CAMBRIDGE INTERNATIONAL AS & A LEVEL PHYSICS · 9702

PHYSICS



EXAM QUESTION PACK

21 ALTERNATING CURRENTS

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Chapter 14

Alternating currents

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316. 9702_s21_qp_42 Q: 10

(a) By reference to heating effect, explain what is meant by the *root-mean-square* (*r.m.s.*) value of an alternating current.

.....

.....

..... [2]

(b) The variations with time t of two currents I_1 and I_2 are shown in Fig. 10.1 and Fig. 10.2.

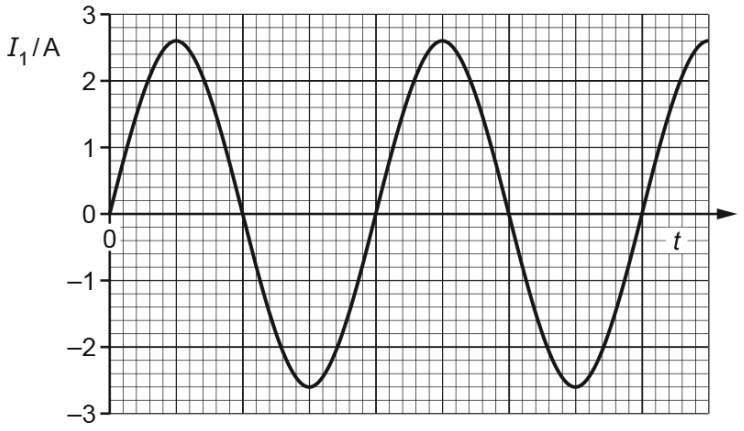


Fig. 10.1

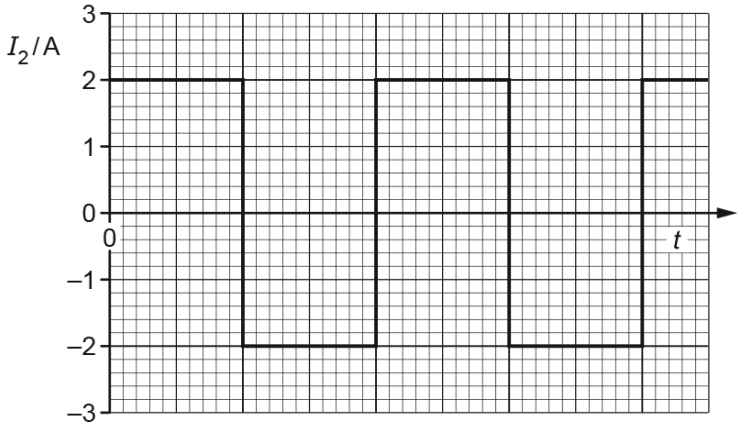


Fig. 10.2

(i) Use Fig. 10.1 to determine the peak value and the r.m.s. value of the current I_1.

peak value = ... A

r.m.s. value = ... A
[1]

(ii) Use Fig. 10.2 to determine the peak value and the r.m.s. value of the current I_2.

peak value = ... A

r.m.s. value = ... A
[1]

(c) The variation with time t of the supply voltage V to a house is given by the expression

$$V = 240 \sin kt$$

where V is in volts, t is in seconds and k is a constant with unit rad s^{-1}.

(i) The frequency of the supply voltage is 50 Hz.

Determine k to two significant figures.

k = ... rad s^{-1} [2]

(ii) The supply voltage is applied to a heater. The mean power of the heater is 3.2 kW.

Calculate the resistance of the heater.

resistance = ... Ω [2]

[Total: 8]

317. 9702_w21_qp_41 Q: 9

(a) State, by reference to the power dissipated in a resistor, what is meant by the *root-mean-square* (*r.m.s.*) value of an alternating voltage.

.....

.....

.....

..... [2]

(b) A coil is rotating freely, on frictionless bearings, at constant speed in a uniform magnetic field. This rotation causes an induced alternating electromotive force (e.m.f.) across the open terminals of the coil. The induced e.m.f. has r.m.s. value 12 V and frequency 50 Hz.

The speed of rotation of the coil is now doubled.

(i) State and explain, with reference to the principles of electromagnetic induction, the effect of the increased speed of rotation on the r.m.s. value of the induced e.m.f.

.....

.....

.....

..... [2]

(ii) On Fig. 9.1, sketch the variation with time t of the induced e.m.f. E across the terminals of the coil at the **increased** speed of rotation. Your line should extend from time $t = 0$ to time $t = 20$ ms. Assume that $E = 0$ when $t = 0$.

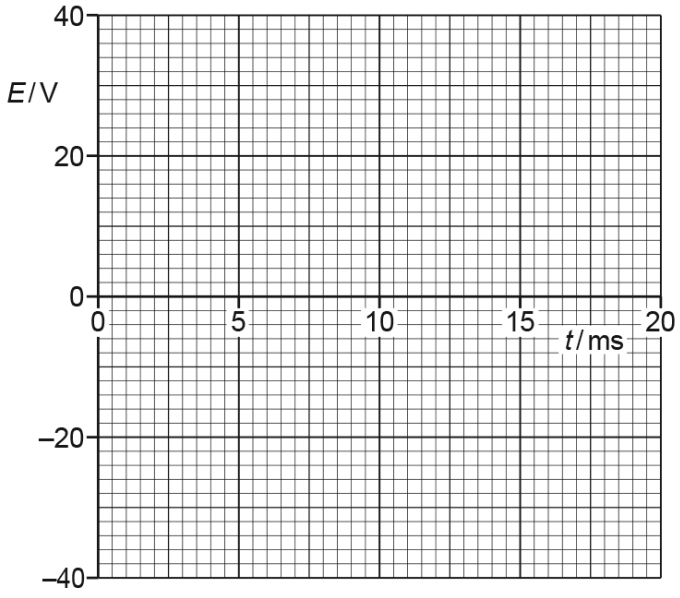


Fig. 9.1

[3]

(c) State and explain the effect on the motion of the coil in **(b)** of connecting a load resistor across its terminals.

.....

.....

.....

..... [2]

[Total: 9]

318. 9702_w21_qp_43 Q: 9

(a) State, by reference to the power dissipated in a resistor, what is meant by the *root-mean-square* (*r.m.s.*) value of an alternating voltage.

.....

.....

.....

..... [2]

(b) A coil is rotating freely, on frictionless bearings, at constant speed in a uniform magnetic field. This rotation causes an induced alternating electromotive force (e.m.f.) across the open terminals of the coil. The induced e.m.f. has r.m.s. value 12 V and frequency 50 Hz.

The speed of rotation of the coil is now doubled.

(i) State and explain, with reference to the principles of electromagnetic induction, the effect of the increased speed of rotation on the r.m.s. value of the induced e.m.f.

.....

.....

.....

..... [2]

(ii) On Fig. 9.1, sketch the variation with time t of the induced e.m.f. E across the terminals of the coil at the **increased** speed of rotation. Your line should extend from time $t = 0$ to time $t = 20$ ms. Assume that $E = 0$ when $t = 0$.

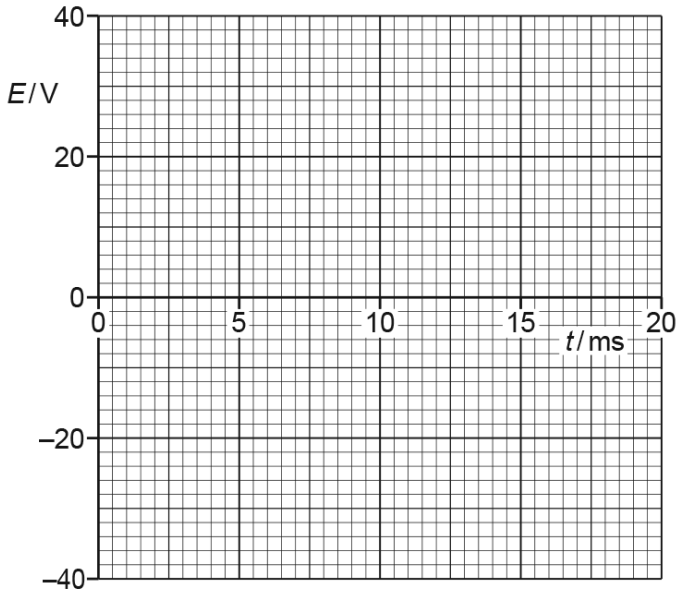


Fig. 9.1

[3]

(c) State and explain the effect on the motion of the coil in **(b)** of connecting a load resistor across its terminals.

.....

.....

.....

..... [2]

[Total: 9]

319. 9702_m19_qp_42 Q: 8

A horseshoe magnet is placed on a top pan balance. A rigid copper wire is fixed between the poles of the magnet, as illustrated in Fig. 8.1.

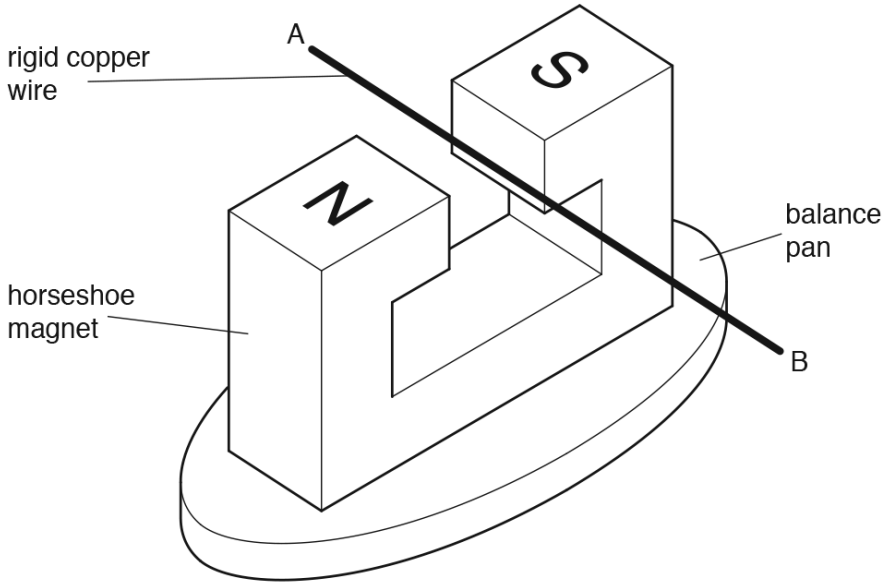


Fig. 8.1

The wire is clamped at ends A and B.

(a) When a direct current is switched on in the wire, the reading on the balance is seen to **decrease**.

State and explain the direction of:

(i) the force acting on the wire

.....

.....

.....

..... [3]

(ii) the current in the wire.

.....

.....

..... [2]

(b) A direct current of 4.6 A in the wire causes the reading on the balance to change by 4.5×10^{-3} N.

The direct current is now replaced by an alternating current of frequency 40 Hz and root-mean-square (r.m.s.) value 4.6 A.

On the axes of Fig. 8.2, sketch a graph to show the change in balance reading over a time of 50 ms.

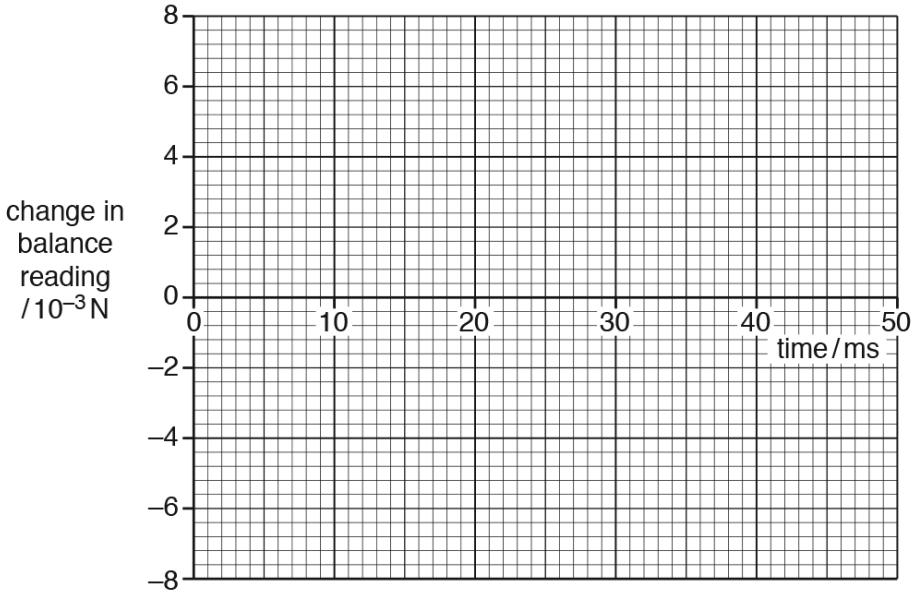


Fig. 8.2

[3]

[Total: 8]

320. 9702_w19_qp_42 Q: 11

(a) State Faraday's law of electromagnetic induction.

.....

.....

..... [2]

(b) A solenoid S has a small coil C placed near to one of its ends, as shown in Fig. 11.1.

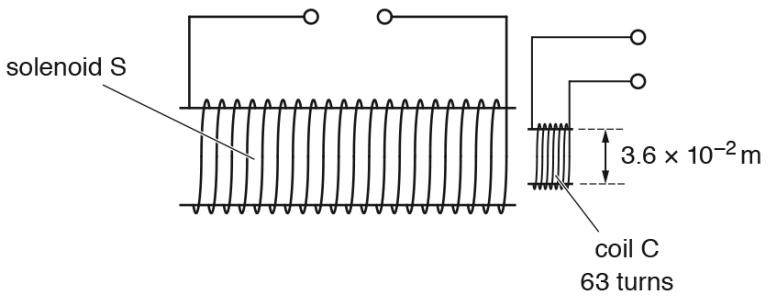


Fig. 11.1

The coil C has a circular cross-section of diameter 3.6×10^{-2} m and contains 63 turns of wire.

The solenoid S produces a uniform magnetic field of flux density B, in tesla, in the region of coil C given by the expression

$$B = 9.4 \times 10^{-4} I$$

where I is the current, in ampere, in the solenoid S.

The variation with time t of the current I in solenoid S is shown in Fig. 11.2.

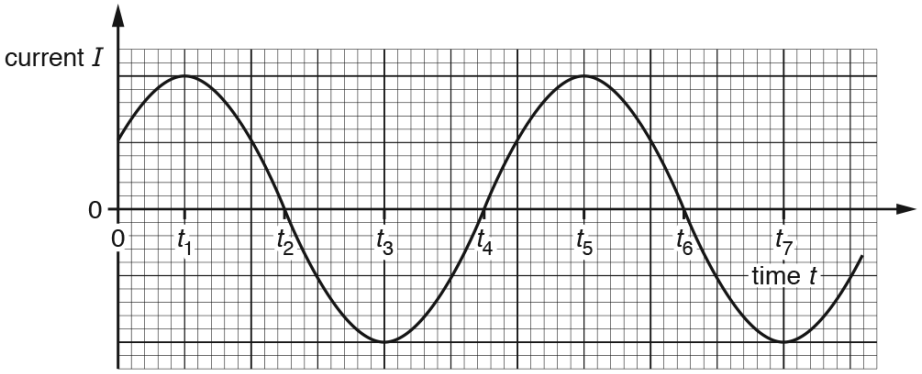


Fig. 11.2

State two times at which:

(i) there is no electromotive force (e.m.f.) induced in coil C

time ..... and time ..... [1]

(ii) the induced e.m.f. in coil C is a maximum but with opposite polarities.

time ..... and time ..... [1]

(c) The alternating current in the solenoid S in **(b)** is replaced by a constant current of 5.0 A.

Calculate the average e.m.f. induced in coil C when the current in solenoid S is reversed in a time of 6.0 ms.

e.m.f. induced = ... V [3]

[Total: 7]

321. 9702_w17_qp_41 Q: 10

(a) The mean value of an alternating current is zero.
Explain why heating occurs when there is an alternating current in a resistor.

.....

.....

.....

..... [2]

(b) Transmission of electrical energy is frequently achieved using alternating high voltages.
Suggest why

(i) high voltages are used,

.....

.....

.....

..... [2]

(ii) the voltage is alternating.

.....

.....

.....

..... [2]

[Total: 6]

---

322. 9702_w17_qp_43 Q: 10

(a) The mean value of an alternating current is zero.
Explain why heating occurs when there is an alternating current in a resistor.

.....

.....

.....

..... [2]

(b) Transmission of electrical energy is frequently achieved using alternating high voltages.
Suggest why

(i) high voltages are used,

.....

.....

.....

..... [2]

(ii) the voltage is alternating.

.....

.....

.....

..... [2]

[Total: 6]

323. 9702_m16_qp_42 Q: 3

(a) Define *specific heat capacity*.

.....

.....

.....[2]

(b) A student carries out an experiment to determine the specific heat capacity of a liquid using the apparatus illustrated in Fig. 3.1.

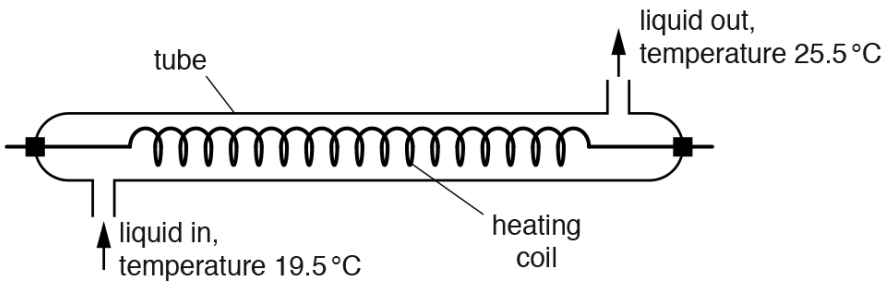


Fig. 3.1

Liquid enters the tube at a constant temperature of 19.5 °C and leaves the tube at a temperature of 25.5 °C. The mass of liquid flowing through the tube per unit time is m. Electrical power P is dissipated in the heating coil.

The student changes m and adjusts P until the final temperature of the liquid leaving the tube is 25.5 °C.

The data shown in Fig. 3.2 are obtained.

m/g s^{-1}	P/W
1.11	33.3
1.58	44.9

Fig. 3.2

(i) Suggest why the student obtains data for two values of m, rather than for one value.

.....

.....[1]

(ii) Calculate the specific heat capacity of the liquid.

Show your working.

specific heat capacity = ... $J\,kg^{-1}\,K^{-1}$ [3]

(c) When the heating coil in **(b)** dissipates 33.3W of power, the potential difference V across the coil is given by the expression

$$V = 27.0 \sin(395t).$$

The potential difference is measured in volts and the time t is measured in seconds.

Determine the resistance of the coil.

resistance = ...Ω [3]

[Total: 9]

324. 9702_w21_qp_42 Q: 10

Fig. 10.1 shows a simple laminated iron-cored transformer consisting of a primary coil of 25 000 turns and a secondary coil of 625 turns.

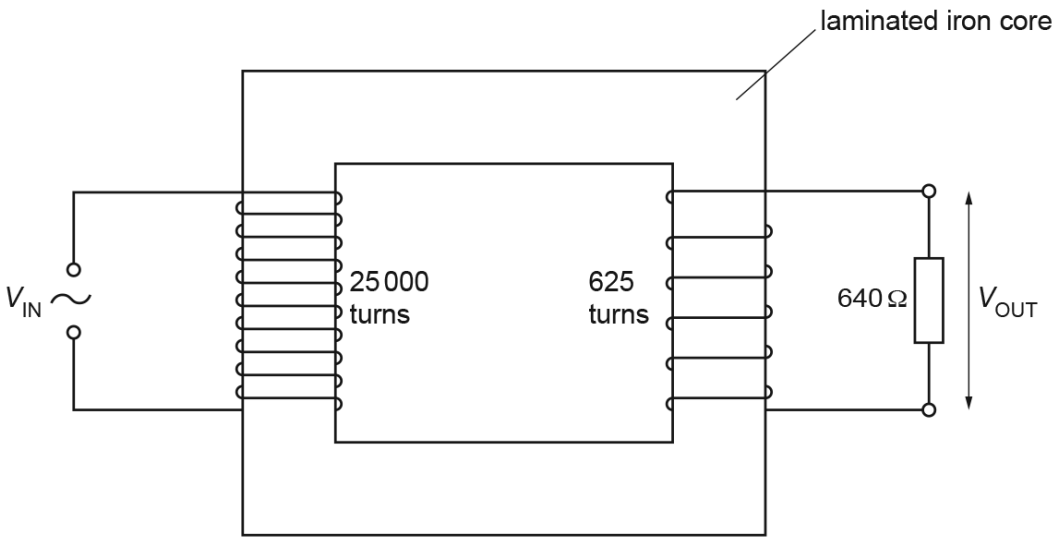


Fig. 10.1

The output potential difference (p.d.) V_{OUT} is applied to a load resistor of resistance 640 Ω.

(a) (i) State the function of the iron core.

.....

..... [1]

(ii) Explain why the iron core is laminated.

.....

.....

..... [2]

(b) The input p.d. V_{IN} is a sinusoidal alternating voltage of peak value 12 kV and period 40 ms.

(i) Calculate the maximum value of V_{OUT}.

maximum V_{OUT} = ... V [1]

(ii) Calculate the root-mean-square (r.m.s.) current in the load resistor.

r.m.s. current = ... A [1]

(iii) On Fig. 10.2, sketch the variation with time t of the power P dissipated in the load resistor for time $t = 0$ to $t = 40$ ms. Assume that $P = 0$ when $t = 0$.

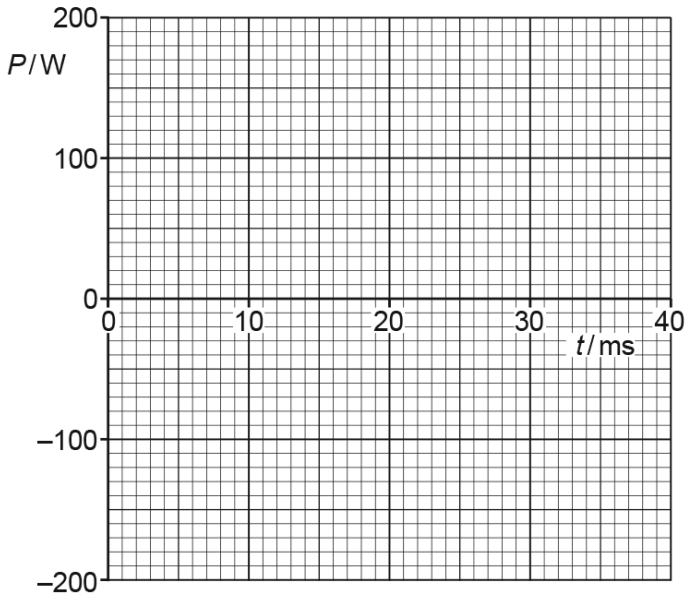


Fig. 10.2

[3]

(c) Explain, with reference to Fig.10.2, why the mean power in the load resistor is 70 W.

.....

.....

.....

..... [2]

[Total: 10]

325. 9702_m20_qp_42 Q: 9

(a) The output of a power supply is represented by:

$$V = 9.0 \sin 20t$$

where V is the potential difference in volts and t is the time in seconds.

Determine, for the output of the supply:

(i) the root-mean-square (r.m.s.) voltage, $V_{r.m.s.}$

$V_{r.m.s}$ = ...V [1]

(ii) the period T.

T = ... s [2]

(b) The variations with time t of the output potential difference V from two different power supplies are shown in Fig. 9.1 and Fig. 9.2.

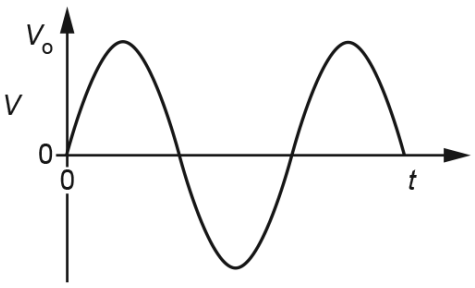


Fig. 9.1

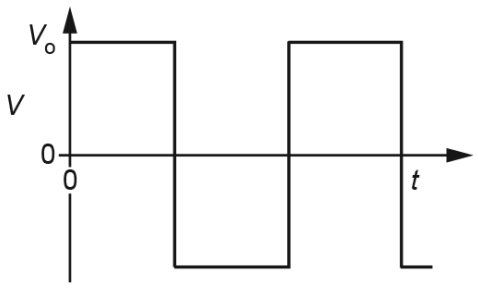


Fig. 9.2

The graphs are drawn to the same scale.

State and explain whether the same power would be dissipated in a 1.0 Ω resistor connected to each power supply.

.....

.....

..... [1]

(c) **(i)** The power supply in **(a)** is connected to a transformer. The input power to the transformer is 80 W.

The secondary coil is connected to a resistor. The r.m.s. voltage across the resistor is 120 V. The r.m.s. current in the secondary coil is 0.64 A.

Calculate the efficiency of the transformer.

efficiency = ... [3]

(ii) State **one** reason why the transformer is not 100% efficient.

.....

..... [1]

[Total: 8]

326. 9702_s20_qp_42 Q: 10

(a) State Faraday's law of electromagnetic induction.

.....

.....

..... [2]

(b) A simple iron-cored transformer is illustrated in Fig. 10.1.

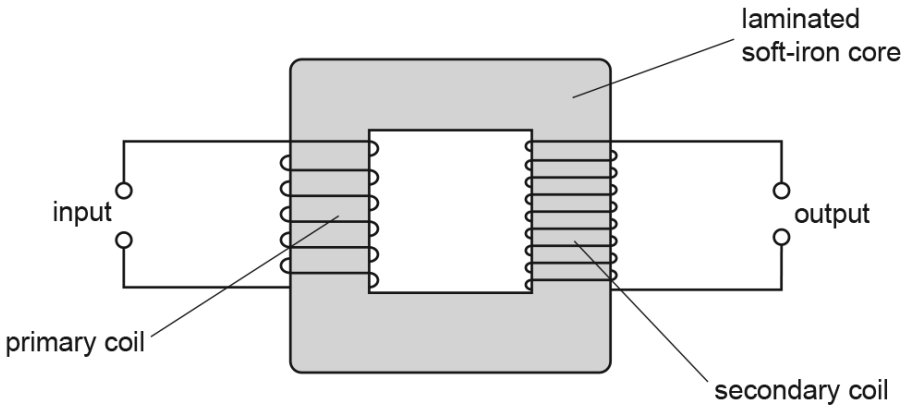


Fig. 10.1

(i) State **one** function of a transformer.

.....

..... [1]

(ii) A sinusoidal alternating current in the primary coil gives rise to a varying magnetic flux linking the secondary coil.

Use Faraday's law to explain why the output from the transformer is an electromotive force (e.m.f.) that is alternating.

.....

.....

.....

.....

..... [3]

(iii) State why the soft-iron core of the transformer is laminated.

.....

..... [1]

[Total: 7]

327. 9702_s19_qp_42 Q: 10

(a) State Faraday's law of electromagnetic induction.

.....

.....

.....[2]

(b) An ideal transformer is illustrated in Fig. 10.1.

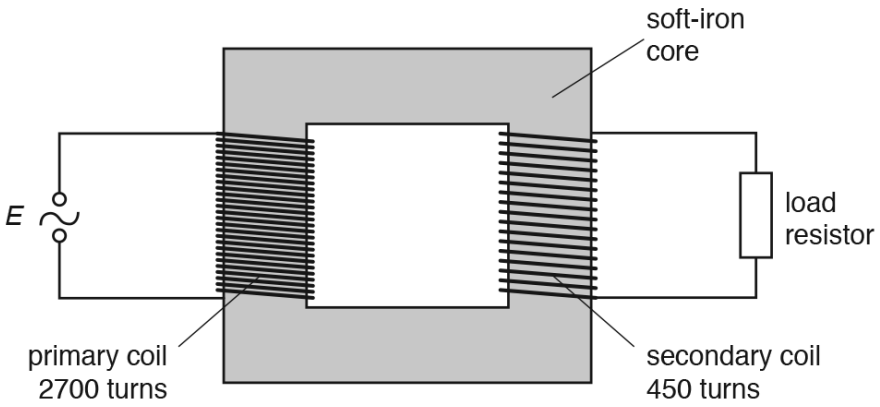


Fig. 10.1

Explain why, when there is an alternating current in the primary coil, there is a current in the load resistor.

.....

.....

.....

.....

.....[3]

(c) The primary coil in **(b)** has 2700 turns. The secondary coil has 450 turns.

The e.m.f. E applied across the primary coil is given by the expression

$$E = 220\sin(100\pi t)$$

where E is measured in volts and t is the time in seconds.

Calculate the root-mean-square (r.m.s.) e.m.f. induced in the secondary coil.

r.m.s. e.m.f. = ... V [3]

[Total: 8]

---

328. 9702_m17_qp_42 Q: 9

An ideal transformer is shown in Fig. 9.1.

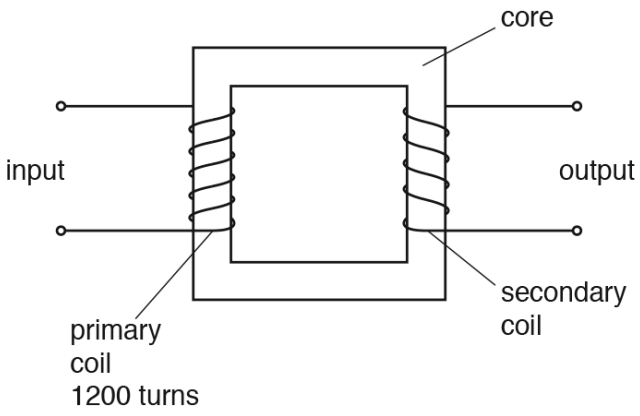


Fig. 9.1

(a) Explain

(i) why the core is made of iron,

.....

.....[1]

(ii) why an electromotive force (e.m.f.) is not induced at the output when a constant direct voltage is at the input.

.....

.....

.....[2]

(b) An alternating voltage of peak value 150 V is applied across the 1200 turns of the primary coil. The variation with time t of the e.m.f. E induced across the secondary coil is shown in Fig. 9.2.

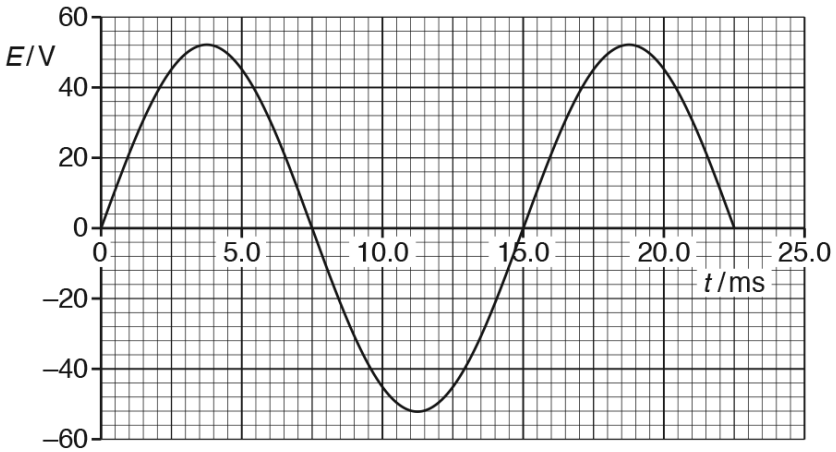


Fig. 9.2

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Use data from Fig. 9.2 to

(i) calculate the number of turns of the secondary coil,

number = ...[2]

(ii) state one time when the magnetic flux linking the secondary coil is a maximum.

time = ...ms [1]

(c) A resistor is connected between the output terminals of the secondary coil. The mean power dissipated in the resistor is 1.2 W. It may be assumed that the varying voltage across the resistor is equal to the varying e.m.f. E shown in Fig. 9.2.

(i) Calculate the resistance of the resistor.

resistance = ...Ω [2]

(ii) On Fig. 9.3, sketch the variation with time t of the power P dissipated in the resistor for $t = 0$ to $t = 22.5$ ms.

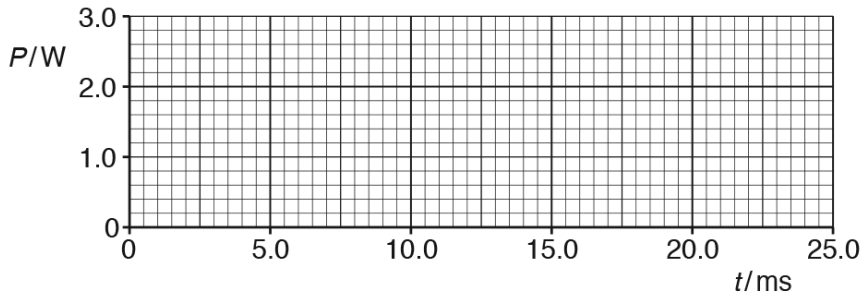


Fig. 9.3

[3]

[Total: 11]

329. 9702_s17_qp_41 Q: 9

A simple transformer is illustrated in Fig. 9.1.

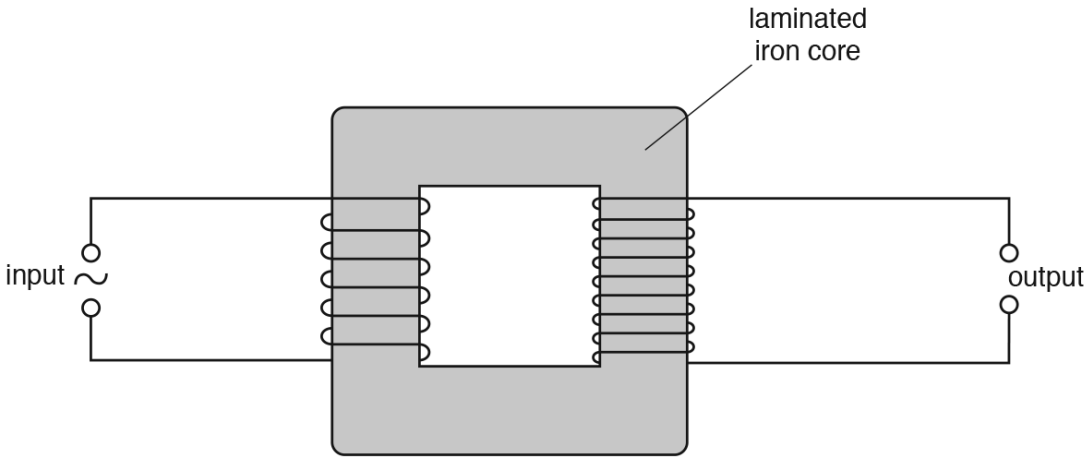


Fig. 9.1

(a) **(i)** State why the transformer has an iron core, rather than having no core.

.....

.....[1]

(ii) Explain why the core is laminated.

.....

.....

.....[2]

(b) By reference to the action of a transformer, explain why the input to the transformer is an alternating voltage, rather than a constant voltage.

.....

.....

.....

.....

.....[3]

[Total: 6]

330. 9702_s17_qp_43 Q: 9

A simple transformer is illustrated in Fig. 9.1.

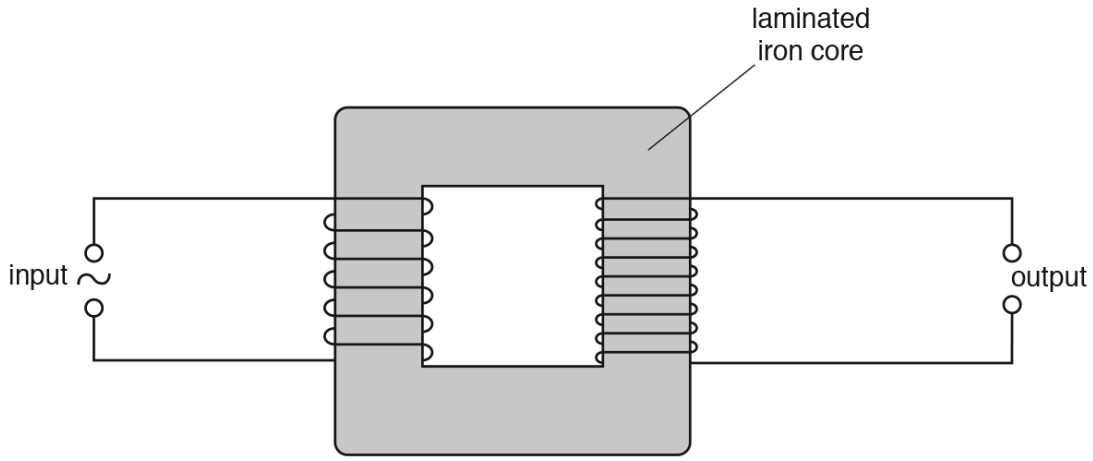


Fig. 9.1

(a) **(i)** State why the transformer has an iron core, rather than having no core.

.....

.....[1]

(ii) Explain why the core is laminated.

.....

.....

.....[2]

(b) By reference to the action of a transformer, explain why the input to the transformer is an alternating voltage, rather than a constant voltage.

.....

.....

.....

.....

.....[3]

[Total: 6]

331. 9702_w16_qp_42 Q: 11

(a) State Faraday's law of electromagnetic induction.

.....

.....

.....[2]

(b) An alternating current is passed through an air-cored solenoid.
An iron core is inserted into the solenoid and then held stationary within the solenoid. The current in the solenoid is now smaller.

Explain why the root-mean-square (r.m.s.) value of the current in the solenoid is reduced as a result of inserting the core.

.....

.....

.....

.....

.....[3]

(c) Practical transformers are very efficient. However, there are some power losses.

State two sources of power loss within a transformer.

1. .....

.....

2. .....

.....
[2]

[Total: 7]

332. 9702_m21_qp_42 Q: 10

The output potential difference (p.d.) of an alternating power supply is represented by

$$V = 320\sin(100\pi t)$$

where V is the p.d. in volts and t is the time in seconds.

(a) Determine the root-mean-square (r.m.s.) p.d. of the power supply.

r.m.s. p.d. = ... V [1]

(b) Determine the period T of the output.

T = ... s [2]

(c) The power supply is connected to resistor R and a diode in the circuit shown in Fig. 10.1.

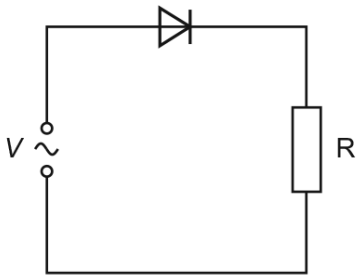


Fig. 10.1

(i) State the name of the type of rectification produced by the diode in Fig. 10.1.

..... [1]

(ii) On Fig. 10.2 sketch the variation with time t of the p.d. V_R across R from time $t = 0$ to time $t = 40$ ms.

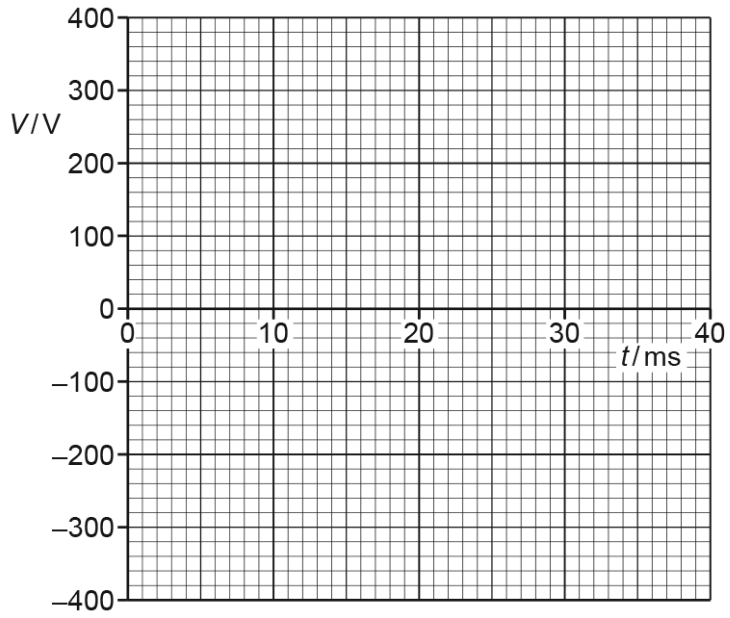


Fig. 10.2

[3]

(iii) On Fig. 10.1, draw the symbol for a component that may be connected to produce smoothing of V_R.

[1]

[Total: 8]

333. 9702_s19_qp_41 Q: 10

A bridge rectifier contains four diodes. The output of the rectifier is connected to a resistor R, as shown in Fig. 10.1.

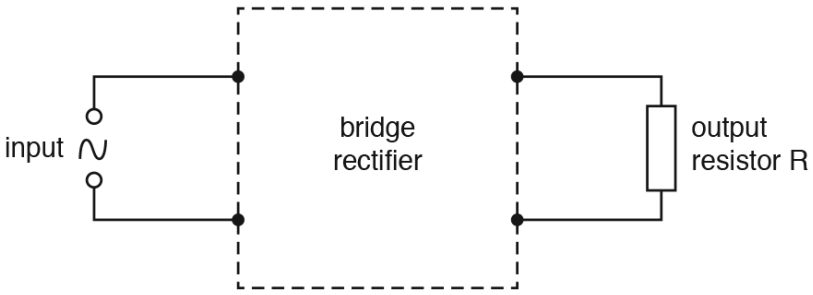


Fig. 10.1

The variation with time t of the input e.m.f. E to the rectifier is given by the expression

$$E = 15\cos(210t)$$

where t is measured in seconds and E in volts.

The variation with time t of the potential difference V across resistor R is shown in Fig. 10.2.

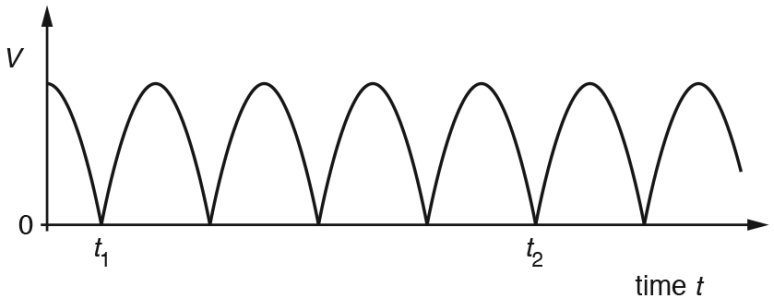


Fig. 10.2

Determine:

(a) the maximum potential difference V_{MAX} across resistor R

V_{MAX} = ...V [1]

(b) the time interval, to two significant figures, between time t_1 and time t_2.

time = ... s [3]

[Total: 4]

---

334. 9702_s19_qp_43 Q: 10

A bridge rectifier contains four diodes. The output of the rectifier is connected to a resistor R, as shown in Fig. 10.1.

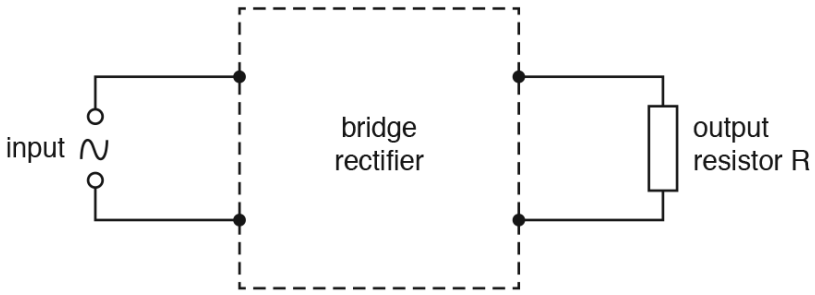


Fig. 10.1

The variation with time t of the input e.m.f. E to the rectifier is given by the expression

$$E = 15\cos(210t)$$

where t is measured in seconds and E in volts.

The variation with time t of the potential difference V across resistor R is shown in Fig. 10.2.

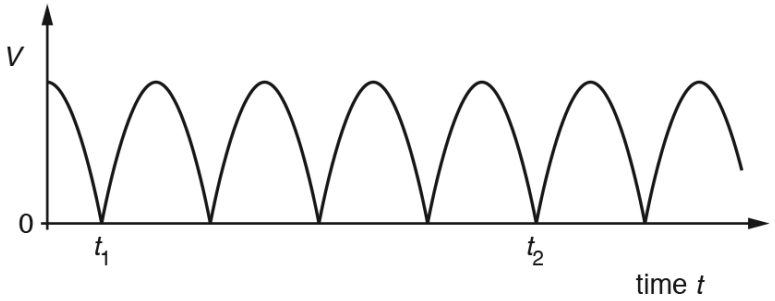


Fig. 10.2

Determine:

(a) the maximum potential difference V_{MAX} across resistor R

V_{MAX} = ...V [1]

(b) the time interval, to two significant figures, between time t_1 and time t_2.

time = ... s [3]

[Total: 4]

---

335. 9702_w19_qp_41 Q: 10

A bridge rectifier using four ideal diodes is shown in Fig. 10.1.

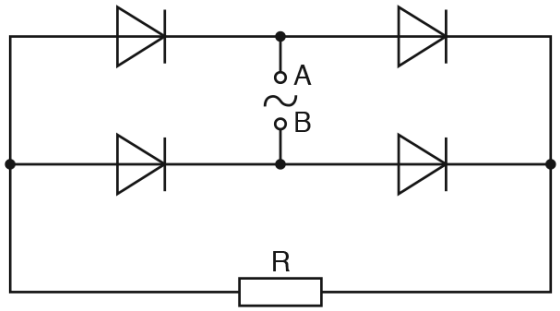


Fig. 10.1

The sinusoidal alternating electromotive force (e.m.f.) applied between points A and B has a root-mean-square (r.m.s.) value of 7.0 V.

(a) (i) On Fig. 10.1, circle the diodes that conduct when point B is positive with respect to point A. [1]

(ii) Calculate the maximum potential difference V_{MAX} across resistor R.

V_{MAX} = ... V [1]

(b) A capacitor is connected into the circuit to produce smoothing of the potential difference across resistor R.

The variation with time *t* of the potential difference *V* across resistor R is shown in Fig. 10.2.

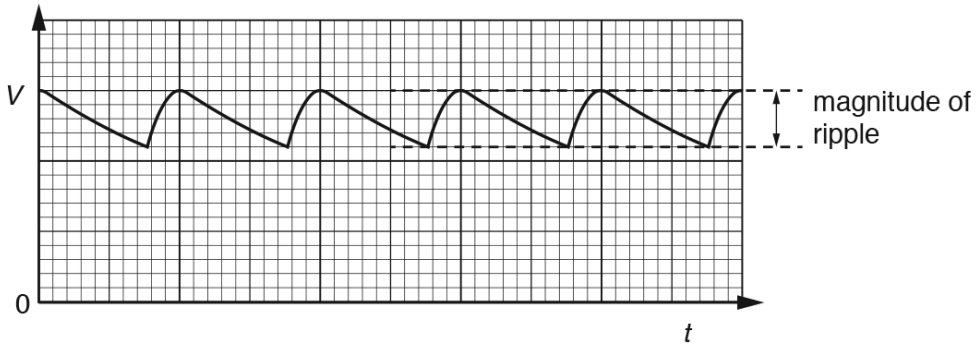


Fig. 10.2

(i) On Fig. 10.1, draw the symbol for a capacitor, connected so as to produce smoothing. [1]

(ii) State the effect, if any, on the magnitude of the ripple on *V* when, separately:

1. a capacitor of larger capacitance is used

.....

2. the resistor R has a smaller resistance.

.....
[2]

[Total: 5]

336. 9702_w19_qp_43 Q: 10

A bridge rectifier using four ideal diodes is shown in Fig. 10.1.

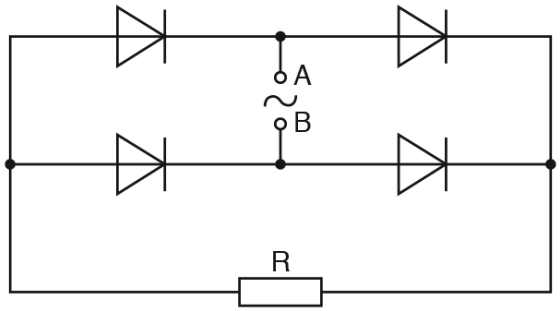


Fig. 10.1

The sinusoidal alternating electromotive force (e.m.f.) applied between points A and B has a root-mean-square (r.m.s.) value of 7.0 V.

(a) (i) On Fig. 10.1, circle the diodes that conduct when point B is positive with respect to point A. [1]

(ii) Calculate the maximum potential difference V_{MAX} across resistor R.

V_{MAX} = ... V [1]

(b) A capacitor is connected into the circuit to produce smoothing of the potential difference across resistor R.

The variation with time *t* of the potential difference *V* across resistor R is shown in Fig. 10.2.

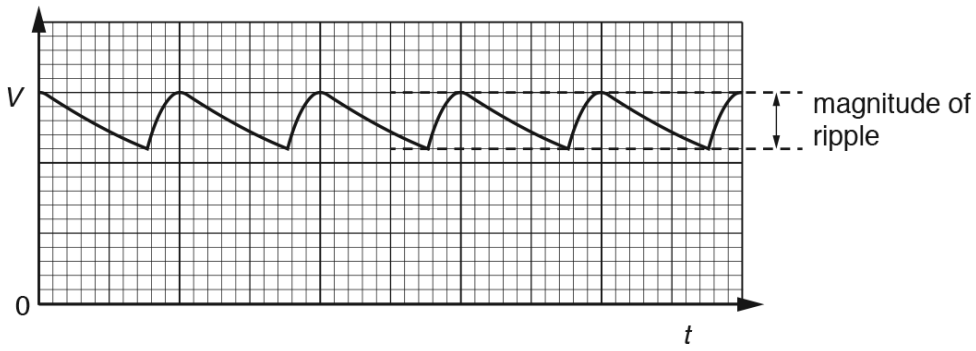


Fig. 10.2

(i) On Fig. 10.1, draw the symbol for a capacitor, connected so as to produce smoothing. [1]

(ii) State the effect, if any, on the magnitude of the ripple on *V* when, separately:

1. a capacitor of larger capacitance is used

.....

2. the resistor R has a smaller resistance.

.....

[2]

[Total: 5]

337. 9702_w17_qp_42 Q: 11

The circuit for a full-wave rectifier using four ideal diodes is shown in Fig. 11.1.

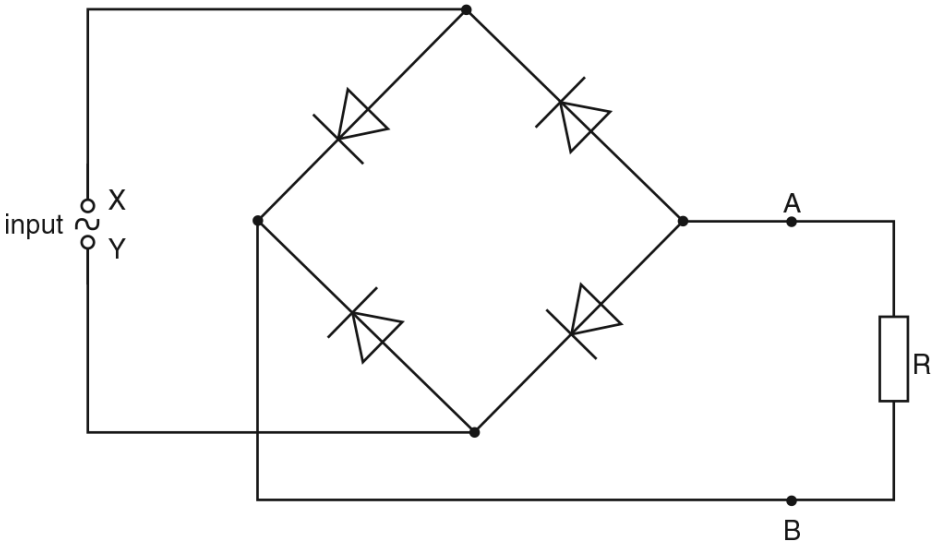


Fig. 11.1

A resistor R is connected across the output AB of the rectifier.

(a) On Fig. 11.1,

(i) draw a circle around any diodes that conduct when the terminal X of the input is positive with respect to terminal Y, [1]

(ii) label the positive (+) and the negative (–) terminals of the output AB. [1]

(b) The variation with time t of the potential difference V across the input XY is given by the expression

$$V = 5.6 \sin 380t$$

where V is measured in volts and t is measured in seconds.

The variation with time t of the rectified potential difference across the resistor R is shown in Fig. 11.2.

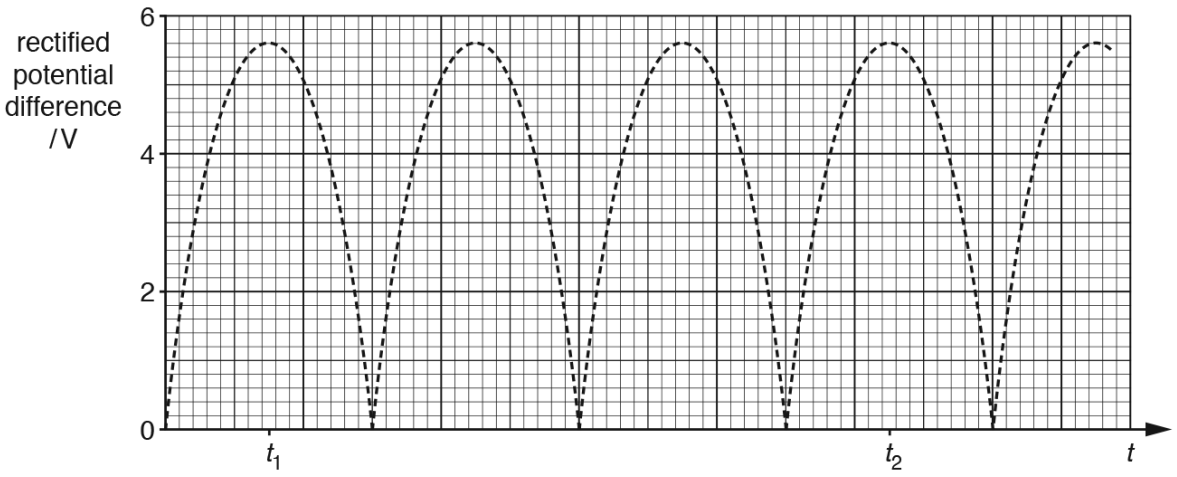


Fig. 11.2

Use the expression for the input potential difference V, or otherwise, to determine

(i) the root-mean-square (r.m.s.) potential difference $V_{r.m.s.}$ of the input,

$V_{r.m.s.}$ = ... V [1]

(ii) the number of times per second that the rectified potential difference at the output reaches a peak value.

number = ... [2]

A capacitor is now connected between the terminals AB of the output.
The capacitor reduces the variation (the ripple) in the output to 1.6 V.

(i) On Fig. 11.2, sketch the variation with time t of the smoothed output voltage for time $t = t_1$ to time $t = t_2$. [4]

(ii) Suggest and explain the effect, if any, on the mean power dissipation in resistor R when the capacitor is connected between terminals AB.

.....

.....

.....[2]

[Total: 11]

Q1.

5 **(a)** Explain, in terms of heating effect, what is meant by the *root-mean-square (r.m.s.) value* of an alternating current.

.....

.....

..... [2]

(b) State the relation between the peak current I_0 and the r.m.s. current I_{rms} of a sinusoidally-varying current.

..... [1]

(c) The value of a direct current and the peak value of a sinusoidal alternating current are equal.

(i) Determine the ratio

$$\frac{\text{power dissipation in a resistor of resistance } R \text{ by the direct current}}{\text{power dissipation in the resistor of resistance } R \text{ by the alternating current}}.$$

ratio = ... [2]

(ii) State one advantage and one disadvantage of the use of alternating rather than direct current in the home.

advantage .....

.....

disadvantage .....

..... [2]

(d) A current I varies with time t as shown in Fig. 5.1.

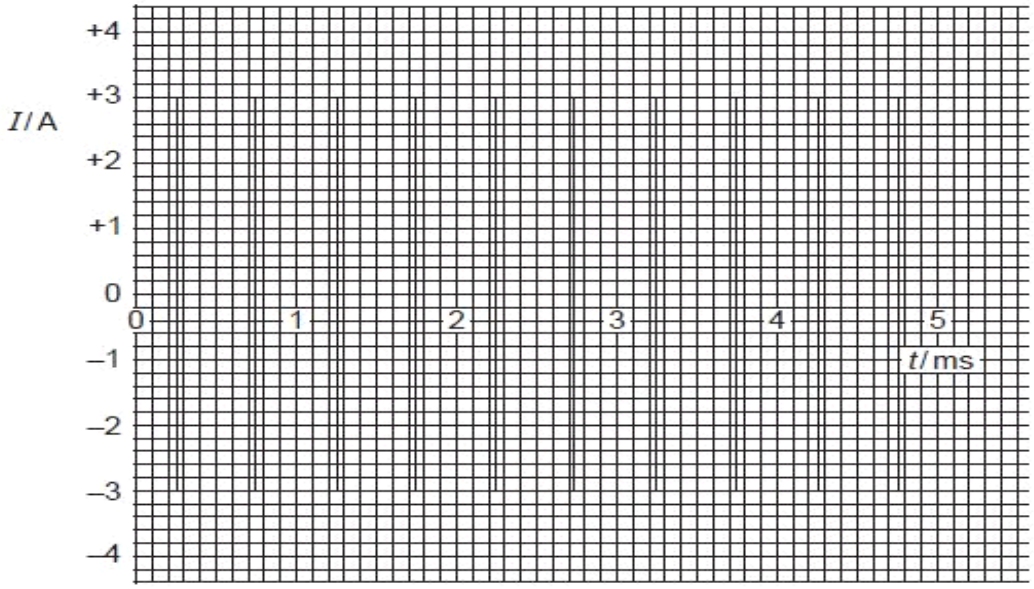


Fig. 5.1

For this varying current, state

(i) the peak value,

peak value = ... A [1]

(ii) the r.m.s. value.

r.m.s. value = ... A [1]

Q2.

4 An ideal transformer has 5000 turns on its primary coil. It is to be used to convert a mains supply of 230V r.m.s. to an alternating voltage having a peak value of 9.0V.

(a) Calculate the number of turns on the secondary coil.

number = ... [3]

(b) The output from the transformer is to be full-wave rectified. Fig. 4.1 shows part of the rectifier circuit.

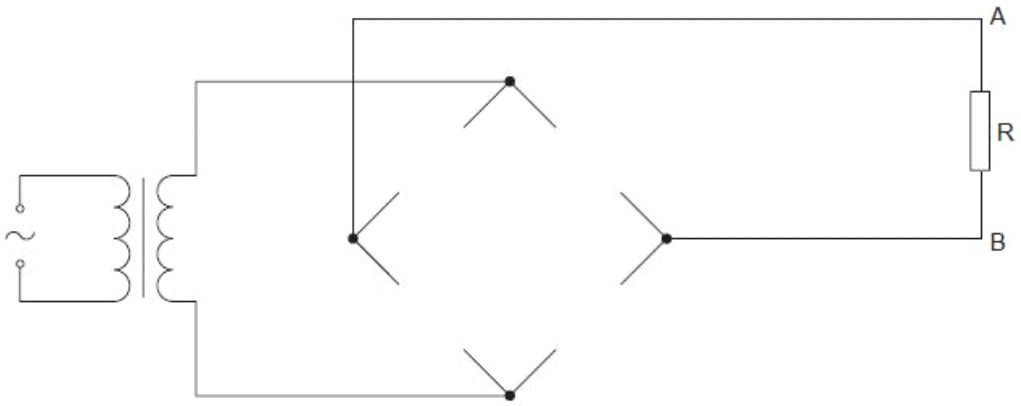


Fig. 4.1

On Fig. 4.1, draw

(i) diode symbols to complete the diagram of the rectifier such that terminal A of the resistor R is positive with respect to terminal B, [2]

(ii) the symbol for a capacitor connected to provide smoothing of the potential difference across the resistor R. [1]

(c) Fig. 4.2 shows the variation with time *t* of the smoothed potential difference *V* across the resistor R.

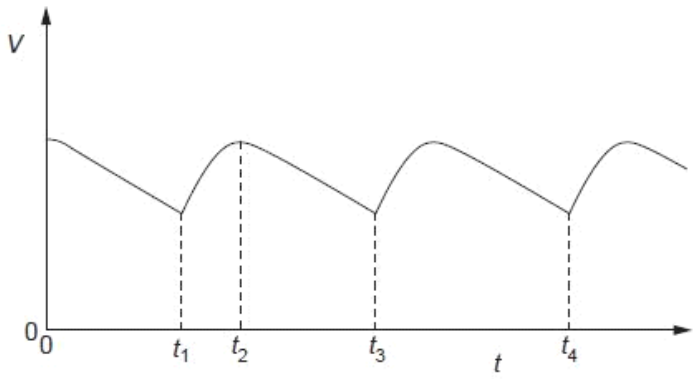


Fig. 4.2

(i) State the interval of time during which the capacitor is being charged from the transformer.

from time ..... to time ..... [1]

(ii) The resistance of the resistor R is doubled. On Fig. 4.2, sketch the variation with time *t* of the potential difference *V* across the resistor. [2]

Q3.

6 A student is asked to design a circuit by which a direct voltage of peak value 9.0 V is obtained from a 240 V alternating supply.
The student uses a transformer that may be considered to be ideal and a bridge rectifier incorporating four ideal diodes.
The partially completed circuit diagram is shown in Fig. 6.1.

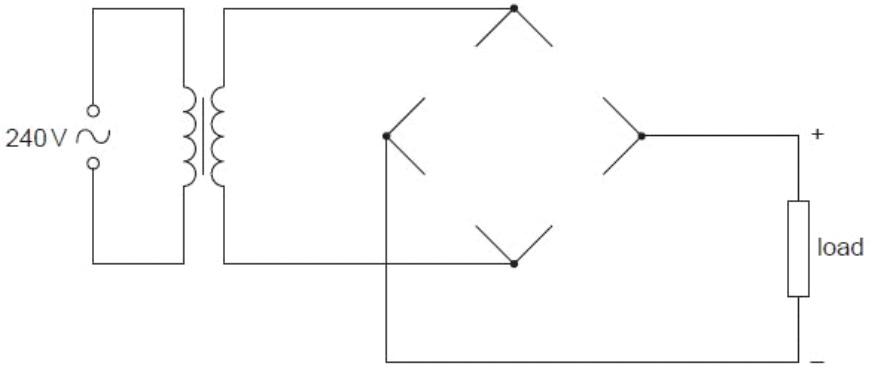


Fig. 6.1

(a) On Fig. 6.1, draw symbols for the four diodes so as to produce the polarity across the load as shown on the diagram. [2]

(b) Calculate the ratio

$$\frac{\text{number of turns on the secondary coil}}{\text{number of turns on the primary coil}}.$$

ratio = ... [3]

Q4.

7 **(a)** Explain what is meant by the *root-mean-square* (r.m.s.) value of an alternating voltage.

For Examiner Use

.....

.....

..... [2]

(b) An alternating voltage V is represented by the equation

$$V = 220 \sin(120\pi t),$$

where V is measured in volts and t is in seconds.

For this alternating voltage, determine

(i) the peak voltage,

peak voltage = ... V [1]

(ii) the r.m.s. voltage,

r.m.s. voltage = ... V [1]

(iii) the frequency.

frequency = ... Hz [1]

(c) The alternating voltage in **(b)** is applied across a resistor such that the mean power output from the resistor is 1.5 kW.

Calculate the resistance of the resistor.

resistance = ... Ω [2]

Q5.

6 A transformer is illustrated in Fig. 6.1.

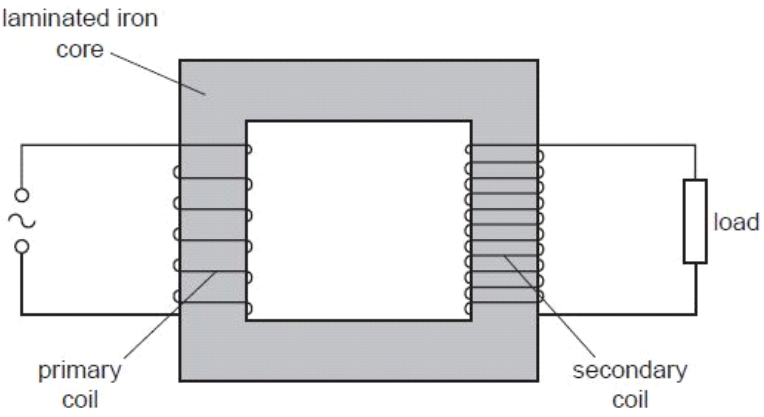


Fig. 6.1

(a) (i) Explain why the coils are wound on a core made of iron.

.....

.....[1]

(ii) Suggest why thermal energy is generated in the core.

.....

.....

.....[2]

(b) (i) State Faraday's law of electromagnetic induction.

.....

.....

.....[2]

(ii) Use Faraday's law to explain why the potential difference across the load and the e.m.f. of the supply are not in phase.

.....

.....

.....

.....[2]

(c) Electrical energy is usually transmitted using alternating current. Suggest why the transmission is achieved using

(i) high voltages,

.....

.....

.....[2]

(ii) alternating current.

.....

.....[1]

Q6.

6 An alternating current supply is connected in series with a resistor R, as shown in Fig. 6.1.

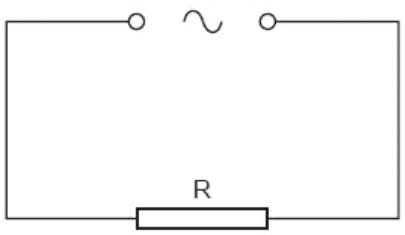


Fig. 6.1

The variation with time t (measured in seconds) of the current I (measured in amps) in the resistor is given by the expression

$$I = 9.9\sin(380t).$$

(a) For the current in the resistor R, determine

(i) the frequency,

frequency = ... Hz [2]

(ii) the r.m.s. current.

r.m.s. current = ... A [2]

(b) To prevent over-heating, the mean power dissipated in resistor R must not exceed 400 W.
Calculate the minimum resistance of R.

For Examin Use

resistance = ... Ω [2]

Q7.

6 A sinusoidal alternating voltage supply is connected to a bridge rectifier consisting of four ideal diodes. The output of the rectifier is connected to a resistor R and a capacitor C as shown in Fig. 6.1.

For Examin Use

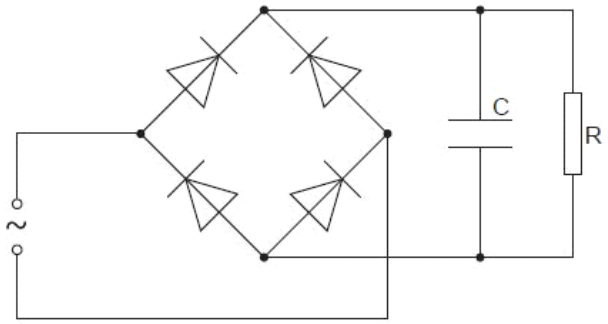
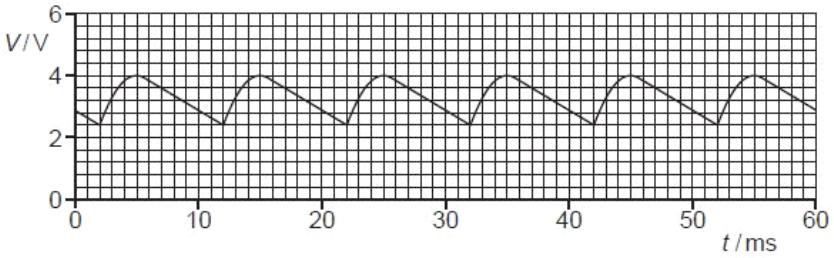


Fig. 6.1

The function of C is to provide some smoothing to the potential difference across R.
The variation with time *t* of the potential difference *V* across the resistor R is shown in Fig. 6.2.



(a) Use Fig. 6.2 to determine, for the alternating supply,

(i) the peak voltage,

peak voltage = ... V [1]

(ii) the root-mean-square (r.m.s.) voltage,

r.m.s. voltage = ... V [1]

(iii) the frequency. Show your working.

frequency = ... Hz [2]

(b) The capacitor C has capacitance 5.0 μF.
For a single discharge of the capacitor through the resistor R, use Fig. 6.2 to

(i) determine the change in potential difference,

change = ... V [1]

(ii) determine the change in charge on each plate of the capacitor,

change = ... C [2]

(iii) show that the average current in the resistor is 1.1×10^{-3} A.

[2]

(c) Use Fig. 6.2 and the value of the current given in **(b)(iii)** to estimate the resistance of resistor R.

resistance = ... Ω [2]

Q8.

6 A simple transformer is illustrated in Fig. 6.1.

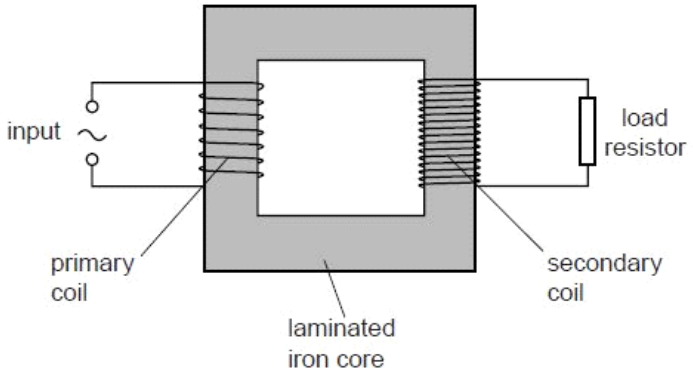


Fig. 6.1

(a) State

(i) why the iron core is laminated,

.....

.....

.....[2]

(ii) what is meant by an *ideal* transformer.

.....

..... [1]

(b) 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.

Calculate the peak voltage across the load resistor connected to the secondary coil.

peak voltage = ... V [2]

Q9.

6 **(a)** State Faraday's law of electromagnetic induction.

For Examiner Use

.....

.....

..... [2]

(b) The output of an ideal transformer is connected to a bridge rectifier, as shown in Fig. 6.1.

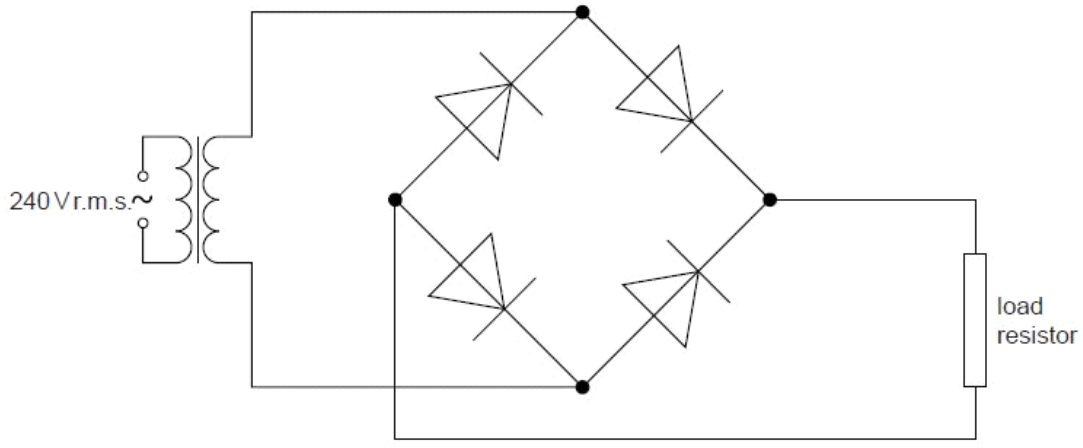


Fig. 6.1

The input to the transformer is 240 V r.m.s. and the **maximum** potential difference across the load resistor is 9.0 V.

(i) On Fig. 6.1, mark with the letter P the positive output from the rectifier. [1]

(ii) Calculate the ratio

$$\frac{\text{number of turns on primary coil}}{\text{number of turns on secondary coil}}.$$

ratio = ... [3]

(c) The variation with time t of the potential difference V across the load resistor in **(b)** is shown in Fig. 6.2.

For Examiner Use

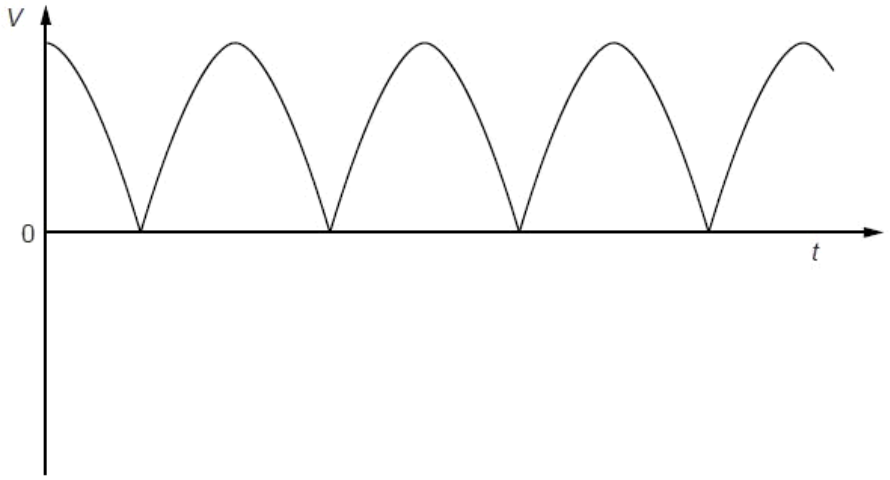


Fig. 6.2

A capacitor is now connected in parallel with the load resistor to produce some smoothing.

(i) Explain what is meant by *smoothing*.

.....

..... [1]

(ii) On Fig. 6.2, draw the variation with time *t* of the smoothed output potential difference. [2]

Q10.

4 The rectified output of a sinusoidal signal generator is connected across a resistor **R** of resistance 1.5 k , as shown in Fig. 4.1.



Fig. 4.1

The variation with time *t* of the potential difference *V* across **R** is shown in Fig. 4.2.

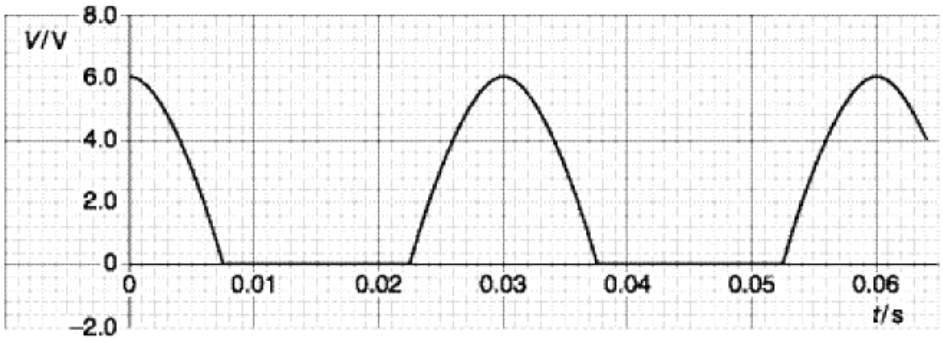


Fig. 4.2

(a) State how the rectification shown in Fig. 4.2 may be achieved.

.....

..... [2]

Use

(b) A capacitor is now connected in parallel with the resistor **R**. The resulting variation with time t of the potential difference V across **R** is shown in Fig. 4.3.

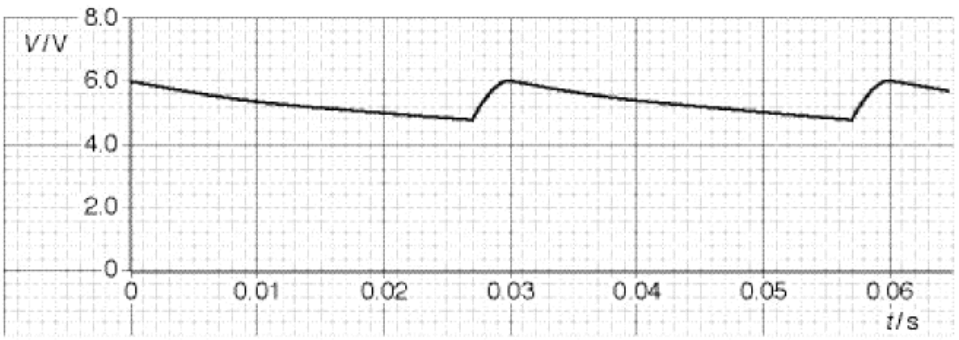


Fig. 4.3

(i) Using Fig. 4.3, determine

1. the mean potential difference across the resistor **R**,

potential difference = ... V

2. the mean current in the resistor,

mean current = ... A

3. the time in each cycle during which the capacitor discharges through the resistor.

time = ... s

[4]

Use

(ii) Using your answers in **(i)**, calculate

1. the charge passing through the resistor during one discharge of the capacitor,

charge = ... C

2. the capacitance of the capacitor.

capacitance = ... F
[4]

(c) A second capacitor is now connected in parallel with the resistor **R** and the first capacitor. On Fig. 4.3, draw a line to show the variation with time *t* of the potential difference *V* across the resistor. [1]

Q11.

6 An alternating supply of frequency 50 Hz and having an output of 6.0 V r.m.s. is to be rectified so as to provide direct current for a resistor R. The circuit of Fig. 6.1 is used.

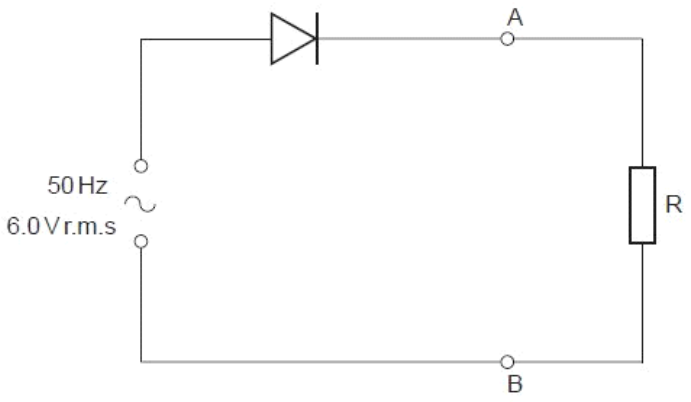


Fig. 6.1

The diode is ideal. The Y-plates of a cathode-ray oscilloscope (c.r.o.) are connected between points A and B.

(a) (i) Calculate the maximum potential difference across the diode during one cycle.

potential difference = ... V [2]

(ii) State the potential difference across R when the diode has maximum potential difference across it. Give a reason for your answer.

.....

..... [1]

(b) The Y-plate sensitivity of the c.r.o. is set at 2.0 V cm^{-1} and the time-base at 5.0 ms cm^{-1}.

On Fig. 6.2, draw the waveform that is seen on the screen of the c.r.o. [3]

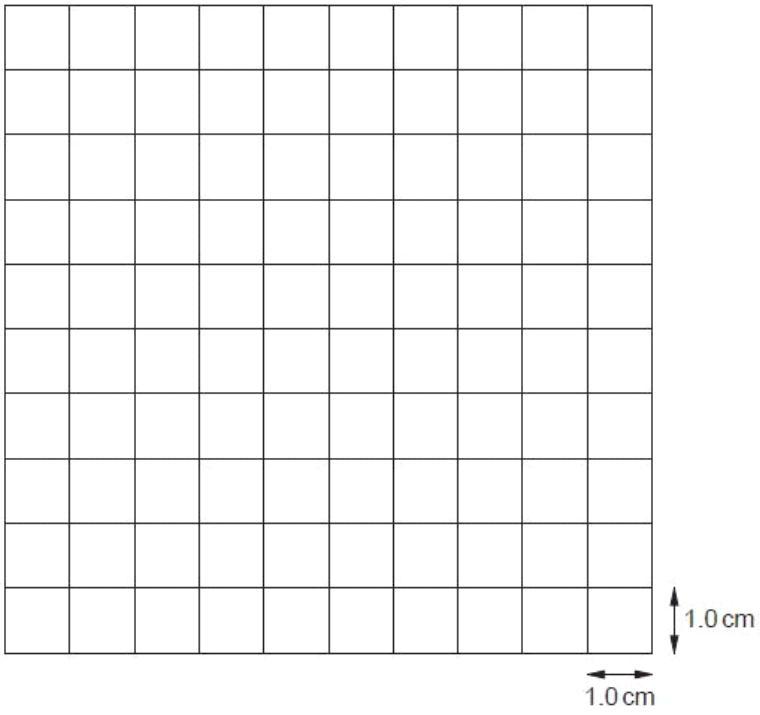


Fig. 6.2

(c) A capacitor of capacitance 180 μF is connected into the circuit to provide smoothing of the potential difference across the resistor R.

(i) On Fig. 6.1, show the position of the capacitor in the circuit. [1]

(ii) Calculate the energy stored in the fully-charged capacitor.

energy = ... J [3]

(iii) During discharge, the potential difference across the capacitor falls to $0.43\,V_0$, where V_0 is the maximum potential difference across the capacitor.

Calculate the fraction of the total energy that remains in the capacitor after the discharge.

fraction = ... [2]

Q12.

6 A simple iron-cored transformer is illustrated in Fig. 6.1.

For Examiner's Use

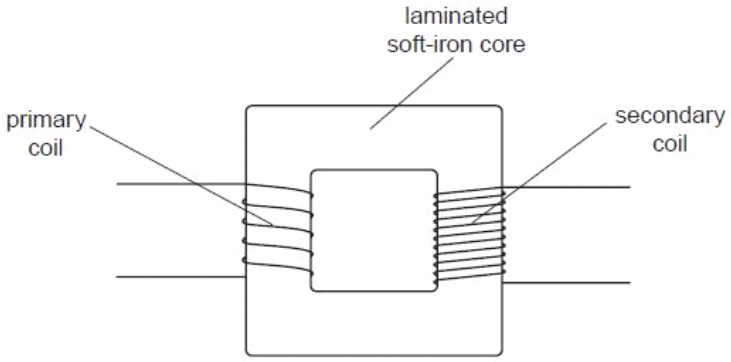


Fig. 6.1

(a) Suggest why the core is

(i) a continuous loop,

.....

..... [1]

(ii) laminated.

.....

.....

.....[2]

(b) **(i)** State Faraday's law of electromagnetic induction.

.....

.....

.....[2]

(ii) Use Faraday's law to explain the operation of the transformer.

.....

.....

.....

.....[3]

(c) State two advantages of the use of alternating voltages for the transmission and use of electrical energy.

1. .....

.....

2. .....

.....

[2]

Fo
Exami
Us

Q13.

7 A sinusoidal alternating voltage is to be rectified.

For Examiner Use

(a) Suggest one advantage of full-wave rectification as compared with half-wave rectification.

.....

..... [1]

(b) The rectification is produced using the circuit of Fig. 7.1.

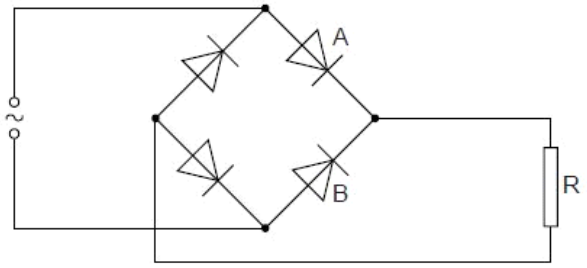


Fig. 7.1

All the diodes may be considered to be ideal.

The variation with time t of the alternating voltage applied to the circuit is shown in Fig. 7.2 and in Fig. 7.3.

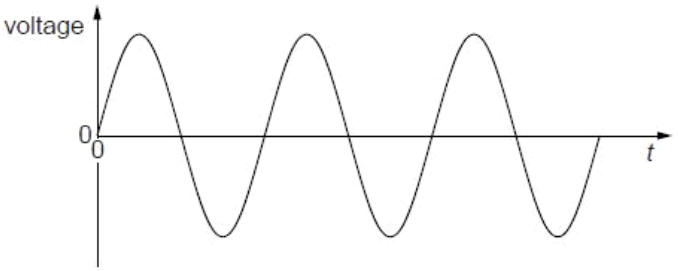


Fig. 7.2

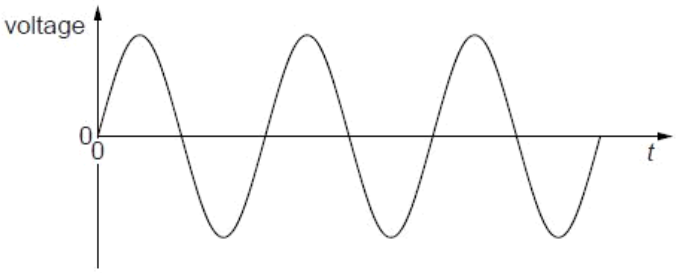


Fig. 7.3

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(i) On the axes of Fig. 7.2, draw a graph to show the variation with time *t* of the potential difference across diode A. [1]

(ii) On the axes of Fig. 7.3, draw a graph to show the variation with time *t* of the potential difference across diode B. [1]

(c) (i) On Fig. 7.1, draw the symbol for a capacitor, connected into the circuit so as to provide smoothing. [1]

(ii) Fig. 7.4 shows the variation with time *t* of the smoothed potential difference across the resistor R in Fig. 7.1.

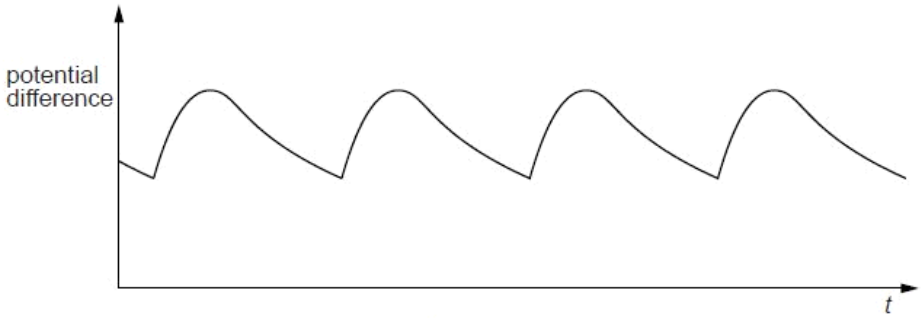


Fig. 7.4

1. State how the amount of smoothing may be increased.

.....

..... [1]

2. On Fig. 7.4, draw the variation with time *t* of the potential difference across resistor R for increased smoothing. [2]

For Examiner's Use

Q14.

6 A simple iron-cored transformer is illustrated in Fig. 6.1.

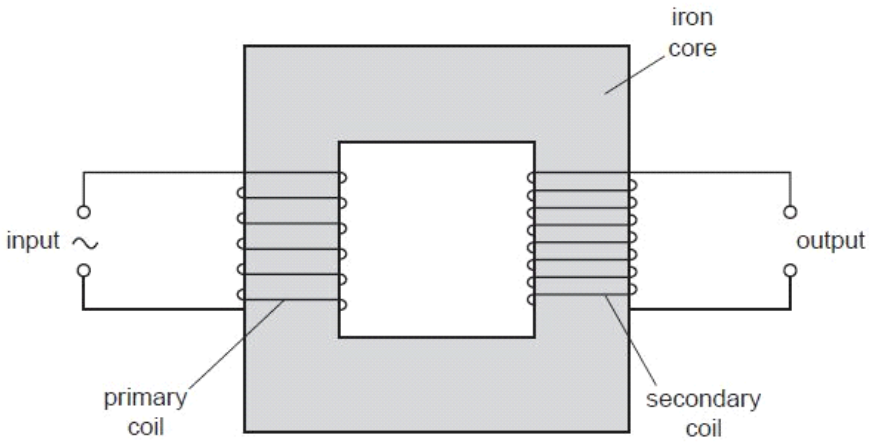


Fig. 6.1

(a) (i) State why the primary and secondary coils are wound on a core made of iron.

.....

.....

.....[1]

(ii) Suggest why thermal energy is generated in the core when the transformer is in use.

.....

.....

.....

.....[3]

(b) The root-mean-square (r.m.s.) voltage and current in the primary coil are V_P and I_P respectively.
The r.m.s. voltage and current in the secondary coil are V_S and I_S respectively.

For Examiner's Use

(i) Explain, by reference to direct current, what is meant by the *root-mean-square* value of an alternating current.

.....

.....

.....[2]

(ii) Show that, for an ideal transformer,

$$\frac{V_S}{V_P} = \frac{I_P}{I_S}.$$

[2]

Q15.

6 The variation with time t of the current I in a resistor is shown in Fig. 6.1.

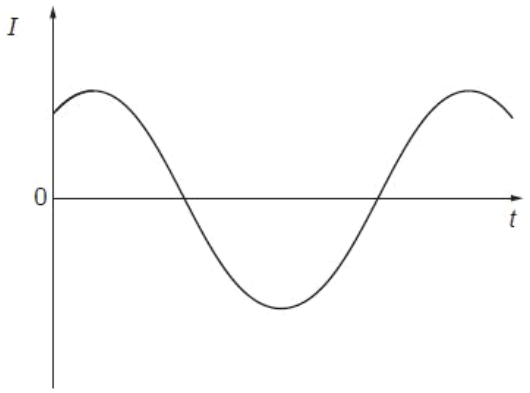


Fig. 6.1

The variation of the current with time is sinusoidal.

(a) Explain why, although the current is not in one direction only, power is converted in the resistor.

.....

.....

..... [2]

(b) Using the relation between root-mean-square (r.m.s.) current and peak current, deduce the value of the ratio

$$\frac{\text{average power converted in the resistor}}{\text{maximum power converted in the resistor}}.$$

ratio = ... [3]

Q16.

6 The variation with time t of the output V of an alternating voltage supply of frequency 50 Hz is shown in Fig. 6.1.

For Examiner Use

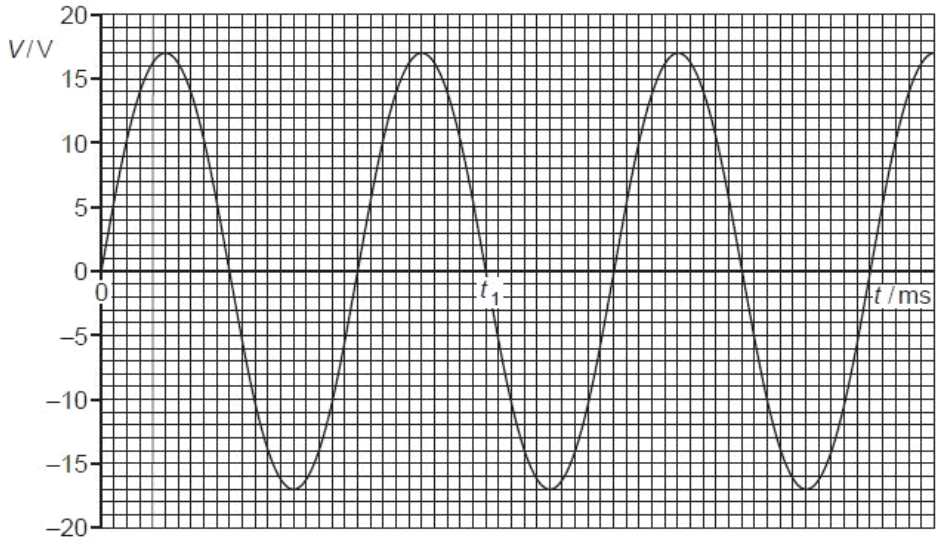


Fig. 6.1

(a) Use Fig. 6.1 to state

(i) the time t_1,

t_1 = ... s [2]

(ii) the peak value V_0 of the voltage,

V_0 = ... V [1]

(iii) the root-mean-square voltage V_{rms},

V_{rms} = ... V [1]

(iv) the mean voltage $<V>$.

$<V>$ = ... V [1]

(b) The alternating supply is connected in series with a resistor of resistance 2.4 Ω. Calculate the mean power dissipated in the resistor.

For Examiner's Use

power = ... W [2]

Q17.

5 The components for a bridge rectifier are shown in Fig. 5.1.

For Examiner's Use

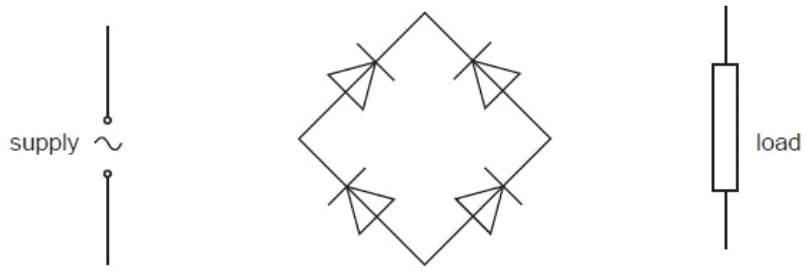


Fig. 5.1

(a) Complete the circuit of Fig. 5.1 by showing the connections of the supply and of the load to the diodes. [2]

(b) Suggest one advantage of the use of a bridge rectifier, rather than a single diode, for the rectification of alternating current.

.....

..... [1]

(c) State

(i) what is meant by *smoothing*,

.....

..... [1]

(ii) the effect of the value of the capacitance of the smoothing capacitor in relation to smoothing.

.....

.....

..... [2]

Q18.

6 A bridge rectifier consists of four ideal diodes A, B, C and D, connected as shown in Fig. 6.1.

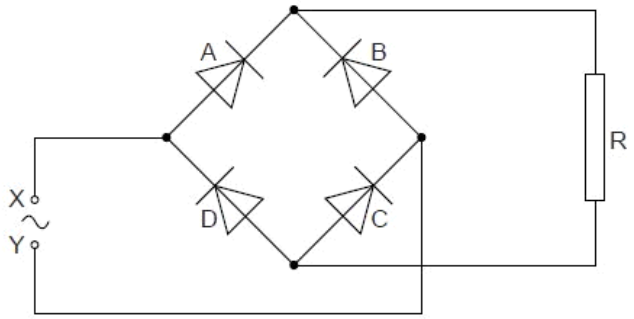


Fig. 6.1

An alternating supply is applied between the terminals X and Y.

(a) **(i)** On Fig. 6.1, label the positive (+) connection to the load resistor R. [1]

(ii) State which diodes are conducting when terminal Y of the supply is positive.

diode ..... and diode .....[1]

(b) The variation with time t of the potential difference V across the load resistor R is shown in Fig. 6.2.

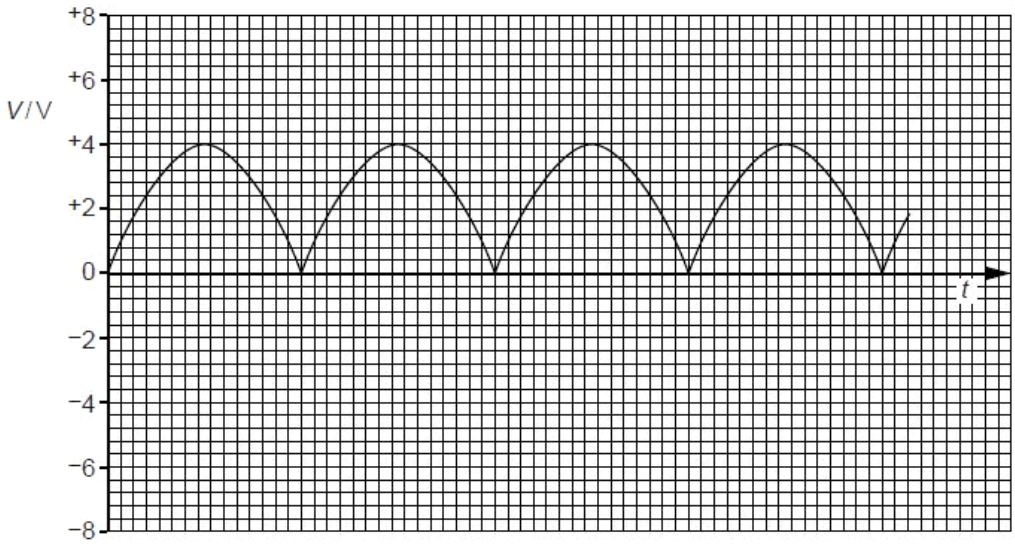


Fig. 6.2

The load resistor R has resistance 2700 Ω.

(i) Use Fig. 6.2 to determine the mean power dissipated in the resistor R.

power = ... W [3]

(ii) On Fig. 6.1, draw the symbol for a capacitor, connected so as to increase the mean power dissipated in the resistor R. [1]

(c) The capacitor in **(b)(ii)** is now removed from the circuit.
The diode A in Fig. 6.1 stops functioning, so that it now has infinite resistance.

On Fig. 6.2, draw the variation with time t of the new potential difference across the resistor R. [2]

Q19.

7 **(a)** The mean value of an alternating current is zero.

Explain

(i) why an alternating current gives rise to a heating effect in a resistor,

.....

.....

..... [2]

(ii) by reference to heating effect, what is meant by the root-mean-square (r.m.s.) value of an alternating current.

.....

.....

.....

..... [2]

(b) A simple iron-cored transformer is illustrated in Fig. 7.1.

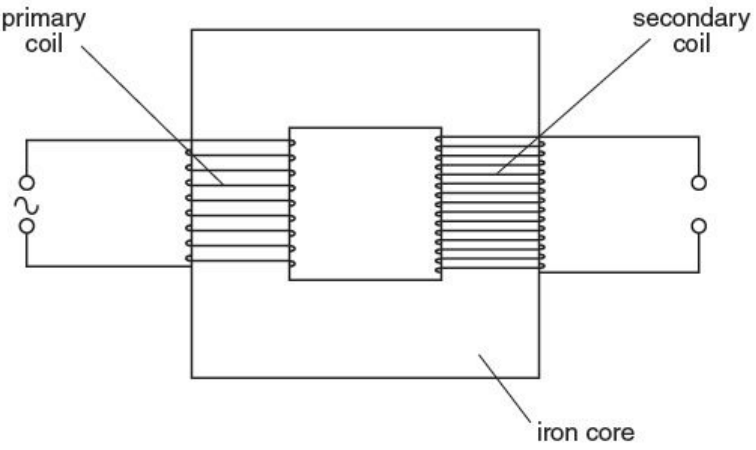


Fig. 7.1

(i) State Faraday's law of electromagnetic induction.

.....

.....

..... [2]

(ii) Use Faraday's law to explain why the current in the primary coil is not in phase with the e.m.f. induced in the secondary coil.

.....

.....

.....

.....

..... [3]

Alternating Current - 2020 A2

1. March/2020/Paper_42/No.9

(a) The output of a power supply is represented by:

$$V = 9.0 \sin 20t$$

where V is the potential difference in volts and t is the time in seconds.

Determine, for the output of the supply:

(i) the root-mean-square (r.m.s.) voltage, $V_{r.m.s.}$

$V_{r.m.s}$ = ...V [1]

(ii) the period T.

T = ... s [2]

(b) The variations with time t of the output potential difference V from two different power supplies are shown in Fig. 9.1 and Fig. 9.2.

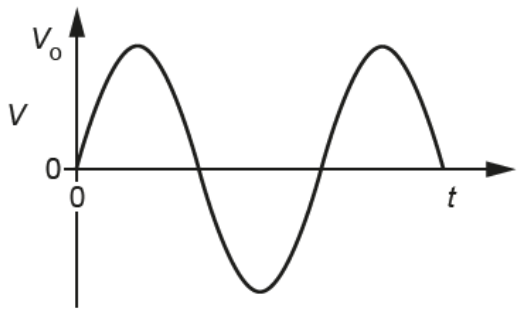


Fig. 9.1

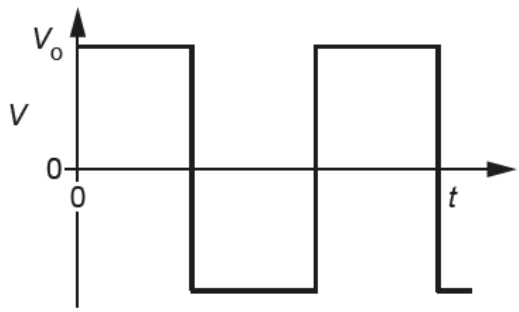


Fig. 9.2

The graphs are drawn to the same scale.

State and explain whether the same power would be dissipated in a 1.0 Ω resistor connected to each power supply.

.....

.....

..... [1]

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(c) **(i)** The power supply in **(a)** is connected to a transformer. The input power to the transformer is 80 W.

The secondary coil is connected to a resistor. The r.m.s. voltage across the resistor is 120 V. The r.m.s. current in the secondary coil is 0.64 A.

Calculate the efficiency of the transformer.

efficiency = ... [3]

(ii) State **one** reason why the transformer is not 100% efficient.

.....

..... [1]

[Total: 8]

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Alternating current - 2021 A2

1. Nov/2021/Paper_41/No.9

(a) State, by reference to the power dissipated in a resistor, what is meant by the *root-mean-square* (*r.m.s.*) value of an alternating voltage.

.....

.....

.....

..... [2]

(b) A coil is rotating freely, on frictionless bearings, at constant speed in a uniform magnetic field. This rotation causes an induced alternating electromotive force (e.m.f.) across the open terminals of the coil. The induced e.m.f. has r.m.s. value 12 V and frequency 50 Hz.

The speed of rotation of the coil is now doubled.

(i) State and explain, with reference to the principles of electromagnetic induction, the effect of the increased speed of rotation on the r.m.s. value of the induced e.m.f.

.....

.....

.....

..... [2]

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(ii) On Fig. 9.1, sketch the variation with time t of the induced e.m.f. E across the terminals of the coil at the **increased** speed of rotation. Your line should extend from time $t = 0$ to time $t = 20$ ms. Assume that $E = 0$ when $t = 0$.

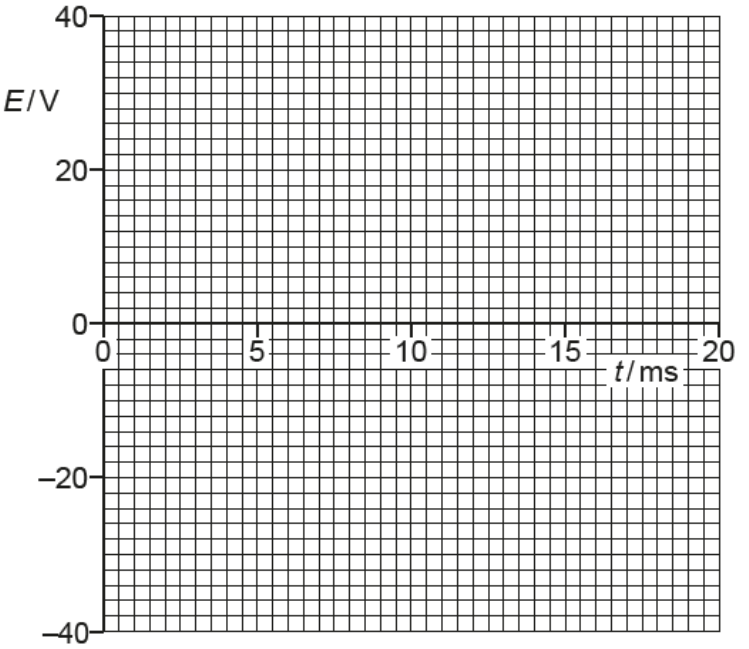


Fig. 9.1

[3]

(c) State and explain the effect on the motion of the coil in **(b)** of connecting a load resistor across its terminals.

.....

.....

.....

..... [2]

[Total: 9]

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2. Nov/2021/Paper_42/No.10

Fig. 10.1 shows a simple laminated iron-cored transformer consisting of a primary coil of 25 000 turns and a secondary coil of 625 turns.

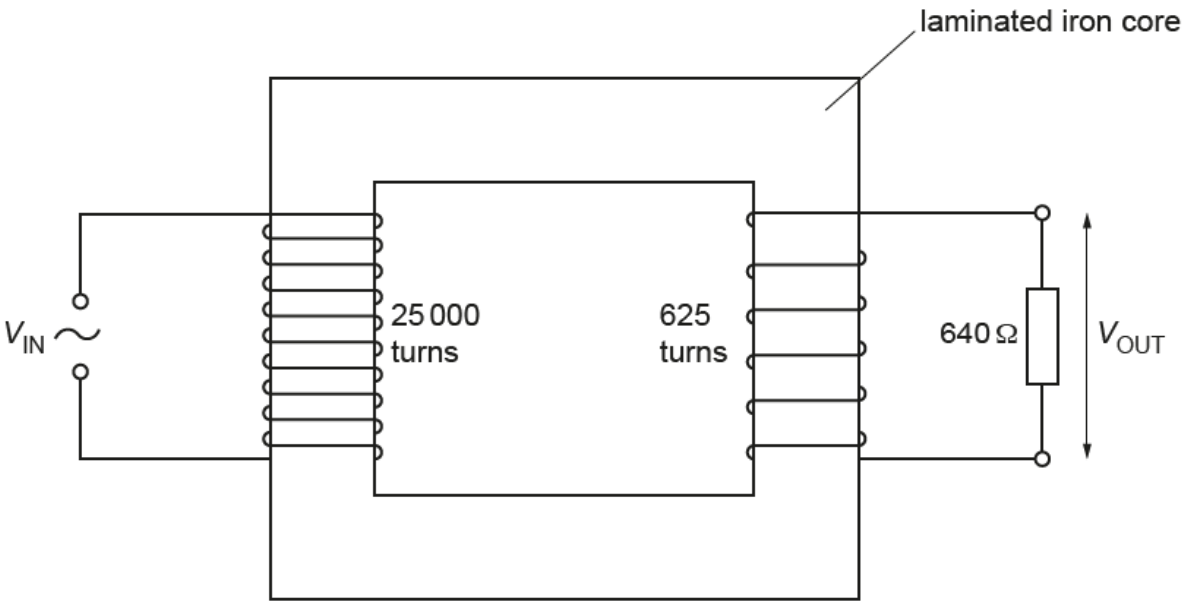


Fig. 10.1

The output potential difference (p.d.) V_{OUT} is applied to a load resistor of resistance 640 Ω.

(a) (i) State the function of the iron core.

.....

..... [1]

(ii) Explain why the iron core is laminated.

.....

.....

..... [2]

(b) The input p.d. V_{IN} is a sinusoidal alternating voltage of peak value 12 kV and period 40 ms.

(i) Calculate the maximum value of V_{OUT}.

maximum V_{OUT} = ... V [1]

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(ii) Calculate the root-mean-square (r.m.s.) current in the load resistor.

r.m.s. current = ... A [1]

(iii) On Fig. 10.2, sketch the variation with time t of the power P dissipated in the load resistor for time $t = 0$ to $t = 40$ ms. Assume that $P = 0$ when $t = 0$.

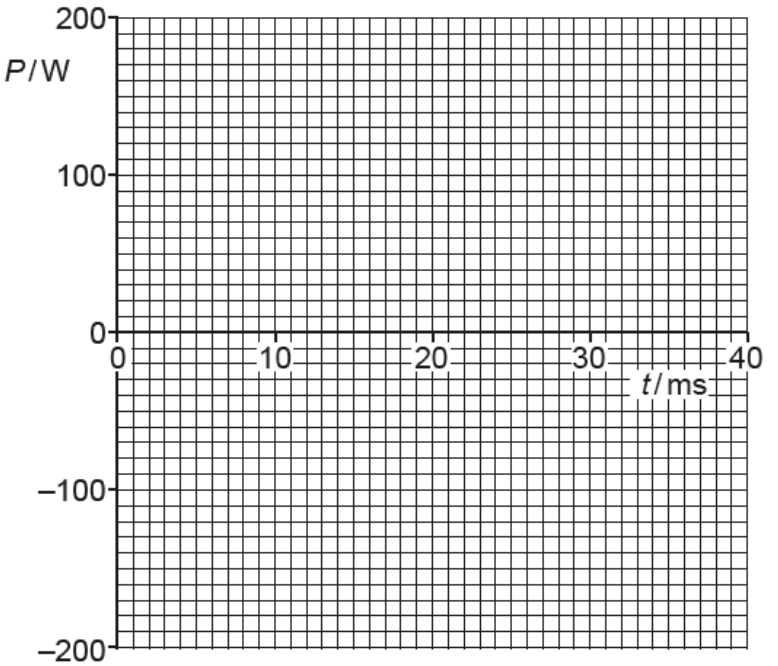


Fig. 10.2

[3]

(c) Explain, with reference to Fig.10.2, why the mean power in the load resistor is 70 W.

.....

.....

.....

..... [2]

[Total: 10]

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3. June/2021/Paper_42/No.10

(a) By reference to heating effect, explain what is meant by the *root-mean-square* (*r.m.s.*) value of an alternating current.

.....

.....

..... [2]

(b) The variations with time t of two currents I_1 and I_2 are shown in Fig. 10.1 and Fig. 10.2.

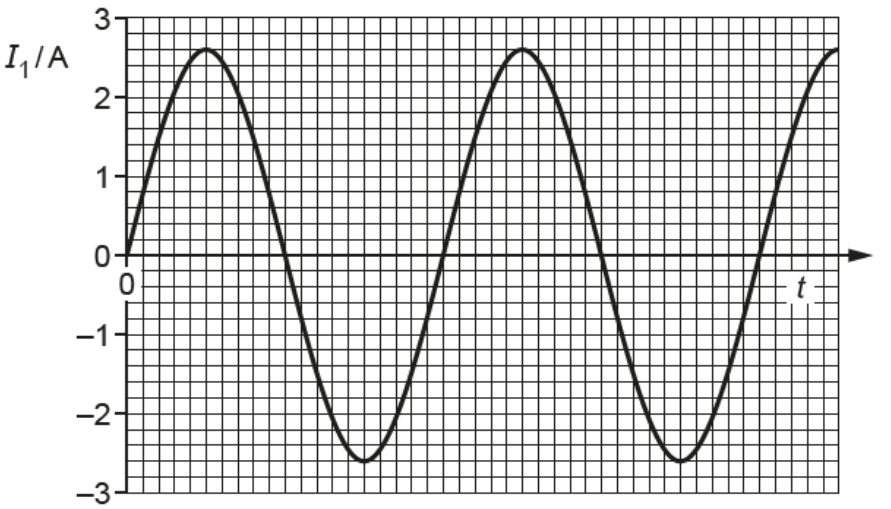


Fig. 10.1

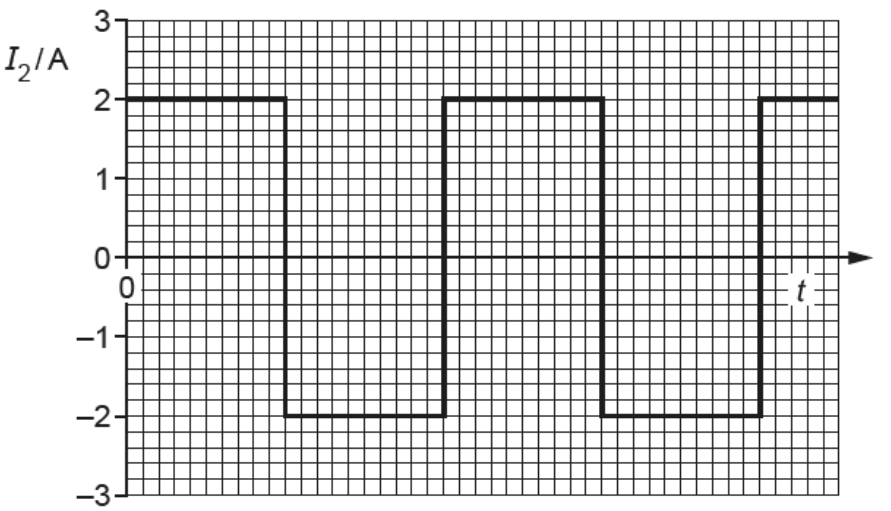


Fig. 10.2

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(i) Use Fig. 10.1 to determine the peak value and the r.m.s. value of the current I_1.

peak value = ... A

r.m.s. value = ... A
[1]

(ii) Use Fig. 10.2 to determine the peak value and the r.m.s. value of the current I_2.

peak value = ... A

r.m.s. value = ... A
[1]

(c) The variation with time t of the supply voltage V to a house is given by the expression

$$V = 240 \sin kt$$

where V is in volts, t is in seconds and k is a constant with unit rad s^{-1}.

(i) The frequency of the supply voltage is 50 Hz.

Determine k to two significant figures.

k = ... rad s^{-1} [2]

(ii) The supply voltage is applied to a heater. The mean power of the heater is 3.2 kW.

Calculate the resistance of the heater.

resistance = ... Ω [2]

[Total: 8]

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4. March/2021/Paper_42/No.10

The output potential difference (p.d.) of an alternating power supply is represented by

$$V = 320\sin(100\pi t)$$

where V is the p.d. in volts and t is the time in seconds.

(a) Determine the root-mean-square (r.m.s.) p.d. of the power supply.

r.m.s. p.d. = ... V [1]

(b) Determine the period T of the output.

T = ... s [2]

(c) The power supply is connected to resistor R and a diode in the circuit shown in Fig. 10.1.

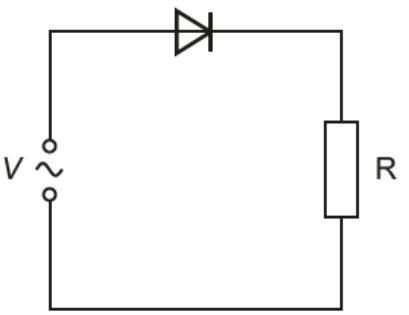


Fig. 10.1

(i) State the name of the type of rectification produced by the diode in Fig. 10.1.

..... [1]

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(ii) On Fig. 10.2 sketch the variation with time t of the p.d. V_R across R from time $t = 0$ to time $t = 40$ ms.

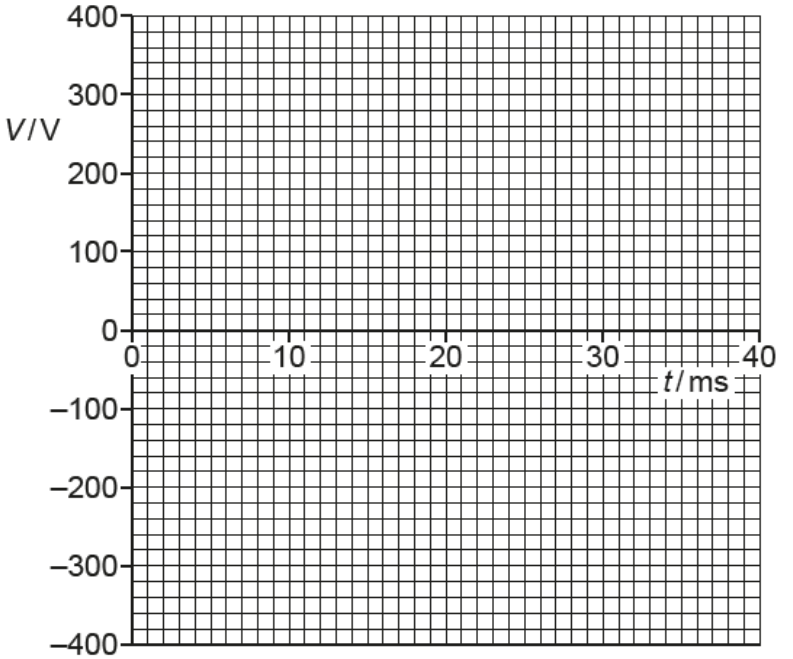


Fig. 10.2

[3]

(iii) On Fig. 10.1, draw the symbol for a component that may be connected to produce smoothing of V_R.

[1]

[Total: 8]

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1. Nov/2023/Paper_9702/41/No.7

A varying current I passes through a resistor of resistance R in the circuit shown in Fig. 7.1.

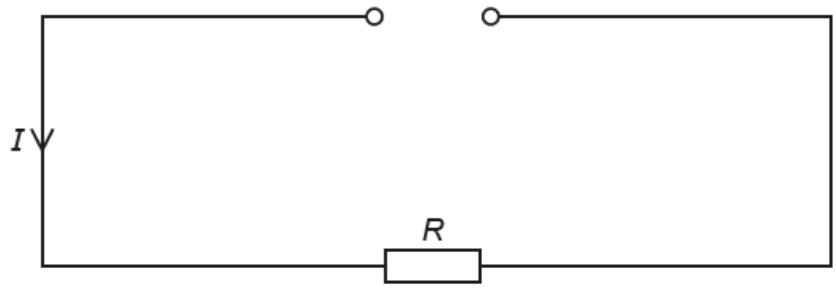


Fig. 7.1

Fig. 7.2 shows the variation with time t of I.

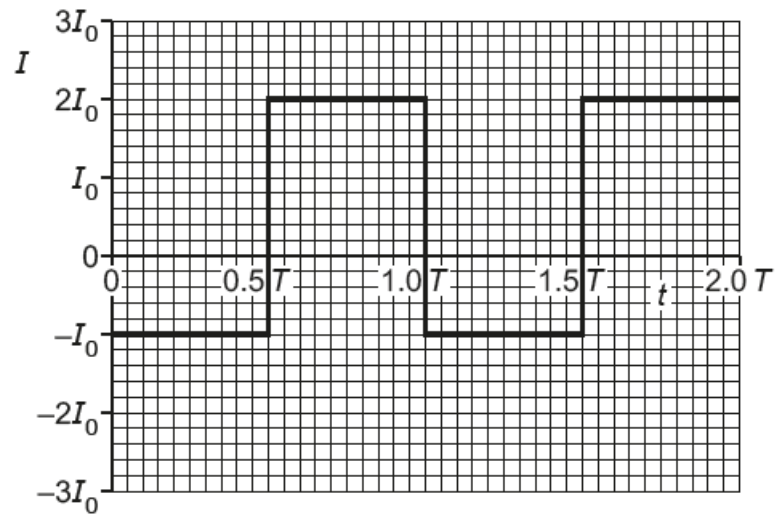


Fig. 7.2

The current has magnitude $2I_0$ when it is in the positive direction and I_0 when it is in the negative direction. The period of the variation of the current is T.

(a) Determine expressions, in terms of I_0 and R, for the power P dissipated in the resistor for the times when:

(i) the current is in the negative direction

P = ... [1]

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(ii) the current is in the positive direction.

P = ... [1]

(b) On Fig. 7.3, sketch the variation of P with t between $t = 0$ and $t = 2.0T$. Label the power axis with an appropriate scale.

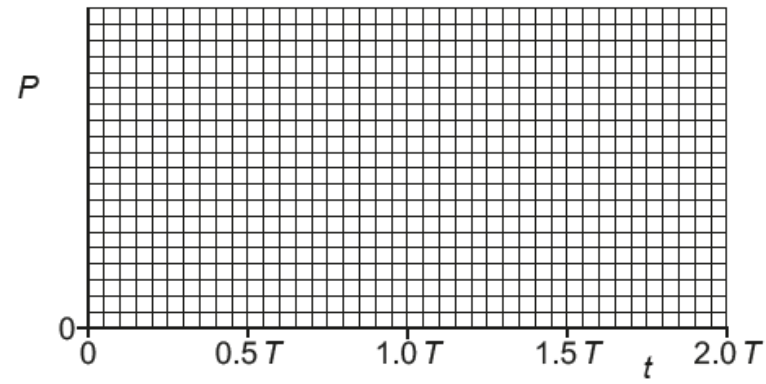


Fig. 7.3

[3]

(c) Use your answer in **(b)** to determine an expression, in terms of I_0 and R, for:

(i) the mean power $\langle P \rangle$ in the resistor

$\langle P \rangle$ = ... [1]

(ii) the root-mean-square (r.m.s.) current $I_{r.m.s.}$ in the resistor.

$I_{r.m.s.}$ = ... [2]

[Total: 8]

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2. Nov/2023/Paper_9702/42/No.4

An electron in a metal rod moves randomly about a mean position. When an alternating voltage is applied to the ends of the rod, the mean position can be considered to oscillate with simple harmonic motion along the axis of the rod. Fig. 4.1 shows the variation with time t of the displacement x of the mean position from a fixed point on the axis of the rod.

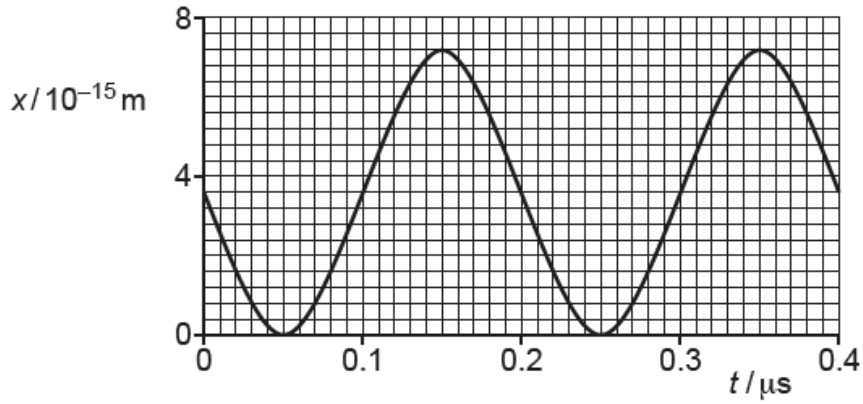


Fig. 4.1

(a) (i) Determine the amplitude of the oscillations.

amplitude = ... m [1]

(ii) Determine the angular frequency of the oscillations.

angular frequency = ... rad s^{-1} [1]

(iii) Use your answers in **(a)(i)** and **(a)(ii)** to show that the maximum drift speed v_0 of the electron is 1.1×10^{-7} m s^{-1}.

[2]

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(b) The rod has a cross-sectional area of $4.3\,cm^2$ and contains a number density of conduction electrons (charge carriers) of $8.5 \times 10^{28}\,m^{-3}$.

All of the conduction electrons in the rod may be assumed to be oscillating in phase with, and with the same amplitude as, the oscillation shown in Fig. 4.1.

(i) Use the information in **(a)(iii)** to calculate the magnitude I_0 of the maximum current in the rod.

I_0 = ...A [2]

(ii) On Fig. 4.2, sketch the variation of the current I in the rod with time t between $t = 0$ and $t = 0.40\,\mu s$.

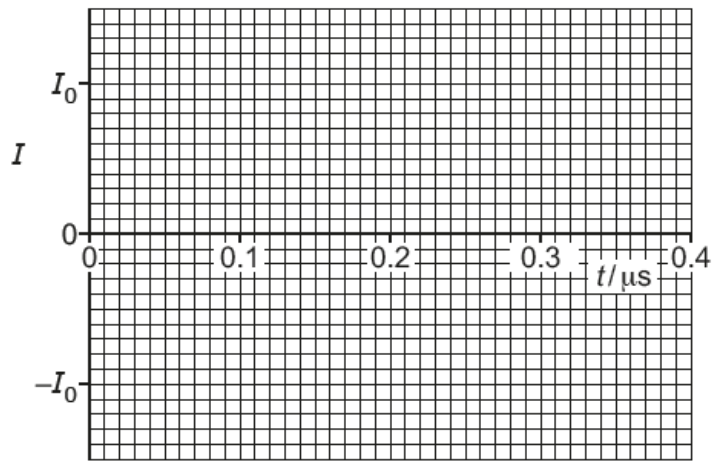


Fig. 4.2

[2]

(iii) Use your answers in **(a)(ii)** and **(b)(i)** to determine an expression for I in terms of t, where I is in A and t is in s.

I = ... [2]

(iv) Determine the root-mean-square (r.m.s.) current in the rod.

r.m.s. current = ...A [1]

[Total: 11]

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3. June/2023/Paper_9702/41/No.5(a, c)

Part of an electric circuit is shown in Fig. 5.1.

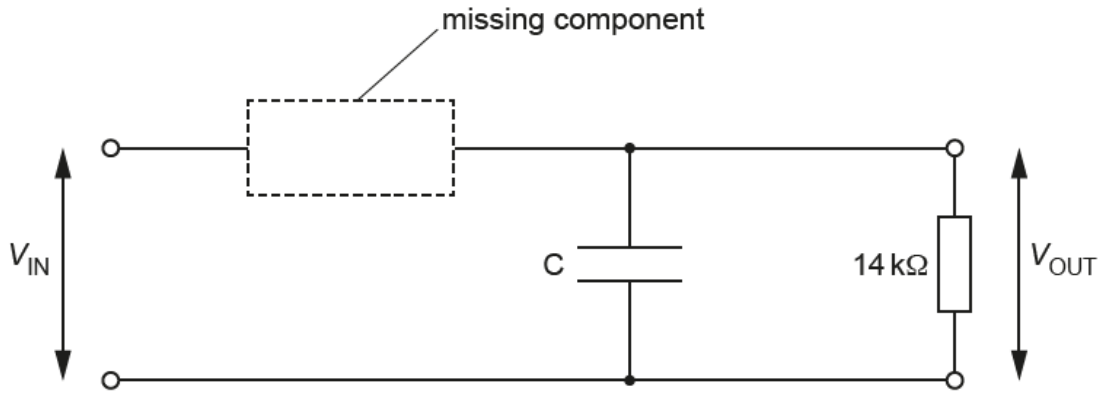


Fig. 5.1

The circuit is used to produce half-wave rectification of an alternating voltage of potential difference (p.d.) V_{IN}.

The output p.d. across the 14 kΩ resistor is V_{OUT}.

(a) (i) A component is missing from the circuit of Fig. 5.1.

Complete the circuit diagram in Fig. 5.1 by adding the circuit symbol for the missing component, correctly connected. [1]

(ii) A capacitor C is shown in the circuit of Fig. 5.1.

State the effect on V_{OUT} of including the capacitor in the circuit.

..... [1]

(c) The circuit of Fig. 5.1 is modified so that it produces full-wave rectification of an input voltage.

Suggest, with a reason, how V_{OUT} now varies with time when V_{IN} is as shown in Fig. 5.2.

.....

.....

..... [2]

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4. June/2023/Paper_9702/42/No.7

Four diodes are used in a bridge rectifier circuit to produce rectification of a sinusoidal a.c. input voltage V_{IN}.
Fig. 7.1 shows part of the circuit, but three of the diodes are missing.

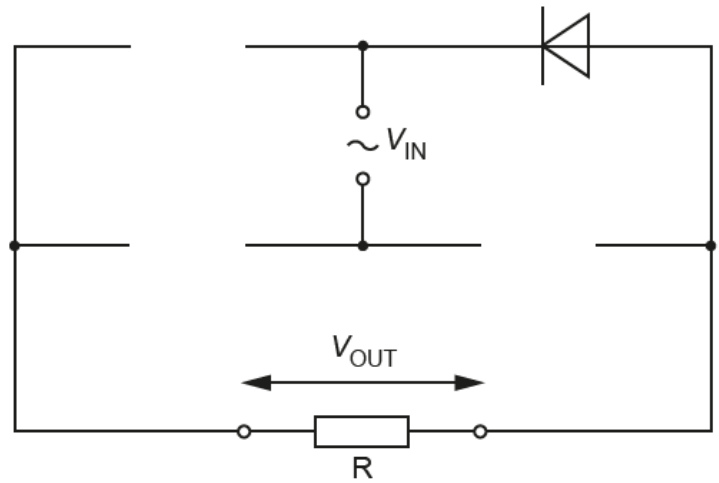


Fig. 7.1

The p.d. across the load resistor R is the output p.d. V_{OUT} of the bridge rectifier.

(a) (i) State the name of the type of rectification produced by a bridge rectifier.

..... [1]

(ii) Complete Fig. 7.1 by drawing the three missing diodes, correctly connected. [2]

(iii) On Fig. 7.1, draw an arrow to indicate the direction of the current in resistor R. [1]

(b) V_{IN} has amplitude V_0 and period T. Fig. 7.2 shows the variation with time t of V_{IN}.

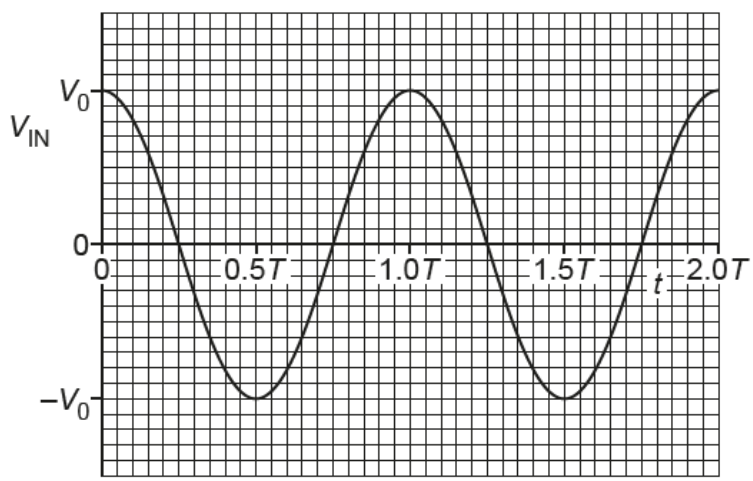


Fig. 7.2

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(i) On Fig. 7.3, sketch the variation of V_{OUT} with t between $t = 0$ and $t = 2.0T$.

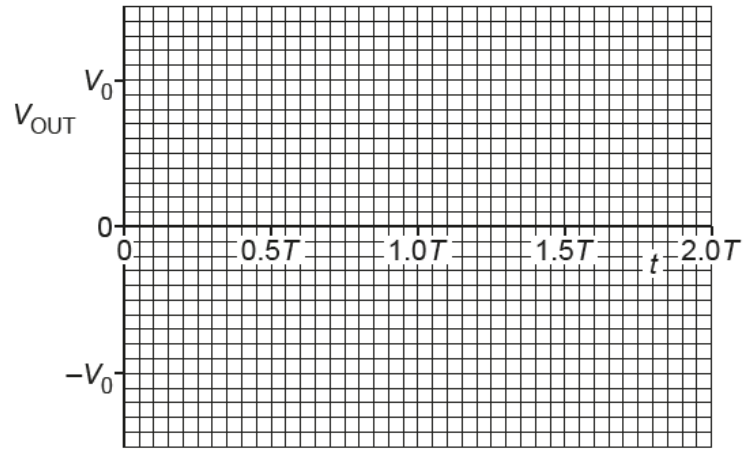


Fig. 7.3

[3]

(ii) The power dissipated in the resistor is P.

On Fig. 7.4, sketch the variation of P with t between $t = 0$ and $t = 2.0T$.

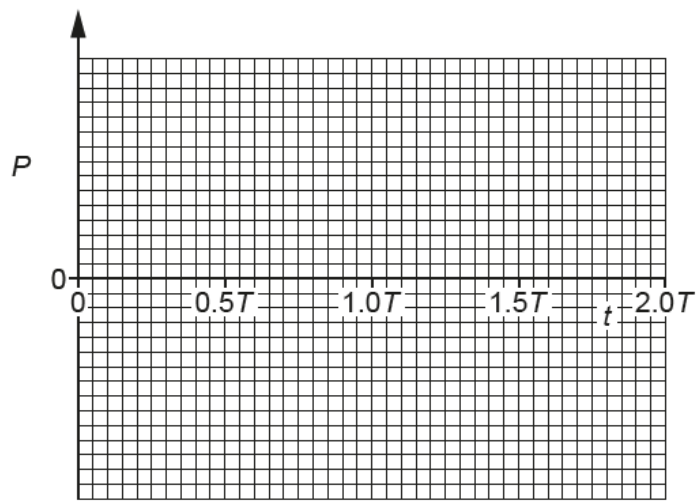


Fig. 7.4

[2]

(iii) Suggest, with a reason, how the root-mean-square (r.m.s.) value of V_{OUT} compares with the r.m.s. value of V_{IN}.

.....

..... [1]

[Total: 10]

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