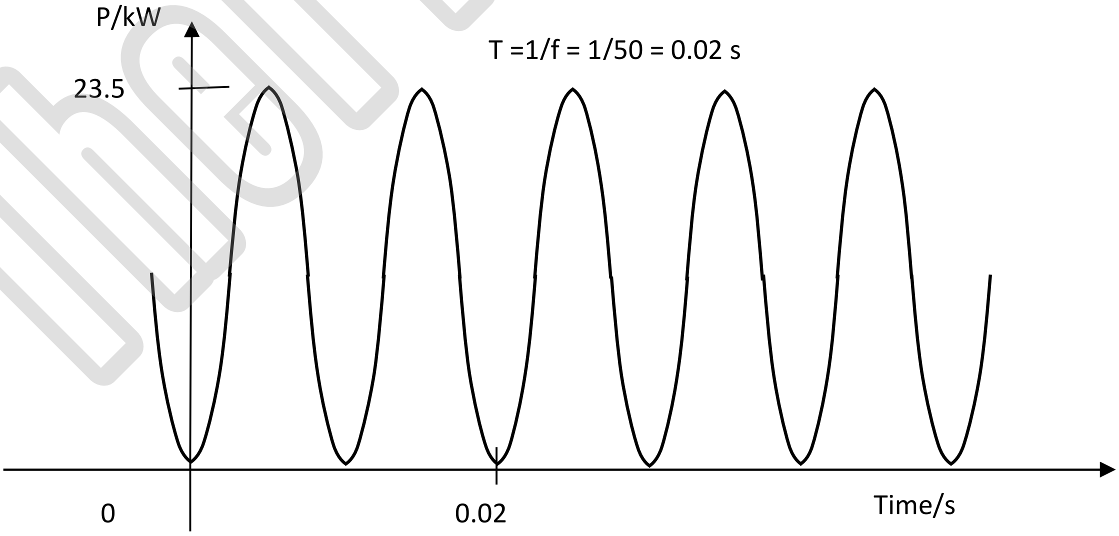
Hence the sensitivity is 229 Vcm^{-1}

5biii

Power = $V_o^2/R = 343^2/5.0$

= 23.5kW

T = 1/f = 1/50 = 0.02 s



3 The primary coil of an ideal transformer has **100 turns** and is connected to a **15V** root-mean-square (r.m.s.) supply at **50 Hz**. The secondary coil has **1600 turns** and is connected to a resistor of resistance **120 Ω** as shown in Fig. 5.1

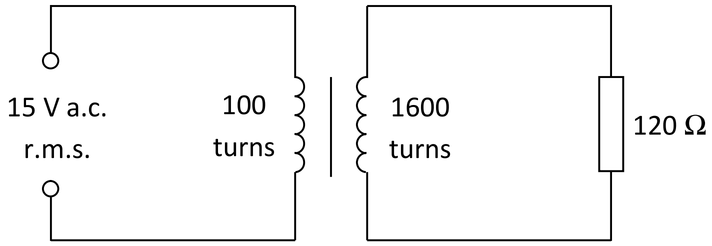


Fig. 5.1

(a) Determine the r.m.s. value of the current in the resistor.

current = ... A [2]

(b) The variation with time *t* of the current *I* in the resistor is given by $I = I_o \sin \omega t$.

On Fig. 5.2, sketch the variation with time *t* of the power *P* dissipated in the resistor from $t = 0$ to $t = 0.020$ s.

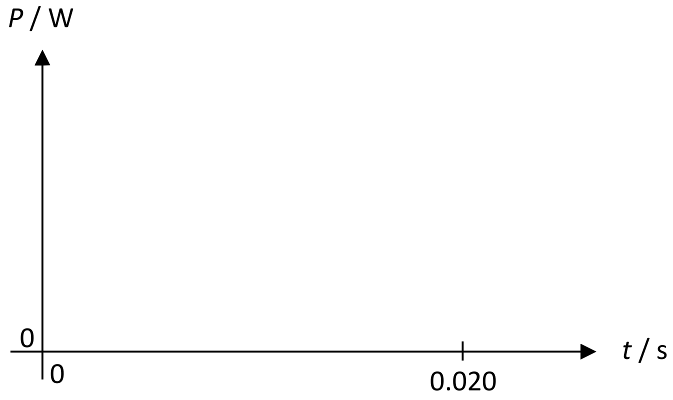


Fig. 5.2

[2]

(c) On Fig. 5.3, sketch the variation of the net amount of charge *Q* which flowed past a point in the resistor from $t = 0$ to $t = 0.020$ s. (Numerical values for the charge are not expected.)

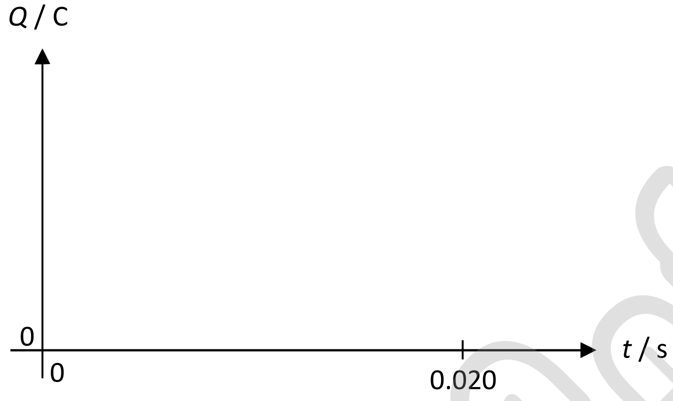


Fig. 5.3

[1]

Ans **(a)**

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

$$\frac{V_s}{15} = \frac{1600}{100}$$

$$V_s = 240\text{ V}$$

Since $R = \dfrac{V_s}{I_s}$,

$$I_s = \frac{240}{120} = 2.0\text{ A}$$

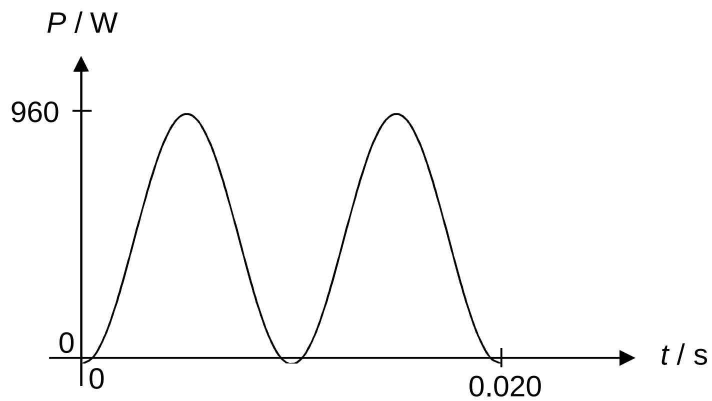
(b)

$$P_o = \frac{V_o^{\,2}}{R}$$

$$P_o = \frac{\left(\sqrt{2}V_s\right)^2}{R}$$

$$P_o = \frac{\left(\sqrt{2} \times 240\right)^2}{120}$$

$$P_o = 960\text{ W}$$



(c)