Write your name here

| Surname | Other names |
|---|---|
| | |

# Edexcel GCE

Centre Number | Candidate Number

# Physics

## Advanced
## Unit 6B: Experimental Physics
## International Alternative to Internal Assessment

Tuesday 15 January 2013 – Morning
**Time: 1 hour 20 minutes**

Paper Reference
**6PH08/01**

**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***

P41631A

6/6/6/6/

P 4 1 6 3 1 A 0 1 1 6

PEARSON

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

**1** A student is asked to determine the density of a metal in the form of a thin sheet.

The sheet is a square of approximately 300 mm × 300 mm and has a thickness of about 0.01 mm.

(a) (i) Explain why a metre rule is suitable to measure the length of each side of the sheet.

**(1)**

..............................................................................................................................................

..............................................................................................................................................

(ii) Describe how the student should use this rule to make the measurements as accurate as possible.

**(1)**

..............................................................................................................................................

..............................................................................................................................................

(b) In order to determine the thickness, the student is told to fold the sheet in half five times.

(i) Explain why this technique would make the value for the thickness of the sheet more precise.

**(2)**

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

(ii) State what instrument the student should use to measure the thickness of the folded sheet.

**(1)**

..............................................................................................................................................

(c) The student makes the following measurements.

| | | **Mean values / mm** |
|---|---|---|
| Length of sheet/mm | 297, 302, 305, 298 | 301 |
| Width of sheet/mm | 303, 297, 299, 301 | 300 |
| Thickness of folded sheet/mm | 0.373, 0.375, 0.362, 0.379, 0.356, 0.369 | 0.369 |

(i) The folded sheet is 32 times thicker than a single sheet.

Use these measurements to show that the volume of the sheet is about $1.0 \times 10^{-6}\ m^3$.

**(2)**

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

(ii) Use the measurements to estimate the percentage uncertainty in the volume.

**(2)**

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

Percentage uncertainty = ..........................................

(iii) The student measures the mass of the sheet as 2.49 g with negligible uncertainty.

Calculate the density of the metal.

**(1)**

........................................................................................................................................

........................................................................................................................................

Density = .......................................... $kg\ m^{-3}$

(iv) A website gives a value for the density of aluminium as $2750\ kg\ m^{-3}$.

Use your calculations to determine whether the sheet might be made from aluminium.

**(2)**

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

**(Total for Question 1 = 12 marks)**

**2** A student writes a plan for an experiment to measure the current as a capacitor discharges through a resistor. His aim is to find a value for the time constant for the exponential decay of the current. His outline plan, which includes a circuit diagram, is shown below.

*Set up the circuit shown using a multimeter as the ammeter and use a stopwatch with a precision of 0.01 s.*

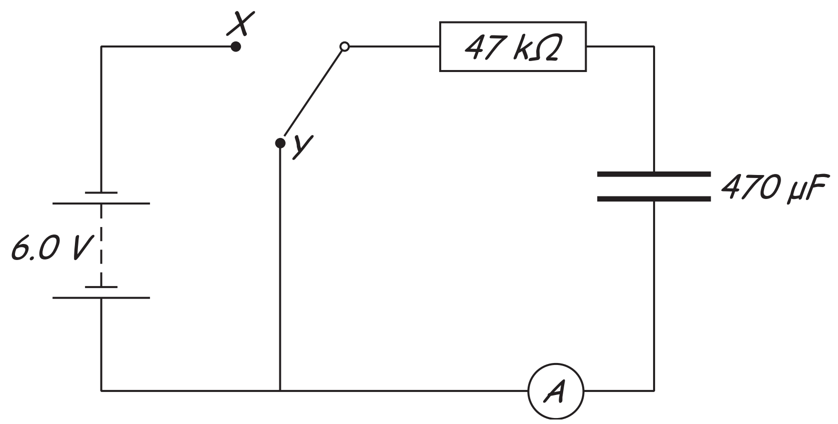
*Set the switch to position X.*

*Move the switch to position Y and record the current at regular time intervals.*

*The current decays according to the equation*

$$I = I_0 e^{-t/RC} \text{ where } RC \text{ is the time constant}$$

*Plot the measurements on a graph to find a value for the time constant.*




Suggest improvements to the plan that would allow the student to carry out the experiment successfully.

Your improvements should include:

(a) the initial current and the range he should set on the multimeter, **(2)**

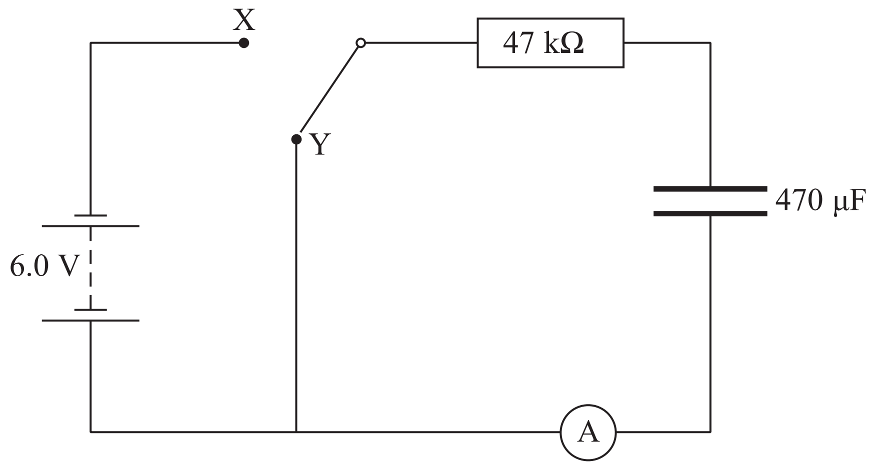
(b) the expected value for the time constant and for how long he should take readings of the current, **(2)**

(c) a reason why this stopwatch is suitable, **(1)**

(d) a technique he should use to ensure his readings are as accurate as possible and one safety precaution that might be necessary, **(2)**

(e) an explanation of why a graph of ln $I$ against $t$ would give a straight line and how he should find a value for the time constant from the graph. **(2)**

(f) A teacher suggests that with this circuit it would be necessary to wait for some time before switching from position X to position Y.




(i) Comment on why this wait is necessary.

**(1)**

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

(ii) Draw below a different arrangement of the circuit components so that there is no time delay.

**(1)**

**(Total for Question 2 = 11 marks)**

BLANK PAGE

**3** A student carries out an experiment on the Stefan-Boltzmann law.

$$L = \sigma T^4 A$$

She uses the filament of a light bulb as a model for a black body radiator.

(a) She obtains the following results.

$L = 23.5$ W ± 2%    $T = 2400$ K ± 4%

The student estimates the surface area of the filament $A$ to be $2.0 \times 10^{-5}$ m$^2$ ± 5%.

(i) Use her results to calculate an experimental value for the Stefan-Boltzmann constant $\sigma$.

**(1)**

....................................................................................................................................................................

....................................................................................................................................................................

Experimental value of $\sigma$ = ........................................................ W m$^{-2}$ K$^{-4}$

(ii) Estimate the percentage uncertainty in the experimental value of $\sigma$.

**(2)**

....................................................................................................................................................................

....................................................................................................................................................................

Percentage uncertainty = ........................................................

(iii) Calculate the percentage difference between the experimental value of $\sigma$ and the accepted value, $\sigma = 5.67 \times 10^{-8}$ W m$^{-2}$ K$^{-4}$.

**(1)**

....................................................................................................................................................................

....................................................................................................................................................................

....................................................................................................................................................................

Percentage difference = ........................................................

(iv) Use these percentages to comment on the reliability of the experimental value for $\sigma$.

**(1)**

....................................................................................................................................................................

....................................................................................................................................................................

....................................................................................................................................................................

....................................................................................................................................................................

(b) The Stefan-Boltzmann law can be written as

$$\ln L = 4\ln T + \ln \sigma A$$

The student obtains a range of values for $L$ and $T$ and plots a graph of ln $L$ against ln $T$.

(i) Explain clearly how she could use this graph to obtain a value for $\sigma$.

**(2)**

........................................................................................................................................................................................................

........................................................................................................................................................................................................

........................................................................................................................................................................................................

........................................................................................................................................................................................................

(ii) She realises that she cannot control the temperature of the room.

Suggest why this will have little effect on the result of the experiment.

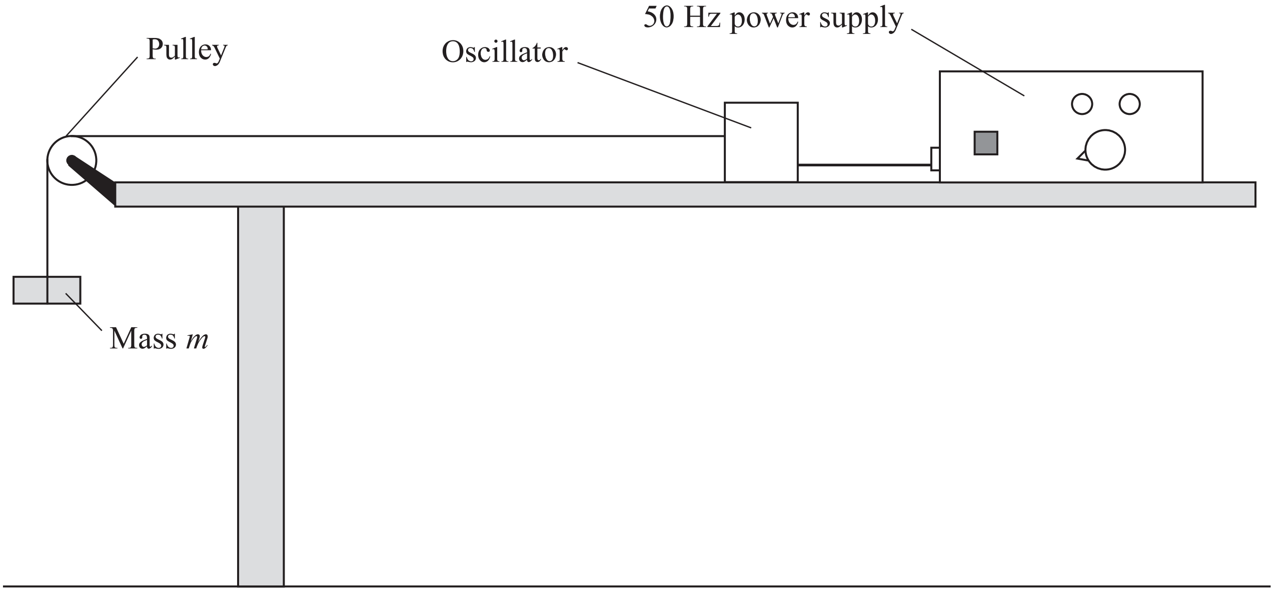
**(1)**

........................................................................................................................................................................................................

........................................................................................................................................................................................................

**(Total for Question 3 = 8 marks)**

**4** A wire is held under tension. A standing wave is set up by an oscillator at one end, as shown in the diagram.




(a) The wire is oscillated at a constant frequency. Measurements are taken to determine the wavelength $\lambda$ for different values of the mass $m$. The following data are obtained:

| $m$/kg | $\lambda$/m | $\lambda^2$/m$^2$ |
|---|---|---|
| 0.100 | 0.641 | |
| 0.150 | 0.776 | |
| 0.200 | 0.905 | |
| 0.250 | 1.012 | |
| 0.300 | 1.103 | |
| 0.350 | 1.196 | |

Use the grid opposite to draw a straight line graph to test the relationship

$$\lambda^2 = k\,m$$

Use the column provided to show your processed data.

**(4)**

**TURN OVER FOR QUESTION 4(b)**

(b) Use your graph to find a value for $k$.

**(2)**

..........................................................................................................................................

..........................................................................................................................................

$k$ = ..............................................................

(c) It is suggested that

$$k = \frac{g}{f^2\mu}$$

where $g = 9.81\ \mathrm{N\ kg^{-1}}$, frequency $f = 50.0$ Hz and $\mu$ = the mass per unit length of the wire.

Use your value for the gradient to calculate a value for $\mu$.

**(3)**

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

$\mu$ = ..............................................................

**(Total for Question 4 = 9 marks)**

**TOTAL FOR PAPER = 40 MARKS**

## 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 | $k = 1/4\pi\varepsilon_0$ | |
| | $= 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$ | |
| 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
$v = u + at$
$s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

Forces
$\Sigma F = ma$
$g = F/m$
$W = mg$

Work and energy
$\Delta W = F\Delta s$
$E_k = \frac{1}{2}mv^2$
$\Delta E_{grav} = mg\Delta h$

*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
Stress $\sigma = F/A$
Strain $\varepsilon = \Delta x/x$

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

***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>$W = VIt$ |

$$\% \text{ efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

$$\% \text{ efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

| | |
|---|---|
| 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 | $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ |

*Quantum physics*

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

**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 | $\lambda = h/p$ |

**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 | $\mathrm{d}N/\mathrm{d}t = -\lambda N$<br>$\lambda = \ln 2/t_{\frac{1}{2}}$<br>$N = N_0 e^{-\lambda t}$ |

*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 | $v = H_0 d$ |