OCR
Oxford Cambridge and RSA

Monday 6 June 2022 – Morning

AS Level Physics A

H156/02 Depth 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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H 1 5 6 0 2

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 **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **20** pages.

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

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Answer **all** the questions.

1 A student investigates the motion of a steel ball in oil in a laboratory.

The radius r of the ball is 8.1 mm.

(a) Describe how the student can determine r accurately in the laboratory.

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

(b) The student uses a measuring cylinder and a digital balance to determine the density of the oil.
The student records the following measurements:

- mass of empty measuring cylinder = 96 g
- volume of oil added to measuring cylinder = 87 cm^3
- total mass of measuring cylinder and oil = 169 g

Show that the density of the oil is about 840 $kg\,m^{-3}$.

[2]

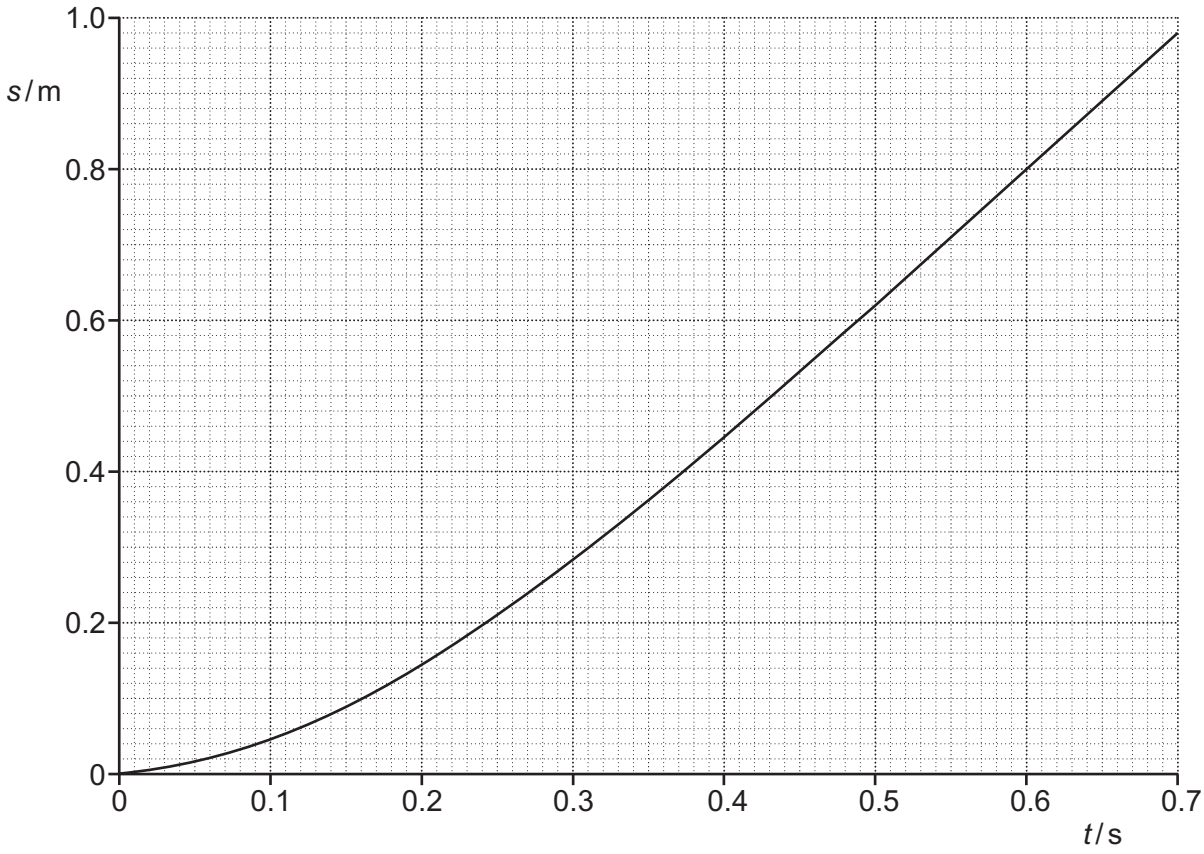
(c) The steel ball is submerged in the oil.

Show that the upthrust acting on the steel ball is 1.8×10^{-2} N.

[2]

(d) The student fills a long tube with the oil.
The student drops the steel ball from rest at the surface of the oil at time $t = 0$.
The displacement s of the ball is measured from the surface of the oil.

The graph shows the displacement s against time t for the steel ball from the instant it enters the oil.



(i) The terminal velocity v of the steel ball is $1.8\,\text{m}\,\text{s}^{-1}$.

Describe and explain how this can be determined from the graph.

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

(ii) Use the graph to calculate the velocity u of the steel ball at time $t = 0.20\,\text{s}$.

u = ... m s^{-1} **[2]**

(e) The mass of the steel ball is 17 g.

The drag F acting on the steel ball falling through the oil is given by the equation

$F = 6\pi\eta rv$

where η is a constant for the oil, r is the radius of the steel ball and v is the speed of the steel ball through the oil.

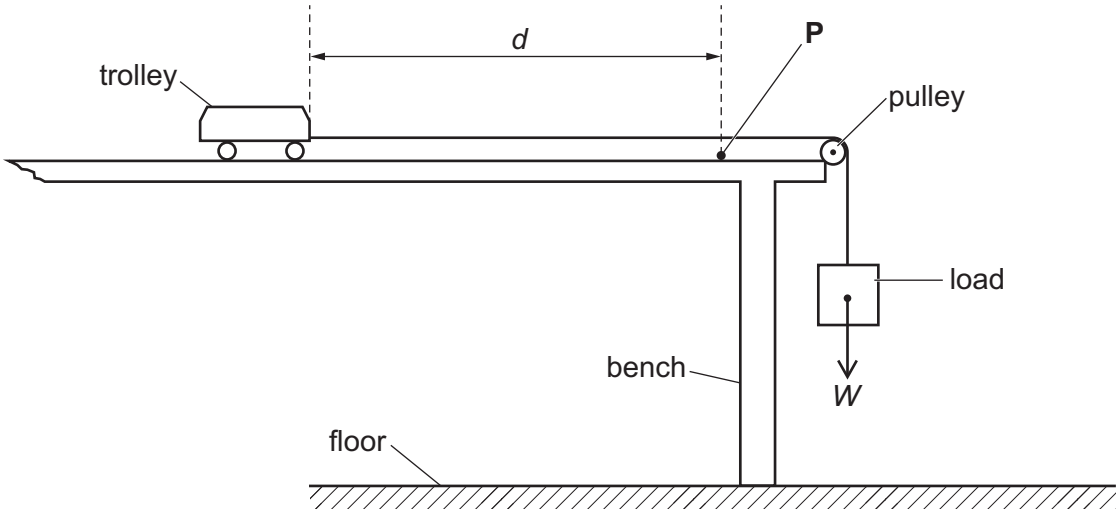
At $v = 1.8\,\text{m s}^{-1}$, the force F is equal to the **difference** between the weight of the steel ball and the upthrust acting on the steel ball.

Calculate η.

Include an appropriate unit.

η = ... unit ..... **[3]**

2* A student is investigating the motion of a trolley as it accelerates from rest along a horizontal surface.
The diagram shows the trolley on a horizontal surface. A load of weight *W* accelerates the trolley.



Point **P** is a distance *d* from the initial position of the trolley.
A light gate connected to a timer is used to determine the velocity *v* of the trolley at point **P**.

It is suggested that the relationship between *v* and the mass *M* of the trolley is

$$\frac{1}{v^2} = \frac{M}{2dW - Q} + R$$

where *Q* and *R* are constants.

Describe, with the aid of a suitable diagram,
- how an experiment can be safely conducted to test this relationship between *v* and *M*, and,
- how the data can be analysed to determine *Q* and *R*. **[6]**

Additional answer space if required

3 **(a)** State the **two** conditions for an object to be in equilibrium.

1. .....

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2. .....

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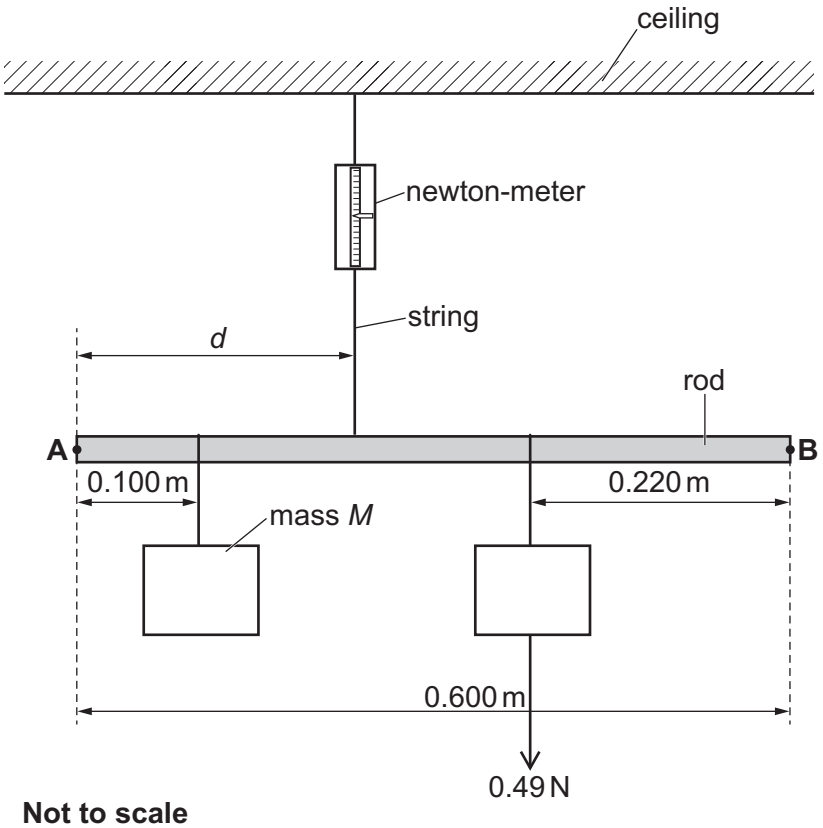
[3]

(b) The diagram shows a uniform rod which is in equilibrium. The rod has a circular cross-section and has length 0.600 m and weight 2.1 N.



Not to scale

Mass *M* is suspended at a distance of 0.100 m from point **A**.
A weight of 0.49 N is suspended at a distance of 0.220 m from point **B**.
A string is attached to the rod at a distance *d* from point **A**.
The tension in the string, measured by the newton-meter (force meter), is 3.9 N.

(i) Show that *M* is about 0.13 kg.

[2]

(ii) By taking moments about point **A**, determine d.

d = ... m **[3]**

4 **(a)** A ball of mass 0.16 kg is dropped from rest from a height of 2.5 m above the ground.

Assume air resistance is negligible.

Calculate

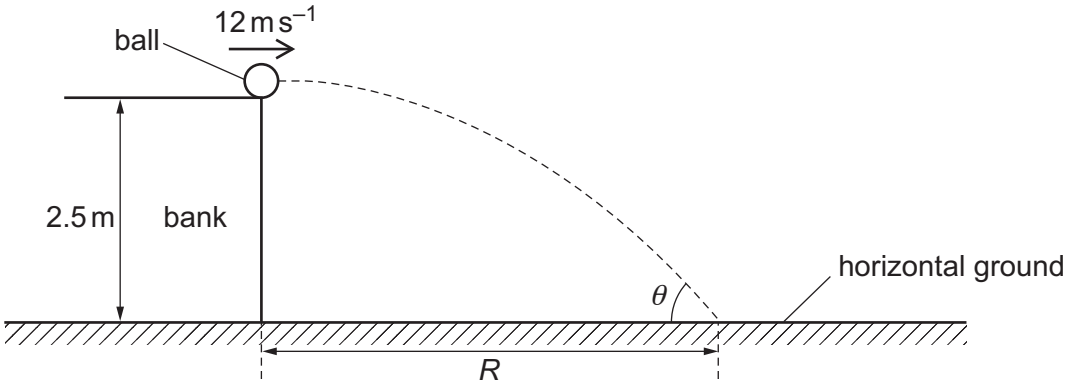
(i) the change in gravitational energy E_p

E_p = ... J **[1]**

(ii) the velocity v of the ball as it reaches the ground.

v = ... $m\,s^{-1}$ **[2]**

(b) The ball from **(a)** is now fired horizontally with a speed of $12\,m\,s^{-1}$ from a bank.
The height of the bank is 2.5 m.
The time for the ball to travel from the edge of the bank to the horizontal ground is 0.71 s.
The path of the ball is shown in the diagram.
The ball hits the horizontal ground a distance R from the bottom of the bank.
Assume air resistance is negligible.



Calculate

(i) R

R = ... m **[1]**

(ii) the kinetic energy E_k of the ball as it reaches the ground

E_k = ... J **[2]**

(iii) the angle θ between the ground and the direction of the ball as it reaches the ground.

θ = ... ° **[1]**

5 The table shows the refractive index of air, glass and oil for red light. It also shows the speed v of red light in air.

	air	**glass**	**oil**
refractive index n	1.00	1.52	1.46
speed of light v / m s^{-1}	3.00×10^8		

(a) Complete the table by determining the missing values for v for glass and oil.
Write your answers to 3 significant figures.

[1]

(b) Show that the critical angle for a ray of red light at the boundary between glass and air is less than 45°.

[2]

(c) **Fig. 5.1** shows a glass block inside a beaker.

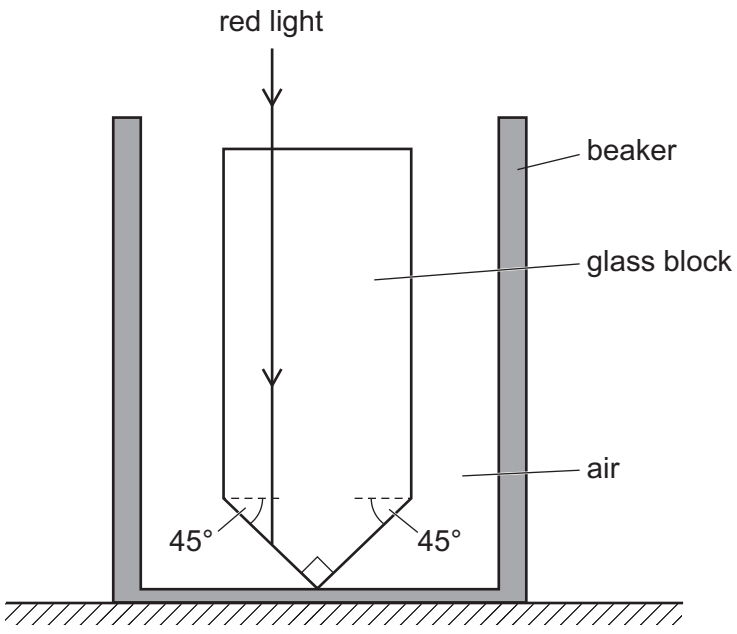


Fig. 5.1

The path of a ray of red light is shown entering the glass block.
Complete **Fig. 5.1** to show the path of the ray through the block until it leaves the block. **[2]**

(d) Oil is now added to the beaker as shown in **Fig. 5.2**.

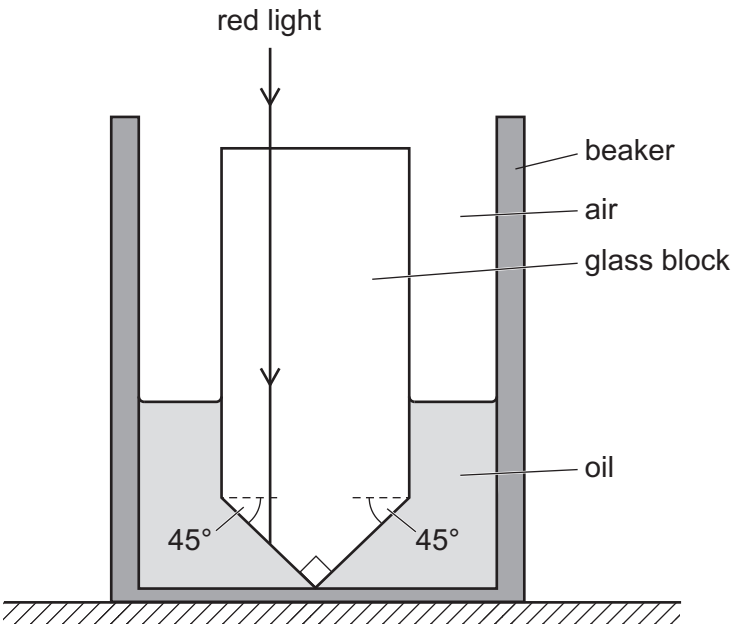


Fig. 5.2

The path of a ray of red light is shown entering the glass block.

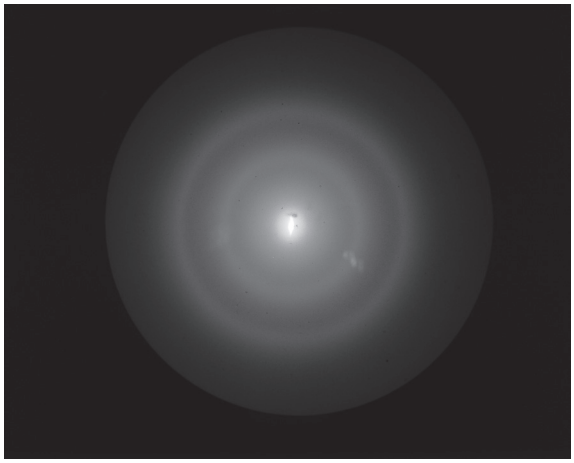
(i) Calculate the critical angle *C* for a ray of red light at the boundary between glass and oil.

C = ...° **[2]**

(ii) Complete **Fig. 5.2** to show the path of the ray through the block until it leaves the block. **[1]**

6 A student is investigating electron diffraction. A beam of electrons is directed towards a thin slice of graphite in an evacuated tube.

The electrons are accelerated by a potential difference of 1800 V. The diagram below shows the pattern formed on the fluorescent screen of the evacuated tube.



(a) Explain why this pattern is formed.

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

(b) The relationship between the de Broglie wavelength λ and the accelerating potential difference V is

$$\lambda = \frac{h}{\sqrt{2meV}}$$

where m is the mass of the electron and e is the elementary charge.

Calculate the momentum p of an electron.

p = ... kg m s^{-1} **[2]**

7 An electric cooker has two independent heating rings **A** and **B** as shown in **Fig. 7.1**.

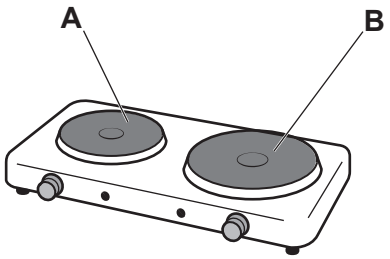


Fig. 7.1

The cooker rings **A** and **B** are connected in parallel to a 230 V power supply. At maximum power, ring **A** has a power of 1100 W and ring **B** has a power of 1700 W.

(a) (i) Show that the maximum current in the cooker is less than 13 A.

[2]

(ii) The cost of 1 kW h of energy is 18p.
Calculate the cost of using the cooker at maximum power for 30 minutes.

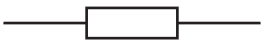
cost = ... p **[1]**

(b) The filament in ring **A** is a metallic wire of length 11.8 m.
At maximum power the wire has resistance 31 Ω and the metal has resistivity 4.8×10^{-7} Ω m.

Calculate the diameter *d* of the wire.

d = ... m **[3]**

(c) **Fig. 7.2** shows the circuit symbol for ring **A**.



ring **A**

Fig. 7.2

A student uses a battery of four cells, an ammeter and a voltmeter to determine the resistance of the wire in ring **A** experimentally.

(i) Complete **Fig. 7.2** to show how the student should connect the circuit to determine the resistance. **[2]**

(ii) The current in the wire is 0.34 ± 0.02 A and the potential difference across the wire is 6.2 ± 0.2 V.
Calculate the resistance *R* of the wire.

R = ... Ω **[1]**

(iii) Calculate the percentage uncertainty in *R*.

percentage uncertainty = ... % **[2]**

(iv) Suggest why *R* from **(c)(ii)** is less than 31 Ω.

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

(v) Suggest **two** improvements to the student's experiment to determine *R* experimentally.

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2. .....

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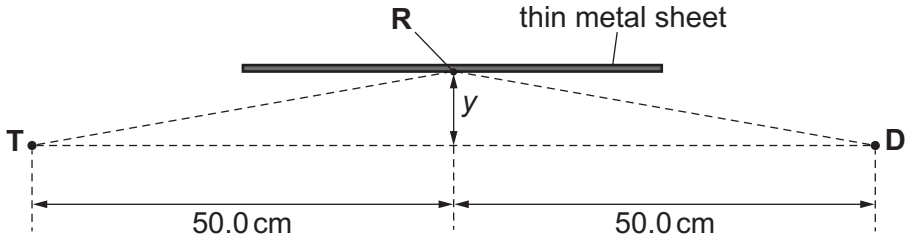
[2]

8* In an experiment to investigate microwaves, a microwave detector **D** is placed 100.0 cm from a microwave transmitter **T**.



A thin metal sheet is placed parallel to the line joining **T** and **D**. Point **R** is at the bottom of the metal sheet. The perpendicular distance between this line and point **R** is *y*.
The diagram shows the path of microwaves travelling directly from **T** to **D** and the path of microwaves from **T** reflected from **R** to **D**. There is a 180° phase change when microwaves are reflected at **R**.

The metal sheet is moved away from the line joining **T** and **D** so that *y* increases. The metal sheet remains parallel to the line from **T** and **D**. A series of maximum and minimum intensities are observed.

The table shows the values of *y* for successive maximum and minimum intensities.

Intensity	***y*** **/ cm**
maximum	8.4
minimum	11.9
maximum	14.6
minimum	17.0

Explain the presence of the regions of maximum and minimum intensities **and** determine the wavelength of the microwaves. **[6]**

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Additional answer space if required

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END OF QUESTION PAPER

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).