Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Wednesday 14 June 2023

Morning (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.

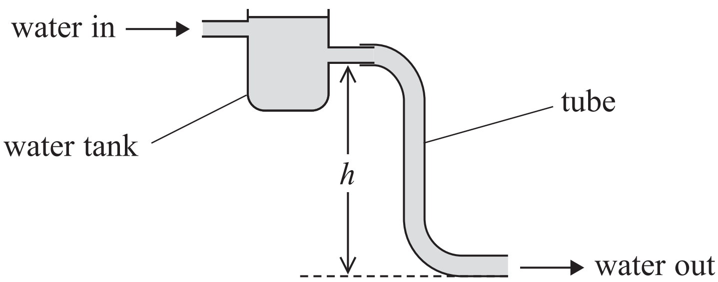
Turn over

Pearson

Answer ALL questions.

1 A water tank is shown below. The depth of water in the water tank is kept constant.

The height h can be adjusted to vary the volume flow rate of the water moving out of the tube.



(a) Describe a simple method to determine the volume flow rate of the water moving out of the tube.

(3)

....

....

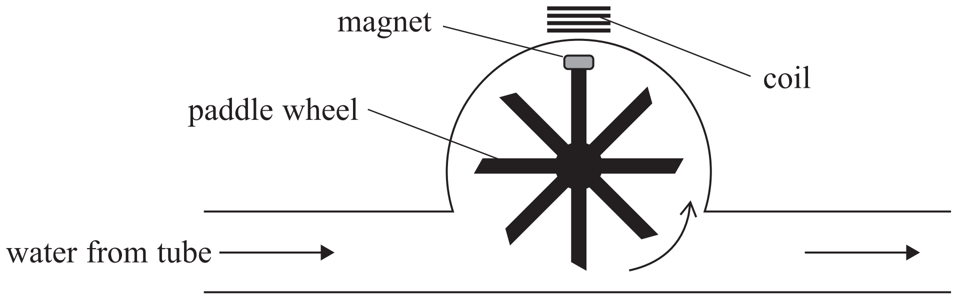
....

....

....

....

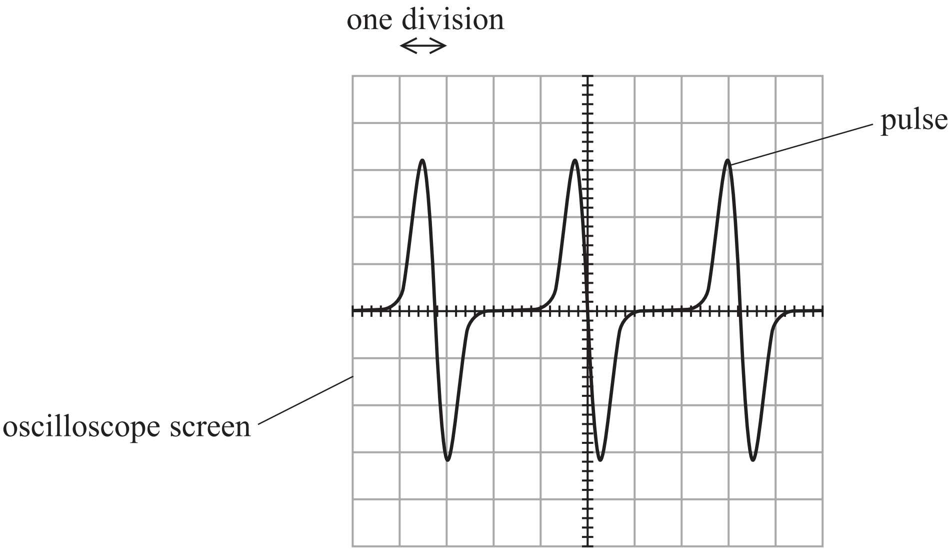
(b) A student connected the tube to the water flow device shown below. A magnet is attached to the paddle wheel.



As water flowed through the device the paddle wheel rotated, making the magnet move past the coil.

The student connected the coil to an oscilloscope.

A series of pulses was displayed on the oscilloscope screen as shown.



The horizontal axis represents time.

The time scale was set to 50 ms per division.

Calculate the frequency *f* of the pulses.

(3)

....

....

....

....

....

....

f = ...

(c) Describe how the student could investigate how f varies with the volume flow rate of the water.

(3)

....

....

....

....

....

....

(d) The student disconnected the water tank and oscilloscope from the water flow device.

The student placed the water flow device in a river to monitor the flow of the river water overnight.

He connected the coil of the water flow device to a data logger. The data logger recorded the frequency of the pulses.

Give **two** reasons why a data logger is an appropriate piece of equipment to use for this task.

(2)

....

....

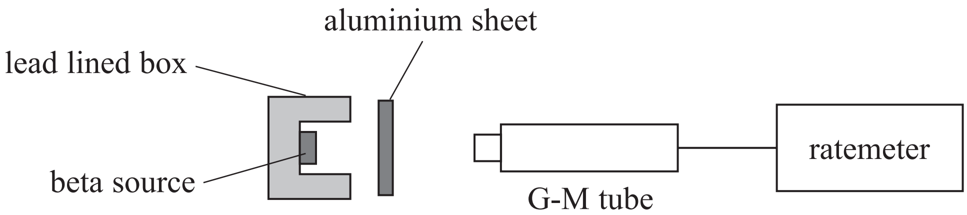
....

....

....

(Total for Question 1 = 11 marks)

2 The absorption of beta particles in aluminium can be investigated using the apparatus shown.



(a) State **two** safety precautions for this investigation.

(2)

....

....

....

....

(b) A student planned to test whether beta particles are absorbed by aluminium according to the relationship

$$C = C_0 e^{-\mu x}$$

where
C is the count rate when the thickness of the aluminium sheet is x
C_0 is the count rate with no aluminium sheet
μ is a constant.

(i) Explain why a graph of $\ln C$ against x could be used to test the validity of this relationship.

(2)

....

....

....

....

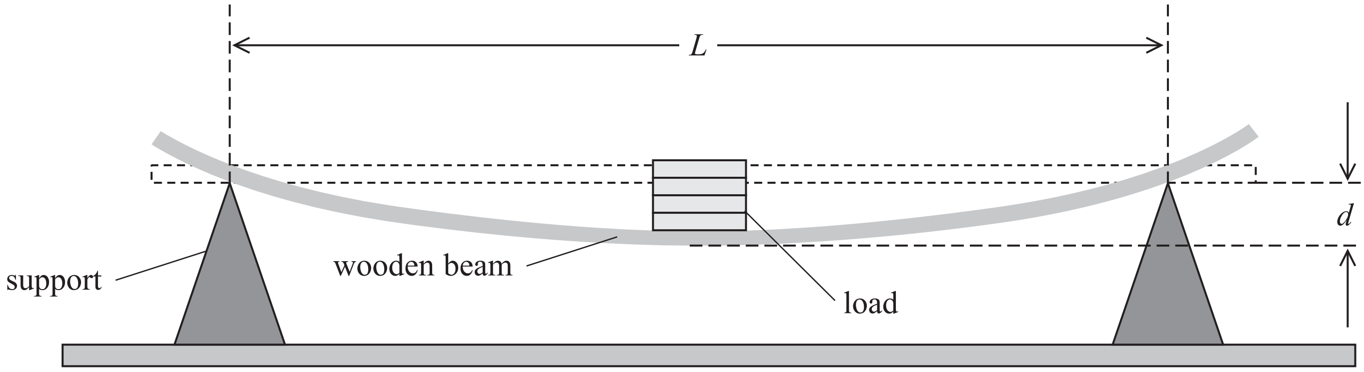
(ii) Devise a plan to obtain the data required to test the validity of this relationship.

(6)

(Total for Question 2 = 10 marks)

3 A student investigated the bending of a flexible wooden beam.

The student placed a load on the wooden beam. The centre of the beam was displaced by a distance *d* as shown.



(a) Describe an accurate method to determine a single value of *d* using a 15 cm ruler.

You should include any additional apparatus.

(3)

....

....

....

....

....

....

(b) The student varied the distance L between the supports. She used vernier calipers to measure the displacement d for a constant load.

She recorded the following data.

L / m	d / m		
0.950	0.0160		
0.850	0.0115		
0.750	0.0080		
0.650	0.0052		
0.550	0.0032		
0.450	0.0018		

(i) Plot a graph of $\log d$ against $\log L$ on the grid opposite.

Use the additional columns for your processed data.

(6)

P 7 3 4 6 1 R A 0 8 2 0

(ii) Determine the gradient of the graph.

(3)

....

....

....

....

....

....

Gradient = ...

(iii) It is suggested that for a given load, the relationship between d and L is of the form

$$d = kL^r$$

where r and k are constants.

Determine the value k from the graph and hence write the mathematical relationship between d and L.

(3)

....

....

....

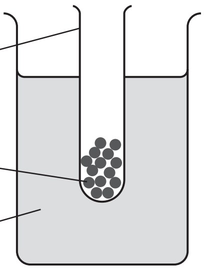
....

....

....

(Total for Question 3 = 15 marks)

4 A student added small lead spheres to a test tube. The student placed the test tube in a small beaker of water. The test tube floated as shown.



The student gave the test tube a small vertical displacement. The test tube then oscillated vertically.

(a) The student measured the time period T of the oscillations using a stopwatch. She repeated the measurement of T and calculated a mean.

(i) Describe **two** other techniques she should use to determine T.

(2)

....

....

....

....

(ii) She recorded the following measurements.

5*T* / s	3.43	3.36	3.28	3.49

Calculate the mean value of T and its uncertainty in seconds.

(3)

....

....

....

....

....

....

Mean value of T = ... s ± .... s

(b) The student estimated that the diameter of the test tube was approximately 2 cm.

Explain why vernier calipers are a suitable instrument to measure the diameter.

Your answer should include a calculation.

(2)

....

....

....

....

(c) The student replaced the water with a different liquid and determined the new value of T.

T is given by the formula

$$T = \sqrt{\frac{16\pi m}{D^2 \rho g}}$$

where
D is the diameter of the test tube
m is the mass of the test tube and lead spheres
ρ is the density of the liquid.

(i) Show that ρ is about 1200 kg m^{-3}.

$D = 2.38\,\text{cm} \pm 0.01\,\text{cm}$
$T = 0.61\,\text{s} \pm 0.01\,\text{s}$
$m = 48.95\,\text{g}$

(2)

....

....

....

....

(ii) Show that the percentage uncertainty in ρ is about 4%.

(3)

....

....

....

....

....

....

(iii) The density of glycerol is 1260 kg m^{-3}.

Deduce whether the liquid could be glycerol.

(2)

....

....

....

....

....

(Total for Question 4 = 14 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

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

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

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

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

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

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	$Q = Q_0 e^{-t/RC}$

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

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

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	$V_{\text{grav}} = \frac{-Gm}{r}$
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	$v = H_0 d$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA