Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | Candidate Number

Physics

Advanced
Unit 6: Experimental Physics

Thursday 19 May 2016 – 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 ▶

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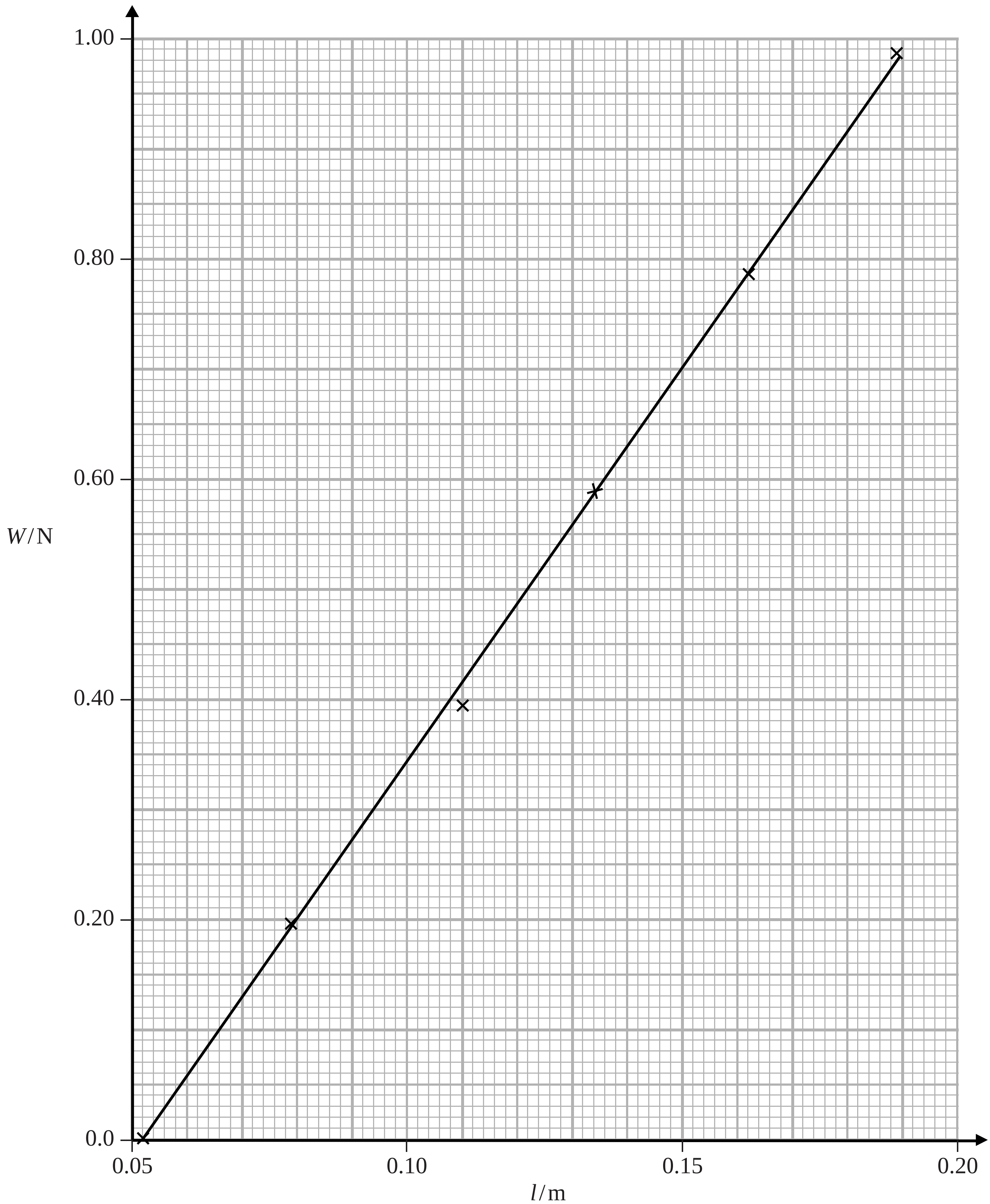
PEARSON

Answer ALL questions in the spaces provided.

1 A student measured the length l_0 of a spring. She suspended different weights W from the spring and measured the new length l each time.

She drew a graph of W against l. She measured the gradient of the line of best fit as 7.14 Nm^{-1}.



(a) She measured l_0 using a metre rule and recorded l_0 = 5.2 cm.
Explain why a metre rule is a suitable instrument to make this measurement.

(2)

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(b) (i) The student suspended a piece of modelling clay from the spring. She recorded the new length of the spring as l = 14.3 cm.

Determine the weight W_1 of the clay.

(1)

....

....

W_1 = ...

(ii) The student estimated the uncertainty in l as 2 mm. Use this uncertainty and the graph to estimate the uncertainty in your value for W_1.

(2)

....

....

....

....

Uncertainty = ...

(iii) Calculate the percentage uncertainty in your value for W_1.

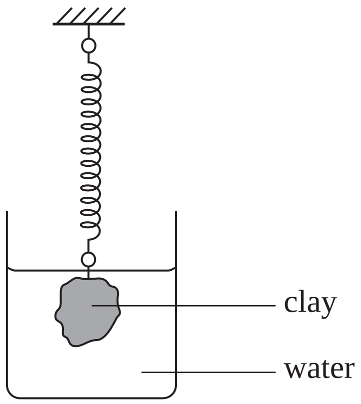
(1)

....

....

Percentage uncertainty = ...

(c) The student immersed the clay in water as shown in the diagram. The upthrust of the water on the clay reduced the force of the clay on the spring to a new value W_2 and so l was also reduced.



(i) On the diagram draw and label the three forces acting on the clay.

(1)

(ii) When the clay was immersed the student recorded l = 9.1 cm.

Determine W_2.

(1)

....

....

W_2 = ...

(d) The ratio $\frac{\text{Density of clay}}{\text{Density of water}} = \frac{W_1}{W_1 - W_2}$

density of water = 1000 kg m^{-3}

Calculate a value for the density of clay.

(2)

....

....

....

Density of clay = ...

(e) The manufacturer's value for the density of this clay is 1680 kg m^{-3}.

Comment on the accuracy of your result.

(3)

....

....

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....

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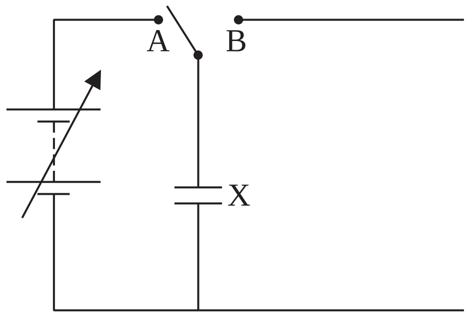
....

(Total for Question 1 = 13 marks)

2 Part of an electric circuit is shown.



When the switch is connected to terminal A the capacitor X is connected to the variable power supply.

(a) (i) Add a second capacitor Y to the circuit so that it is connected in parallel with X when the switch is moved to B.

(1)

(ii) Add a voltmeter so that the potential difference (p.d.) across X can be measured when the switch is in either position.

(1)

(b) The capacitance of X is C_X. If C_X is known, this circuit can be used to determine the capacitance C_Y of capacitor Y using the equation

$$V_2 = \frac{C_X}{C_Y}(V_1 - V_2)$$

where

- V_1 is the p.d. across X when it is connected to the power supply
- V_2 is the p.d. across X when Y is connected in parallel with it.

Write a plan for an experiment using this circuit and a graphical method to determine C_Y.

Your plan should include

(i) the readings you would take

(2)

(ii) the graph you would plot and how you would use the graph to determine C_Y

(2)

(iii) how you would ensure the capacitors would not be damaged during the experiment

(1)

(iv) a precaution you would take to ensure the results are accurate.

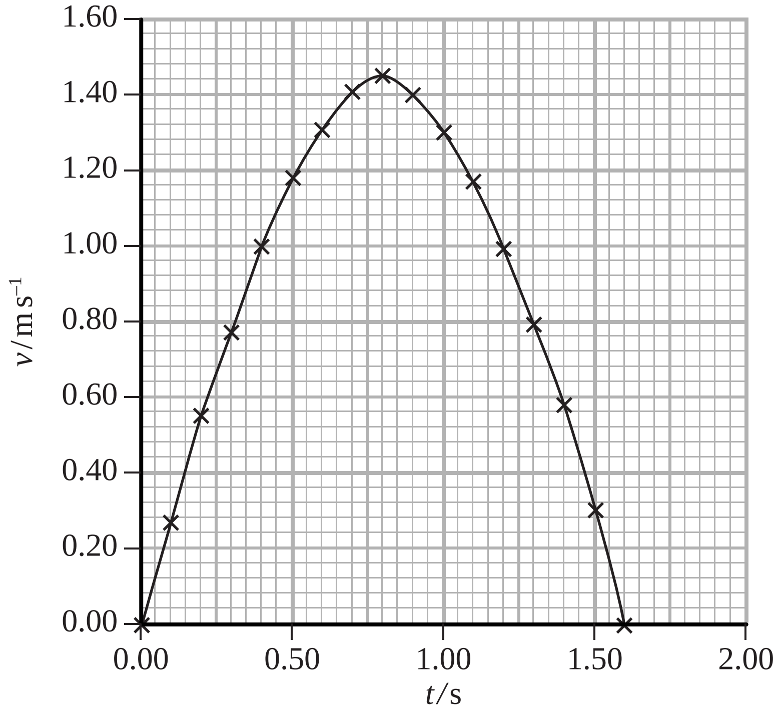
(1)

(Total for Question 2 = 8 marks)

3 A pendulum is made using a heavy mass suspended on a length of string. The pendulum was suspended from a high ceiling. The pendulum was pulled to one side to a maximum displacement and released.

The velocity v of the mass and the corresponding time t were recorded using a sensor and a data logger. Readings were recorded from the instant the pendulum was released.

The readings were plotted on the graph shown.



(a) (i) Determine the time period T of the pendulum.

(1)

....

T = ...

(ii) State the value for t when the pendulum is at the centre of the oscillation.

(1)

t = ...

(iii) Explain why the graph has a horizontal tangent at t = 0.80 s.

(2)

....

....

....

(b) (i) Draw a tangent to the graph at $t = 0.40$ s and use it to calculate the acceleration at this point.

(2)

....

....

Acceleration = ...

(ii) State the next time the mass had the same magnitude of acceleration as in (b)(i).

(1)

t = ...

(c) State **one** advantage of using a data logger.

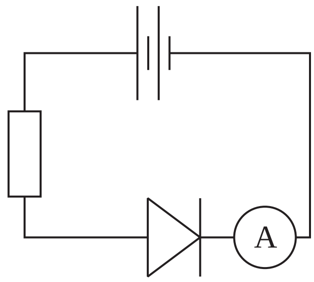
(1)

....

....

(Total for Question 3 = 8 marks)

4 The diode connected in the circuit shown will allow a current to flow.



For a constant potential difference, the current I and the temperature T of the diode are related by

$$I = I_0 e^{-\frac{p}{T}}$$

where I_0 and p are constants and T is measured in kelvin.

(a) Explain why a graph of ln I against $1/T$ should produce a straight line.

(2)

....

....

....

....

(b) A student carried out an experiment using this circuit. He recorded I and the temperature θ of the diode for different values of θ measured in °C. The results are shown in the table.

θ/°C	**I/mA**			
0	1.2			
20	3.0			
40	6.0			
60	12.5			
80	22.6			
100	41.7			

(i) Draw on the grid opposite a graph of ln I against $1/T$. Use the columns in the table for your processed data.

(4)

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

(2)

....

....

....

....

p = ...

(iii) Theory suggests that the electron charge e is given by $e = \frac{kp}{V}$

where k is the Boltzmann constant and $V = 0.32$ V.

Calculate a value for e.

(1)

....

....

....

e = ...

(iv) Comment on the accuracy of the result.

(2)

....

....

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....

....

(Total for Question 4 = 11 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	$k = 1/4\pi\varepsilon_0$	
	$= 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$	
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	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{½}$
	$N = N_0 e^{-\lambda t}$

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	$F = Gm_1m_2/r^2$

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	$v = H_0 d$