OCR
Oxford Cambridge and RSA

# Friday 8 October 2021 – Morning

## AS Level Physics A

**H156/01** Breadth in physics

**Time allowed: 1 hour 30 minutes**

**You must have:**
- the Data, Formulae and Relationships Booklet

**You can use:**
- a scientific or graphical calculator
- a ruler (cm/mm)

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Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

**INSTRUCTIONS**
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

**INFORMATION**
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **20** pages.

**ADVICE**
- Read each question carefully before you start your answer.

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## SECTION A

**You should spend a maximum of 25 minutes on this section.**

Answer **all** the questions.

Write your answer to each question in the box provided.

**1** Archimedes' principle is written below with one word missing.

The upthrust acting on an object in a fluid is equal to the _____ of the fluid displaced.

What is the missing word?

**A** density

**B** mass

**C** volume

**D** weight

Your answer ☐ **[1]**

**2** Which of the following is **not** a source of electromotive force (e.m.f.)?

**A** chemical cell

**B** light-dependent resistor

**C** power supply

**D** solar cell

Your answer ☐ **[1]**

**3** A student is explaining the photoelectric effect to his friend.

Which statement is correct?

**A** An electron is emitted when the photon energy is greater than the threshold frequency.

**B** Increasing the intensity increases the maximum kinetic energy of the emitted electrons.

**C** Photons are emitted from the metal during the photoelectric effect.

**D** The energy of a photon is proportional to the frequency of the electromagnetic radiation.

Your answer ☐ **[1]**

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**4** The air resistance $F$ acting on an object falling vertically through air is given by the expression

$F = 0.13v^2$

where $v$ is the speed of the object.

The mass of the object is 30 g.

What is the terminal velocity of this object?

**A** $0.20\,m\,s^{-1}$

**B** $0.48\,m\,s^{-1}$

**C** $1.5\,m\,s^{-1}$

**D** $2.3\,m\,s^{-1}$

Your answer ☐ **[1]**

**5** An object is travelling along a horizontal surface with kinetic energy 16 J and speed $v$.
A force acts against the motion of the object. The work done by this force is 4.0 J.

What is the final speed of the object in terms of $v$?

**A** $0.75v$

**B** $0.87v$

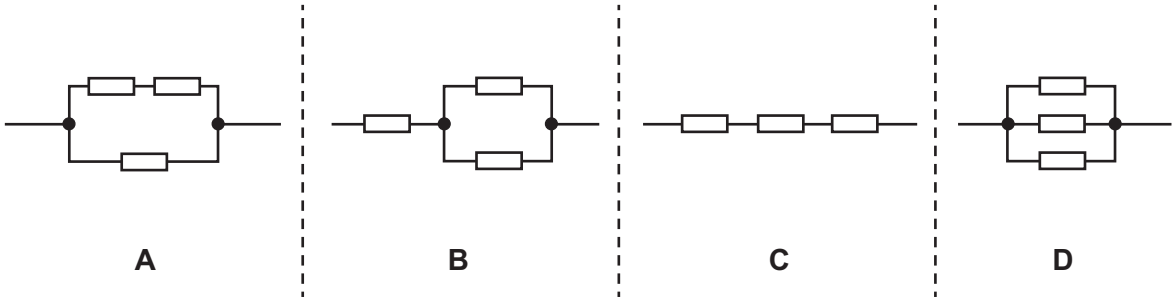
**C** $1.1v$

**D** $1.3v$

Your answer ☐ **[1]**

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**6** Four electrical circuits are shown below.




All the resistors are identical.
Each circuit is connected to the same power supply.

Which circuit dissipates the **least** power?

Your answer ☐ **[1]**

**7** A student investigated four different springs **A**, **B**, **C** and **D**.
A mass of different weight is hung from each spring and the extensions are measured.

The results are shown in the table below.

| | **Weight hung from spring / N** | **Extension of spring / cm** |
|---|---|---|
| **A** | 2.0 | 5.2 |
| **B** | 4.0 | 4.6 |
| **C** | 6.0 | 3.5 |
| **D** | 8.0 | 1.5 |

All of the springs obey Hooke's law.

Which spring has the **largest** elastic potential energy?

Your answer ☐ **[1]**

**8** Which pair of quantities have the same S.I. base units?

**A** strain, elastic potential energy

**B** strain, force constant

**C** stress, force constant

**D** stress, Young modulus

Your answer ☐ **[1]**

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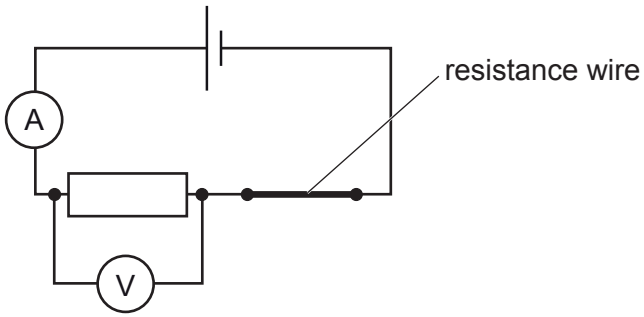
**9** The number density of charge carriers in material **X** is about $10^{28}\,m^{-3}$.
The number density of charge carriers in material **Y** is about $10^{5}\,m^{-3}$.

Which row of the table correctly classifies both materials?

| | **Material X** | **Material Y** |
|---|---|---|
| **A** | conductor | insulator |
| **B** | insulator | conductor |
| **C** | insulator | semiconductor |
| **D** | semiconductor | conductor |

Your answer ☐ **[1]**

**10** A resistance wire is part of an electrical circuit, as shown below.




The resistance wire is pulled so that it becomes longer and thinner.

Which statement is correct?

**A** The ammeter reading increases.

**B** The resistance of the wire decreases.

**C** The total resistance of the circuit remains constant.

**D** The voltmeter reading decreases.

Your answer ☐ **[1]**

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**11** Monochromatic light is incident on a double slit.

A pattern of dark and bright fringes is formed on a distant screen.

Which term, together with diffraction, can be used to explain these fringes?

**A** interference

**B** polarisation

**C** reflection

**D** refraction

Your answer ☐ **[1]**

**12** A cylinder of conducting material has length $6.0 \times 10^{-2}$ m and diameter $2.0 \times 10^{-2}$ m. It has resistance 24 Ω.

What is the resistivity of the material?

**A** 0.13 Ω m

**B** 0.50 Ω m

**C** 7.9 Ω m

**D** 25 Ω m

Your answer ☐ **[1]**

**13** The stationary wave shown below is formed on a stretched string.



The frequency of this stationary wave is 72 Hz.

What is the fundamental frequency for a stationary wave on the same string?

**A** 18 Hz

**B** 24 Hz

**C** 48 Hz

**D** 72 Hz

Your answer ☐ **[1]**

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**14** The de Broglie wavelength of a proton is 160 pm.
The kinetic energy of this proton is doubled.

What is the de Broglie wavelength of the proton now?

**A** 80 pm

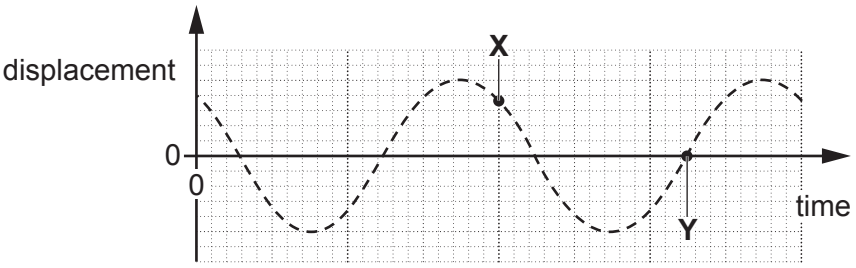
**B** 110 pm

**C** 230 pm

**D** 320 pm

Your answer ☐ **[1]**

**15** The displacement against time graph for a progressive wave is shown below.




Which statement is correct about the phase difference $\phi$ between points **X** and **Y**?

**A** $0 < \phi < 90°$

**B** $\phi = 90°$

**C** $\phi = 180°$

**D** $180° < \phi < 270°$

Your answer ☐ **[1]**

**16** The energy of a photon is 2.5 eV.

What is the principal radiation for this photon?

**A** infrared

**B** radio waves

**C** visible light

**D** x-rays

Your answer ☐ **[1]**

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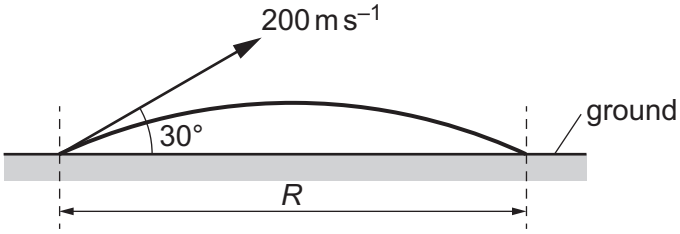
**17** A student is recording results in a table.
The calculated value for the stress in a wire is 7 260 000 Pa.

Which of the following is correct for the heading in the student's table and the value of the stress written to **2** significant figures?

| | Heading in table | Value of stress |
|---|---|---|
| **A** | stress / Pa | 7 200 000 |
| **B** | stress / kPa | 730 |
| **C** | stress / MPa | 7.2 |
| **D** | stress / $10^6$ Pa | 7.3 |

Your answer ☐ **[1]**

**18** A bullet is fired at an angle of 30° to the horizontal ground at a velocity of 200 m s$^{-1}$.
The bullet is in flight for a time $t$.
Air resistance has negligible effect on the motion of the bullet.




What is the correct expression for the horizontal distance $R$ travelled by the bullet?

**A** $R = 200 \times \cos 30° \times t$

**B** $R = 200 \times \sin 30° \times t$

**C** $R = \dfrac{(200 \times \cos 30°)^2}{2 \times 9.81}$

**D** $R = \dfrac{(200 \times \sin 30°)^2}{2 \times 9.81}$

Your answer ☐ **[1]**

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**19** What can be deduced from the diffraction of electrons by graphite atoms?

**A** Electrons are electromagnetic waves.

**B** Electrons can also become photons.

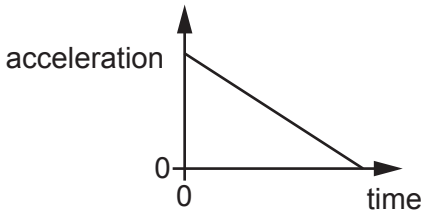
**C** Electrons interact with photons on a one-to-one basis.

**D** Electrons show wave-like behaviour.

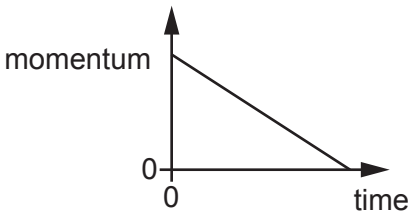
Your answer ☐ **[1]**

**20** Which one of the graphs below can be used to determine the impulse of a force from the area under the graph?

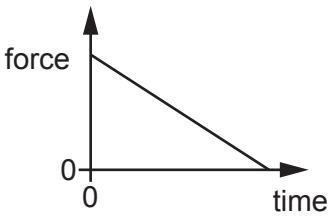
**A**



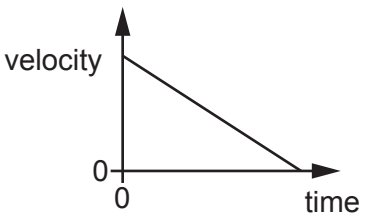

**B**




**C**




**D**



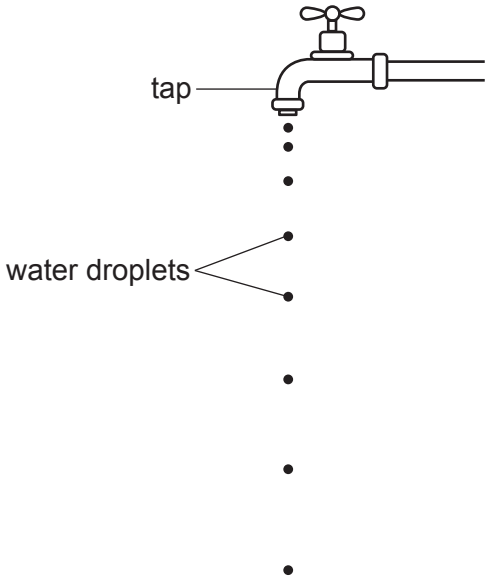

Your answer ☐ **[1]**

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## SECTION B

Answer **all** the questions.

**21 (a)** Droplets of water drip at a constant rate from a tap.
The diagram below shows this dripping tap.

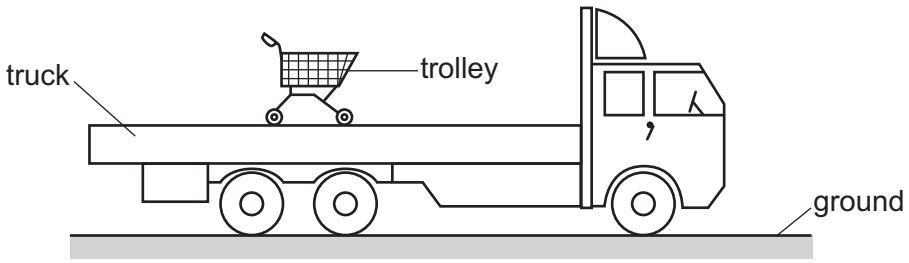



Explain how you can deduce that the droplets are accelerating.

.....

..... **[1]**

**(b)** The diagram below shows a trolley loaded onto the back of a truck.




The truck suddenly accelerates. The trolley is observed to remain in the same position relative to the ground.

Explain the lack of motion of the trolley in terms of one of Newton's laws of motion.

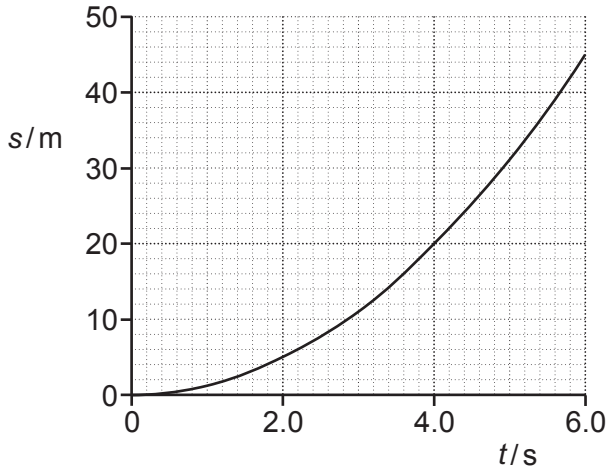
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**(c)** A car starts from rest at time $t = 0$.
The car travels in a straight line with a **constant** acceleration.
The displacement $s$ against time $t$ graph for this car is shown below.




**(i)** Use the graph to show that the speed of the car at $t = 4.0\,s$ is $10\,m\,s^{-1}$.

**[3]**

**(ii)** The mass of the car is 1200 kg.

Calculate the rate of change of momentum of the car from $t = 0$ to $t = 4.0\,s$. Include an appropriate unit for your answer.

rate of change of momentum = ..... unit ..... **[3]**

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**22** A student is determining the acceleration of free fall $g$ using a metal sphere on a ramp.
The sphere is released from the ramp at different heights. The speed $v$ of the sphere at the bottom of the ramp is determined.

The acceleration of free fall $g$ is given by the expression $g = \frac{v^2}{2d}$, where $d$ is the initial height of the sphere and $v$ is speed of the sphere at the bottom of the ramp.

The student records the following data.

- $d = 0.100 \pm 0.002\,\text{m}$
- $v = 1.4 \pm 0.1\,\text{m s}^{-1}$

**(a)** Name the instrument the student should use to measure $d$.

..... **[1]**

**(b)** Calculate the absolute uncertainty in $g$. Write your answer to **2** significant figures.

absolute uncertainty = ..... $\text{m s}^{-2}$ **[3]**

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**23** **(a)** A light-emitting diode (LED) emits visible light when the potential difference across it exceeds a threshold voltage.

Describe, with the help of a circuit diagram, how you could carry out an experiment to accurately determine the threshold voltage of an LED in a brightly-lit laboratory.

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.....

.....

..... **[3]**

**(b)** The current in a filament lamp is 0.045A.
The filament wire of the lamp has diameter 0.24 mm. The number density $n$ of charge carriers (electrons) within the material of the filament is $6.3 \times 10^{28}\,m^{-3}$.

**(i)** Calculate the number of electrons passing through the filament in one second.

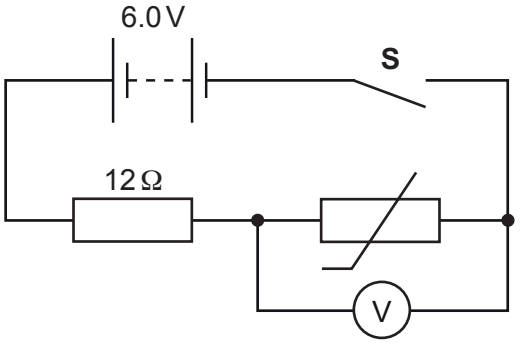
number of electrons = ..... **[2]**

**(ii)** Calculate the mean drift velocity $v$ of the electrons within the filament.

$v$ = ..... $m\,s^{-1}$ **[3]**

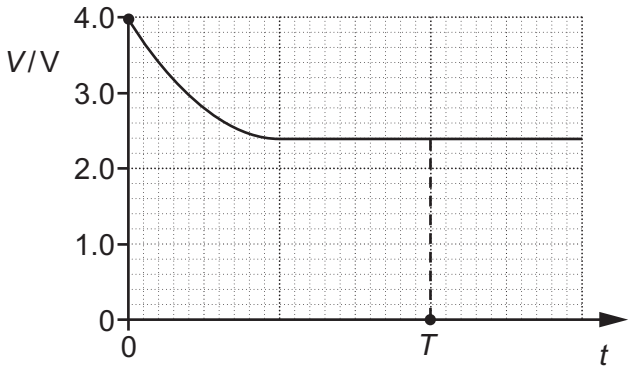
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**(c)** A student connects a resistor and a thermistor in a circuit, as shown in the circuit diagram below.




The battery has electromotive force (e.m.f.) 6.0 V and negligible internal resistance.
The resistor has resistance 12 Ω.
The thermistor is at room temperature. The student closes the switch **S** at time $t = 0$.

The student draws the following graph which shows potential difference (p.d.) $V$ across the thermistor against time $t$.




**(i)** Explain why $V$ decreases at the start.

.....

.....

.....

..... **[2]**

**(ii)** Use the graph to calculate the resistance of the thermistor at $t = T$.

resistance = ..... Ω **[3]**

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**24** An exploding star in a distant galaxy emitted a burst of electromagnetic radiation. X-rays and ultraviolet radiation from this burst were detected simultaneously at the Earth.
The wavelength of the X-rays was $2.5 \times 10^{-11}$ m.

**(a)** State why the X-rays and ultraviolet radiation from this burst were detected simultaneously.

.....

..... **[1]**

**(b)** Calculate the frequency $f$ of the X-rays.

$f$ = ..... Hz **[2]**

**(c)** Special detectors at the Earth were used to detect the individual X-ray photons.
In one type of detector, the interaction of a single X-ray photon with the material of the detector produced many photons of visible light with wavelength of about 500 nm.

Estimate the number of visible light photons emitted in each interaction.

number of visible light photons = ..... **[3]**

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**25** **(a)** Sound waves cannot be polarised, but they do show diffraction.

**(i)** State why sound waves **cannot** be polarised.

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..... **[1]**

**(ii)** Describe and explain how you could demonstrate the diffraction of sound waves in the laboratory.

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..... **[3]**

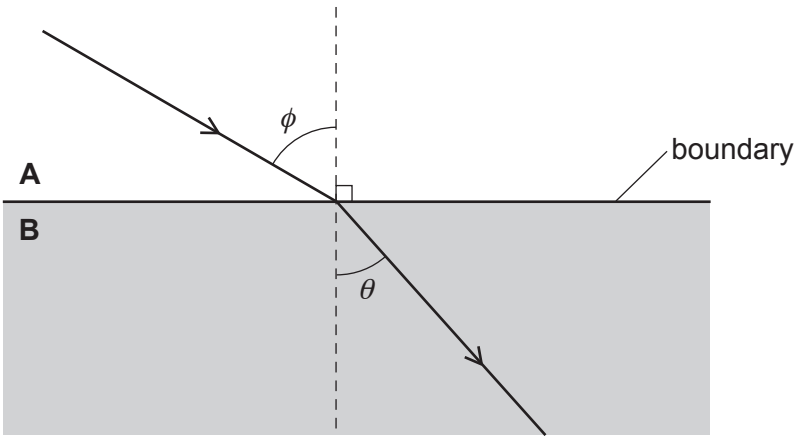
**(b)** Light can be refracted. Light can also show total internal reflection.

**(i)** Define **refractive index** of a material.

.....

..... **[1]**

**(ii)** The diagram below shows the path of light in two transparent materials **A** and **B**.




**Not to scale**

The refractive index of **B** is 1.3 times greater than the refractive index of **A**.
The wavelength of the light in **A** is $\lambda_A$ and the wavelength of the light in **B** is $\lambda_B$.

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**1** Explain how $\lambda_B$ compares with $\lambda_A$.

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.....

.....

.....

..... **[3]**

**2** Calculate the angle of refraction $\theta$ when the angle $\phi$ is 60°. Show your working.

$\theta$ = ..... ° **[2]**

**3** The angle $\phi$ is now varied between 0° and 90° with the light still travelling from material A towards the boundary.

Explain whether or not total internal reflection will be observed at the boundary between the two materials.

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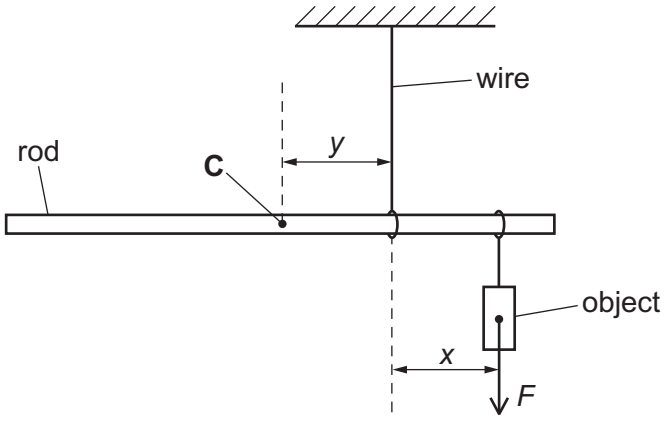
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..... **[1]**

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**26** A student is doing an experiment in the laboratory to determine the density of a metal rod.

A **uniform** metal rod is suspended horizontally from a wire.
The rod has an object attached to it, as shown in the diagram below.

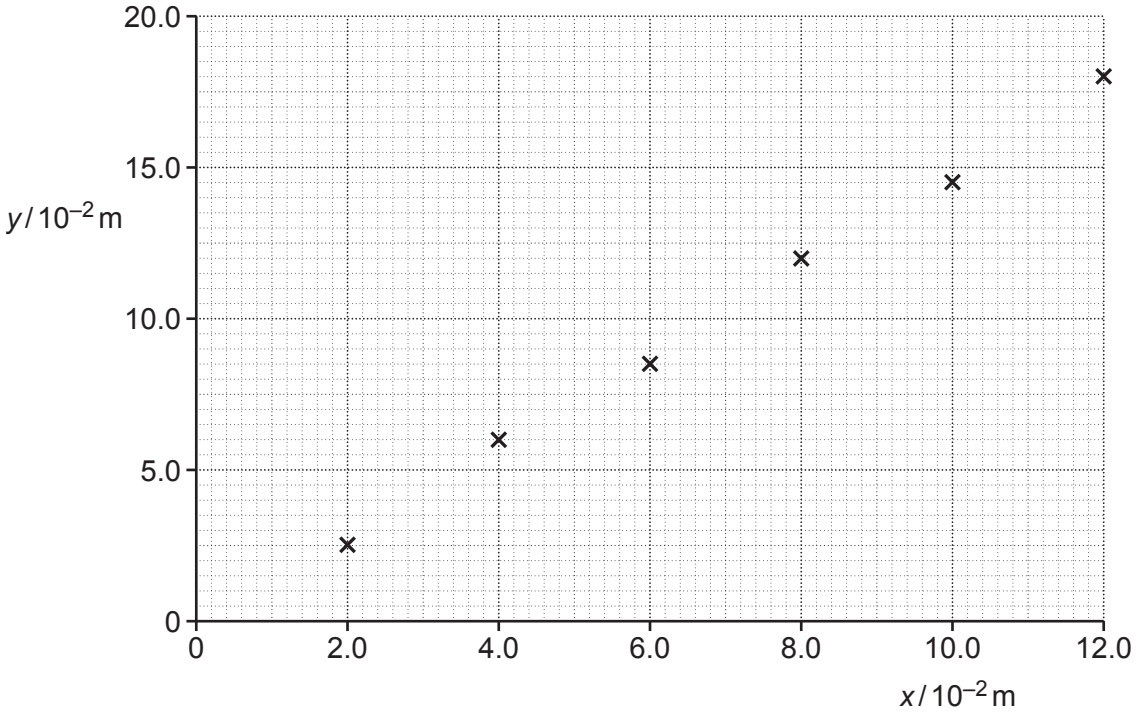



The rod is in equilibrium.
The centre of gravity **C** of the rod is a perpendicular distance *y* from the wire. The line of action of the weight *F* of the object is a perpendicular distance *x* from the wire.
The rod has length *L* and cross-sectional area *A*. The density of the metal rod is $\rho$.

**(a)** Show that the distances *x* and *y* are given by the expression $y = \left(\frac{F}{AL\rho g}\right)x$, where *g* is the acceleration of free fall.

**[2]**

**(b)** The data points shown below are plotted by the student on a *y* against *x* grid.




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**(i)** Draw a straight line of best fit through the data points plotted by the student. Determine the gradient of the straight line of best fit.

gradient = ..... **[2]**

**(ii)** Use your answer to **(i)** and the data below to determine the density $\rho$ of the metal.

- $F = 6.8\,\text{N}$
- $L = 0.90\,\text{m}$
- $A = 6.4 \times 10^{-5}\,\text{m}^2$

$\rho$ = ..... $\text{kg}\,\text{m}^{-3}$ **[3]**

**END OF QUESTION PAPER**

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## ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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