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 ▶

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

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

PEARSON

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)

....

....

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)

....

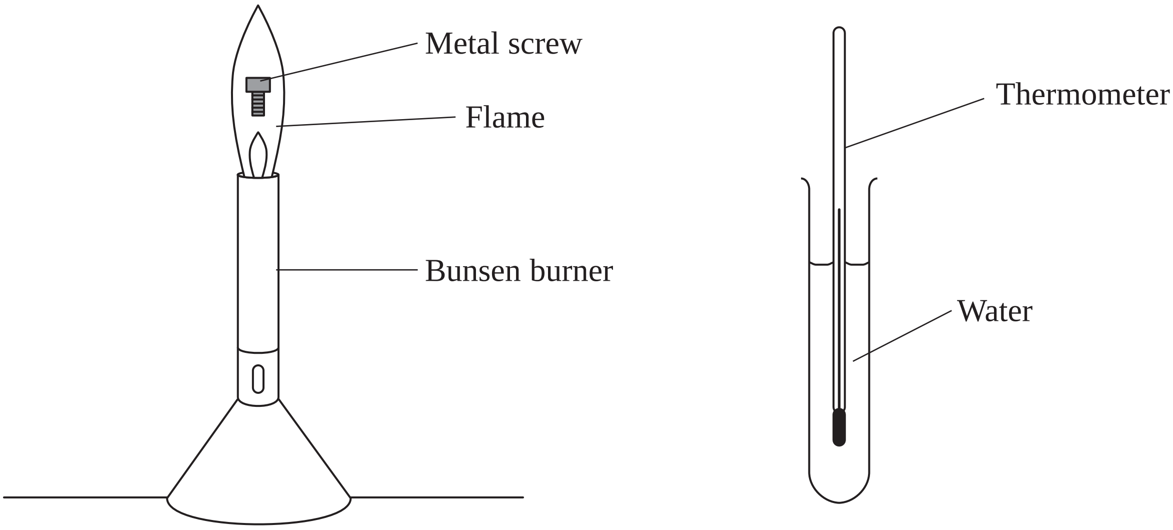
....

....

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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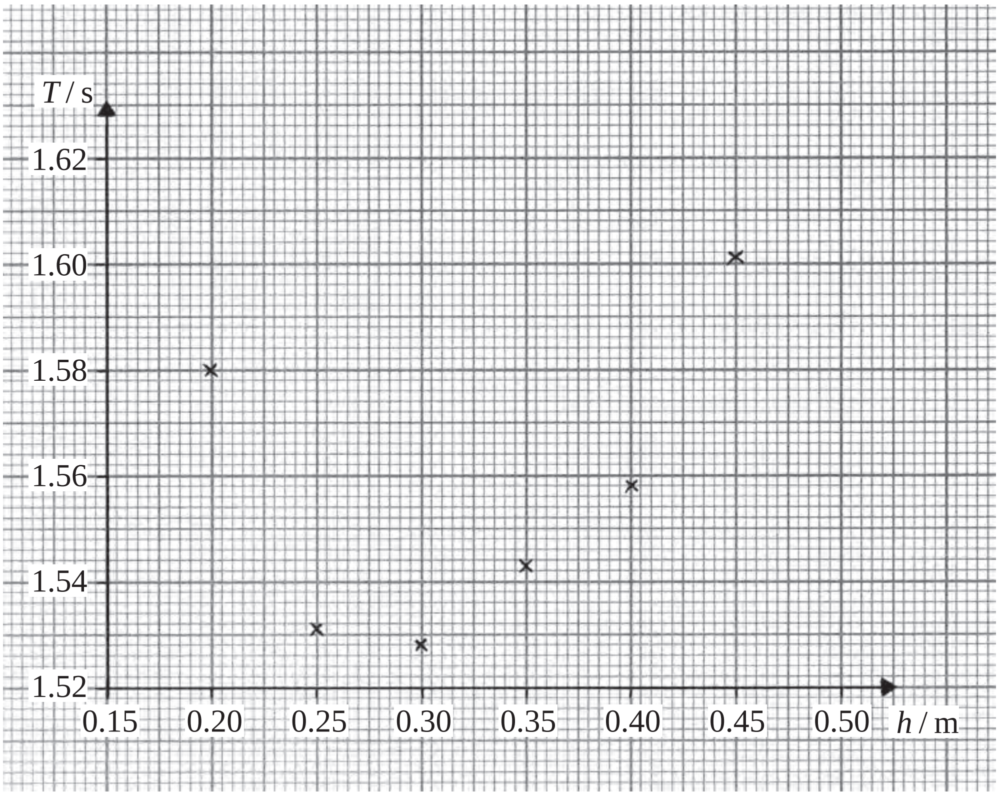
(Total for Question 2 = 8 marks)

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.



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

(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

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

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)

(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)

(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)

(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	$v = u + at$ $s = ut + ½at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = ½mv^2$ $\Delta E_{grav} = mg\Delta h$

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	$E_{el} = ½F\Delta x$

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	$\varepsilon = -\mathrm{d}(N\phi)/\mathrm{d}t$

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	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{½}$
	$N = N_0 e^{-\lambda t}$

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	$F = Gm_1 m_2/r^2$

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	$v = H_0 d$