Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Time 1 hour 20 minutes

Paper reference **WPH16/01**

Physics

International Advanced Level
UNIT 6: Practical Skills in Physics II

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- **Show all your working out** in calculations and **include units** where appropriate.

Information

- The total mark for this paper is 50.
- 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.

Advice

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

Turn over ▶

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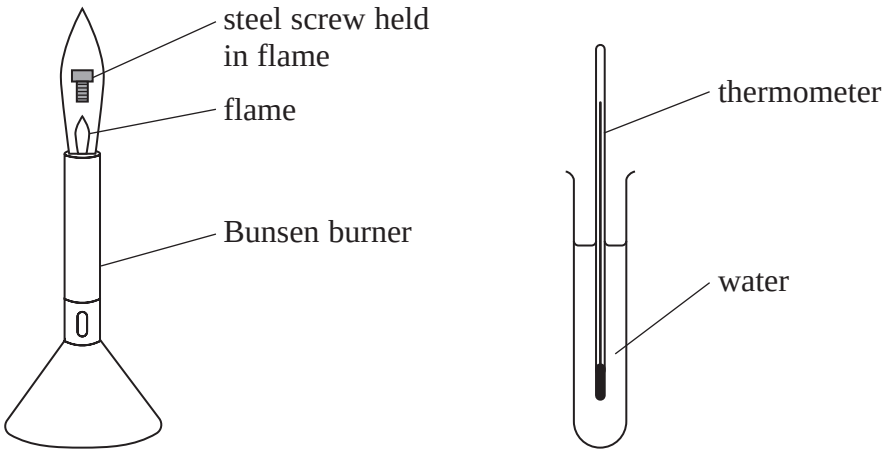
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Pearson

Answer ALL questions.

1 A student estimated the temperature of a Bunsen burner flame using the apparatus shown.



The student held the steel screw in the flame and then cooled it in a test tube of water.

(a) Identify one safety issue and how it may be dealt with.

(2)

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(b) The student stated:

energy dissipated by screw in cooling = energy gained by water in heating

The student measured the temperature increase for different masses of water. She recorded the following results.

Mass of water / g	Temperature increase
9.9	62
16.6	37.5
20	31

(i) Criticise the recording of the results.

(2)

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(ii) State one variable that should be controlled for this experiment.

(1)

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(iii) Show that the temperature of the Bunsen burner flame is about 1500 °C above the initial temperature of the water.

mass of screw = 4.11 g
specific heat capacity of steel = 420 J kg^{-1} K^{-1}
specific heat capacity of water = 4180 J kg^{-1} K^{-1}

(3)

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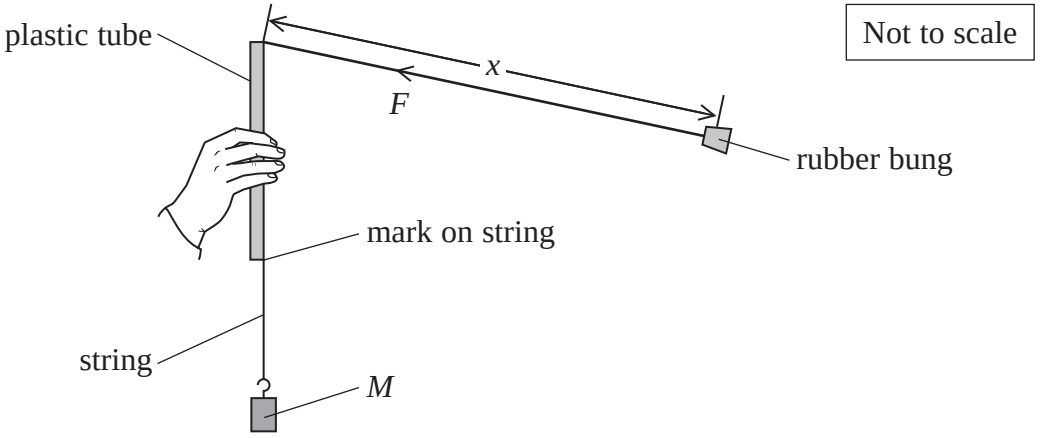
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(Total for Question 1 = 8 marks)

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2 A student used the apparatus shown to investigate circular motion.



The rubber bung with mass m was rotated around the plastic tube at a constant angular velocity ω. The part of the string between the rubber bung and the plastic tube was almost horizontal.

The mark on the string was kept level with the bottom of the plastic tube so that the length x stayed constant.

The mass M provided the tension F in the string.

(a) The variables in this experiment are related by the formula $Mg = mx\omega^2$.

(i) Show that the relationship between the period of rotation T and mass M can be written as

$$T^2 = 4\pi^2 \frac{mx}{Mg}$$

(2)

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(ii) The student used a stopwatch to determine T for different values of M.

Devise a plan to test the validity of the relationship between T^2 and M.

The method should use a suitable graph.

(6)

(b) The student suggested that using a video recording of the motion would improve the determination of T.

Comment on this suggestion.

(2)

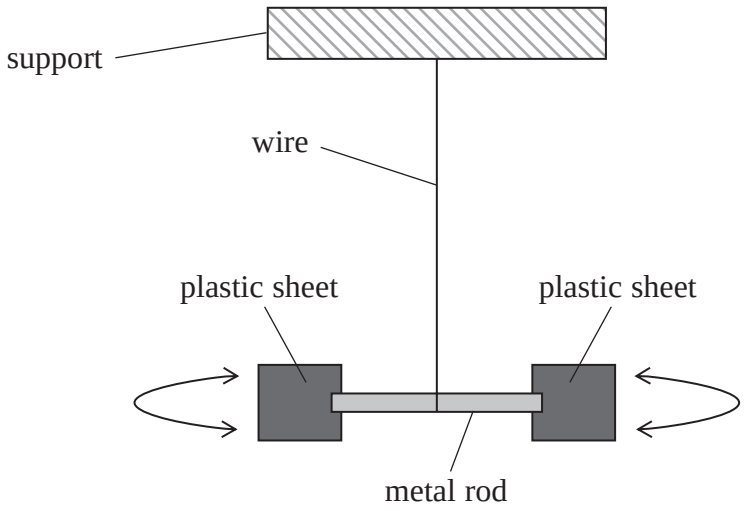
(Total for Question 2 = 10 marks)

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3 A student investigated the damping of a rotational pendulum using the apparatus shown.



When the metal rod is rotated through an angle and released, the rod performs angular oscillations about a vertical axis through the wire. The plastic sheets dampen the oscillations as they move through the air.

(a) The relationship between the maximum displacement angle θ and number of oscillations n is given by

$$\theta = \theta_0 e^{-\lambda n}$$

where θ_0 is the initial displacement angle and λ is a constant.

Explain why a graph of $\ln \theta$ against n could be used to determine a value for λ.

(2)

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(b) The student displaced the metal rod by a large angle.

He recorded the maximum displacement angle every 10 oscillations.

n	θ / °	
10	124	
20	82	
30	55	
40	37	
50	25	
60	16	

(i) Plot a graph of $\ln\theta$ against n on the grid opposite. Use the additional column for your processed data.

(5)

(ii) Determine the value of λ from the graph.

(3)

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λ = ...

(iii) The student claimed that the initial displacement angle was greater than 180 °.

Deduce whether this claim is correct.

(3)

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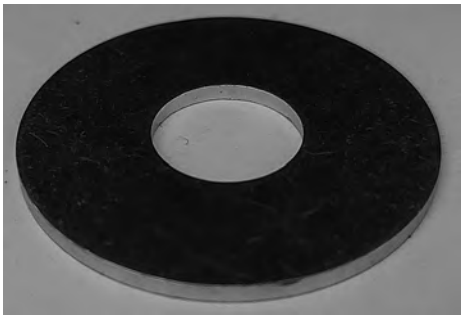
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(Total for Question 3 = 13 marks)

4 A student measured a metal ring of the type shown below.



(a) The student measured the diameter *d* of the hole in the centre of the metal ring with a set of digital calipers.

(i) Explain one technique she should use to reduce the uncertainty in the measurement of *d*.

(2)

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(ii) She recorded the following measurements.

***d*/mm**	8.53	8.56	8.55	8.53

Determine the mean value of *d* and its uncertainty in mm.

(3)

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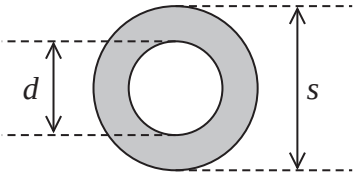
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Mean value of *d* = ... mm ± ..... mm

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(b) The student was given a metal ring of a different size. She measured the distances shown.



She calculated the shaded area A of the metal using the formula

$$A = \frac{\pi}{4}(s^2 - d^2)$$

(i) Show that the uncertainty in d^2 is about $1\,\text{mm}^2$.

$d = 10.70\,\text{mm} \pm 0.06\,\text{mm}$

(3)

(ii) Show that the percentage uncertainty in A is about 0.4 %.

$s^2 = 881\,\text{mm}^2 \pm 2\,\text{mm}^2$

(4)

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(c) The student measured the total mass m_{10} of 10 identical metal rings as 63 g.

Explain why measuring the total mass of 10 metal rings is better than measuring the mass of one metal ring.

(2)

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(d) She measured the total thickness x_{10} of a stack of these 10 metal rings.

(i) Determine the mean density ρ, in g cm^{-3}, of the metal the ring is made from.

$m_{10} = 63.0\,\text{g} \pm 0.5\,\text{g}$
$x_{10} = 14.03\,\text{mm} \pm 0.04\,\text{mm}$
$A = 602\,\text{mm}^2 \pm 0.4\,\%$

(2)

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ρ = ... g cm^{-3}

(ii) The density of stainless steel ranges from 7.48 g cm^{-3} to 7.95 g cm^{-3}.

Deduce whether the metal rings could be made from stainless steel.

(3)

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(Total for Question 4 = 19 marks)

TOTAL FOR PAPER = 50 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

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

$$\Delta W = F\Delta s$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

Power

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

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Efficiency

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

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

Materials

Density $\rho = \frac{m}{V}$

Stokes' law $F = 6\pi\eta r v$

Hooke's law $\Delta F = k\Delta x$

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

Young modulus $E = \frac{\sigma}{\varepsilon}$ where

Stress $\sigma = \frac{F}{A}$

Strain $\varepsilon = \frac{\Delta x}{x}$

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Unit 2

Waves

Wave speed	$v = f\lambda$
Speed of a transverse wave on a string	$v = \sqrt{\frac{T}{\mu}}$
Intensity of radiation	$I = \frac{P}{A}$
Refractive index	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
	$n = \frac{c}{v}$
Critical angle	$\sin C = \frac{1}{n}$
Diffraction grating	$n\lambda = d\sin\theta$

Electricity

Potential difference	$V = \frac{W}{Q}$
Resistance	$R = \frac{V}{I}$
Electrical power, energy	$P = VI$
	$P = I^2R$
	$P = \frac{V^2}{R}$
	$W = VIt$
Resistivity	$R = \frac{\rho l}{A}$
Current	$I = \frac{\Delta Q}{\Delta t}$
	$I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Particle nature of light

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$
de Broglie wavelength	$\lambda = \frac{h}{p}$

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Unit 4

Further mechanics

Impulse	$F\Delta t = \Delta p$
Kinetic energy of a non-relativistic particle	$E_k = \frac{p^2}{2m}$
Motion in a circle	$v = \omega r$
	$T = \frac{2\pi}{\omega}$
	$a = \frac{v^2}{r}$
	$a = r\omega^2$
Centripetal force	$F = ma = \frac{mv^2}{r}$
	$F = mr\omega^2$

Electric and magnetic fields

Electric field	$E = \frac{F}{Q}$
Coulomb's law	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \frac{V}{d}$
Electrical potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
Capacitance	$C = \frac{Q}{V}$
Energy stored in capacitor	$W = \frac{1}{2}QV$
	$W = \frac{1}{2}CV^2$
	$W = \frac{1}{2}\frac{Q^2}{C}$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$

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Resistor-capacitor discharge $I = I_0 e^{-t/RC}$

$V = V_0 e^{-t/RC}$

$\ln Q = \ln Q_0 - \frac{t}{RC}$

$\ln I = \ln I_0 - \frac{t}{RC}$

$\ln V = \ln V_0 - \frac{t}{RC}$

In a magnetic field $F = Bqv \sin \theta$

$F = BIl \sin \theta$

Faraday's and Lenz's laws $\mathscr{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$

Nuclear and particle physics

In a magnetic field $r = \frac{p}{BQ}$

Mass-energy $\Delta E = c^2 \Delta m$

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Unit 5

Thermodynamics

Heating

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

$$\Delta E = L\Delta m$$

Ideal gas equation

$$pV = NkT$$

Molecular kinetic theory

$$\tfrac{1}{2}m\langle c^2\rangle = \tfrac{3}{2}kT$$

Nuclear decay

Mass-energy

$$\Delta E = c^2\Delta m$$

Radioactive decay

$$A = \lambda N$$

$$\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$$

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$N = N_0 \mathrm{e}^{-\lambda t}$$

$$A = A_0 \mathrm{e}^{-\lambda t}$$

Oscillations

Simple harmonic motion

$$F = -kx$$

$$a = -\omega^2 x$$

$$x = A\cos\omega t$$

$$v = -A\omega\sin\omega t$$

$$a = -A\omega^2\cos\omega t$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$\omega = 2\pi f$$

Simple harmonic oscillator

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

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Astrophysics and cosmology

Gravitational field strength	$g = \frac{F}{m}$
Gravitational force	$F = \frac{Gm_1m_2}{r^2}$
Gravitational field	$g = \frac{Gm}{r^2}$
Gravitational potential	$V_{grav} = \frac{-Gm}{r}$
Stefan-Boltzmann law	$L = \sigma AT^4$
Wien's law	$\lambda_{max}T = 2.898 \times 10^{-3}\,\text{m K}$
Intensity of radiation	$I = \frac{L}{4\pi d^2}$
Redshift of electromagnetic radiation	$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$
Cosmological expansion	$v = H_0 d$

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