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.
- **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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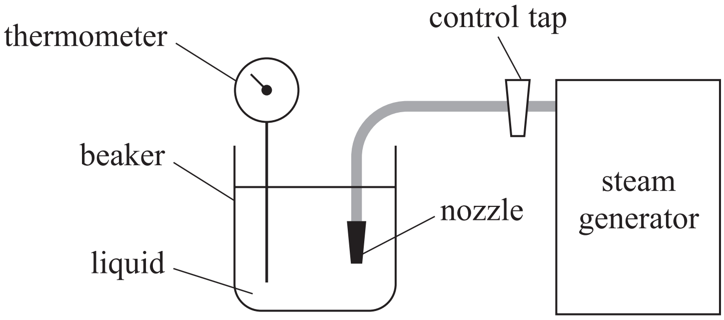
Q:1/1/

P 7 3 6 3 5 A 0 1 2 0

Pearson

Answer ALL questions.

1 A student investigated heating a liquid using the apparatus shown.



The control tap adjusts the rate of flow of steam from the nozzle. The steam heats the liquid in the beaker.

(a) The student used a kitchen thermometer. The thermometer scale is shown below.

(i) State the resolution of the thermometer in °C.

(1)

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(ii) The student heated the liquid. He started a stopwatch and recorded the temperature of the liquid. He recorded the time at fixed intervals of temperature, as the temperature increased.

Explain why this method was better than starting a stopwatch and recording the temperature at fixed intervals of time.

(2)

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(b) The student repeated the investigation with a different liquid. He started timing at the same initial temperature.

(i) State another control variable that would allow him to compare the specific heat capacities for the two liquids.

(1)

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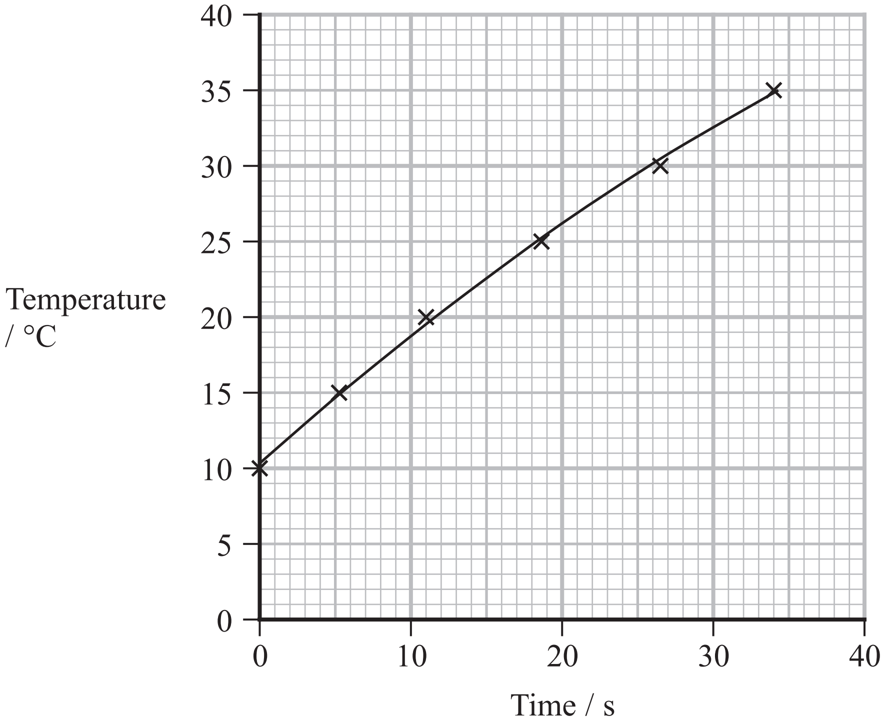
(ii) The student plotted a graph of temperature against time for the first liquid, as shown.



Sketch on the graph the line for a liquid with a greater specific heat capacity.

(2)

(c) Another student performed the investigation using a temperature probe connected to a data logger.

Give two reasons why this would improve the investigation.

(2)

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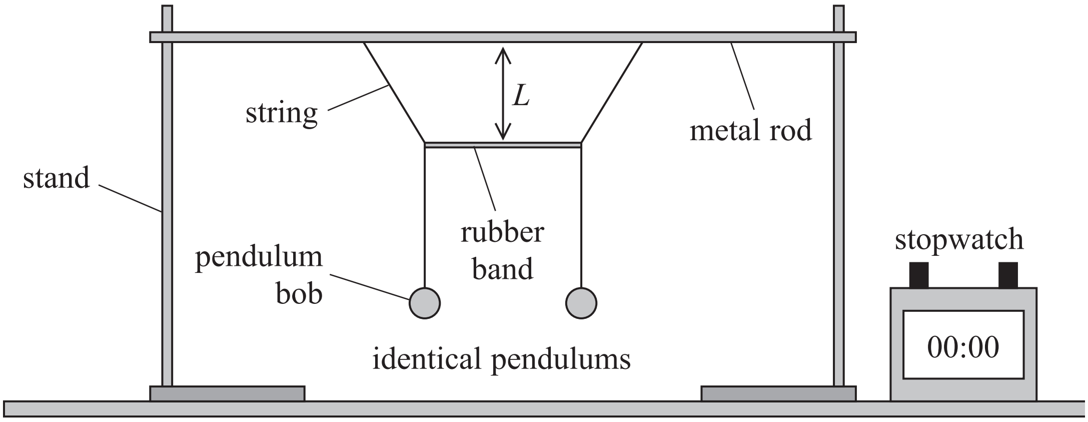
(Total for Question 1 = 8 marks)

2 Two identical pendulums are linked together using a rubber band as shown.



One pendulum is set in motion. The amplitude of oscillation of this pendulum decreases to zero as the rubber band transfers energy to the other pendulum, which oscillates with increasing amplitude.

Energy is continually transferred between the two pendulums, so their oscillations alternately increase and decrease in amplitude.

(a) The time taken for the amplitude of one pendulum to change from zero to a maximum and back to zero again is P.

It is suggested that the relationship between P and the vertical distance L between the metal rod and the rubber band is

$$P = a L^b$$

where a and b are constants.

Devise a plan to test the validity of this relationship using a graphical method.

(6)

(b) A student recorded the motion of the pendulums using a video camera.

Suggest how this may improve the measurement of P.

(2)

(Total for Question 2 = 8 marks)

3 Atoms of an element emit characteristic spectral lines when they are bombarded with a beam of high energy electrons. The spectral lines can be used to identify the element.

(a) The relationship between the atomic number Z and the frequency f of the most intense spectral line is given by

$$Z = k f^n$$

where k and n are constants.

Explain why a graph of log Z against log f would give a straight line.

(2)

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(b) The table shows the frequency of the most intense spectral line for a range of elements.

Element	***Z***	**f / 10^{15} Hz**		
Li	3	0.16		
C	6	0.69		
Si	14	4.19		
Mn	25	13.82		
Sr	38	33.98		
Hg	80	154.64		

(i) Plot a graph of log Z against log f on the grid opposite. Use the additional columns for your processed data.

You should **not** convert the values of f from 10^{15} Hz to Hz.

(6)

(ii) Determine the value of n.

(3)

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n = ...

(iii) Determine the value of k using your graph.

(3)

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k = ...

(c) A scientist named Henry Moseley suggested that $Z \propto f^{0.5}$

Explain whether the graph supports this suggestion.

(2)

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(Total for Question 3 = 16 marks)

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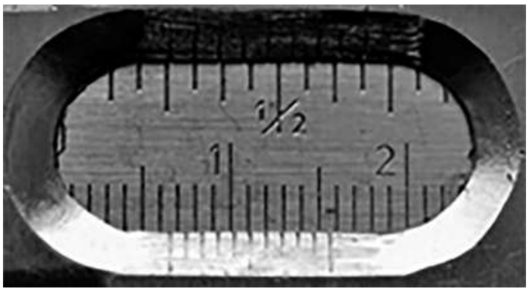
4 A student measured a metal nut of the type shown below.

(a) The student measured the diameter *d* of the hole in the centre of the metal nut.

(i) She made one measurement in cm using Vernier calipers and one measurement in mm using digital calipers. The photographs show the measurements.



Explain why the digital calipers would be a better choice of instrument for this measurement.

You should include calculations in your answer.

(4)

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(ii) The student determined a more accurate value for *d*.

Explain one technique she could have used.

(2)

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(iii) The student recorded the following measurements.

***d* / mm**	6.57	6.58	6.54	6.52

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

(3)

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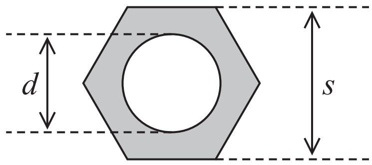
Mean value of d = ... mm ± .... mm

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



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

$$A = \frac{\sqrt{3}}{2}\, s^2 - \frac{\pi}{4} d^2$$

$s = 16.83\,\text{mm} \pm 0.02\,\text{mm}$
$d = 8.55\,\text{mm} \pm 0.04\,\text{mm}$
$A = 1.88\,\text{cm}^2$

Show that the uncertainty in A is about $0.01\,\text{cm}^2$.

(4)

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(c) The student measured the mass m and the thickness x of the metal nut.

$m = 10.3\,\text{g} \pm 0.1\,\text{g}$
$x = 7.92\,\text{mm} \pm 0.03\,\text{mm}$
$A = 1.88\,\text{cm}^2 \pm 0.01\,\text{cm}^2$

(i) Determine the density ρ of the metal from which the nut is made.

(2)

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ρ = ...

(ii) The density of steel ranges from $7.85\,\text{g}\,\text{cm}^{-3}$ to $8.03\,\text{g}\,\text{cm}^{-3}$.

Deduce whether the metal nut could be made from steel.

(3)

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(Total for Question 4 = 18 marks)

TOTAL FOR PAPER = 50 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

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

$$v = u + at$$

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

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

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

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

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

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 $\rho = \dfrac{m}{V}$

Stokes' law $F = 6\pi\eta rv$

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

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

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

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

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

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	$E_k = \dfrac{p^2}{2m}$
Motion in a circle	$v = \omega r$
	$T = \dfrac{2\pi}{\omega}$
	$a = \dfrac{v^2}{r}$
	$a = r\omega^2$
Centripetal force	$F = ma = \dfrac{mv^2}{r}$
	$F = mr\omega^2$

Electric and magnetic fields

Electric field	$E = \dfrac{F}{Q}$
Coulomb's law	$F = \dfrac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{V}{d}$
Electrical potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
Capacitance	$C = \dfrac{Q}{V}$
Energy stored in capacitor	$W = \dfrac{1}{2}QV$
	$W = \dfrac{1}{2}CV^2$
	$W = \dfrac{1}{2}\dfrac{Q^2}{C}$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$

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

Unit 5

Thermodynamics

Heating	$\Delta E = mc\Delta\theta$
	$\Delta E = L\Delta m$
Ideal gas equation	$pV = NkT$
Molecular kinetic theory	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$

Nuclear decay

Mass-energy	$\Delta E = c^2\Delta m$
Radioactive decay	$A = \lambda N$
	$\frac{dN}{dt} = -\lambda N$
	$\lambda = \frac{\ln 2}{t_{1/2}}$
	$N = N_0 e^{-\lambda t}$
	$A = A_0 e^{-\lambda t}$

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

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	$V_{\text{grav}} = \frac{-Gm}{r}$
Stefan-Boltzmann law	$L = \sigma AT^4$
Wien's law	$\lambda_{\text{max}}T = 2.898 \times 10^{-3}\,\text{m K}$
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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