Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|

Centre Number | Candidate Number

# Pearson Edexcel International Advanced Level

## Monday 22 May 2023

Morning (Time: 1 hour 20 minutes)

Paper reference **WPH13/01**

# Physics

## International Advanced Subsidiary/Advanced Level
## UNIT 3: Practical Skills in Physics I

**You must have:**
Scientific calculator, ruler

Total Marks

### Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- **Show all your working out** in calculations and **include units** where appropriate.

### Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- The list of data, formulae and relationships is printed at the end of this booklet.

### Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

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**Answer ALL questions.**

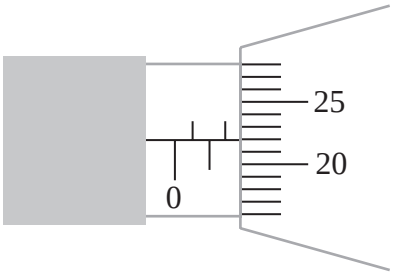
**1** A student made measurements of the ruler shown.




(Source: © Dragance137/Shutterstock)

(a) She used a micrometer screw gauge to measure the thickness $t$ at the centre of the ruler.

The diagram below shows the reading on the micrometer.




(i) State the value of $t$ shown on the micrometer.

**(1)**

$t$ = .....

(ii) Determine the percentage uncertainty in this value of $t$.

**(2)**

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Percentage uncertainty in $t$ = .....

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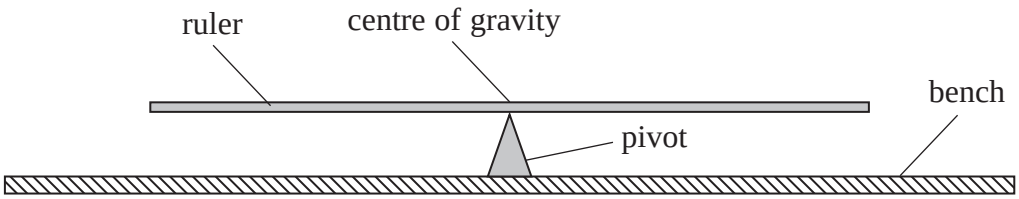
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(iii) Explain how she should reduce a source of error in this measurement of *t*.

**(2)**

(b) The student balanced the ruler on a pivot as shown, and recorded the position of the centre of gravity of the ruler.




The student has a 20 g mass.

Describe how the student should determine an accurate value for the mass of the ruler using the 20 g mass and the apparatus shown.

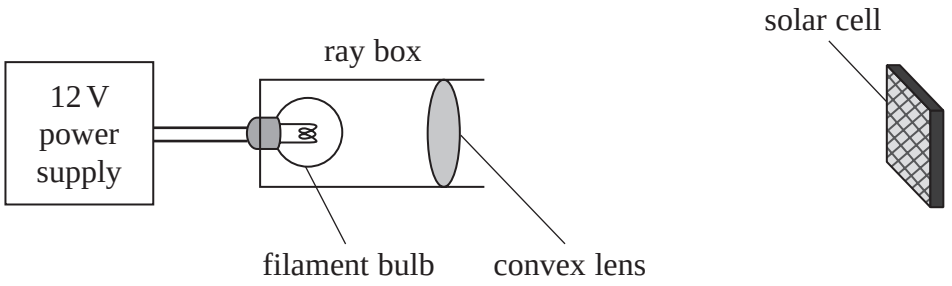
**(4)**

**(Total for Question 1 = 9 marks)**

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**2** A student investigated the properties of a solar cell.

He illuminated the solar cell using the apparatus shown.




(a) (i) Explain the purpose of the convex lens.

**(2)**

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(ii) The power supply provided a constant 12 V potential difference across the filament bulb.

Describe **two** more ways to keep the light intensity incident on the solar cell constant.

**(2)**

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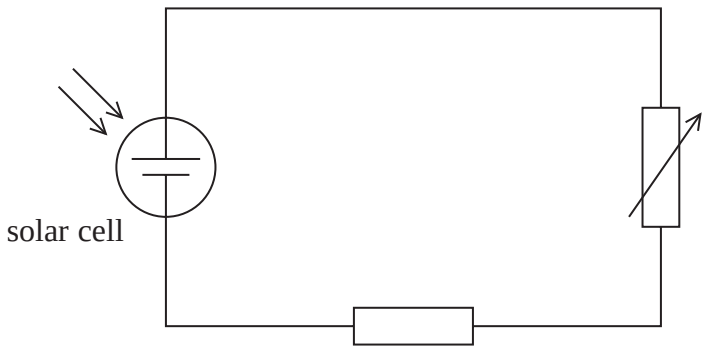
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(b) The student investigated how the potential difference across the solar cell varied with the current through the solar cell.

The light intensity incident on the solar cell was kept constant during the investigation.

The circuit diagram for the investigation is shown below.




(i) Add to the diagram to show how an ammeter and a voltmeter should be connected in the circuit.

**(2)**

(ii) Suggest a reason for using a fixed resistor in the circuit.

**(1)**

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(c) Solar cells are used as a source of electrical power.

Describe **two** advantages of using solar cells to power a small water pump in a garden.

**(2)**

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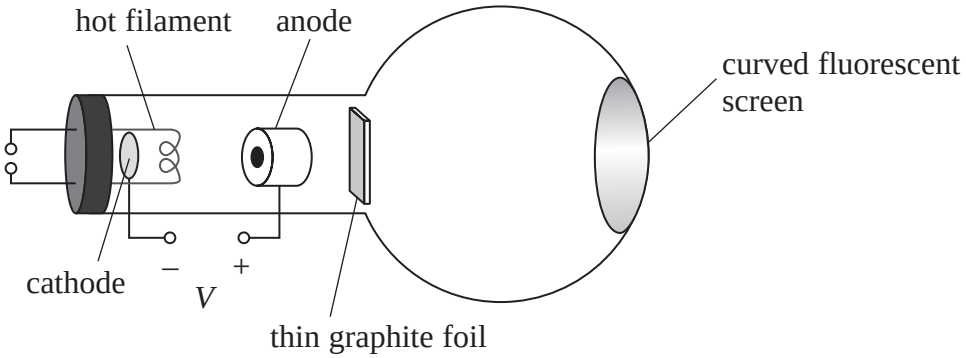
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**(Total for Question 2 = 9 marks)**

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**3** A student investigated the diffraction of electrons using an electron beam tube as shown.




The potential difference, *V*, accelerates electrons from the hot filament towards the thin graphite foil.

The electrons diffract as they pass through the foil, producing a ring pattern on the curved fluorescent screen as shown below.



(Source: © ANDREW LAMBERT PHOTOGRAPHY/SCIENCE PHOTO LIBRARY)

(a) The student used vernier calipers to measure the diameters of the rings on the curved screen.

(i) Give **two** reasons why vernier calipers are more appropriate for these measurements than a transparent ruler.

**(2)**

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(ii) Describe how the student should measure the diameter of a ring as accurately as possible.

**(2)**

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(b) The student used the diameter of the rings to determine the wavelength $\lambda$ of the electrons.

He repeated this for two more values of $V$.

The student also determined the value of a constant $a$ using the formula

$$a = V\lambda^2$$

The results are shown in the table below.

| $V$ / kV | $\lambda$ / $10^{-12}$ m | $a$ / $10^{-18}$ m$^2$ V |
|---|---|---|
| 200 | 2.67 | 1.23 |
| 250 | 2.44 | 1.11 |
| 300 | 2.14 | 1.32 |

(i) Determine the mean value of $a$ in m$^2$ V.

**(2)**

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Mean value of $a$ = ..... m$^2$ V

(ii) Determine the percentage uncertainty in the mean value of $a$.

**(2)**

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Percentage uncertainty in the mean value of $a$ = .....

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(iii) A different student repeated the investigation using six values of $V$. She plotted a graph of $V$ against $\frac{1}{\lambda^2}$ and determined the constant $a$ from the gradient.

Give **two** reasons why this is a better method to determine a value for $a$.

**(2)**

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(c) The value of $a$ can also be calculated using the formula

$$a = \frac{h^2}{2em_e}$$

where
$h$ is the Planck constant
$e$ is the electron charge
$m_e$ is the electron mass.

(i) Calculate the value of $h$, in J s, when $a$ is $1.46 \times 10^{-18}$ m$^2$ V.

**(2)**

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$h$ = ..... J s

(ii) The percentage uncertainty in the calculated value of $h$ is 6%.

Comment on the accuracy of your calculated value of $h$.

**(2)**

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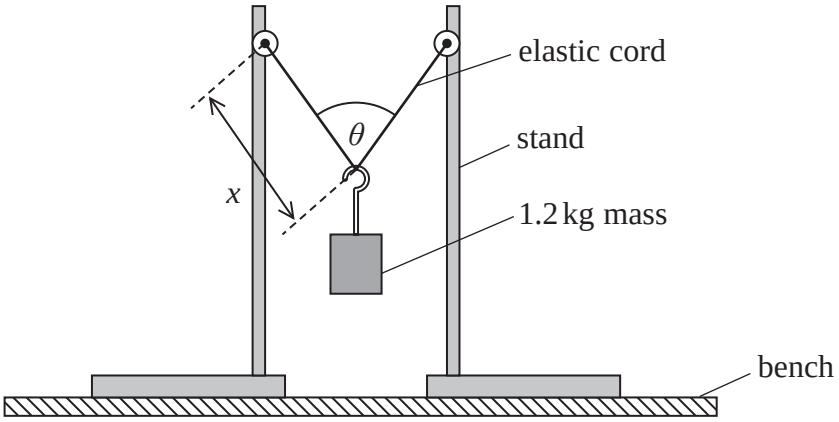
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**(Total for Question 3 = 14 marks)**

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**4** A student investigated the extension of an elastic cord. She hung a 1.2 kg mass from the elastic cord as shown.




(a) Identify a health and safety issue and how it may be dealt with.

**(2)**

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(b) The student varied the distance between the two stands to vary the angle $\theta$.

She measured $\theta$ using a protractor. For each value of $\theta$ she measured the corresponding length $x$ with a metre rule.

(i) Identify **two** sources of uncertainty with this method.

**(2)**

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(ii) Suggest a modification to reduce the effect of **one** of these sources of uncertainty.

**(1)**

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(c) The student determined the extension $\Delta x$ of the elastic cord for each value of $\theta$.

The relationship between $\theta$ and $\Delta x$ is given by

$$\cos\left(\frac{\theta}{2}\right) = \frac{mg}{k\Delta x}$$

where
$m$ is the mass hung from the elastic cord
$k$ is the stiffness of the elastic material.

(i) Explain why a graph of $\cos\left(\frac{\theta}{2}\right)$ against $\frac{1}{\Delta x}$ can be used to determine a value for $g$.

**(2)**

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(ii) The student recorded the following data.

| $\cos\left(\frac{\theta}{2}\right)$ | $\Delta x$ / m | |
|---|---|---|
| 0.938 | 0.165 | |
| 0.926 | 0.169 | |
| 0.911 | 0.175 | |
| 0.902 | 0.178 | |
| 0.891 | 0.183 | |

Plot a graph of $\cos\left(\frac{\theta}{2}\right)$ on the $y$-axis against $\frac{1}{\Delta x}$ on the $x$-axis on the grid opposite.

Use the additional column of the table for your processed data.

**(6)**

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(iii) Determine the gradient of the graph.

**(3)**

Gradient = .....

(iv) Determine a value for $g$ from the gradient of the graph.

$m = 1.20\,\text{kg}$
$k = 145\,\text{N m}^{-1}$

**(2)**

$g$ = .....

**(Total for Question 4 = 18 marks)**

**TOTAL FOR PAPER = 50 MARKS**

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## List of data, formulae and relationships

| | | |
|---|---|---|
| Acceleration of free fall | $g = 9.81$ m s$^{-2}$ | (close to Earth's surface) |
| Electron charge | $e = -1.60 \times 10^{-19}$ C | |
| Electron mass | $m_e = 9.11 \times 10^{-31}$ kg | |
| Electronvolt | $1\,\text{eV} = 1.60 \times 10^{-19}$ J | |
| Gravitational field strength | $g = 9.81$ N kg$^{-1}$ | (close to Earth's surface) |
| Planck constant | $h = 6.63 \times 10^{-34}$ J s | |
| Speed of light in a vacuum | $c = 3.00 \times 10^{8}$ m s$^{-1}$ | |

***Unit 1***

*Mechanics*

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

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

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

$$\Delta W = F\Delta s$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

Power

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

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Efficiency

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

*Materials*

Density $\rho = \frac{m}{V}$

Stokes' law $F = 6\pi\eta rv$

Hooke's law $\Delta F = k\Delta x$

Elastic strain energy $\Delta E_{\text{el}} = \frac{1}{2}F\Delta x$

Young modulus $E = \frac{\sigma}{\varepsilon}$ where

Stress $\sigma = \frac{F}{A}$

Strain $\varepsilon = \frac{\Delta x}{x}$

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***Unit 2***

*Waves*

| | |
|---|---|
| Wave speed | $v = f\lambda$ |
| Speed of a transverse wave on a string | $v = \sqrt{\frac{T}{\mu}}$ |
| Intensity of radiation | $I = \frac{P}{A}$ |
| Refractive index | $n_1 \sin\theta_1 = n_2 \sin\theta_2$ |
| | $n = \frac{c}{v}$ |
| Critical angle | $\sin C = \frac{1}{n}$ |
| Diffraction grating | $n\lambda = d \sin\theta$ |

*Electricity*

| | |
|---|---|
| Potential difference | $V = \frac{W}{Q}$ |
| Resistance | $R = \frac{V}{I}$ |
| Electrical power, energy | $P = VI$ |
| | $P = I^2R$ |
| | $P = \frac{V^2}{R}$ |
| | $W = VIt$ |
| Resistivity | $R = \frac{\rho l}{A}$ |
| Current | $I = \frac{\Delta Q}{\Delta t}$ |
| | $I = nqvA$ |
| Resistors in series | $R = R_1 + R_2 + R_3$ |
| Resistors in parallel | $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ |

*Particle nature of light*

| | |
|---|---|
| Photon model | $E = hf$ |
| Einstein's photoelectric equation | $hf = \phi + \frac{1}{2}mv^2_{max}$ |
| de Broglie wavelength | $\lambda = \frac{h}{p}$ |

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