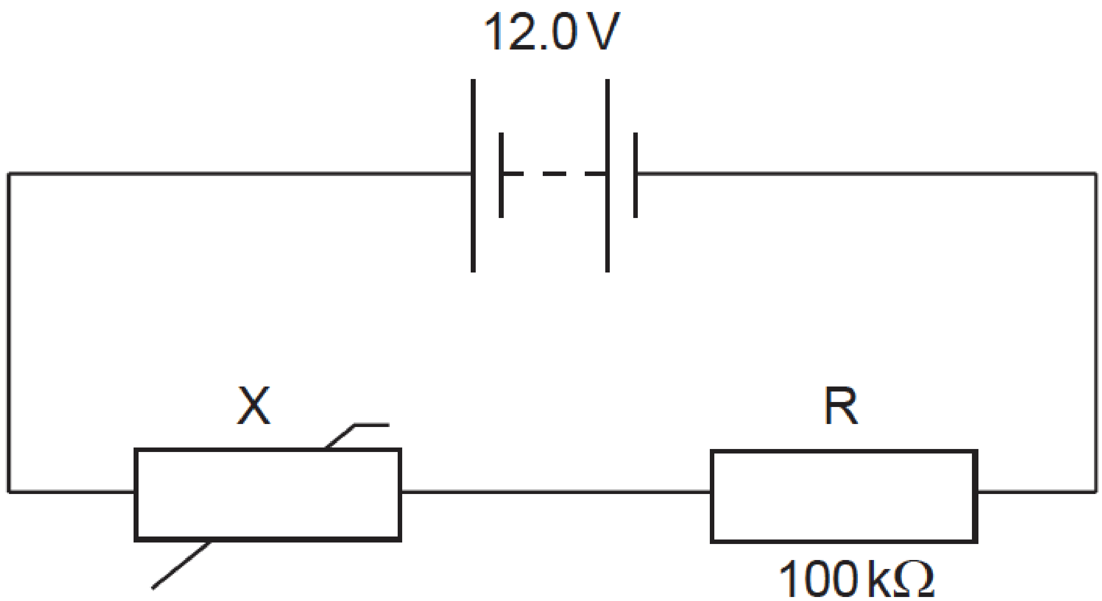
Electricity-practice-2-ShortA

[265 marks]

This question is in two parts. Part 1 is about a thermistor circuit. Part 2 is about vibrations and waves.

Part 1 Thermistor circuit
The circuit shows a negative temperature coefficient (NTC) thermistor X and a 100 kΩ fixed resistor R connected across a battery.



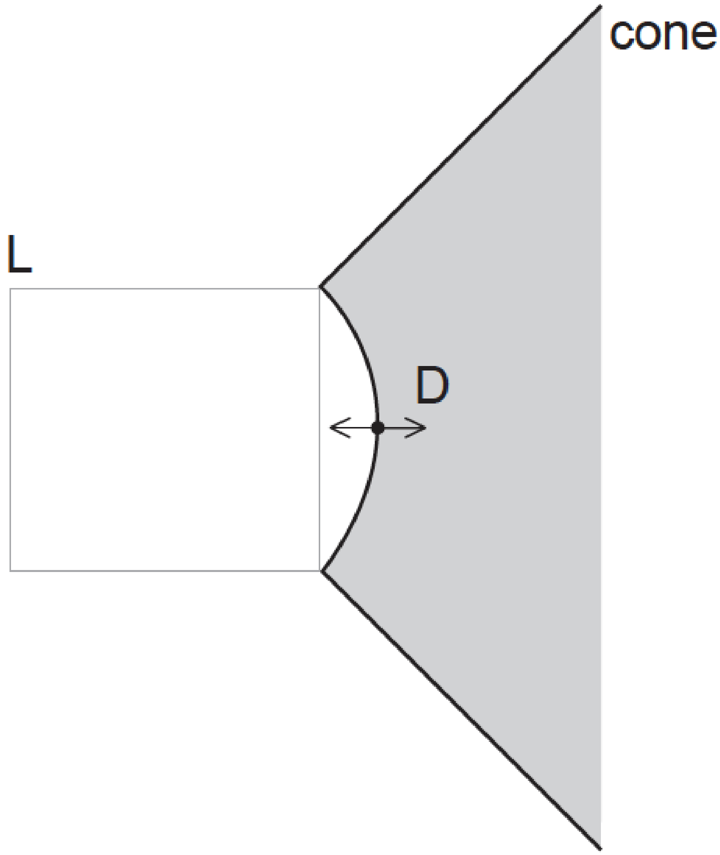
The battery has an electromotive force (emf) of 12.0 V and negligible internal resistance.

1a. (i) Define *electromotive force (emf)*. *[2 marks]*

(ii) State how the emf of the battery can be measured.

Part 2 Vibrations and waves

The cone and dust cap D of a loudspeaker L vibrates with a frequency of 1.25 kHz with simple harmonic motion (SHM).



1b. Define *simple harmonic motion (SHM)*. *[2 marks]*

1c. D has mass 6.5×10^{-3} kg and vibrates with amplitude 0.85 mm. *[4 marks]*

(i) Calculate the maximum acceleration of D.

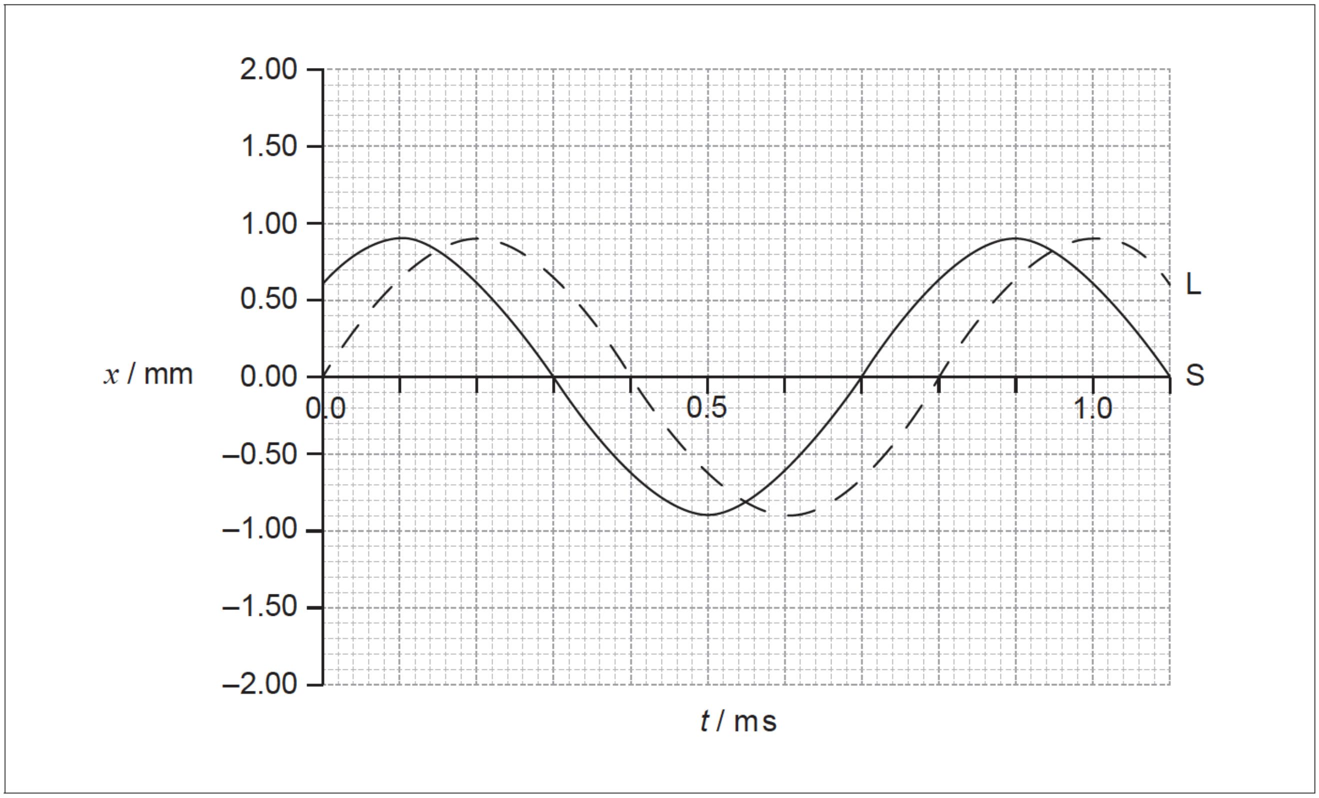
(ii) Determine the total energy of D.

1d. The sound waves from the loudspeaker travel in air with speed 330 ms^{-1}. *[2 marks]*

(i) Calculate the wavelength of the sound waves.

(ii) Describe the characteristics of sound waves in air.

1e. A second loudspeaker S emits the same frequency as L but vibrates out of phase with L. The graph below shows the variation with time *t* of the displacement *x* of the waves emitted by S and L. *[6 marks]*



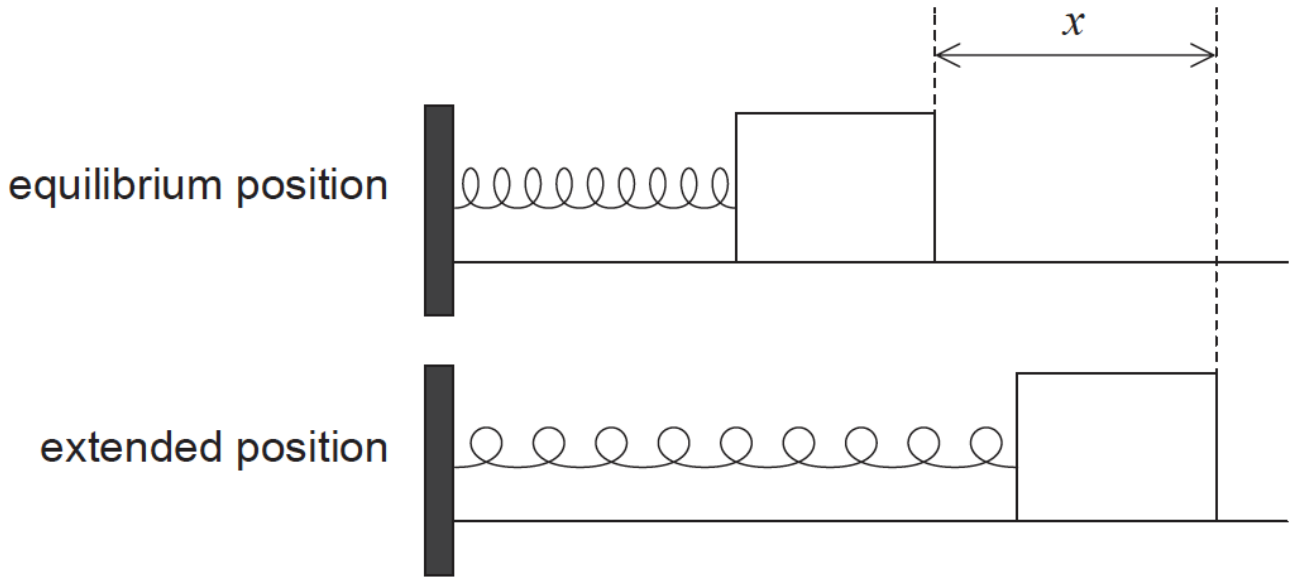
(i) Deduce the relationship between the phase of L and the phase of S.

(ii) On the graph, sketch the variation with *t* of *x* for the wave formed by the superposition of the two waves.

This question is in two parts. **Part 1** is about simple harmonic motion (SHM). **Part 2** is about current electricity.

Part 1 Simple harmonic motion (SHM)

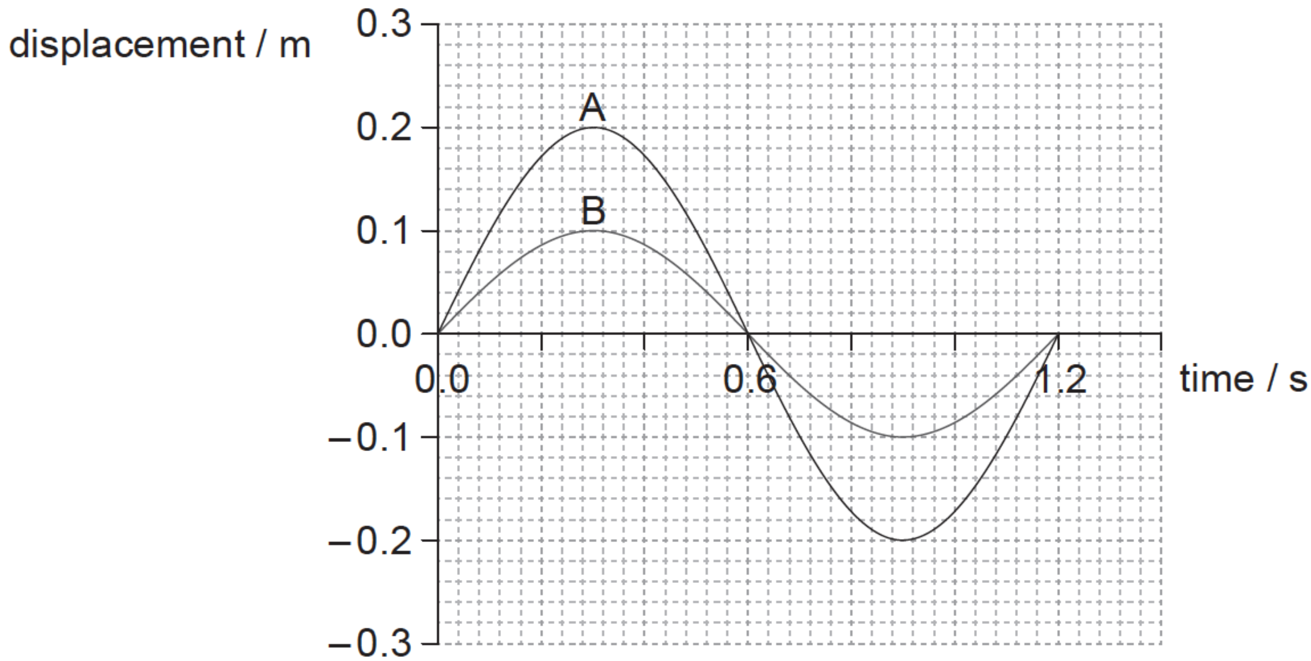
An object is placed on a frictionless surface. The object is attached by a spring fixed at one end and oscillates at the end of the spring with simple harmonic motion (SHM).



The tension F in the spring is given by $F = k\,x$ where x is the extension of the spring and k is a constant.

2a. Show that $\omega^2 = \frac{k}{m}$. *[2 marks]*

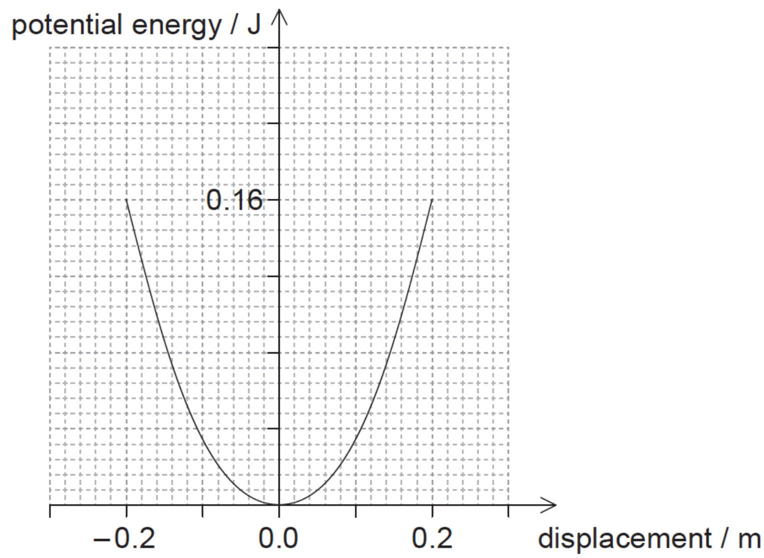
2b. One cycle of the variation of displacement with time is shown for two separate mass–spring systems, A and B. *[3 marks]*



(i) Calculate the frequency of the oscillation of A.

(ii) The springs used in A and B are identical. Show that the mass in A is equal to the mass in B.

2c. The graph shows the variation of the potential energy of A with displacement. *[5 marks]*



On the axes,

(i) draw a graph to show the variation of kinetic energy with displacement for the mass in A. Label this A.

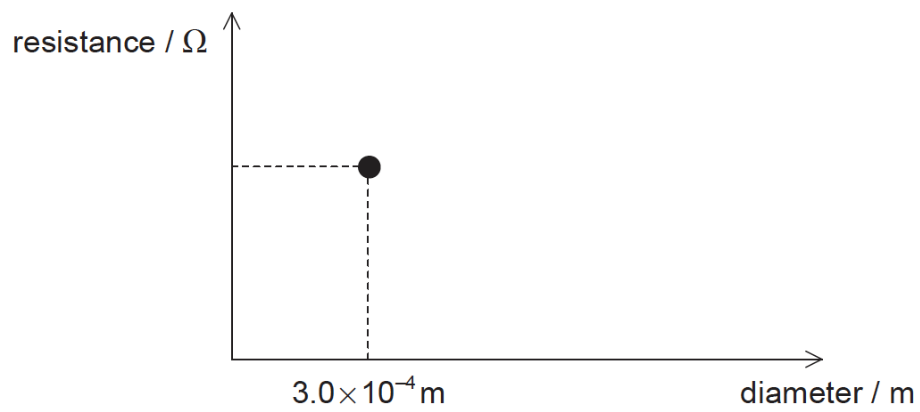
(ii) sketch a graph to show the variation of kinetic energy with displacement for the mass in B. Label this B.

Part 2 Current electricity

2d. A 24 Ω resistor is made from a conducting wire. *[4 marks]*

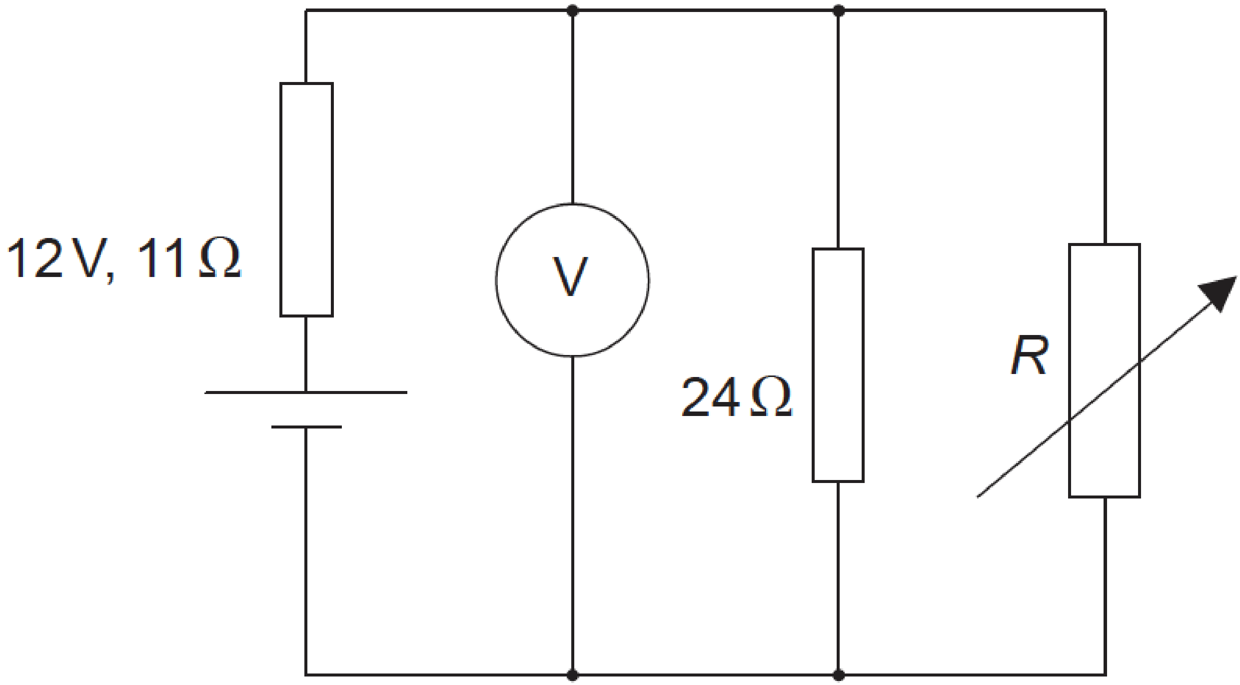
(i) The diameter of the wire is 0.30 mm and the wire has a resistivity of 1.7×10^{-8} Ωm. Calculate the length of the wire.

(ii) On the axes, draw a graph to show how the resistance of the wire in (d)(i) varies with the diameter of the wire when the length is constant. The data point for the diameter of 0.30 mm has already been plotted for you.



2e. The 24 Ω resistor is covered in an insulating material. Explain the reasons for the differences between the electrical properties of the insulating material and the electrical properties of the wire. *[3 marks]*

2f. An electric circuit consists of a supply connected to a 24Ω resistor in parallel with a variable resistor of resistance *R*. The supply has an emf of 12V and an internal resistance of 11Ω. *[8 marks]*



Power supplies deliver maximum power to an external circuit when the resistance of the external circuit equals the internal resistance of the power supply.

(i) Determine the value of *R* for this circuit at which maximum power is delivered to the external circuit.

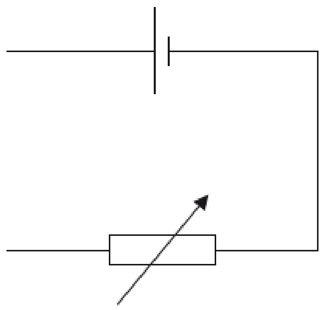
(ii) Calculate the reading on the voltmeter for the value of *R* you determined in (f)(i).

(iii) Calculate the total power dissipated in the circuit when the maximum power is being delivered to the external circuit.

This question is about the internal resistance of a cell.

3a. Define *electromotive force (emf)*. *[1 mark]*

A circuit is used to determine the internal resistance and emf of a cell. It consists of the cell, a variable resistor, an ideal ammeter and an ideal voltmeter. The diagram shows part of the circuit with the ammeter and voltmeter missing.



The variable resistor is set to $1.5\ \Omega$. When the cell converts 7.2 mJ of energy, 5.8 mC of charge moves completely around the circuit. The potential difference across the variable resistor is 0.55 V.

3b. Draw on the diagram the positions of the ammeter and voltmeter. *[1 mark]*

3c. Show that the emf of the cell is 1.25 V. *[1 mark]*

3d. Determine the internal resistance of the cell. *[2 marks]*

3e. Calculate the energy dissipated per second in the variable resistor. *[2 marks]*

This question is in **two** parts. **Part 1** is about energy resources. **Part 2** is about electric fields.

Part 1 Energy resources

4a. The Sun is a renewable energy source whereas a fossil fuel is a non-renewable energy source. Outline the difference between renewable and non-renewable energy sources. *[2 marks]*

4b. With reference to the energy transformations and the operation of the devices, distinguish between a photovoltaic cell and a solar heating panel. *[2 marks]*

A photovoltaic panel is made up of a collection (array) of photovoltaic cells. The panel has a total area of $1.3\ \mathrm{m}^2$ and is mounted on the roof of a house. The maximum intensity of solar radiation at the location of the panel is $750\ \mathrm{W\,m}^{-2}$. The panel produces a power output of 210 W when the solar radiation is at its maximum intensity.

4c. Determine the efficiency of the photovoltaic panel. *[2 marks]*

4d. State **two** reasons why the intensity of solar radiation at the location of the panel is not constant. *[2 marks]*

1.

2.

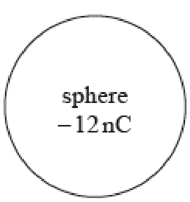
The owner of the house chooses between photovoltaic panels and solar heating panels to provide 4.2 kW of power to heat water. The solar heating panels have an efficiency of 70%. The maximum intensity of solar radiation at the location remains at $750\ \mathrm{W\,m}^{-2}$.

4e. Calculate the minimum area of solar heating panel required to provide this power. *[2 marks]*

4f. Comment on whether it is better to use a solar heating panel rather than an array of photovoltaic panels for the house. Do not consider the installation cost of the panels in your answer. *[2 marks]*

Part 2 Electric fields

An isolated metal sphere is placed in a vacuum. The sphere has a negative charge of magnitude 12 nC.

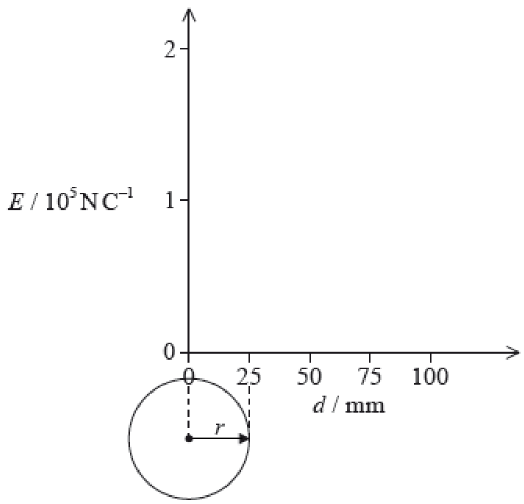


4g. Using the diagram, draw the electric field pattern due to the charged sphere. *[2 marks]*

Outside the sphere, the electric field strength is equivalent to that of a point negative charge of magnitude 12 nC placed at the centre of the sphere. The radius r of the sphere is 25 mm.

4h. Show that the magnitude of the electric field strength at the surface of the sphere is about $2 \times 10^5\ \mathrm{N\,C^{-1}}$. *[2 marks]*

4i. On the axes, draw a graph to show the variation of the electric field strength E with distance d from the centre of the sphere. *[2 marks]*



An electron is initially at rest on the surface of the sphere.

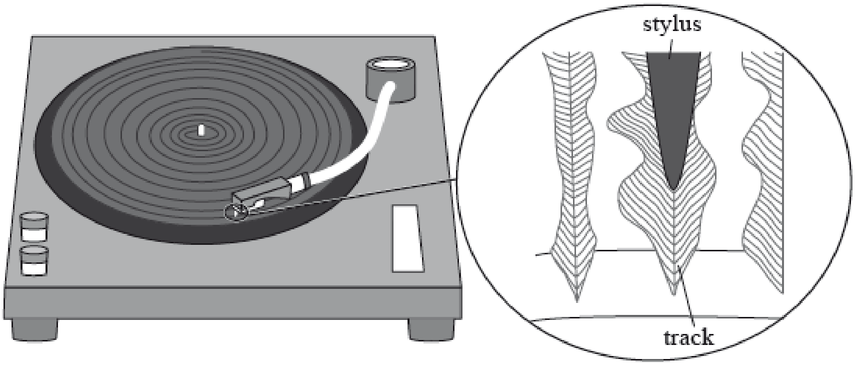
4j. Calculate the initial acceleration of the electron. *[2 marks]*

4k. Discuss the subsequent motion of the electron. *[2 marks]*

This question is in **two** parts. **Part 1** is about simple harmonic motion (SHM) and sound. **Part 2** is about electric and magnetic fields.

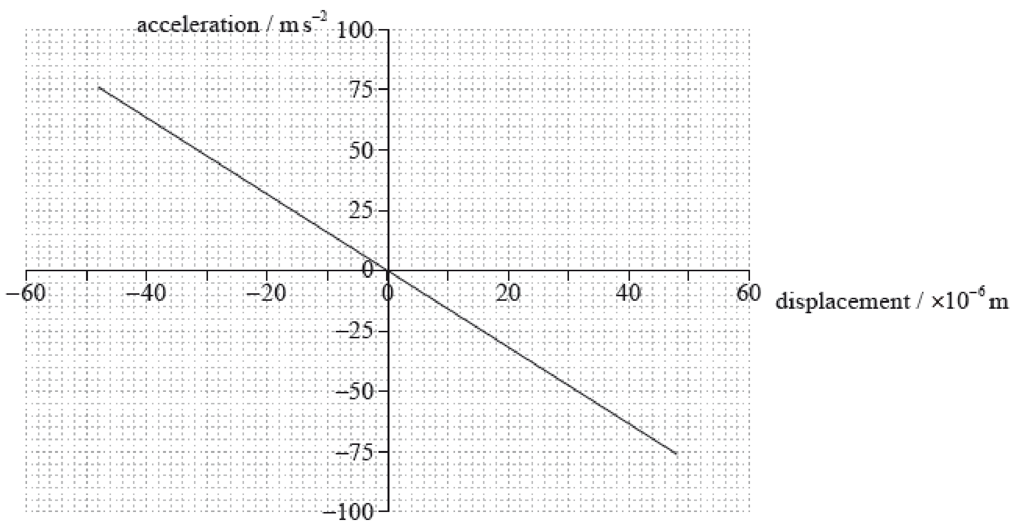
Part 1 Simple harmonic motion (SHM) and sound

The diagram shows a section of continuous track of a long-playing (LP) record. The stylus (needle) is placed in the track of the record.



As the LP record rotates, the stylus moves because of changes in the width and position of the track. These movements are converted into sound waves by an electrical system and a loudspeaker.

A recording of a single-frequency musical note is played. The graph shows the variation in horizontal acceleration of the stylus with horizontal displacement.



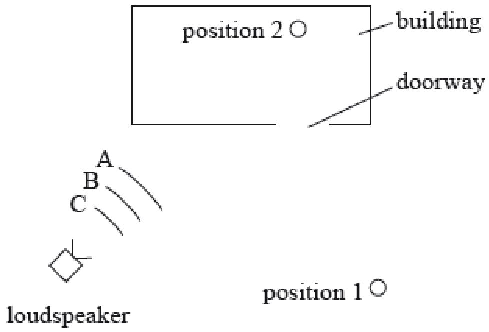
5a. Explain why the graph shows that the stylus undergoes simple harmonic motion. *[4 marks]*

5b. (i) Using the graph on page 14, show that the frequency of the note being played is about 200 Hz. *[5 marks]*

(ii) On the graph on page 14, identify, with the letter P, the position of the stylus at which the kinetic energy is at a maximum.

Sound is emitted from a loudspeaker which is outside a building. The loudspeaker emits a sound wave that has the same frequency as the recorded note.

A person standing at position 1 outside the building and a person standing at position 2 inside the building both hear the sound emitted by the loudspeaker.



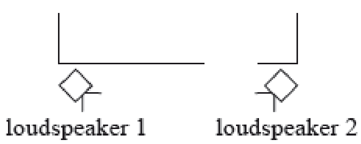
A, B and C are wavefronts emitted by the loudspeaker.

5c. (i) Draw rays to show how the person at **position 1** is able to hear the sound emitted by the loudspeaker. *[4 marks]*

(ii) The speed of sound in the air is $330\ \mathrm{m\,s^{-1}}$. Calculate the wavelength of the note.

(iii) The walls of the room are designed to absorb sound. Explain how the person at **position 2** is able to hear the sound emitted by the loudspeaker.

5d. The arrangement in (c) is changed and another loudspeaker is added. Both loudspeakers emit the same recorded note in phase with each other. *[3 marks]*



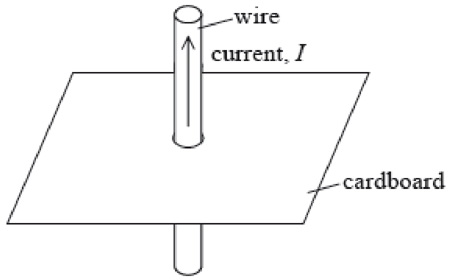
Outline why there are positions between the loudspeakers where the sound can only be heard faintly.

Part 2 Electric and magnetic fields

Electrical leads used in physics laboratories consist of a central conductor surrounded by an insulator.

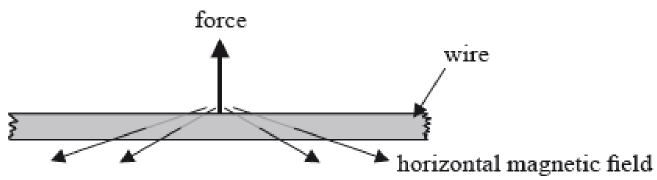
5e. Distinguish between an insulator and a conductor. *[2 marks]*

5f. The diagram shows a current *I* in a vertical wire that passes through a hole in a horizontal piece of cardboard. *[3 marks]*



On the cardboard, draw the magnetic field pattern due to the current.

5g. (i) The diagram shows a length of copper wire that is horizontal in the magnetic field of the Earth. *[4 marks]*



The wire carries an electric current and the force on the wire is as shown. Identify, with an arrow, the direction of electron flow in the wire.

(ii) The horizontal component of the magnetic field of the Earth at the position of the wire is $40\ \mu\mathrm{T}$. The mass per unit length of the wire is $1.41 \times 10^{-4}\ \mathrm{kg\,m^{-2}}$. The net force on the wire is zero. Determine the current in the wire.

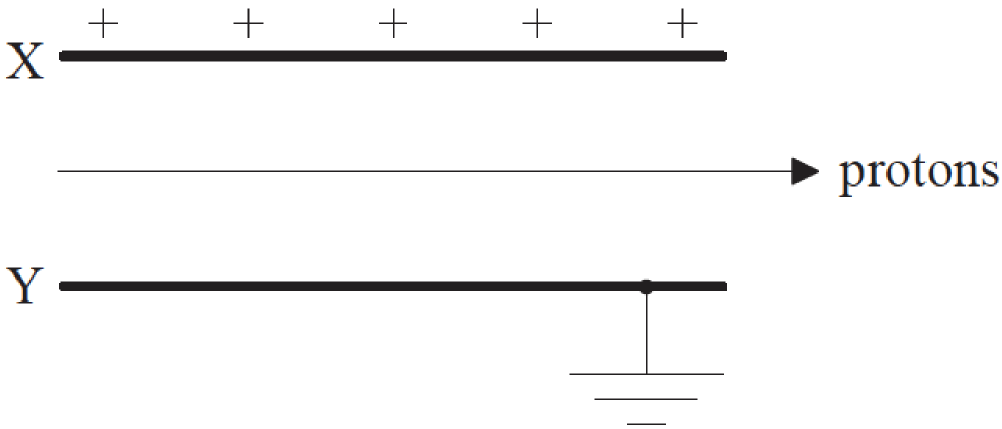
This question is in **two** parts. **Part 1** is about electric fields and radioactive decay. **Part 2** is about change of phase.

Part 1 Electric fields and radioactive decay

6a. Define *electric field strength*. *[2 marks]*

6b. A simple model of the proton is that of a sphere of radius 1.0×10^{-15}m with charge concentrated at the centre of the sphere. Estimate the magnitude of the field strength at the surface of the proton. *[2 marks]*

6c. Protons travelling with a speed of $3.9 \times 10^6 \text{ms}^{-1}$ enter the region between two charged parallel plates X and Y. Plate X is positively charged and plate Y is connected to earth. *[4 marks]*



A uniform magnetic field also exists in the region between the plates. The direction of the field is such that the protons pass between the plates without deflection.

(i) State the direction of the magnetic field.

(ii) The magnitude of the magnetic field strength is 2.3×10^{-4}T. Determine the magnitude of the electric field strength between the plates, stating an appropriate unit for your answer.

6d. Protons can be produced by the bombardment of nitrogen-14 nuclei with alpha particles. The nuclear reaction equation for this process is given below. *[1 mark]*

$$^{14}_{7}\text{N} + ^{4}_{2}\text{He} \rightarrow \text{X} + ^{1}_{1}\text{H}$$

Identify the proton number and nucleon number for the nucleus X.

6e. The following data are available for the reaction in (d). *[3 marks]*

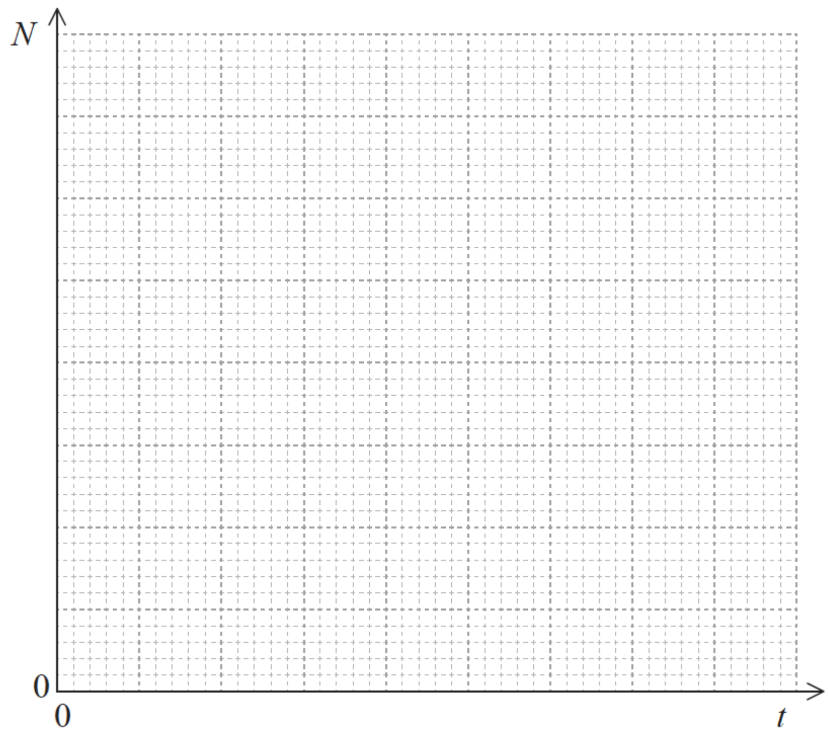
Rest mass of nitrogen-14 nucleus =14.0031 u
Rest mass of alpha particle =4.0026 u
Rest mass of X nucleus =16.9991 u
Rest mass of proton =1.0073 u

Show that the minimum kinetic energy that the alpha particle must have in order for the reaction to take place is about 0.7 Me V.

6f. A nucleus of another isotope of the element X in (d) decays with a half-life $T_{\frac{1}{2}}$ to a nucleus of an isotope of fluorine-19 (F-19). *[5 marks]*

(i) Define the terms *isotope* and *half-life*.

(ii) Using the axes below, sketch a graph to show how the number of atoms N in a sample of X varies with time t, from t=0 to $t = 3T_{\frac{1}{2}}$. There are N_0 atoms in the sample at t=0.



Part 2 Change of phase

6g. Water at constant pressure boils at constant temperature. Outline, in terms of the energy of the molecules, the reason for this. *[2 marks]*

6h. In an experiment to measure the specific latent heat of vaporization of water, steam at 100°C was passed into water in an insulated container. The following data are available. *[4 marks]*

Initial mass of water in container = 0.300kg
Final mass of water in container = 0.312kg
Initial temperature of water in container = 15.2°C
Final temperature of water in container = 34.6°C
Specific heat capacity of water = 4.18×10^{3} Jkg^{-1}K^{-1}

Show that the data give a value of about 1.8×10^{6} Jkg^{-1} for the specific latent heat of vaporization L of water.

6i. Explain why, other than measurement or calculation error, the accepted value of L is greater than that given in (h). *[2 marks]*

This question is in **two** parts. **Part 1** is about simple harmonic motion (SHM) and waves. **Part 2** is about voltage–current (V–I) characteristics.

Part 1 Simple harmonic motion (SHM) and waves

7a. A particle P moves with simple harmonic motion. State, with reference to the motion of P, what is meant by simple harmonic motion. *[2 marks]*

7b. The particle P in (b) is a particle in medium M_1 through which a transverse wave is travelling. *[5 marks]*

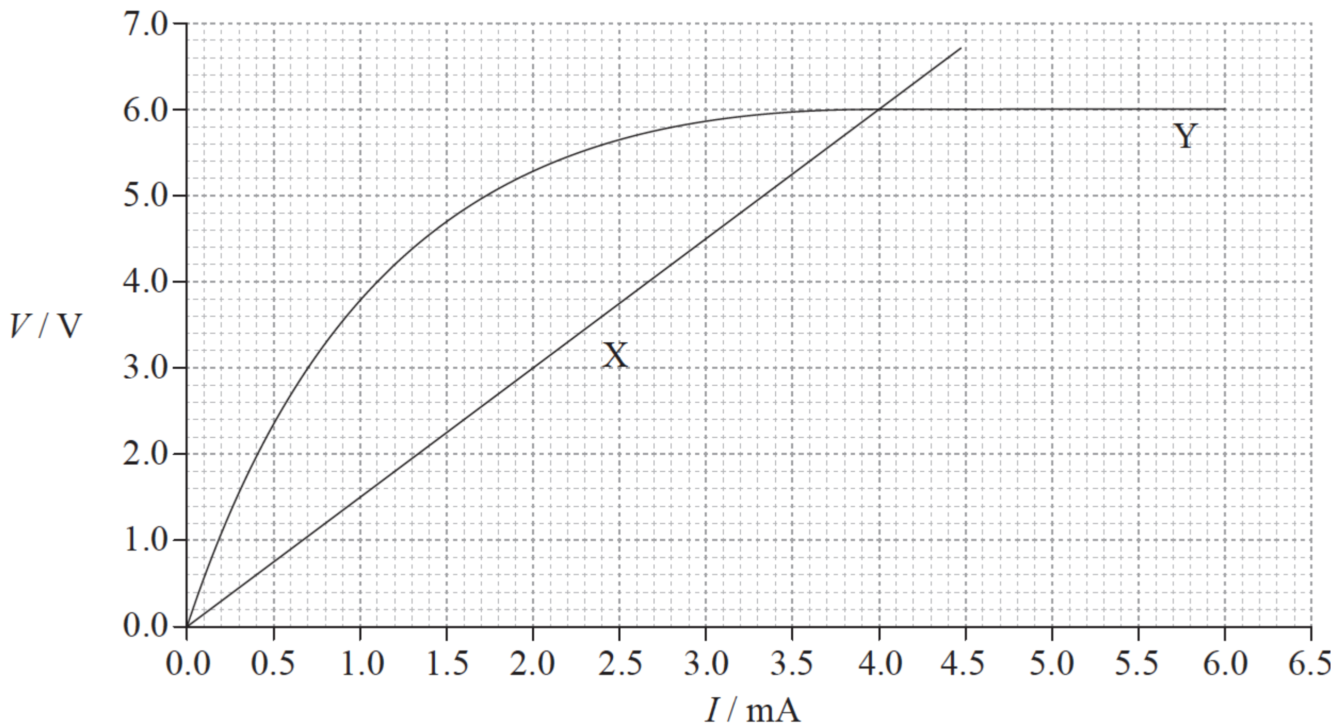
(i) Describe, in terms of energy propagation, what is meant by a transverse wave.

(ii) The speed of the wave through the medium is $0.40 ms^{-1}$. Calculate, using your answer to (b)(i), the wavelength of the wave.

(iii) The wave travels into another medium M_2. The refractive index of M_2 relative to M_1 is 1.8. Calculate the wavelength of the wave in M_2.

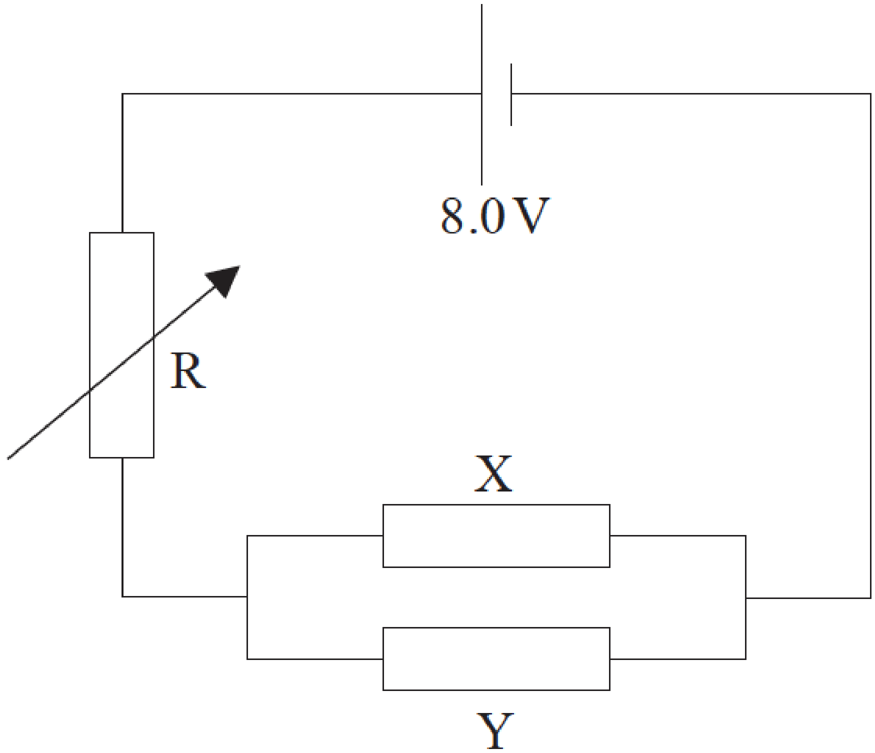
Part 2 Voltage–current (V–I) characteristics

The graph shows the voltage–current (V–I) characteristics, at constant temperature, of two electrical components X and Y.



7c. Outline, with reference to the graph and to Ohm's law, whether or not each component is ohmic. *[3 marks]*

7d. Components X and Y are connected in parallel. The parallel combination is then connected in series with a variable resistor R and a cell of emf 8.0V and negligible internal resistance. *[8 marks]*



The resistance of R is adjusted until the currents in X and Y are equal.

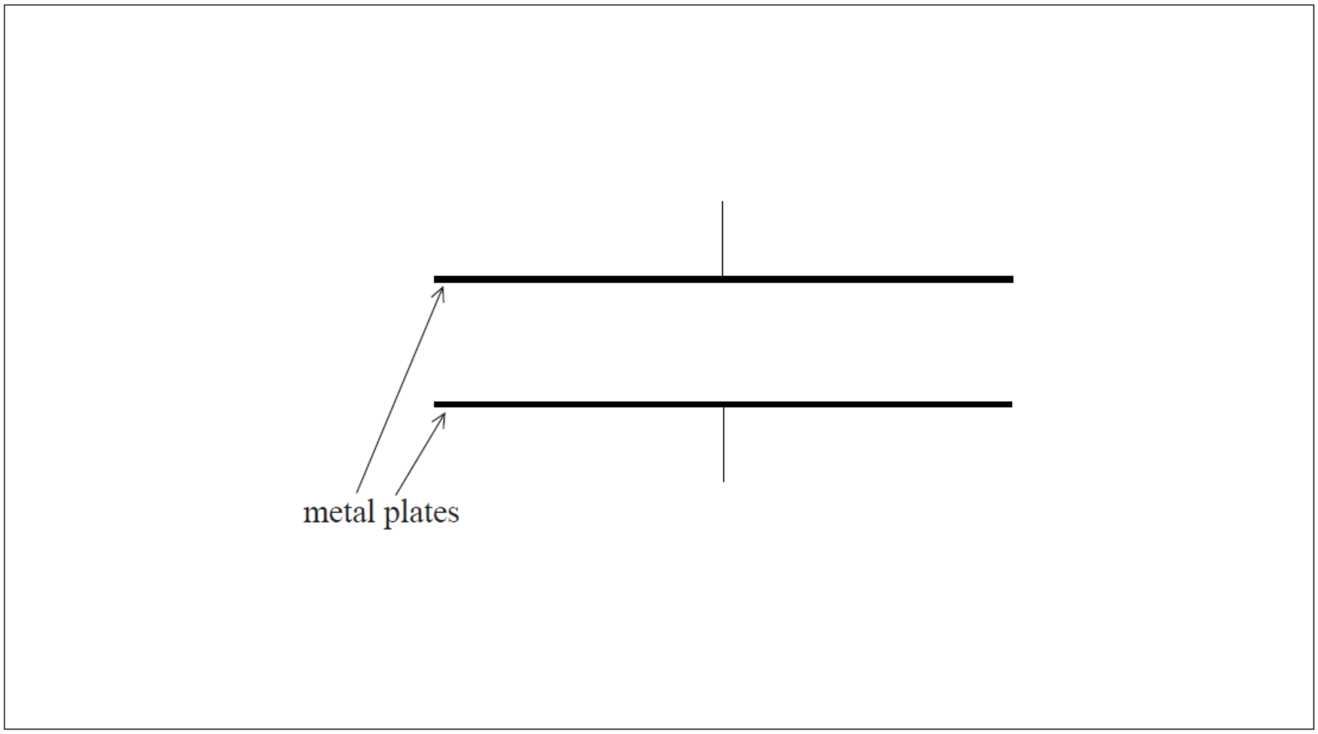
(i) Using the graph, calculate the resistance of the parallel combination of X and Y.

(ii) Using your answer to (e)(i), determine the resistance of R.

(iii) Determine the power delivered by the cell to the circuit.

8a. Define *electric field strength*. *[2 marks]*

8b. The diagram shows a pair of horizontal metal plates. Electrons can be deflected vertically using an electric field between the plates. *[5 marks]*

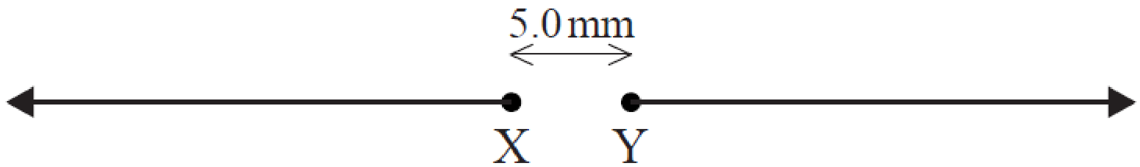


(i) Label, on the diagram, the polarity of the metal plates which would cause an electron
positioned between the plates to accelerate upwards.

(ii) Draw the shape and direction of the electric field between the plates on the diagram.

(iii) Calculate the force on an electron between the plates when the electric field strength has a value of 2.5×10^3 NC^{-1}.

8c. The diagram shows two isolated electrons, X and Y, initially at rest in a vacuum. The initial separation of the electrons is 5.0 mm. The electrons subsequently move apart in the directions shown. *[8 marks]*

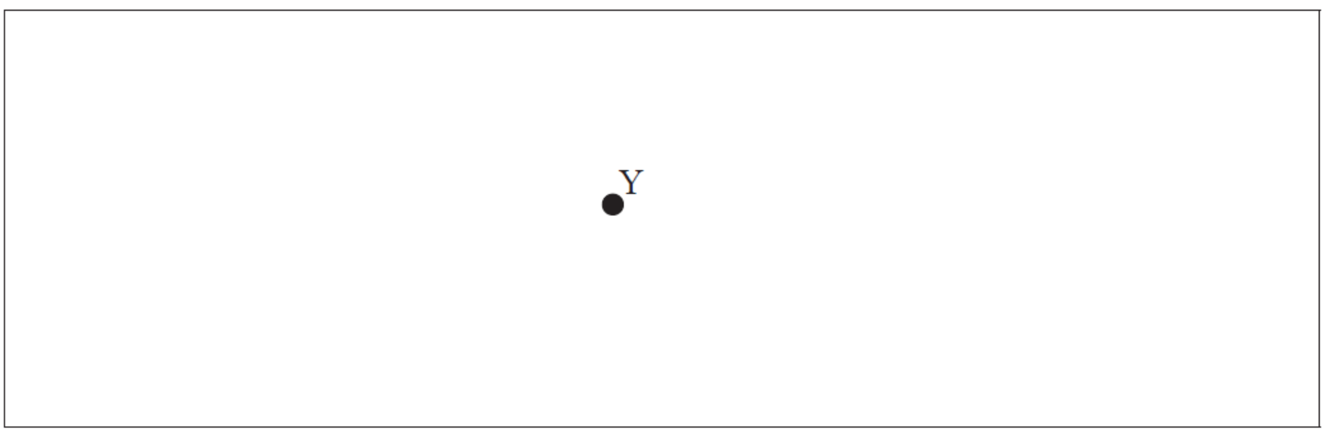


(i) Show that the initial electric force acting on each electron due to the other electron is approximately 9×10^{-24} N.

(ii) Calculate the initial acceleration of one electron due to the force in (c)(i).

(iii) Discuss the motion of one electron after it begins to move.

(iv) The diagram shows Y as seen from X, at one instant. Y is moving into the plane of the paper. For this instant, draw on the diagram the shape and direction of the magnetic field produced by Y.



This question is about alternative energy supplies.

A small island community requires a peak power of 850 kW. Two systems are available for supplying the energy: using wind power or photovoltaic cells.

9a. (i) Outline, with reference to the energy conversions in the machine, the main features of a conventional horizontal-axis wind generator. *[7 marks]*

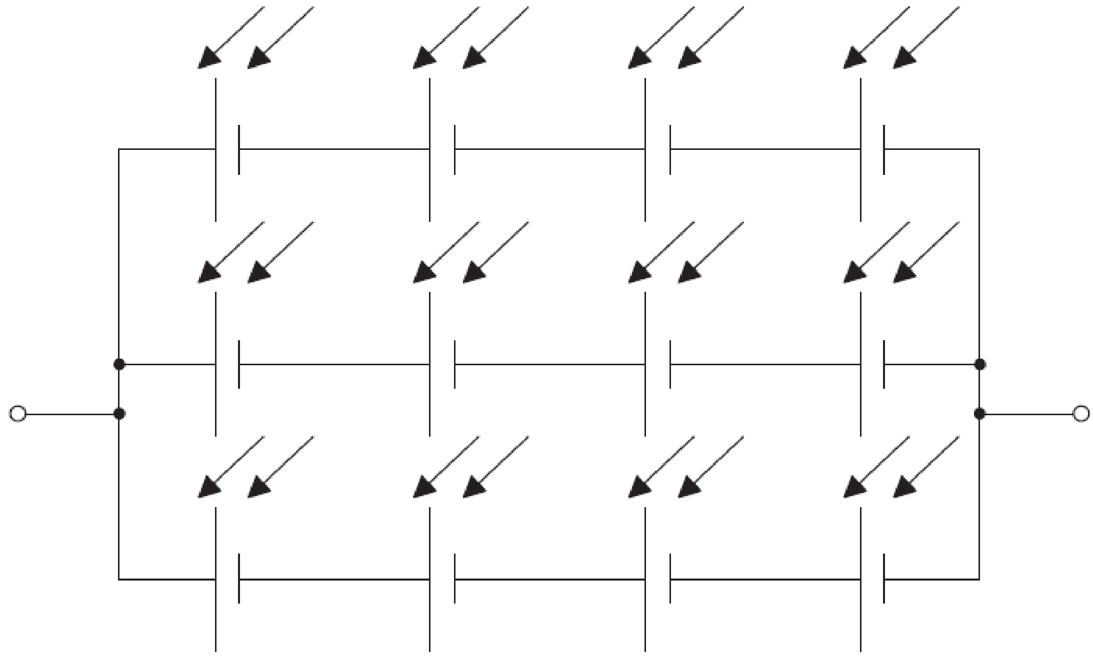
(ii) The mean wind speed on the island is 8.0 ms^{-1}. Show that the maximum power available from a wind generator of blade length 45 m is approximately 2 MW.

Density of air = 1.2 kg m^{-3}

(iii) The efficiency of the generator is 24%. Deduce the number of these generators that would be required to provide the islanders with enough power to meet their energy requirements.

9b. Distinguish between photovoltaic cells and solar heating panels. *[2 marks]*

9c. The diagram shows 12 photovoltaic cells connected in series and in parallel to form a module to provide electrical power. *[8 marks]*

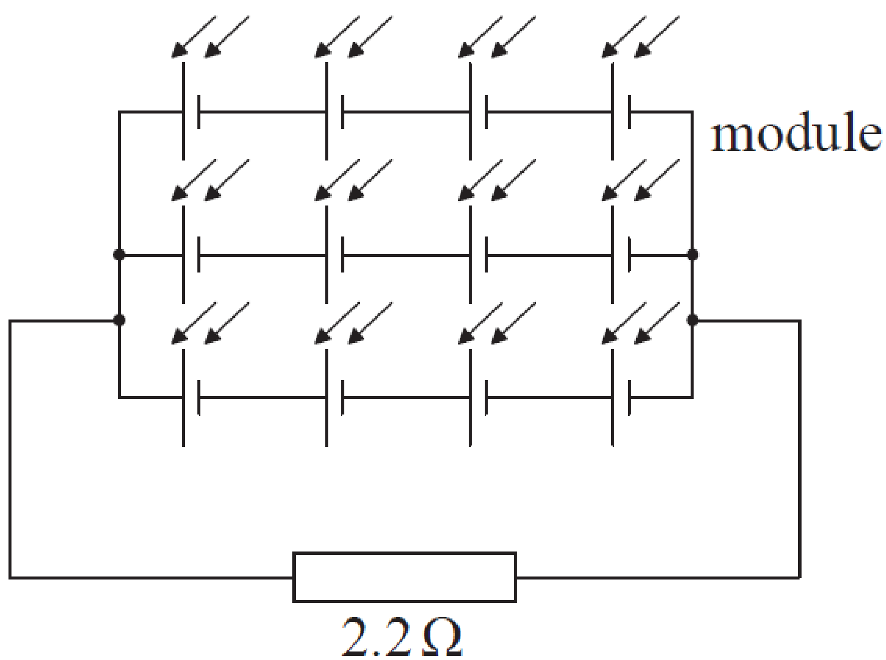


Each cell in the module has an emf of 0.75V and an internal resistance of 1.8Ω.

(i) Calculate the emf of the module.

(ii) Determine the internal resistance of the module.

(iii) The diagram below shows the module connected to a load resistor of resistance 2.2Ω.



Calculate the power dissipated in the load resistor.

(iv) Discuss the benefits of having cells combined in series and parallel within the module.

9d. The intensity of the Sun's radiation at the position of the Earth's orbit (the solar constant) is approximately 1.4×10^{3} Wm^{-2}. *[5 marks]*

(i) Explain why the average solar power per square metre arriving at the Earth is 3.5×10^{2} W.

(ii) State why the solar constant is an approximate value.

(iii) Photovoltaic cells are approximately 20% efficient. Estimate the minimum area needed to supply an average power of 850kW over a 24 hour period.

This question is in two parts. **Part 1** is about electric charge and electric circuits. **Part 2** is about momentum.

Part 1 Electric charge and electric circuits

10a. State Coulomb's law. *[2 marks]*

10b. In a simple model of the hydrogen atom, the electron can be regarded as being in a circular orbit about the proton. The radius of the orbit is 2.0×10^{-10} m. *[7 marks]*

(i) Determine the magnitude of the electric force between the proton and the electron.

(ii) Calculate the magnitude of the electric field strength E and state the direction of the electric field due to the proton at a distance of 2.0×10^{-10} m from the proton.

(iii) The magnitude of the gravitational field due to the proton at a distance of 2.0×10^{-10} m from the proton is H.
Show that the ratio $\frac{H}{E}$ is of the order 10^{-28}C kg^{-1}.

(iv) The orbital electron is transferred from its orbit to a point where the potential is zero. The gain in potential energy of the electron is 5.4×10^{-19}J. Calculate the value of the potential difference through which the electron is moved.

10c. An electric cell is a device that is used to transfer energy to electrons in a circuit. A particular circuit consists of a cell of emf ε and internal resistance r connected in series with a resistor of resistance 5.0 Ω. *[6 marks]*

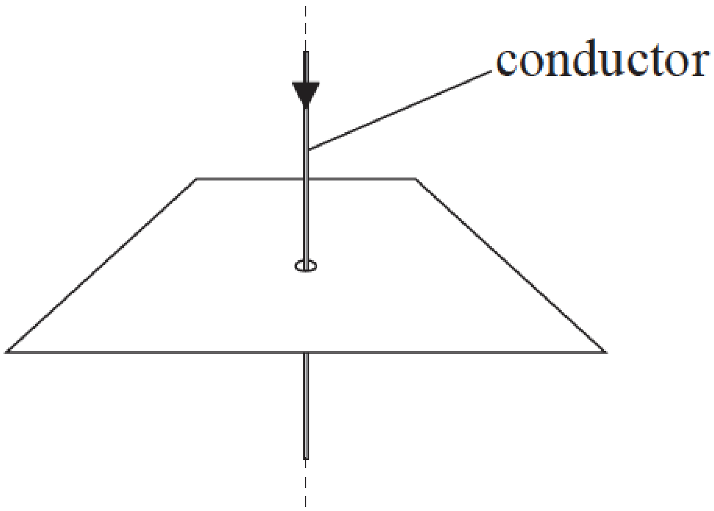
(i) Define *emf of a cell.*

(ii) The energy supplied by the cell to one electron in transferring it around the circuit is 5.1×10^{-19}J. Show that the emf of the cell is 3.2V.

(iii) Each electron in the circuit transfers an energy of 4.0×10^{-19} J to the 5.0 Ω resistor. Determine the value of the internal resistance r.

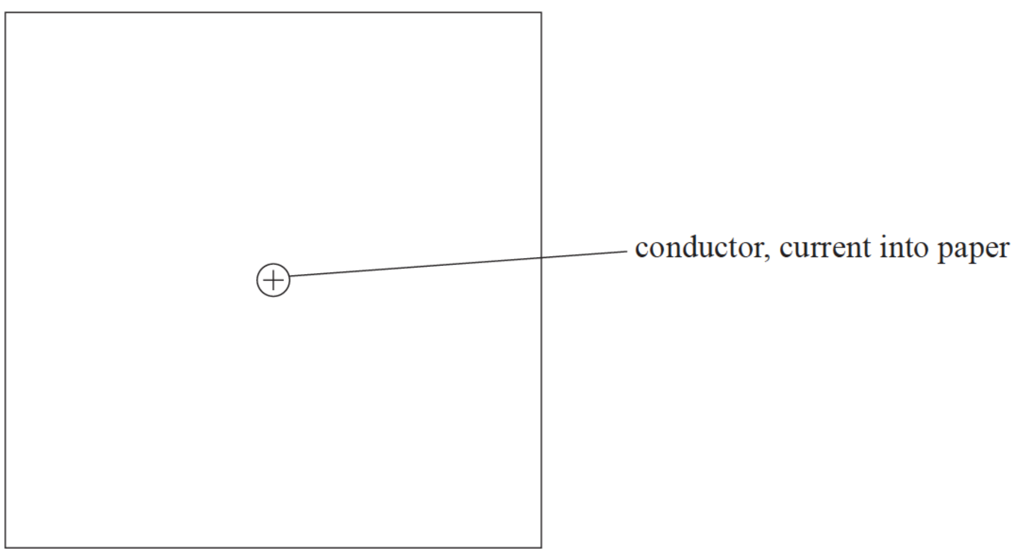
This question is about magnetic fields.

A long straight vertical conductor carries an electric current. The conductor passes through a hole in a horizontal piece of paper.



11a. State how a magnetic field arises. *[1 mark]*

11b. On the diagram below, sketch the magnetic field pattern around the long straight current-carrying conductor. The direction of the current is into the plane of the paper. *[2 marks]*

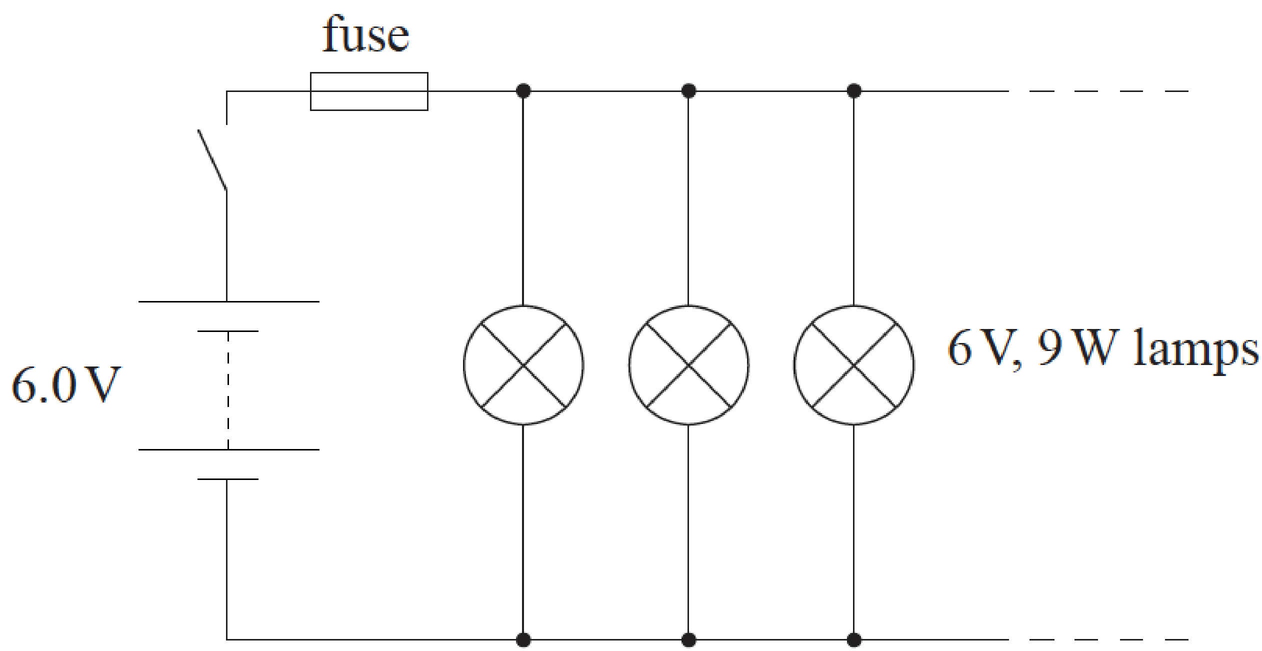


This question is in **two** parts. **Part 1** is about a lighting system. **Part 2** is about a satellite.

Part 1 Lighting system

12a. State Ohm’s law. *[1 mark]*

12b. A lighting system is designed so that additional lamps can be added in parallel. *[8 marks]*



The diagram shows three 6V, 9W lamps connected in parallel to a supply of emf 6.0V and negligible internal resistance. A fuse in the circuit melts if the current in the circuit exceeds 13A.

(i) Determine the maximum number of lamps that can be connected in parallel in the circuit without melting the fuse.

(ii) Calculate the resistance of a lamp when operating at its normal brightness.

(iii) By mistake, a lamp rated at 12V, 9W is connected in parallel with three lamps rated at 6V, 9W. Estimate the resistance of the circuit stating any assumption that you make.

Part 2 Electric potential difference and electric circuits

13a. Ionized hydrogen atoms are accelerated from rest in the vacuum between two vertical parallel conducting plates. The potential difference between the plates is *V*. As a result of the acceleration each ion gains an energy of 1.9×10^{-18}J. *[2 marks]*

Calculate the value of *V*.

13b. The plates in (a) are replaced by a cell that has an emf of 12.0 V and internal resistance 5.00 Ω. A resistor of resistance *R* is connected in series with the cell. The energy transferred by the cell to an electron as it moves through the resistor is 1.44×10^{-18} J. *[8 marks]*

(i) Define *resistance* of a resistor.

(ii) Describe what is meant by internal resistance.

(iii) Show that the value of *R* is 15.0 Ω.

(iv) Calculate the total power supplied by the cell.

Part 2 Gravitational fields and electric fields

14. The magnitude of gravitational field strength *g* is defined from the equation shown below. *[4 marks]*

$$g = \frac{F_g}{m}$$

The magnitude of electric field strength *E* is defined from the equation shown below.

$$E = \frac{F_E}{q}$$

For each of these defining equations, state the meaning of the symbols

(i) F_g.

(ii) F_E.

(iii) *m*.

(iv) *q*.

This question is about the properties of tungsten.

15a. Tungsten is a conductor used as the filament of an electric lamp. The filament of the lamp is surrounded by glass which is an insulator. *[2 marks]*

Outline, in terms of their atomic structure, the difference between the electrical properties of tungsten and of glass.

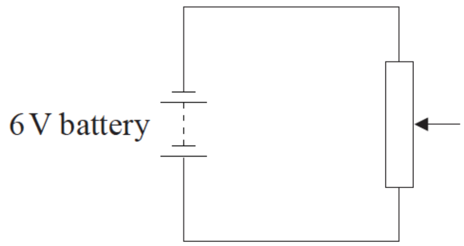
15b. A tungsten filament lamp is marked 6.0 V, 15 W. *[3 marks]*

(i) Show that the resistance of the lamp at its working voltage is 2.4 Ω.

(ii) The length of the filament is 0.35 m and the resistivity of tungsten is 5.6×10^{-7} Ω m at its working voltage.

Calculate the cross-sectional area of the tungsten filament.

15c. The diagram shows part of a potential divider circuit used to measure the current-potential difference (*I*–*V*) characteristic of the bulb. *[2 marks]*



Draw the complete circuit showing the correct position of the bulb, ammeter and voltmeter.

Part 2 Electric motor

An electric motor is used to raise a load.

16a. Whilst being raised, the load accelerates uniformly upwards. The weight of the cable is negligible compared to the weight of the load. *[6 marks]*

(i) Draw a labelled free-body force diagram of the forces acting on the accelerating load. The dot below represents the load.

(ii) The load has a mass of 350 kg and it takes 6.5 s to raise it from rest through a height of 8.0 m.

Determine the tension in the cable as the load is being raised.

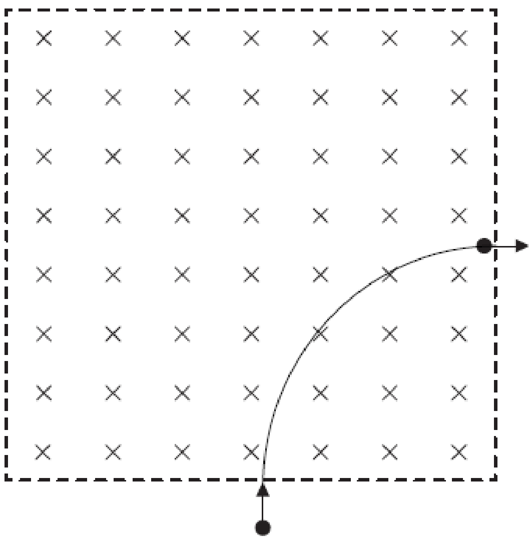
16b. The electric motor can be adjusted such that, after an initial acceleration, the load moves at constant speed. The motor is connected to a 450 V supply and with the load moving at constant speed, it takes the motor 15 s to raise the load through 7.0 m. *[4 marks]*

(i) Calculate the power delivered to the load by the motor.

(ii) The current in the motor is 30 A. Estimate the efficiency of the motor.

This question is about motion in a magnetic field.

An electron, that has been accelerated from rest by a potential difference of 250 V, enters a region of magnetic field of strength 0.12 T that is directed into the plane of the page.

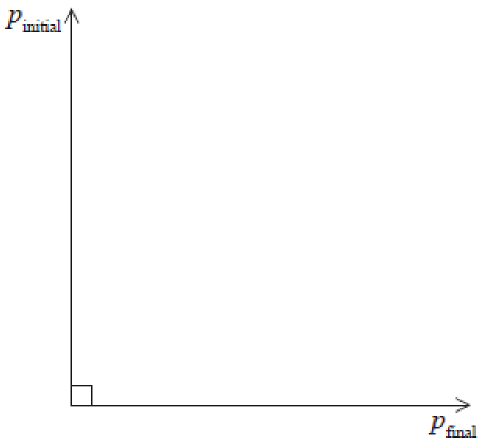


17a. The electron's path while in the region of magnetic field is a quarter circle. Show that the *[4 marks]*

(i) speed of the electron after acceleration is $9.4\times10^{6} ms^{-1}$.

(ii) radius of the path is 4.5×10^{-4}m.

17b. The diagram below shows the momentum of the electron as it enters and leaves the region of magnetic field. The magnitude of the initial momentum and of the final momentum is 8.6×10^{-24}Ns. *[3 marks]*



(i) On the diagram above, draw an arrow to indicate the vector representing the change in the momentum of the electron.

(ii) Show that the magnitude of the change in the momentum of the electron is 1.2×10^{-23}Ns.

(iii) The time the electron spends in the region of magnetic field is 7.5×10^{-11}s. Estimate the magnitude of the average force on the electron.

This question is in **two** parts. **Part 1** is about electric circuits. **Part 2** is about the energy balance of the Earth.

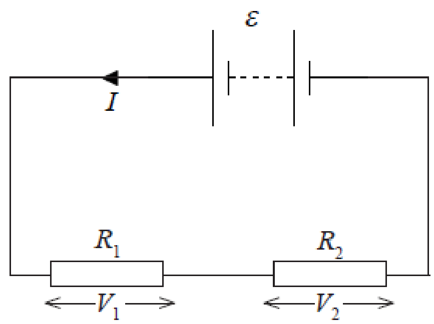
Part 1 Electric circuits

18a. Define *[2 marks]*

(i) *electromotive force* (emf) of a battery.

(ii) *electrical resistance* of a conductor.

18b. A battery of emf ε and negligible internal resistance is connected in series to two resistors. The current in the circuit is I. *[3 marks]*

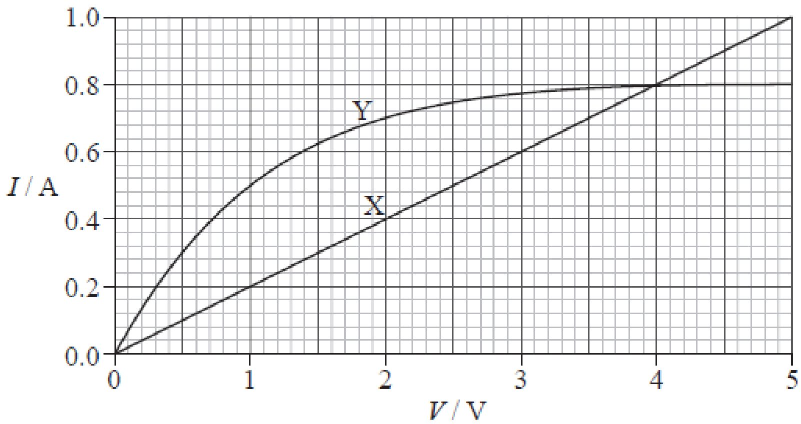


(i) State an equation giving the total power delivered by the battery.

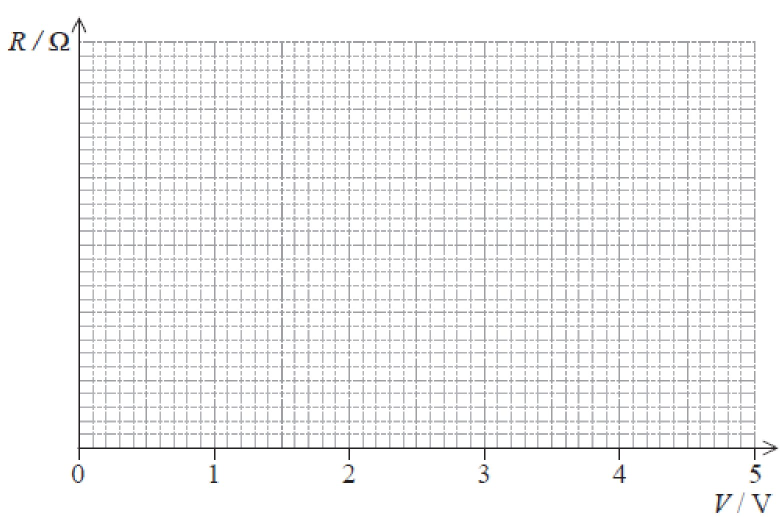
(ii) The potential difference across resistor R_1 is V_1 and that across resistor R_2 is V_2. Using the law of the conservation of energy, deduce the equation below.

$\varepsilon = V_1 + V_2$

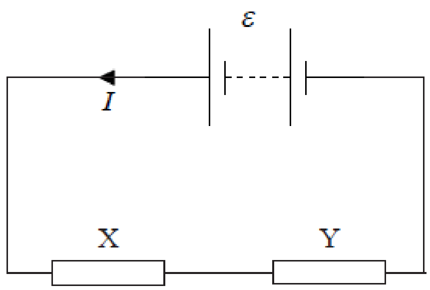
18c. The graph shows the I-V characteristics of two conductors, X and Y. *[3 marks]*



On the axes below, sketch graphs to show the variation with potential difference V of the resistance of conductor X (label this graph X) and conductor Y (label this graph Y). You do not need to put any numbers on the vertical axis.



18d. The conductors in (c) are connected in series to a battery of emf ε and negligible internal resistance. *[4 marks]*



The power dissipated in each of the two resistors is the same.

Using the graph given in (c),

(i) determine the emf of the battery.

(ii) calculate the total power dissipated in the circuit.

Part 2 Electrical resistance

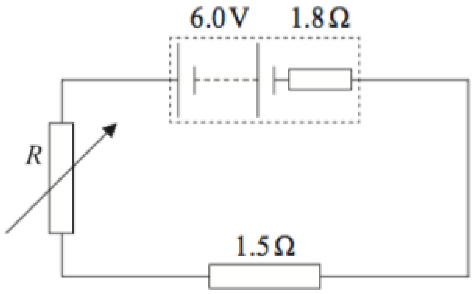
19a. A resistor of resistance 1.5Ω is made from copper wire of radius 0.18mm. The resistivity of copper is 1.7×10^{-8}Ωm. Determine the length of copper wire used to make the resistor. *[2 marks]*

19b. The manufacturer of the resistor in (a) guarantees that the resistance is within 10% of 1.5Ω, provided that the power dissipation in the resistor does not exceed 1.0W. *[6 marks]*

(i) Suggest why the resistance of the resistor might be greater than 1.65Ω if the power dissipation in the resistor is greater than 1.0W.

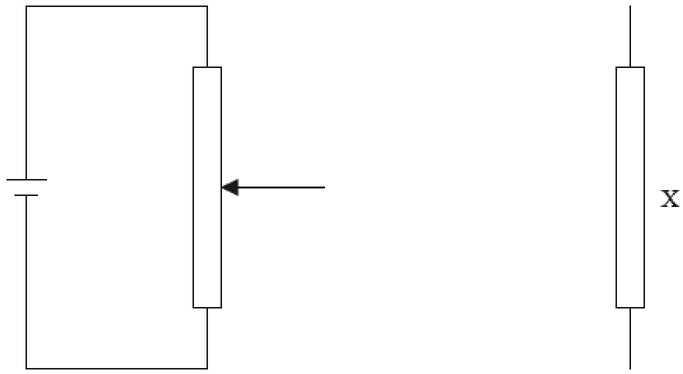
(ii) Show that, for a power dissipation of 1.0W, the current in a resistor of resistance 1.5Ω is 0.82A.

(iii) The 1.5Ω resistor is connected in series with a variable resistor and battery of emf 6.0V and internal resistance 1.8Ω.

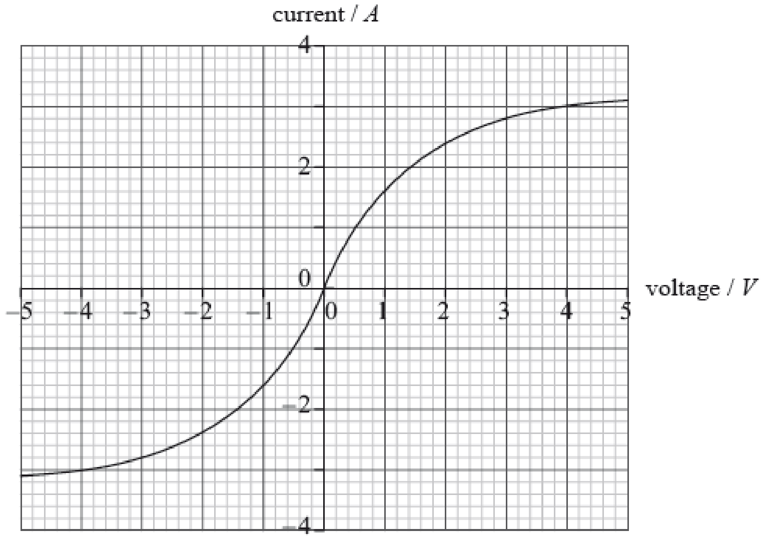


Estimate the resistance R of the variable resistor that will limit the current to 0.82A.

20a. Draw the complete diagram of the circuit that uses a potential divider, ammeter, voltmeter and cell to measure the current-voltage characteristics for component X. *[3 marks]*



20b. The graph shows the current-voltage characteristics for the component X. *[2 marks]*



Component X is now connected across the terminals of a cell of emf 2.0 V and negligible internal resistance. Use the graph to show that the resistance of X is $0.83\ \Omega$.