8 **(a)** A standard 2.0 Ω resistor and a length *x* of a uniform wire are connected in series with a d.c. power supply of e.m.f. *E* and internal resistance *r*, as shown in Fig. 8.1.

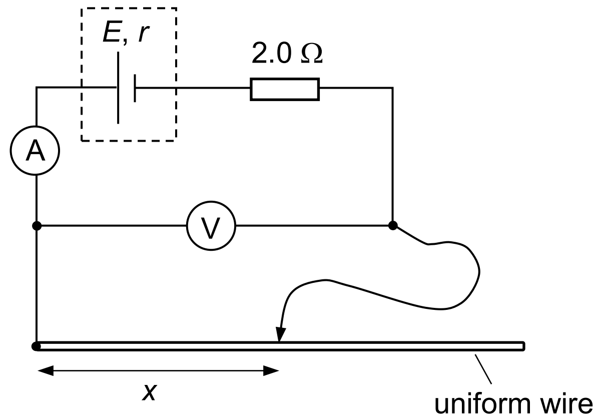

Fig 8.1

Current I and potential difference *V* are measured for different values of *x*.

Fig. 8.2 shows the variation of V with I.

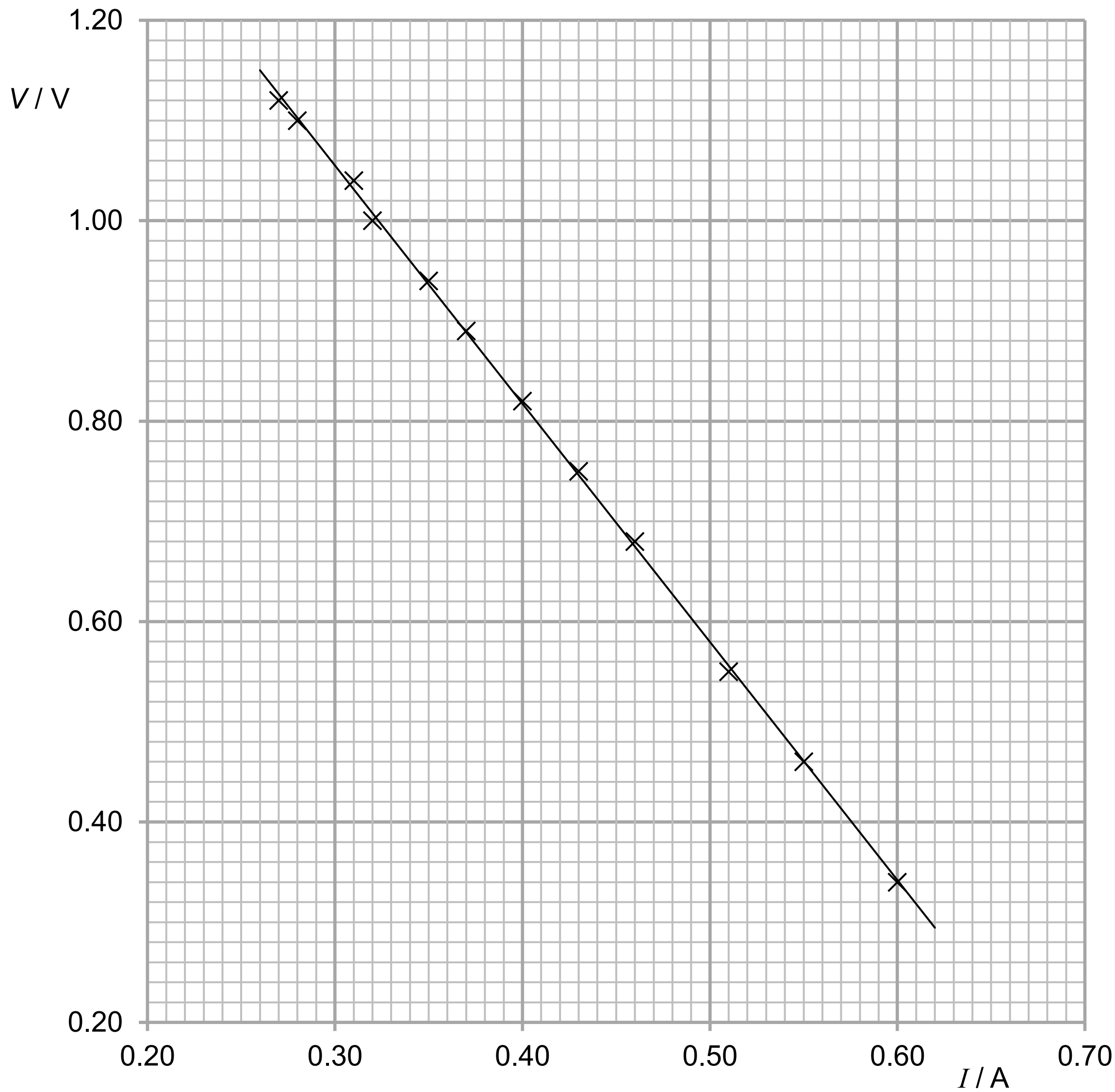

Fig 8.2

(i) Use Fig. 8.2 to determine the internal resistance r of the d.c. source.

r = ... Ω [3]

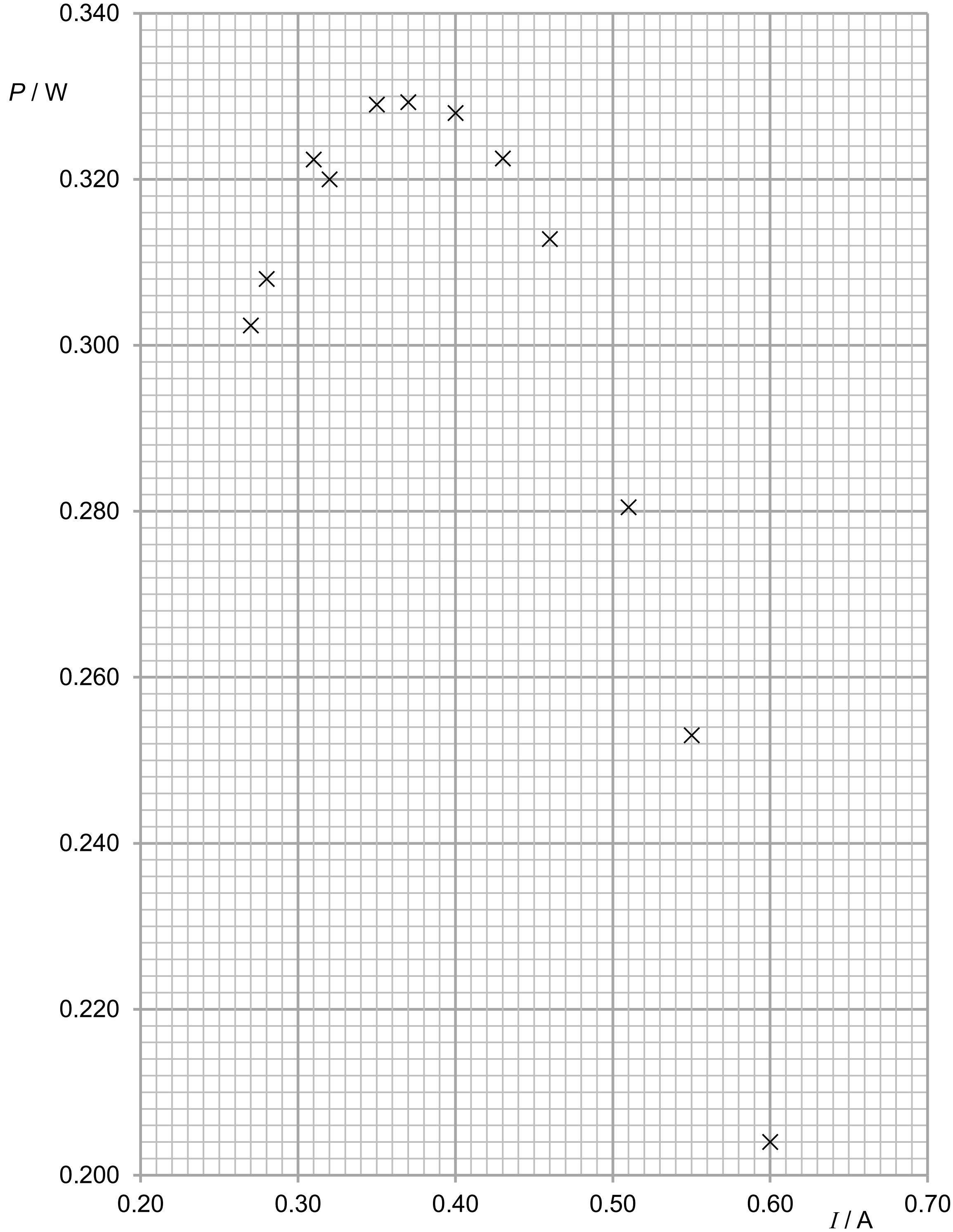

Fig 8.3

Fig. 8.3 shows the variation of the output power *P* in length *x* of the wire, with *I*.

(ii) On Fig. 8.3,

1. draw the best fit line, [1]

2. read off the maximum output power P_o and the corresponding current I_o.

P_o = ... W

I_o = ... A [1]

(iii) The *maximum power transfer theorem* states that maximum power is transferred to a load if the load resistance is equal to the resistance of the source.

Use your answers in **(a)(i)** and **(a)(ii)** to explain whether the experiment results support the theorem.

....

.... [4]

(iv) In an application of the *maximum power transfer theorem* from **(a)(iii)**, a high resistance load (R_L Ω) is to draw power from a very low resistance d.c. source (R_S Ω). In order to 'match' the resistances of the load and the source, another resistor (R Ω) is placed in series with the source so that $R_L = (R_S + R)$.

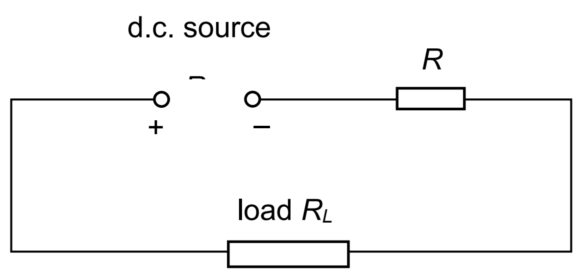

Fig 8.4

1. Show that the efficiency of the power transfer in the load is about 50%.

[2]

2. Explain why this is not an efficient arrangement to 'match' the resistances of the load and the source.

....

.... [1]

(b) Fig. 8.5 shows an a.c. source of resistance r_S connected across the primary coil of an ideal transformer. A load resistance r_L is connected across the secondary coil. There are N_p turns in the primary coil, and N_s turns in the secondary coil.

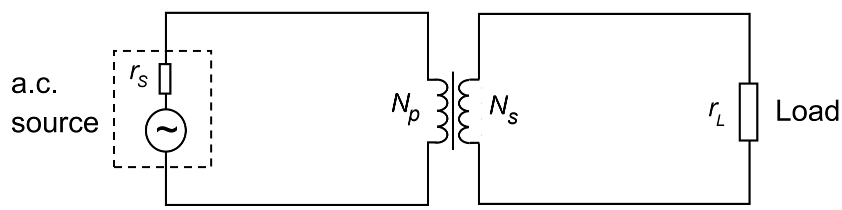

Fig 8.5

This circuit is equivalent to a circuit in which a single resistance r_E is connected directly across the a.c. source without the transformer, as illustrated in Fig. 8.6.

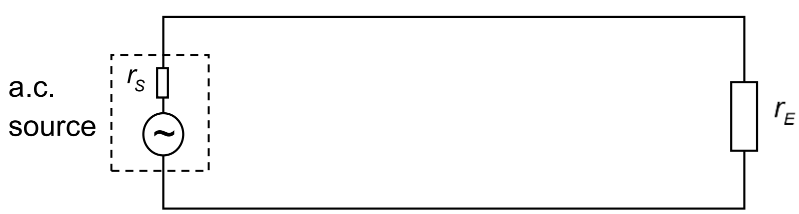

Fig 8.6

(i) Use the principle of conservation of energy to show that $r_E = \left(\frac{N_P}{N_S}\right)^2 r_L$.

[2]

(ii) The *maximum power transfer theorem* in **(a)** can also be applied to an a.c. circuit. Maximum transfer of power from the source to the load occurs when the load resistance is equal to the source resistance. If the load resistance is not equal to the source resistance, a transformer can be used to make the load resistance appear to the source as a larger or smaller resistance than what it actually is, thus achieving the desired 'resistance matching'. The setup of the circuit is similar to Fig. 8.5.

In one such application, an audio amplifier of resistance $r_S = 1000\,\Omega$ is an a.c. source that powers a speaker of resistance $r_L = 10\,\Omega$. Calculate the ratio

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

ratio = ... [2]

(c) Electrical devices do not function properly if they overheat. They can be cooled down through having good thermal contact with a heat sink, as shown in Fig. 8.7.

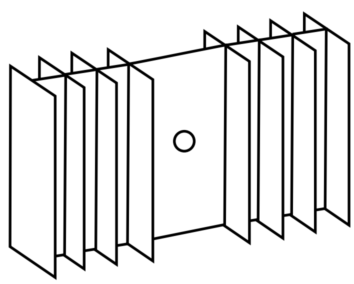

Fig 8.7

(i) Suggest why this is called a heat sink.

....

.... [1]

(ii) Suggest what *good thermal contact* with the heat sink means.

....

.... [1]

(iii) Identify the main means of heat transfer from the electrical device to the air outside the device.

....

.... [2]

[Total: 20]

END OF PAPER