Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | Candidate Number

Physics

Advanced
Unit 6: Experimental Physics

Thursday 16 January 2014 – Afternoon
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 ▶

6/6/6/6/6/5/

Answer ALL questions in the spaces provided.

1 A student determines the circumference C of a glass test tube by wrapping a piece of string around the outside. C is given by

$$C = (x/10) - \pi d$$

where x is the length of string wrapped 10 times around the outside of the test tube and d is the diameter of the string.

(a) (i) She measures the diameter d of the string as 1.70 ± 0.04 mm.

State **one** precaution she should take when using a micrometer screw gauge to make this measurement.

(1)

....

(ii) She finds $x = 803 \pm 4$ mm.

Use the equation above to calculate a value for C.

(2)

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....

C = ...

(iii) State why the uncertainty in $x/10$ is 0.4 mm.

(1)

....

....

(iv) Show that the uncertainty in πd is about 0.13 mm.

(1)

....

....

(v) State why the uncertainty in C is obtained by adding together 0.4 mm and 0.13 mm.

(1)

....

....

(vi) Calculate the percentage uncertainty in your value for C.

(1)

....

Percentage uncertainty = ...

(b) (i) Use your value for C to calculate a value for the external cross-sectional area A of the test tube where

$$A = C^2/4\pi$$

(1)

....

....

A = ...

(ii) Calculate the percentage uncertainty in your value for A.

(1)

....

....

Percentage uncertainty = ...

(c) The student then uses another method to find A by measuring the external diameter D of the test tube using digital callipers. The precision of the callipers is 0.01 mm.

She records the following measurements.

D/mm	23.96	23.86	23.91

(i) State why digital callipers are a suitable choice of measuring instrument.

(1)

....

....

(ii) Estimate the percentage uncertainty in her value for A.

(2)

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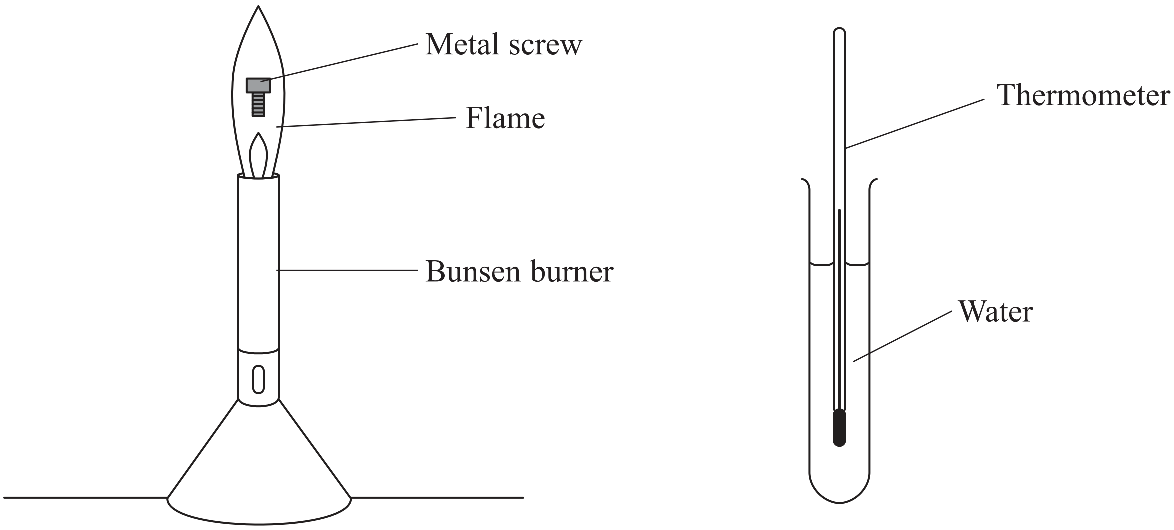
....

Percentage uncertainty = ...

(Total for Question 1 = 12 marks)

2 One method to find the temperature of a Bunsen burner flame involves heating a metal screw. The screw is held in the flame and then cooled in a test tube of water.



The thermal energy lost by the screw raises the temperature of the water so that

energy lost by screw in cooling down = energy gained by water in heating up

For both the screw and the water, energy transferred ΔE is given by

$$\Delta E = mc\Delta\theta$$

where m is the mass, c is the specific heat capacity and $\Delta\theta$ is the change in temperature of either the screw or the water. The values of c can be found on the internet.

For the method described above:

(a) state the measurements to be made,

(2)

(b) state **one** technique to improve accuracy,

(1)

(c) give **two** sources of error in your experiment,

(2)

(d) explain which measurement is likely to give the greatest percentage uncertainty,

(2)

(e) comment on safety.

(1)

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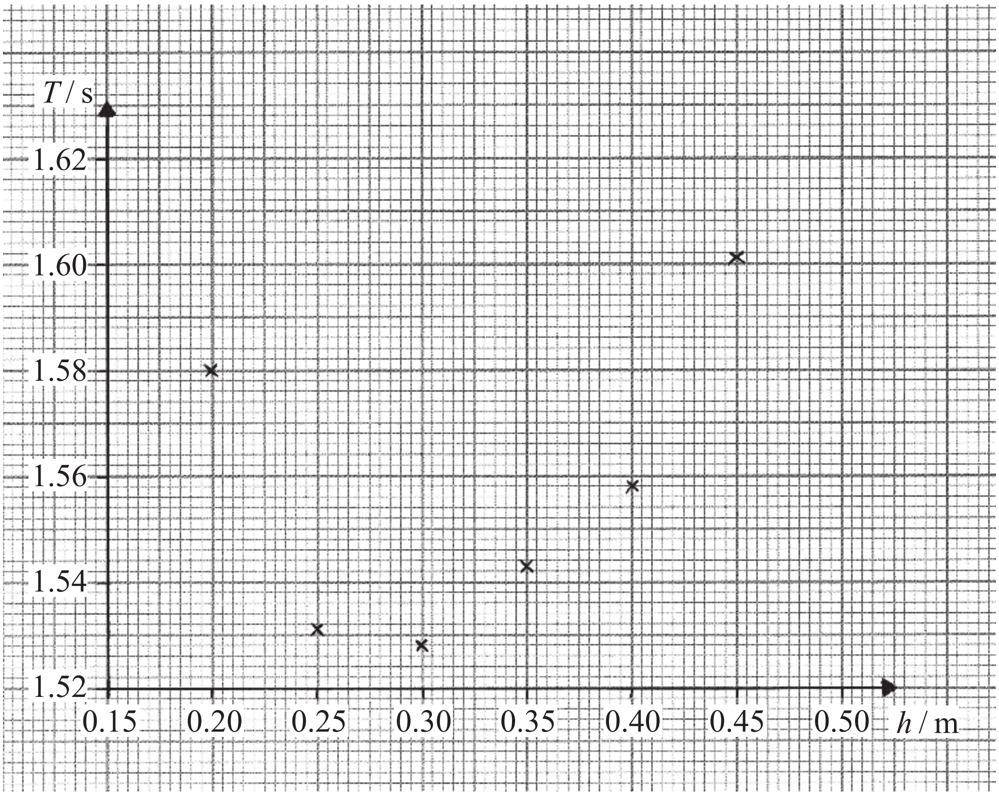
(Total for Question 2 = 8 marks)

3 A metre rule has a small hole drilled at the 5 cm mark. The rule is hung on a horizontal pin passing through the hole.

The rule is rotated through a small angle and released. It then oscillates about the pin as a pendulum with a time period T.

There are five more holes drilled at 5 cm intervals down the rule. The rule is hung from each hole and the distance h from the pin to the 50 cm mark is recorded. T is determined for each value of h.

A graph of T against h is plotted.



(a) (i) Draw the line of best fit on the graph.

(2)

(ii) Use your line to determine the value of h that would produce the smallest value of T.

Record these values.

(1)

h = ... T = ...

(b) The variables T and h are related by

$$T^2h = \frac{4\pi^2h^2}{g} + C$$

where C is a constant.

The graph of T against h does **not** produce a straight line.

State:

- the graph you would plot to get a straight line
- how you would determine a value for C from this graph
- the unit for C.

(3)

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(Total for Question 3 = 6 marks)

4 (a) The electrons in an atom of an element can only occupy discrete energy levels.

Describe how discrete energy levels result in the emission of photons of specific frequencies.

(2)

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(b) Theory predicts that the frequency f of the photons emitted is related to the proton number Z of the element by

$$f = P Z^n$$

where P and n are constants.

Show that a graph of $\ln f$ against $\ln Z$ will give a straight line of gradient n.

(2)

....

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....

(c) The following data were recorded.

Z	f / 10^{15} Hz		
8	1.22		
14	4.19		
23	12.0		
38	34.0		
56	75.0		
80	155		

(i) Use the grid opposite to draw a graph of $\ln f$ against $\ln Z$. Use the columns in the table for your processed data.

(4)

P 4 3 1 1 7 R A 0 8 1 6

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

(2)

....

....

....

....

n = ...

Question 4 continues on next page

(d) Theory suggests that $n = 2.00$

Use your value for n to comment on this suggestion.

(2)

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(e) Describe how you would use your graph to determine a value for P.

(2)

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(Total for Question 4 = 14 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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

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

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

Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
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	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$
In a magnetic field	$F = BIl \sin\theta$ $F = Bqv \sin\theta$ $r = p/BQ$
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	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{\frac{1}{2}}$
	$N = N_0 e^{-\lambda t}$

Mechanics

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

Observing the universe

Radiant energy flux	$F = L/4\pi d^2$
Stefan-Boltzmann law	$L = \sigma T^4 A$ $L = 4\pi r^2 \sigma T^4$
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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