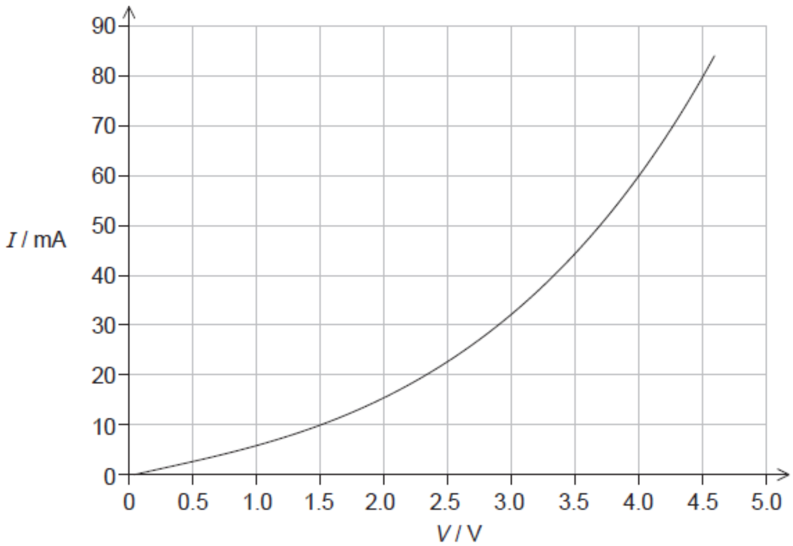
Red 2 [most common] *[85 marks]*

The graph shows how current I varies with potential difference V across a component X.



1a. Outline why component X is considered non-ohmic. *[1 mark]*

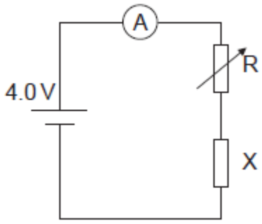
. . . .

. . . .

. . . .

Component X and a cell of negligible internal resistance are placed in a circuit.

A variable resistor R is connected in series with component X. The ammeter reads 20 mA.



1b. Determine the resistance of the variable resistor. *[3 marks]*

....

....

....

....

....

....

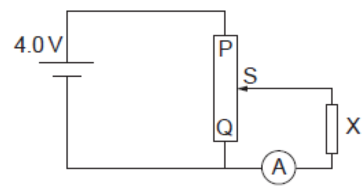
1c. Calculate the power dissipated in the circuit. *[1 mark]*

....

....

....

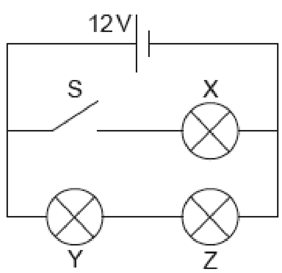
Component X and the cell are now placed in a potential divider circuit.



1d. State the range of current that the ammeter can measure as the slider S of the potential divider is moved from Q to P. *[1 mark]*

1e. Describe, by reference to your answer for (c)(i), the advantage of the potential divider arrangement over the arrangement in (b). *[2 marks]*

Three identical light bulbs, X, Y and Z, each of resistance 4.0 Ω are connected to a cell of emf 12 V. The cell has negligible internal resistance.



2a. The switch S is initially open. Calculate the total power dissipated in the circuit. *[2 marks]*

2b. The switch is now closed. State, without calculation, why the current in the cell will increase. *[1 mark]*

. . . .

. . . .

. . . .

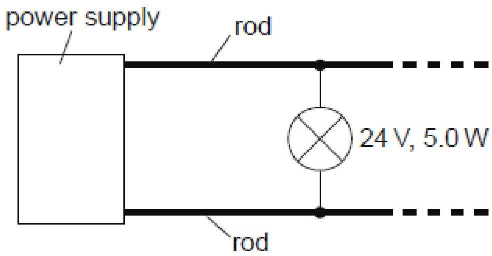
2c. The switch is now closed. Deduce the ratio $\frac{\text{power dissipated in Y with S open}}{\text{power dissipated in Y with S closed}}$. *[2 marks]*

. . . .

. . . .

. . . .

A lighting system consists of two long metal rods with a potential difference maintained between them. Identical lamps can be connected between the rods as required.



The following data are available for the lamps when at their working temperature.

Lamp specifications 24 V, 5.0 W

Power supply emf 24 V

Power supply maximum current 8.0 A

Length of each rod 12.5 m

Resistivity of rod metal $7.2 \times 10^{-7}\ \Omega\,m$

3a. Each rod is to have a resistance no greater than 0.10 Ω. Calculate, in m, the minimum radius of each rod. Give your answer to an appropriate number of significant figures. *[3 marks]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

3b. Calculate the maximum number of lamps that can be connected between the rods. Neglect the resistance of the rods. *[2 marks]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

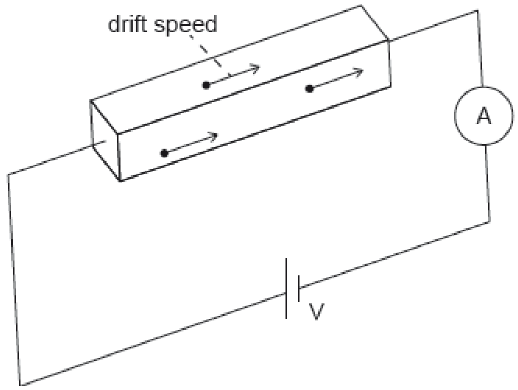
3c. One advantage of this system is that if one lamp fails then the other lamps in the circuit remain lit. Outline **one** other electrical advantage of this system compared to one in which the lamps are connected in series. *[1 mark]*

. . . .

. . . .

. . . .

An ohmic conductor is connected to an ideal ammeter and to a power supply of output voltage V.



The following data are available for the conductor:

density of free electrons = 8.5×10^{22} cm^{-3}

resistivity $\rho = 1.7 \times 10^{-8}$ Ωm

dimensions w × h × l = 0.020 cm × 0.020 cm × 10 cm.

The ammeter reading is 2.0 A.

4a. Calculate the resistance of the conductor. *[2 marks]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

4b. Calculate the drift speed *v* of the electrons in the conductor in cm s^{-1}. *[3 marks]*
State your answer to an appropriate number of significant figures.

. . . .

. . . .

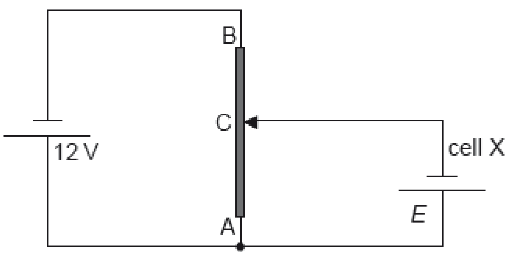
. . . .

. . . .

. . . .

. . . .

The diagram shows a potential divider circuit used to measure the emf *E* of a cell X. Both cells have negligible internal resistance.



5a. State what is meant by the emf of a cell. *[2 marks]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

AB is a wire of uniform cross-section and length 1.0 m. The resistance of wire AB is 80 Ω. When the length of AC is 0.35 m the current in cell X is zero.

5b. Show that the resistance of the wire AC is 28 Ω. *[2 marks]*

....

....

....

....

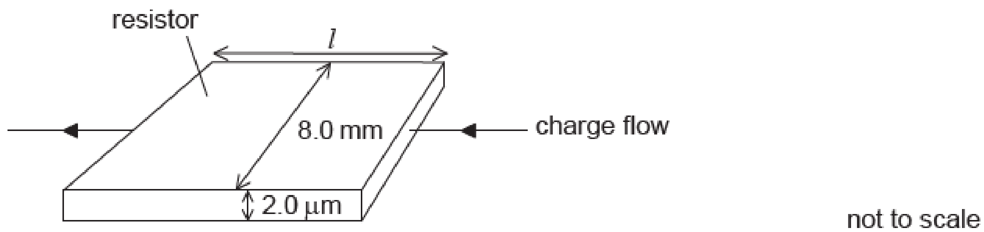
....

....

5c. Determine *E*. *[2 marks]*

Electrical resistors can be made by forming a thin film of carbon on a layer of an insulating material.

A carbon film resistor is made from a film of width 8.0 mm and of thickness 2.0 µm. The diagram shows the direction of charge flow through the resistor.



6a. The resistance of the carbon film is 82 Ω. The resistivity of carbon is 4.1 x 10^{-5} Ω m. Calculate the length *l* of the film. *[1 mark]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

6b. The film must dissipate a power less than 1500 W from each square metre of its surface to avoid damage. Calculate the maximum allowable current for the resistor. *[2 marks]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

6c. State why knowledge of quantities such as resistivity is useful to scientists. *[1 mark]*

. . . .

. . . .

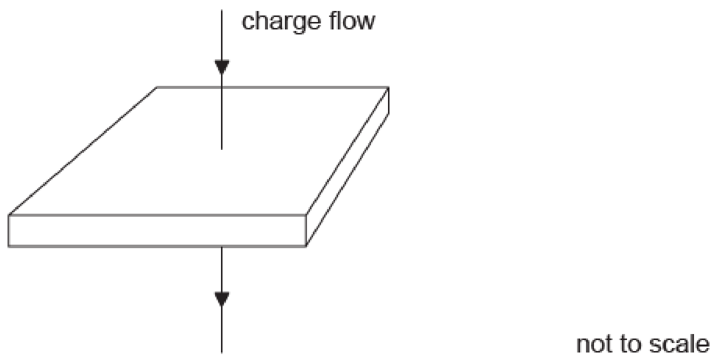
. . . .

. . . .

. . . .

. . . .

6d. The current direction is now changed so that charge flows vertically through the film. *[2 marks]*



Deduce, without calculation, the change in the resistance.

. . . .

. . . .

. . . .

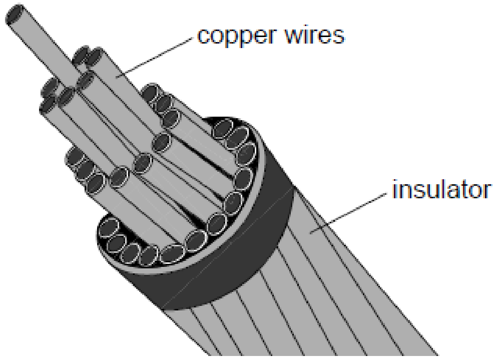
. . . .

. . . .

. . . .

6e. Draw a circuit diagram to show how you could measure the resistance of the carbon-film resistor using a potential divider arrangement to limit the potential difference across the resistor. *[2 marks]*

A cable consisting of many copper wires is used to transfer electrical energy from a generator to an electrical load. The copper wires are protected by an insulator.



7a. The copper wires and insulator are both exposed to an electric field. Discuss, with reference to charge carriers, why there is a significant electric current only in the copper wires. *[3 marks]*

....

....

....

....

....

....

The cable consists of 32 copper wires each of length 35 km. Each wire has a resistance of 64 Ω. The resistivity of copper is 1.7×10^{-8} Ω m.

7b. Calculate the radius of each **wire**. *[2 marks]*

....

....

....

....

....

....

7c. There is a current of 730 A in the cable. Show that the power loss in 1 m of the cable is about 30 W. *[2 marks]*

....

....

....

....

....

....

7d. When the current is switched on in the cable the initial rate of rise of temperature of the cable is 35 mK s^{-1}. The specific heat capacity of copper is 390 J kg^{-1} K^{-1}. Determine the mass of a length of one metre of the cable. *[2 marks]*

....

....

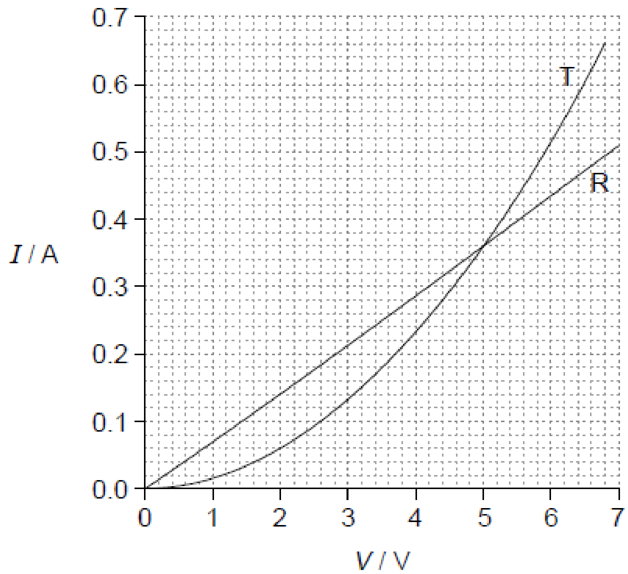
....

....

....

....

The graph shows how current *I* varies with potential difference *V* for a resistor R and a non-ohmic component T.



8a. (i) State how the resistance of T varies with the current going through T. *[3 marks]*

(ii) Deduce, without a numerical calculation, whether R **or** T has the greater resistance at I=0.40 A.

. . . .

. . . .

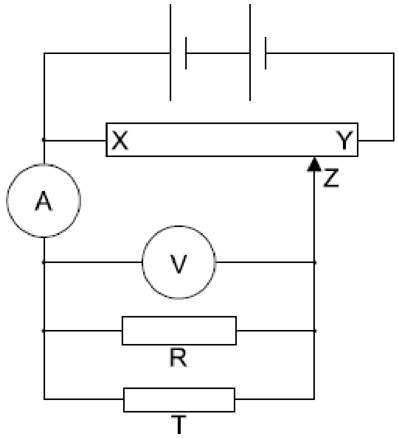
. . . .

. . . .

. . . .

. . . .

8b. Components R and T are placed in a circuit. Both meters are ideal. *[3 marks]*



Slider Z of the potentiometer is moved from Y to X.

(i) State what happens to the magnitude of the current in the ammeter.

(ii) Estimate, with an explanation, the voltmeter reading when the ammeter reads 0.20 A.

....

....

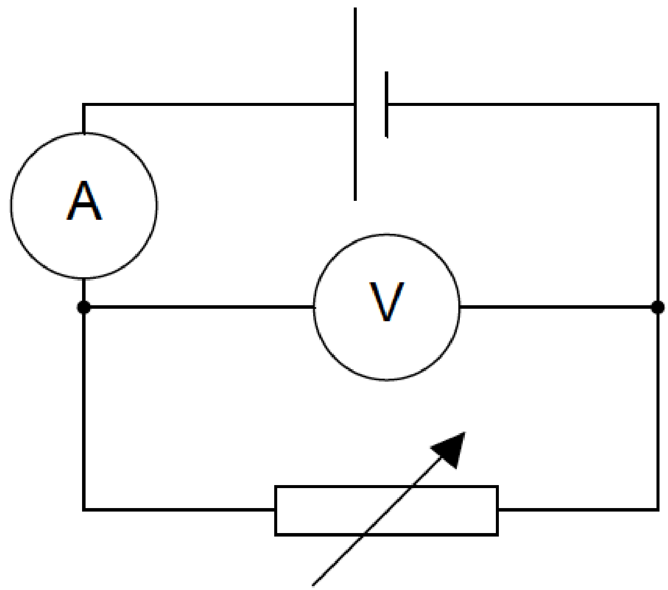
....

....

....

....

In an experiment a student constructs the circuit shown in the diagram. The ammeter and the voltmeter are assumed to be ideal.



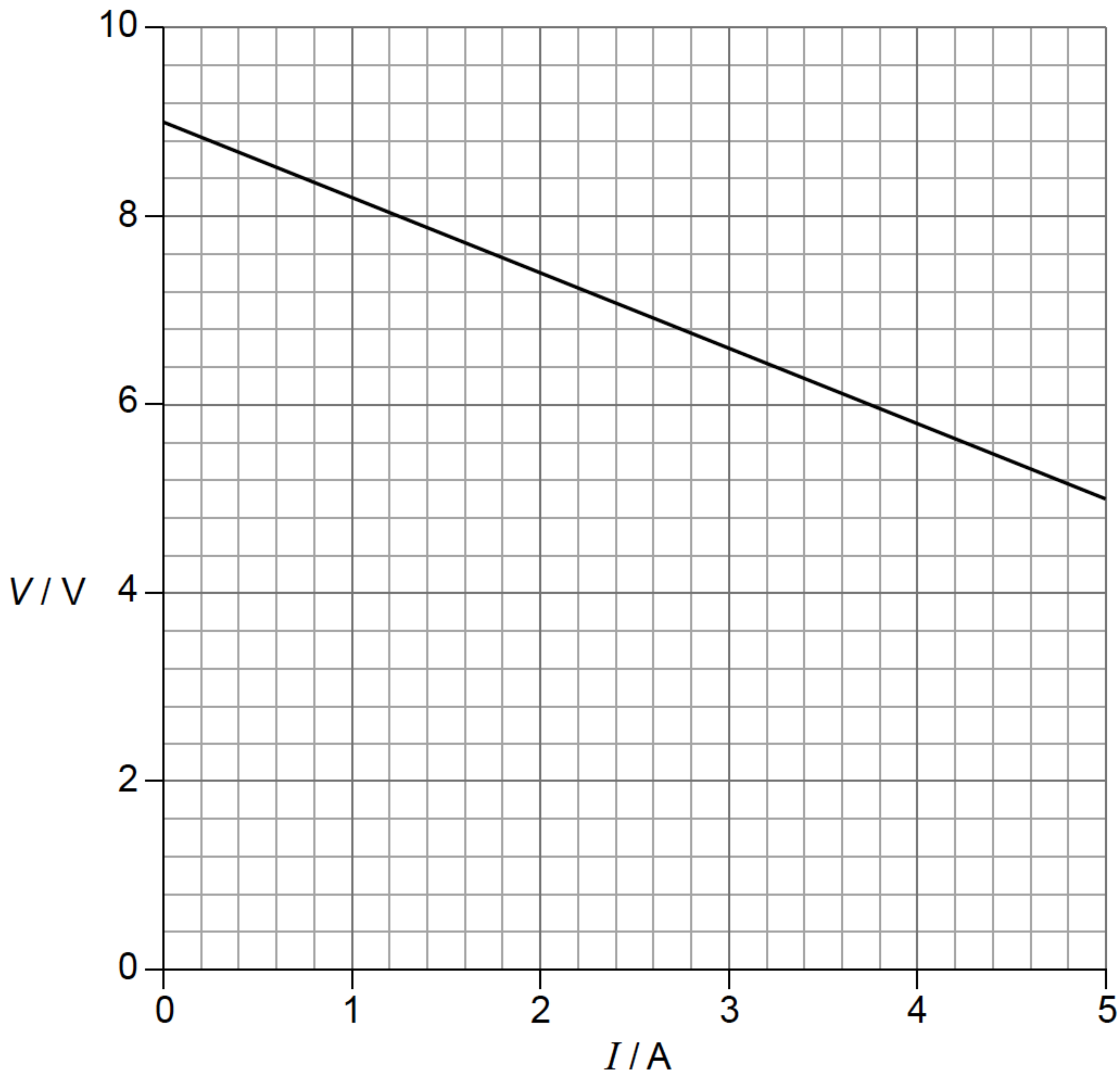
9a. State what is meant by an ideal voltmeter. *[1 mark]*

....

....

....

9b. The student adjusts the variable resistor and takes readings from the ammeter and voltmeter. The graph shows the variation of the voltmeter reading V with the ammeter reading I. *[3 marks]*



Use the graph to determine

(i) the electromotive force (emf) of the cell.

(ii) the internal resistance of the cell.

....

....

....

....

....

....

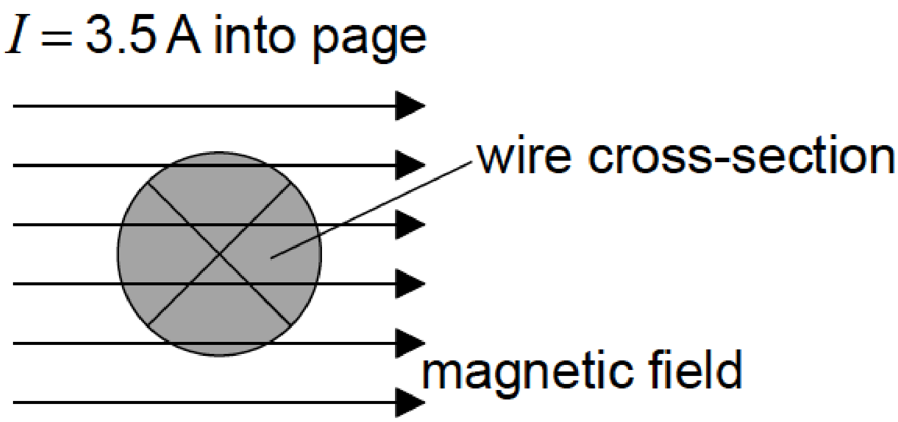
9c. A connecting wire in the circuit has a radius of 1.2mm and the current in it is 3.5A. The number of electrons per unit volume of the wire is $2.4\times10^{28}m^{-3}$. Show that the drift speed of the electrons in the wire is $2.0\times10^{-4}ms^{-1}$. *[1 mark]*

. . . .

. . . .

. . . .

9d. The diagram shows a cross-sectional view of the connecting wire in (c). *[2 marks]*



The wire which carries a current of 3.5A into the page, is placed in a region of uniform magnetic field of flux density 0.25T. The field is directed at right angles to the wire.

Determine the magnitude **and** direction of the magnetic force on one of the charge carriers in the wire.

. . . .

. . . .

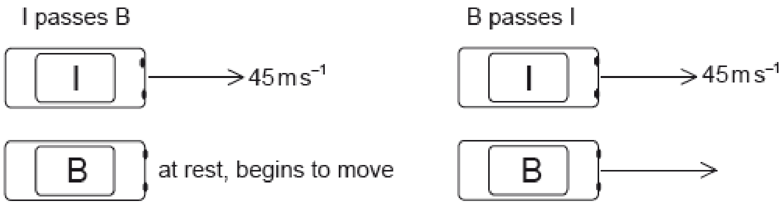
. . . .

This question is in **two** parts. **Part 1** is about kinematics and Newton’s laws of motion.

Part 2 is about electrical circuits.

Part 1 Kinematics and Newton’s laws of motion

Cars I and B are on a straight race track. I is moving at a constant speed of $45\ \mathrm{m\,s^{-1}}$ and B is initially at rest. As I passes B, B starts to move with an acceleration of $3.2\ \mathrm{m\,s^{-2}}$.



At a later time B passes I. You may assume that both cars are point particles.

10a. Show that the time taken for B to pass I is approximately 28 s. *[4 marks]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

10b. Calculate the distance travelled by B in this time. *[2 marks]*

....

....

....

....

....

....

10c. B slows down while I remains at a constant speed. The driver in each car wears a seat belt. Using Newton’s laws of motion, explain the difference in the tension in the seat belts of the two cars. *[3 marks]*

....

....

....

....

....

....

A third car O with mass 930 kg joins the race. O collides with I from behind, moving along the same straight line as I. Before the collision the speed of I is $45\ \mathrm{m\,s^{-1}}$ and its mass is 850 kg. After the collision, I and O stick together and move in a straight line with an initial combined speed of $52\ \mathrm{m\,s^{-1}}$.

10d. Calculate the speed of O immediately before the collision. *[2 marks]*

....

....

....

....

....

....

10e. The duration of the collision is 0.45 s. Determine the average force acting on O. *[2 marks]*

....

....

....

....

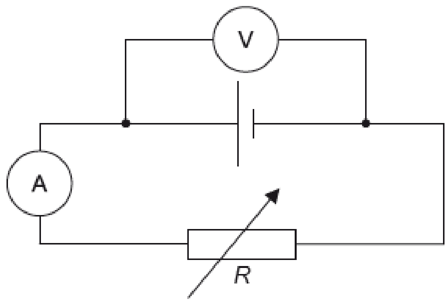
....

....

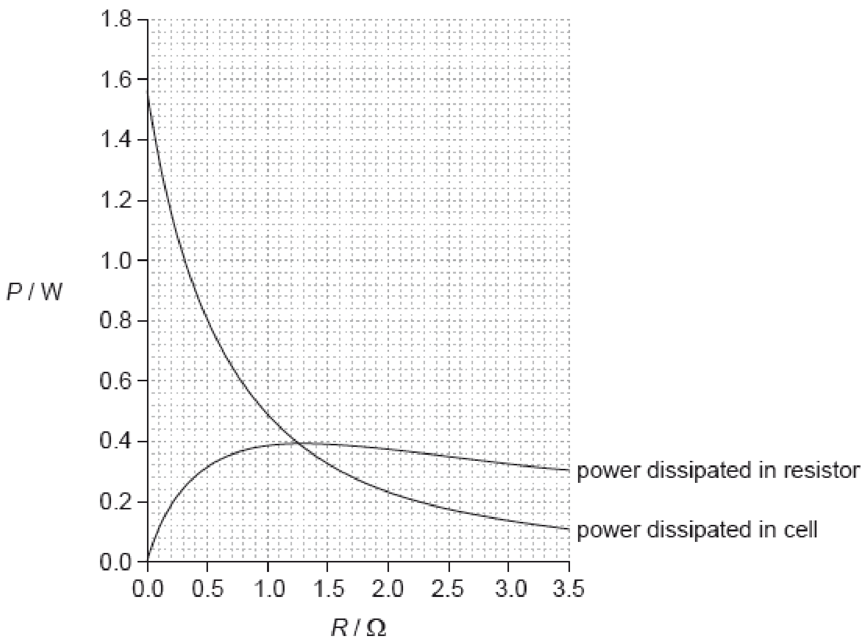
This question is in **two** parts. **Part 1** is about kinematics and Newton's laws of motion.

Part 2 Electrical circuits

The circuit shown is used to investigate how the power developed by a cell varies when the load resistance R changes.



The variable resistor is adjusted and a series of current and voltage readings are taken. The graph shows the variation with R of the power dissipated in the cell and the power dissipated in the variable resistor.



10f. An ammeter and a voltmeter are used to investigate the characteristics of a variable resistor of resistance R. State how the resistance of the ammeter and of the voltmeter compare to R so that the readings of the instruments are reliable. *[2 marks]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

10g. Show that the current in the circuit is approximately 0.70 A when $R = 0.80\ \Omega$. *[3 marks]*

....

....

....

....

....

....

The cell has an internal resistance.

10h. Outline what is meant by the internal resistance of a cell. *[2 marks]*

....

....

....

....

....

....

10i. Determine the internal resistance of the cell. *[3 marks]*

....

....

....

....

....

....

10j. Calculate the electromotive force (emf) of the cell. *[2 marks]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .