AS Level Physics B (Advancing Physics)
H157/02 Physics in depth
Sample Question Paper

Date – Morning/Afternoon
Time allowed: 1 hour 30 minutes

You must have:
• the Data, Formulae and Relationships Booklet

You may use:
• a scientific calculator

First name	
Last name	

Centre number		Candidate number	

INSTRUCTIONS
• Use black ink. You may use an HB pencil for graphs and diagrams.
• Complete the boxes above with your name, centre number and candidate number.
• Answer **all** the questions.
• Write your answer to each question in the space provided.
• Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
• Do **not** write in the bar codes.

INFORMATION
• The total mark for this paper is **70**.
• The marks for each question are shown in brackets **[ ]**.
• Quality of extended responses will be assessed in questions marked with an asterisk (*).
• This document consists of **16** pages.

SECTION A

Answer **all** the questions.

1   This question is about driving a cylinder into the ground. A block of mass of 200 kg is released from rest at a height of 4.5 m above a steel cylinder already in the ground. The cylinder is driven into the ground a further 8.0 cm by the falling block. It is assumed that the mass of the block is far greater than that of the cylinder.
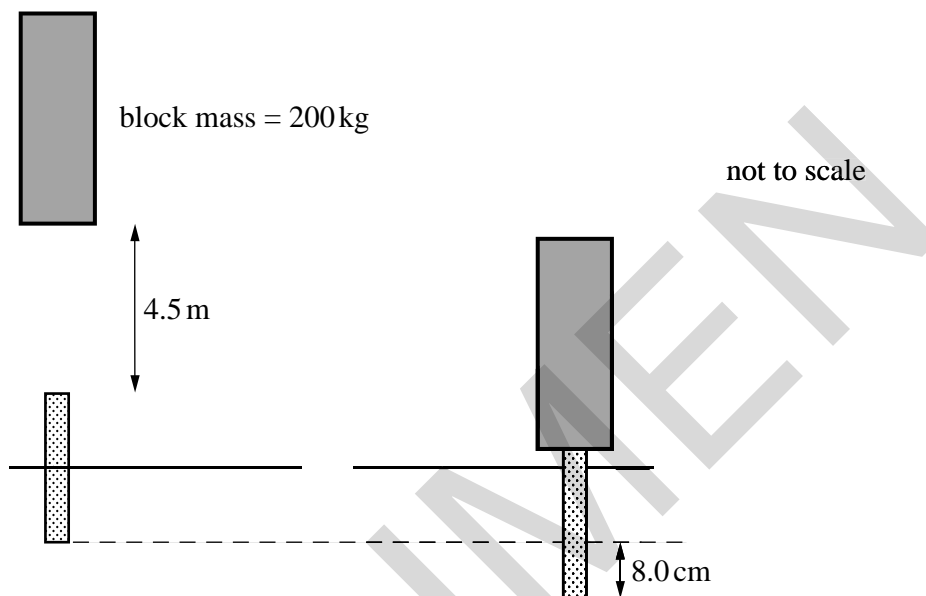
block mass = 200 kg

not to scale

4.5 m

8.0 cm

Fig.1.1

(a) Calculate the change in potential energy of the block from release point to the point it comes to rest.

change in potential energy = **……….…………** J   **[2]**

(b) Use your answer to **(a)** to calculate the average force exerted on the block by the cylinder as it decelerates.

average force = **…………..………** N   **[2]**

(c) The process is repeated and the cylinder is pushed into the ground by a further 6.0 cm. Suggest and explain why the depth did **not** increase by 8.0 cm.

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.... **[2]**

2 This question is about momentum and impulse.

(a) The impulse of a force is given by the equation *impulse = force × time*

Show that the units of impulse are equivalent to kg m s⁻¹.

[2]

(b) Fig. 2.1 shows a collision between two balls. Ball **A** has mass 0.60 kg, ball **B** has mass 0.40 kg.

| $6\,\text{m s}^{-1}$ | $0\,\text{m s}^{-1}$ | $3\,\text{m s}^{-1}$ | $4.5\,\text{m s}^{-1}$ |

ball **A**   ball **B**   ball **A**   ball **B**

before   **after**
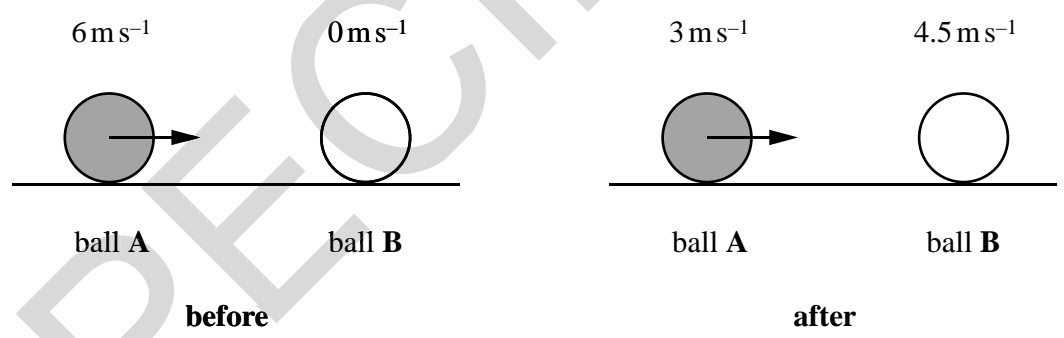
Fig. 2.1

(i) Calculate the total momentum **before** the collision.

momentum = **……………………….. ** kg m s⁻¹ **[2]**

(ii) Show that kinetic energy is **not** conserved in the collision.

[3]

4

(iii) The balls are in contact for 40 ms. Calculate the average force exerted on ball **A** as it decelerated from 6 m s^{-1} to 3 m s^{-1}. Suggest why this is an average value.

[3]

3 This question is about a phone capturing and sending a digital photograph.

Here are some data about the photograph and the broadband system the phone uses.

> The image is 640 × 960 pixels.
> Each pixel is coded for three colours. Each colour is coded by 8 bits.
> The broadband speed is 5×10^6 bits per second.

(a) Calculate the time required to send the uncompressed photograph.

time = …...…………..……… s   **[2]**

(b) The phone's camera can record video at 30 frames per second. The phone can store 6.2 gigabytes of data. Calculate how many seconds of video recording the phone can store if each frame has the same data requirement as a still photograph.

recording time = …………………………… s   **[2]**

(c) Digital images can be compressed to reduce the number of bits required to represent the image and they may be manipulated in other ways to edit or change the image. The modified images and videos may then be posted to social media websites. Give a reason for processing images in one of these ways and identify the benefits or any risk associated with this.

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SECTION B

Answer **all** the questions.

4   This question is about different models of light.

A coherent beam of light passes through two slits and forms a pattern on a distant screen. The slit spacing is 2.5×10^{-4} m. The distance from the slits to the screen is 2.3 m.
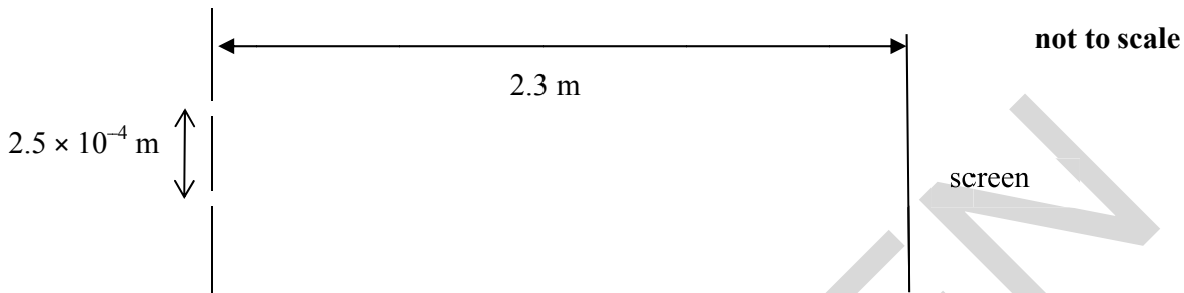
Fig. 4.1

(a)   Explain what the term *coherent* means in this context.

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....   **[1]**

(b)   **Fig. 4.2** represents the pattern of bright fringes on the screen.
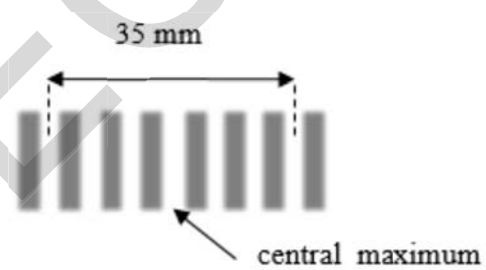
Fig. 4.2

Use the data below and information from **Fig. 4.2** to calculate the wavelength of the light passing through the slits.

slit spacing = 2.5×10^{-4} m
distance from the slits to the screen = 2.3 m.

wavelength = ….………………………. m   **[3]**

(c) Phasors can be represented by rotating arrows. The phasors representing the waves from the two slits reaching the screen at a bright patch at one instant of time are shown in **Fig. 4.3.**
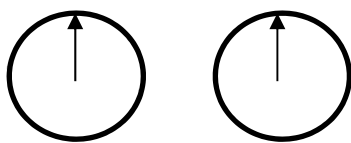
bright patch   dark patch
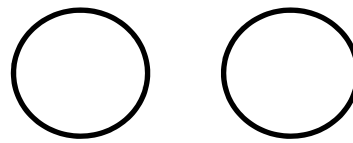
Fig. 4.3   **Fig. 4.4**

(i) On **Fig. 4.4** draw arrows representing phasors arriving at the same instant of time, for light from the two slits, at a **dark patch** on the screen. **[1]**

(ii) **Fig. 4.5** shows two pairs of phasor arrows meeting at the screen. Draw a scale diagram showing the resultant phasor arrow in both cases.

case 1:

phasor arrows: resultant phasor arrow:

↑ + ↑

case 2:

phasor arrows   resultant phasor arrow:

↑ + →

Fig. 4.5

[2]

(iii) Use the relationship *probability of arrival of photon* α *(phasor amplitude)^2* to find the ratio of the probabilities of arrival of photons for the two resultant phasors.

$$\text{ratio } \frac{probability\ of\ arrival\ of\ photons\ in\ case\ 1}{probability\ of\ arrival\ of\ photons\ in\ case\ 2} =$$

[2]

When interference patterns were first observed in the nineteenth century they were interpreted as evidence for the wave picture of light. Early in the twentieth century, Albert Einstein showed that light interacts as small quanta of energy, photons. This idea is supported by images such as **Fig. 4.6.** This shows an image of a girl's face gradually building up as more light falls on the photographic film. Image (1) is the least exposed and (6) the most. In the early stages of building up an image the pattern is quite random.

Fig. 4.6

Photons can be modelled as small quanta of energy that have a probability of arrival at a point. This probability is found by using phasors to combine the amplitude and phase for all possible paths to that point.

(d)* Describe how this phasor model can explain the gradual build-up of images such as **Fig. 4.6** and also explain two-slit interference. In your description you should also explain why a wave model cannot explain the effect shown in **Fig 4.6** and why a simple particle model cannot explain interference effects.

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5 This question is about the properties and microscopic structure of metal wire. **Fig. 5.1** shows a graph of force against extension for a steel wire.
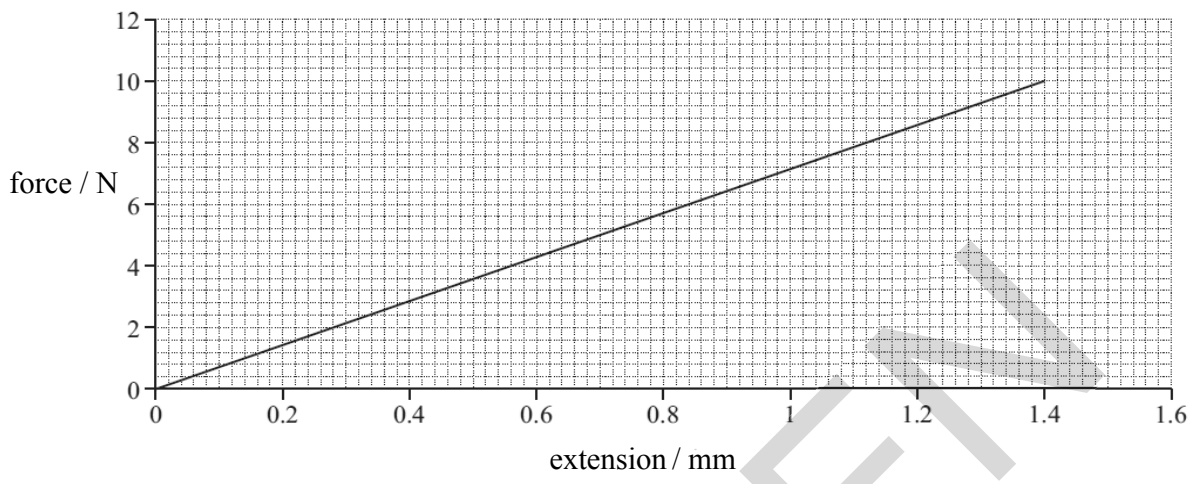
Fig. 5.1

(a) State how the graph shows that the wire is behaving elastically.

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.... **[1]**

(b) The wire has a diameter of 0.40 mm. The original length of the wire is 3.85 m.

Use data from **Fig. 5.1** to calculate the Young modulus of the steel.

Young modulus = **........................** N m^{-2} **[4]**

10

(c) **Fig. 5.2** shows a stress–strain graph of the same material, obtained from a tensile testing machine.
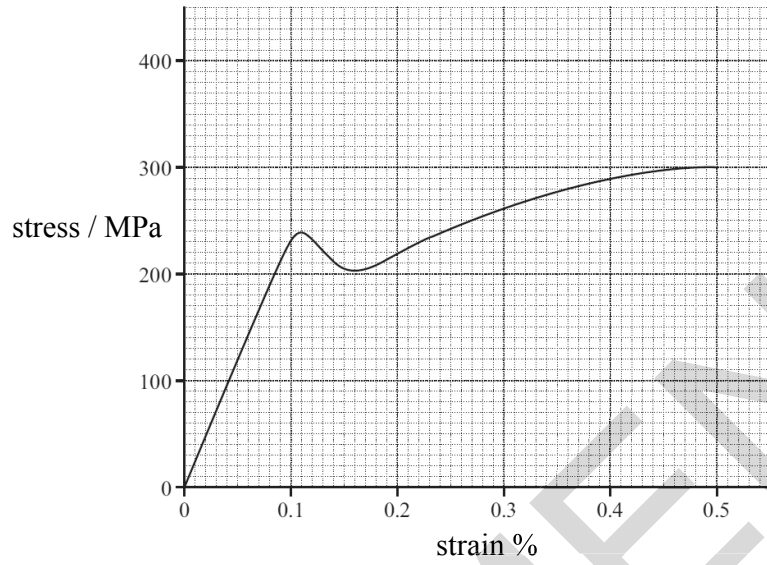
Fig. 5.2

(i) Mark with an X the point on the graph in **Fig. 5.2** where plastic deformation begins. **[1]**

(ii) State the feature of the graph that represents the stiffness of the material and describe how the stiffness varies between a strain of 0.2% and 0.5%.

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.... **[2]**

(d)* Steel is an alloy. Its main constituent is iron. Using ideas about dislocations and metallic structure explain why the steel first shows elastic behaviour (up to point X) and then shows plastic behaviour (beyond point X). Explain how the presence of atoms other than iron makes the resulting metal harder and less plastic than pure iron.

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.... **[6]**

Section C begins on page 12

 Turn over

SECTION C

Answer **all** the questions.

6 This question is about an experiment performed in AS physics to determine the internal resistance of a battery (two cells combined in series). The experiment can be set up as shown in **Fig. 6.1.**
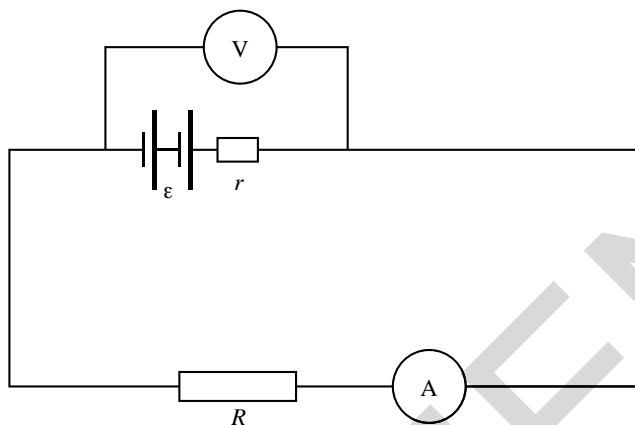
Fig. 6.1

Measurements of p.d. *V* and current *I* for a range of values of resistors *R* are taken in order to determine a value for the combined internal resistance of the cells.
In planning the experiment it is important to select suitable equipment.

(a) Explain why the following equipment was chosen

- A voltmeter with very high internal resistance.
- An ammeter with negligible internal resistance.

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.... **[2]**

(b) A student suggests that using much higher value resistors will improve the quality of measurements by reducing the uncertainty in the current readings.

Comment on this suggestion. Explain your reasoning.

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.... **[3]**

(c) Data obtained from the experiment on page 12 is given in the table below

p.d. / V	*I* /mA
2.86	286
2.82	352
2.78	462
2.66	666
2.40	1200

Plot a graph of the values on **Fig. 6.2**. Draw a suitable line.

Fig. 6.2

[2]

14
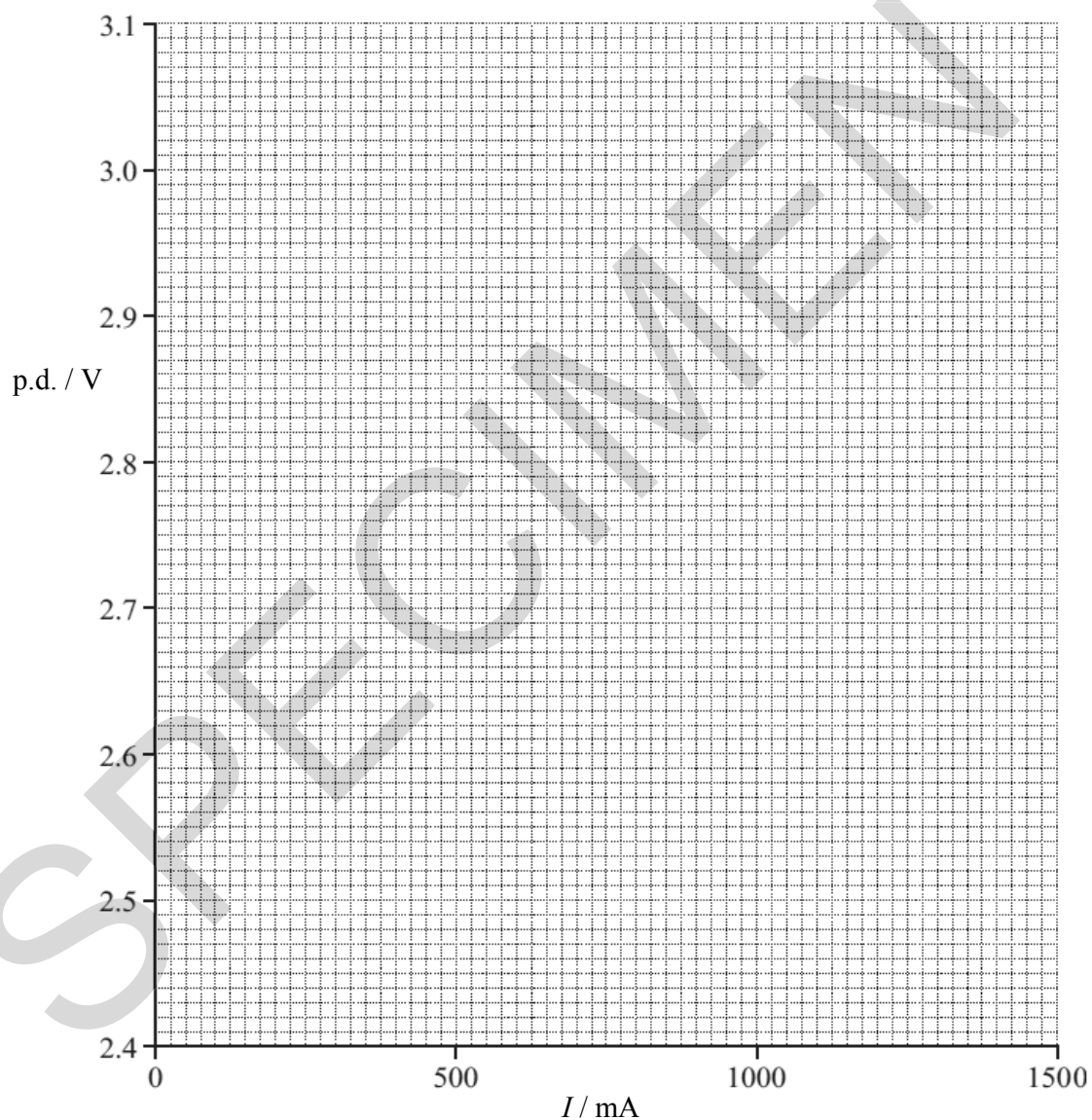
The equation relating p.d. V and current is

$V = \varepsilon - Ir$

Where ε is the e.m.f. of the battery and r is the internal resistance of the battery.

(d) Use the graph to determine a value for the e.m.f. ε for the cells. Show your working clearly and include the unit in your answer.

e.m.f. ε = **…………………..** **[2]**

(e) Determine a value for the internal resistance.

internal resistance = **…………………..** Ω **[3]**

(f)* A student suggests three possible variations to extend the experiment.

      1) Adding a switch into the circuit so that the circuit can be disconnected between readings.

      2) Adding another cell.

      3) Reversing one of the cells.

Discuss the effect that each of these three suggested changes would have on the accuracy of the experiment, the uncertainty of measurement and the data collected.

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.... **[6]**

END OF QUESTION PAPER