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

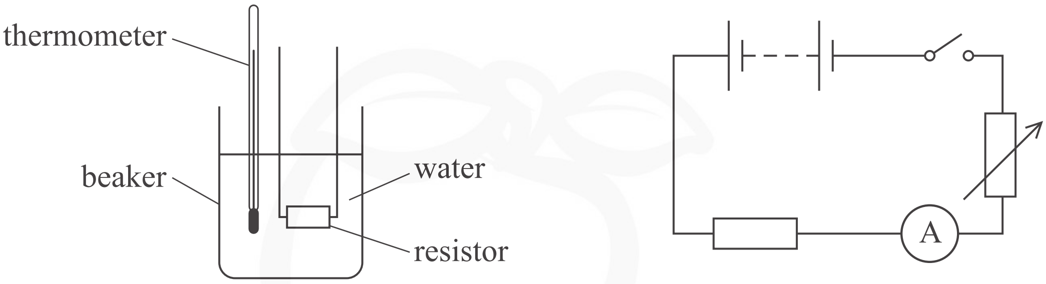
- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over

Pearson

Answer ALL questions.

1 A wire-wound resistor can become hot when there is a current in it. This heating effect can be investigated using the apparatus shown.



A student investigated whether the temperature rise of the water $\Delta\theta$ was proportional to the current I in the resistor. For each value of current, the student refilled the beaker with water at the same initial temperature.

(a) (i) Identify two other control variables for this investigation.

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(ii) The student recorded the following data.

***I*/A**	1.5	2	2.5	3
$\Delta\theta$	3.5	7	9.5	15

Criticise the recording of this data.

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(b) Explain one improvement the student could make to reduce the uncertainty in the measurement of $\Delta\theta$ for each value of I.

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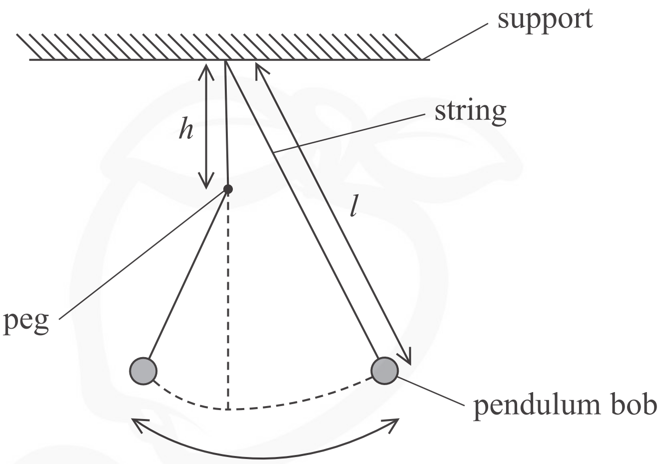
(Total for Question 1 = 7 marks)

2 A pendulum of length l swings in a vertical plane. The string hits a peg placed at a distance h vertically below the point of suspension as shown. This makes the pendulum shorter for part of its motion.



(a) Determine the time period T for the whole oscillation when $h = 0.25\,\text{m}$.

$l = 1.00\,\text{m}$

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$T =$ ....

(b) A student suggests that an approximate relationship between T and h is given by

$$T^2 = \frac{\pi^2}{g}(2l - h)$$

Devise a plan to test the validity of the relationship using a graphical method.
Include the use of a stopwatch and any additional apparatus as required.

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(c) Another student suggests determining T by setting up a light gate attached to a data logger.

Discuss whether this modification would improve the investigation.

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(Total for Question 2 = 12 marks)

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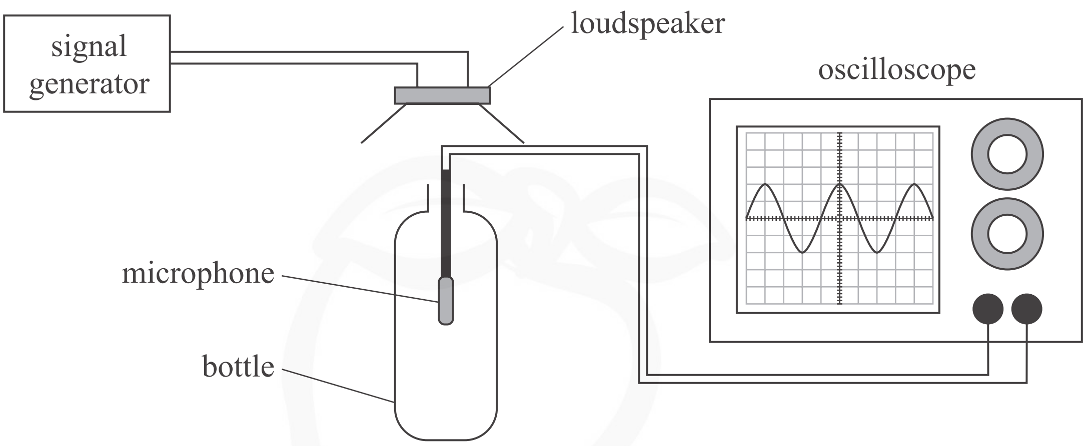
3 A student investigated standing waves using the apparatus shown.



The signal generator was adjusted until a loud sound was heard at a particular frequency, known as the resonant frequency.

(a) Describe how the student should use the oscilloscope to identify the resonant frequency and determine its value.

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(b) The student reduced the volume V of air inside the bottle by adding known volumes of water. He recorded the following values of the resonant frequency f for each value of V.

V / cm^3	**f / Hz**		
576	221		
476	244		
376	275		
276	323		
176	408		
126	485		

(i) Plot a graph of log f against log V on the grid opposite. Use the additional columns in the table to record your processed data.

(6)

(ii) It is suggested that the relationship between f and V is given by

$$f = kV^{-\frac{1}{2}}$$

where k is a constant.

Discuss whether the graph supports this suggestion.

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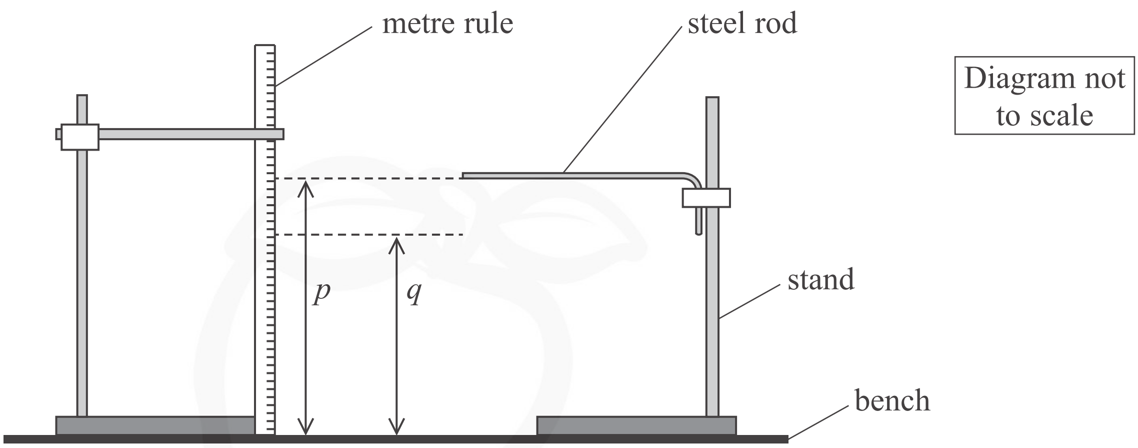
(Total for Question 3 = 15 marks)

4 An L-shaped steel rod was held horizontally in a stand clamped by its shorter end as shown.



The end of the steel rod was at a height p above the bench.

A student attached a mass m to the end of the steel rod causing it to bend towards the bench. The end of the steel rod was then at a height q above the bench.

(a) (i) Describe two techniques she should use when measuring p and q.

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(ii) The difference between p and q was recorded as 26 mm ± 1 mm.

Explain why the uncertainty in this value is given as 1 mm.

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(b) The steel rod had a circular cross-section with a diameter *d* of approximately 2 mm.

(i) Explain the most appropriate instrument the student should use to measure *d*.

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(ii) Explain one technique that she should use to measure *d*.

(2)

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(iii) She recorded the following measurements.

d **/ mm**				
2.35	2.37	2.34	2.35	2.33

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

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Mean value of *d* = ... mm ± .... mm

(c) The shear modulus G is a measure of a material's resistance to bending, and is given by

$$G = \frac{32mglx^2}{\pi y d^4}$$

where m is the mass attached to the end of the rod and y is the vertical deflection.

l and x are the lengths as shown below.

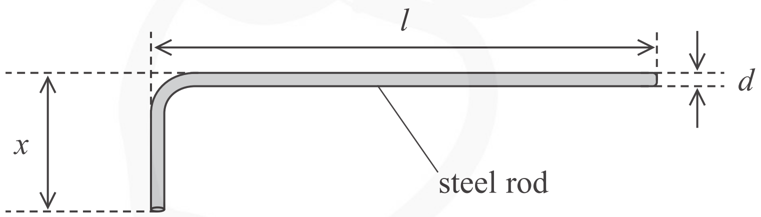

Diagram not to scale

Determine a value of G for steel in $\mathrm{N\,m^{-2}}$.

m = 100 g with negligible uncertainty
l = 58.9 cm ± 0.1 cm
x = 10.3 cm ± 0.1 cm
y = 26 mm ± 1 mm

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G = ... $\mathrm{N\,m^{-2}}$

(d) The table shows values of *G* for different types of steel.

Type of steel	Structural steel	Carbon steel
$G/10^9\,N\,m^{-2}$	79.3	77.0

Deduce whether the data provided in part (c) would allow the student to determine the type of steel the rod was made from.

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(Total for Question 4 = 16 marks)

TOTAL FOR PAPER = 50 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\ s^{-2}}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\ K^{-1}}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \mathrm{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\ m^2\ kg^{-2}}$	
Gravitational field strength	$g = 9.81\ \mathrm{N\ kg^{-1}}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\ m^{-1}}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^{9}\ \mathrm{N\ m^2\ C^{-2}}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\ s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$	

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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P 6 7 1 5 0 A 0 1 4 2 0

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 $F = 6\pi\eta rv$

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

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	$\lambda = \frac{h}{p}$

Unit 4

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	$F = ma = \dfrac{mv^2}{r}$
	$F = m\omega^2 r$

Electric and magnetic fields

Electric field	$E = \dfrac{F}{Q}$
Coulomb's law	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{V}{d}$
Electrical potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
Capacitance	$C = \dfrac{Q}{V}$
Energy stored in capacitor	$W = \frac{1}{2}QV$
	$W = \frac{1}{2}CV^2$
	$W = \frac{1}{2}\dfrac{Q^2}{C}$
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 $\frac{1}{2}m < c^2 > = \frac{3}{2}kT$

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	$V_{grav} = \frac{-Gm}{r}$
Stefan-Boltzmann law	$L = \sigma T^4 A$
Wien's law	$\lambda_{\max} T = 2.898 \times 10^{-3}\ \mathrm{m\,K}$
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	$v = H_0 d$