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| | |

**Pearson Edexcel**
**International**
**Advanced Level**

Centre Number | | | | | |

Candidate Number | | | | |

# Physics

## Advanced
## Unit 6: Experimental Physics

Monday 1 February 2016 – Morning
**Time: 1 hour 20 minutes**

Paper Reference
**WPH06/01**

**You must have:**
Ruler

Total Marks

### Instructions

- Use **black** ink or ball-point pen.
- **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.*

### Information

- The total mark for this paper is 40.
- 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.
- Candidates may use a scientific calculator.

### Advice

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

*Turn over* ▶

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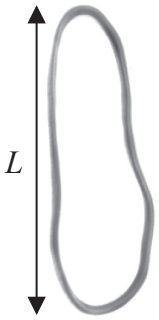
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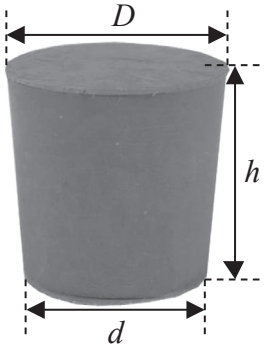
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**Answer ALL questions in the spaces provided.**

**1** A student investigates the properties of a rubber band and a rubber bung to determine whether they are made from the same type of rubber.




Rubber band




Rubber bung

(a) The volume $V_1$ of the band is given by

$$V_1 = 2Lwt$$

where $w$ is the width of the band and $t$ is the thickness and $L$ is the length shown in the diagram.

(i) The student uses a metre rule to measure $L$ which is approximately 10 cm. Explain why a metre rule is suitable for this measurement.

**(2)**

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(ii) She uses a micrometer screw gauge to measure $w$ and $t$ and records the following readings with negligible uncertainties.

| $L$/cm | $w$/mm | $t$/mm |
|---|---|---|
| 10.0 | 9.33 | 1.03 |

Use these measurements to calculate $V_1$ in cm$^3$.

**(2)**

$V_1 =$ ..... cm$^3$

(b) The volume $V_2$ of the bung is given by

$$V_2 = \frac{\pi h}{12}\left(D^2 + d^2 + Dd\right)$$

where $D$, $d$ and $h$ are the dimensions shown on the diagram.
The student uses callipers to take measurements of the bung.

(i) Describe how $h$ should be measured.

**(2)**

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(ii) She records values for the diameters with negligible uncertainty.

$D = 3.45\,\text{cm}$ $d = 3.06\,\text{cm}$

She records the following values for $h$

| $h$/cm | 3.51 | 3.49 | 3.53 |
|---|---|---|---|

Use these measurements to calculate $V_2$ in $\text{cm}^3$.

**(2)**

$V_2 =$ ..... $\text{cm}^3$

(iii) Estimate the percentage uncertainty in $V_2$.

**(1)**

Percentage uncertainty = .....

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(c) The student uses a top pan balance to record the following readings with negligible uncertainty.

mass of band = 2.23 g  mass of bung = 44.48 g

Calculate the densities of the band and the bung.

**(3)**

Density of band = .....

Density of bung = .....

(d) The percentage uncertainty in the density of the band is 4%.

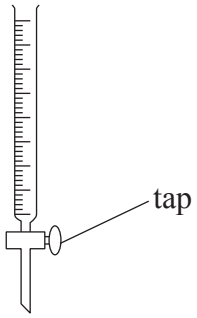
Use this value and your results to comment on the suggestion that both the band and the bung are made from the same type of rubber.

**(2)**

**(Total for Question 1 = 14 marks)**

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**2** A burette is a transparent tube that can contain a liquid. It has a tap at the bottom to allow the liquid to flow out. The volume $V$ of liquid remaining in the burette is measured using a scale on the side of the tube.




It is suggested that $V$ decreases exponentially with time as shown by the equation

$$V = V_0 e^{-\frac{t}{b}}$$

where $V_0$ is the initial volume, $t$ is the time since the tap was opened and $b$ is a constant.

(a) Write a plan for an experiment to determine a value for $b$ using a graphical method and a burette where $V_0 = 100$ cm$^3$.

Your plan should include

(i) a description of how you would measure $V$ and $t$ and **two** precautions you would take to make your readings as accurate as possible,

**(4)**

(ii) one source of uncertainty in the measurements,

**(1)**

(iii) the graph you would plot and how you would use the graph to determine $b$.

**(2)**

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(b) The temperature of the liquid in the burette is increased. This reduces the viscosity of the liquid.

Explain the effect of this on the value of *b* in the equation.

**(2)**

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

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**3** A student carried out an experiment to measure how the resistance of a thermistor decreases as the temperature increases.

(a) Draw a diagram of the apparatus that could be used to carry out this experiment in a school laboratory.

**(3)**

(b) The following readings were recorded.

| $T$/°C | $R$/kΩ |
|---|---|
| 14 | 8.16 |
| 30 | 4.03 |
| 45 | 2.29 |
| 61 | 1.32 |
| 83 | 0.65 |

(i) Suggest why it would be a good idea to take extra readings in the range 14 °C to 45 °C.

**(1)**

.....

.....

(ii) Suggest how the range of readings could have been increased.

**(1)**

.....

.....

**(Total for Question 3 = 5 marks)**

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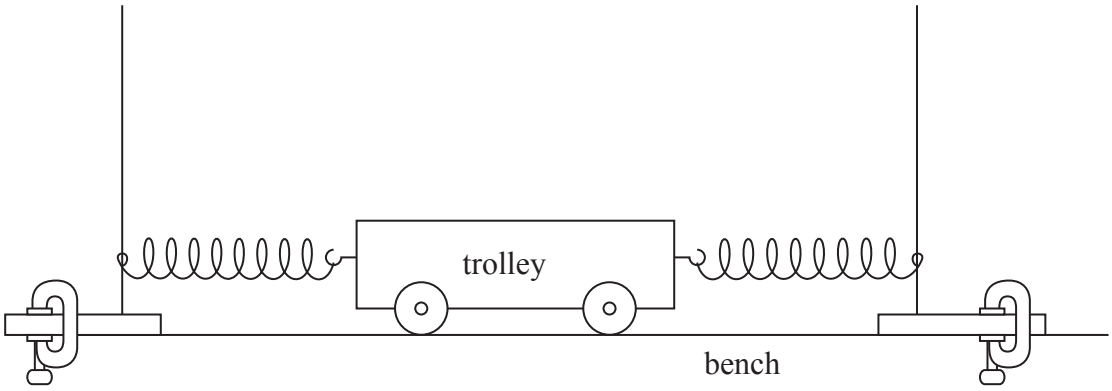
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**4** A trolley is attached to two fixed points by springs as shown.




When pulled to one side and released, the trolley oscillates with simple harmonic motion. The periodic time $T$ of this oscillation is measured. Masses $m$ are placed on the trolley and the new periodic times are measured. The results are shown in the table.

| ***m*/kg** | ***T*/s** | |
|---|---|---|
| 0 | 1.59 | |
| 0.5 | 1.94 | |
| 1.0 | 2.19 | |
| 1.5 | 2.47 | |
| 2.0 | 2.66 | |

(a) The relationship between $T$ and $m$ is

$$T^2 = \frac{4\pi^2 m}{k} + \frac{4\pi^2 M}{k}$$

where $k$ is the stiffness of the arrangement of the springs and $M$ is the mass of the trolley.

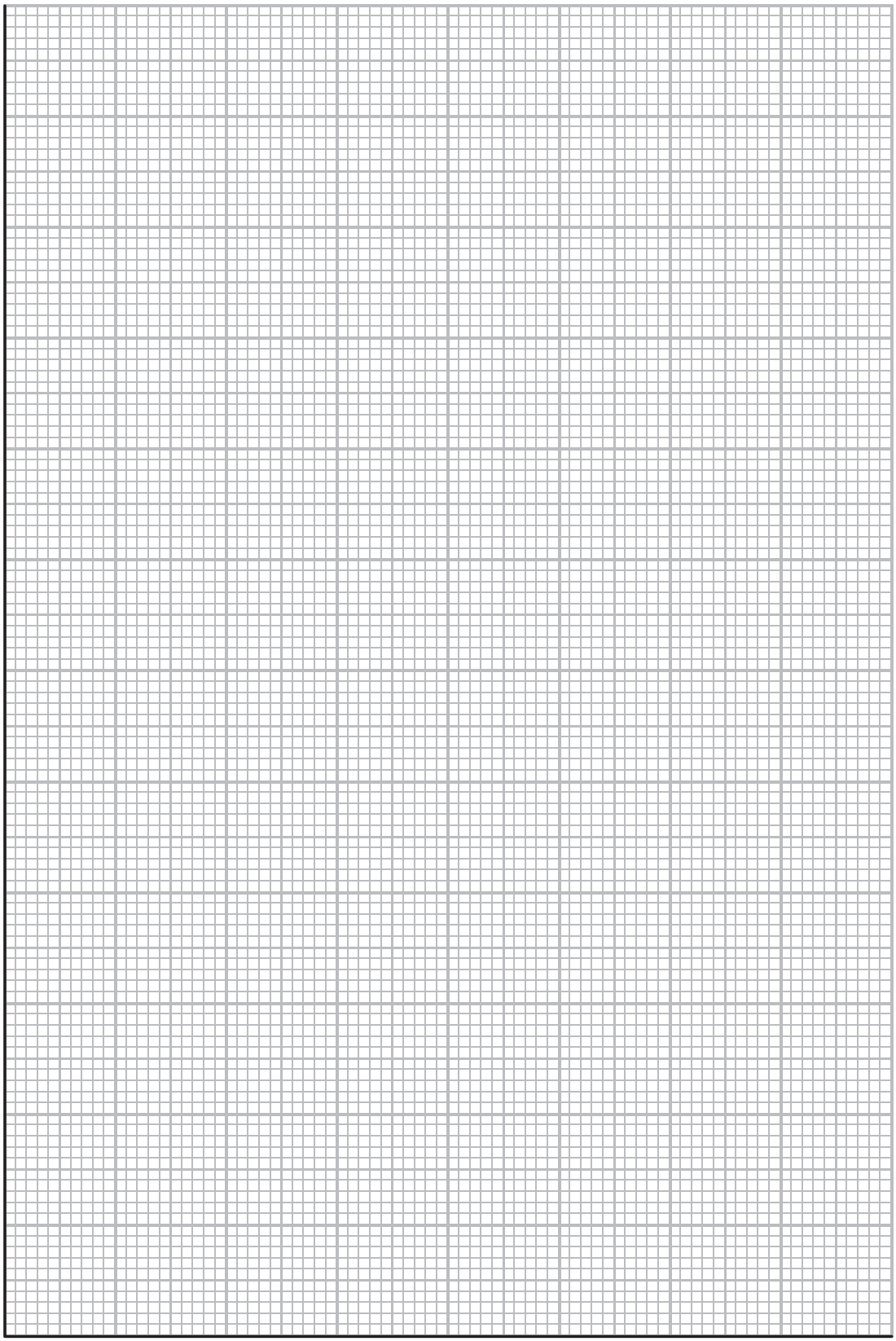
(i) Draw a graph of $T^2$ against $m$ on the grid opposite. Use the extra column in the table for your processed data.

**(4)**

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**Question 4 continues on the next page**

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(ii) Use your graph to determine a value for $k$.

**(3)**

$k$ = .....

(iii) Use your graph to determine a value for $M$.

**(3)**

$M$ = .....

(b) The mass of the trolley is measured using a balance and recorded as 1.05 kg.
Comment on the accuracy of your answer for (a)(iii).

**(2)**

**(Total for Question 4 = 12 marks)**

**TOTAL FOR PAPER = 40 MARKS**

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## List of data, formulae and relationships

| | | |
|---|---|---|
| Acceleration of free fall | $g = 9.81\ \text{m s}^{-2}$ | (close to Earth's surface) |
| Boltzmann constant | $k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$ | |
| Coulomb's law constant | $k = 1/4\pi\varepsilon_0$<br>$= 8.99 \times 10^9\ \text{N m}^2\ \text{C}^{-2}$ | |
| Electron charge | $e = -1.60 \times 10^{-19}\ \text{C}$ | |
| Electron mass | $m_e = 9.11 \times 10^{-31}\ \text{kg}$ | |
| Electronvolt | $1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$ | |
| Gravitational constant | $G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$ | |
| Gravitational field strength | $g = 9.81\ \text{N kg}^{-1}$ | (close to Earth's surface) |
| Permittivity of free space | $\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$ | |
| Planck constant | $h = 6.63 \times 10^{-34}\ \text{J s}$ | |
| Proton mass | $m_p = 1.67 \times 10^{-27}\ \text{kg}$ | |
| Speed of light in a vacuum | $c = 3.00 \times 10^8\ \text{m s}^{-1}$ | |
| Stefan-Boltzmann constant | $\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$ | |
| Unified atomic mass unit | $u = 1.66 \times 10^{-27}\ \text{kg}$ | |

### *Unit 1*

*Mechanics*

| | |
|---|---|
| Kinematic equations of motion | $v = u + at$<br>$s = ut + \frac{1}{2}at^2$<br>$v^2 = u^2 + 2as$ |
| Forces | $\Sigma F = ma$<br>$g = F/m$<br>$W = mg$ |
| Work and energy | $\Delta W = F\Delta s$<br>$E_k = \frac{1}{2}mv^2$<br>$\Delta E_{grav} = mg\Delta h$ |

*Materials*

| | |
|---|---|
| Stokes' law | $F = 6\pi\eta rv$ |
| Hooke's law | $F = k\Delta x$ |
| Density | $\rho = m/V$ |
| Pressure | $p = F/A$ |
| Young modulus | $E = \sigma/\varepsilon$ where<br>Stress $\sigma = F/A$<br>Strain $\varepsilon = \Delta x/x$ |
| Elastic strain energy | $E_{el} = \frac{1}{2}F\Delta x$ |

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***Unit 2***

*Waves*

| | |
|---|---|
| Wave speed | $v = f\lambda$ |
| Refractive index | ${}_1\mu_2 = \sin i / \sin r = v_1 / v_2$ |

*Electricity*

| | |
|---|---|
| Potential difference | $V = W/Q$ |
| Resistance | $R = V/I$ |
| Electrical power, energy and efficiency | $P = VI$<br>$P = I^2R$<br>$P = V^2/R$<br>$W = VIt$ |
| | $\%\ \text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ |
| | $\%\ \text{efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$ |
| Resistivity | $R = \rho l / A$ |
| Current | $I = \Delta Q / \Delta t$<br>$I = nqvA$ |
| Resistors in series | $R = R_1 + R_2 + R_3$ |
| Resistors in parallel | $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$ |

*Quantum physics*

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

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***Unit 4***

*Mechanics*

| | |
|---|---|
| Momentum | $p = mv$ |
| Kinetic energy of a non-relativistic particle | $E_k = p^2/2m$ |
| Motion in a circle | $v = \omega r$<br>$T = 2\pi/\omega$<br>$F = ma = mv^2/r$<br>$a = v^2/r$<br>$a = r\omega^2$ |

*Fields*

| | |
|---|---|
| Coulomb's law | $F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$ |
| Electric field | $E = F/Q$<br>$E = kQ/r^2$<br>$E = V/d$ |
| Capacitance | $C = Q/V$ |
| Energy stored in capacitor | $W = \frac{1}{2}QV$ |
| Capacitor discharge | $Q = Q_0e^{-t/RC}$ |
| In a magnetic field | $F = BIl \sin \theta$<br>$F = Bqv \sin \theta$<br>$r = p/BQ$ |
| Faraday's and Lenz's Laws | $\varepsilon = -d(N\phi)/dt$ |

*Particle physics*

| | |
|---|---|
| Mass-energy | $\Delta E = c^2 \Delta m$ |
| de Broglie wavelength | $\lambda = h/p$ |

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***Unit 5***

*Energy and matter*

| | |
|---|---|
| Heating | $\Delta E = mc\Delta\theta$ |
| Molecular kinetic theory | $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$ |
| Ideal gas equation | $pV = NkT$ |

*Nuclear Physics*

| | |
|---|---|
| Radioactive decay | $\mathrm{d}N/\mathrm{d}t = -\lambda N$ |
| | $\lambda = \ln 2/t_{\frac{1}{2}}$ |
| | $N = N_0 \mathrm{e}^{-\lambda t}$ |

*Mechanics*

| | |
|---|---|
| Simple harmonic motion | $a = -\omega^2 x$<br>$a = -A\omega^2 \cos \omega t$<br>$v = -A\omega \sin \omega t$<br>$x = A \cos \omega t$<br>$T = 1/f = 2\pi/\omega$ |
| Gravitational force | $F = Gm_1m_2/r^2$ |

*Observing the universe*

| | |
|---|---|
| Radiant energy flux | $F = L/4\pi d^2$ |
| Stefan-Boltzmann law | $L = \sigma T^4 A$<br>$L = 4\pi r^2 \sigma T^4$ |
| Wien's Law | $\lambda_{max} T = 2.898 \times 10^{-3}$ m K |
| Redshift of electromagnetic radiation | $z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$ |
| Cosmological expansion | $v = H_0 d$ |

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