Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Monday 10 June 2024

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.

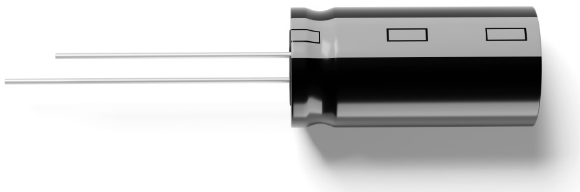
Advice

- 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

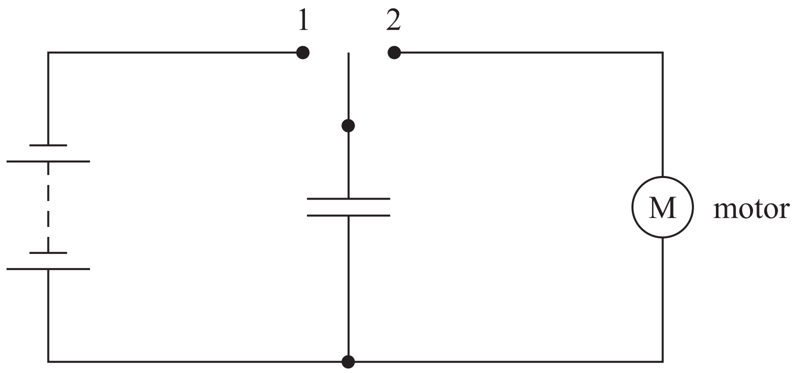
Answer ALL questions.

1 The electrolytic capacitor shown can be used to store energy.



(Source: © Andrei Kuzmik/Shutterstock)

A student connected the electrolytic capacitor into the circuit below.



(a) State **two** safety precautions the student should take when connecting and using the circuit.

(2)

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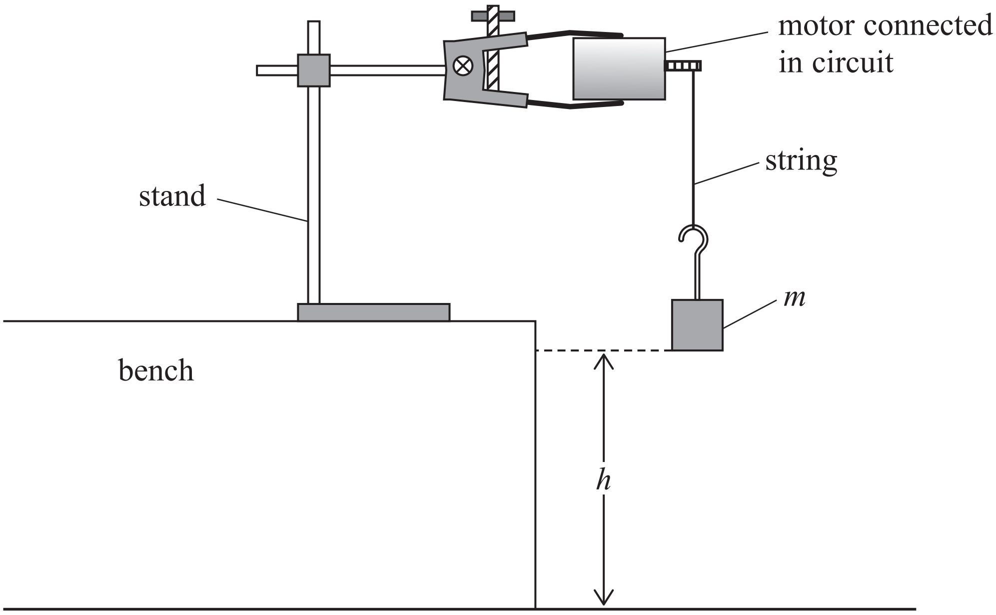
P 7 5 8 1 2 A 0 2 2 4

(b) The student used the switch in position 1 to charge the capacitor.

The student changed the switch to position 2 to discharge the capacitor through the motor.

As the capacitor discharged, the motor raised a small mass *m* through a height *h*, as shown.



The student used a metre rule to measure *h*.

Describe an accurate method to determine a single value of *h* using a metre rule.

You may include additional apparatus.

(3)

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(c) The student repeated the procedure in (b) several times. She recorded the following measurements.

***h* / m**	0.246	0.239	0.243	0.241

(i) Calculate the mean value of *h*.

(1)

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Mean value of *h* = ...

(ii) Determine the percentage uncertainty in the mean value of *h*.

(2)

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Percentage uncertainty = ...

(iii) Determine the efficiency of the electric motor.

maximum potential difference across capacitor = 6 V
capacitance of capacitor = 4700 μF
m = 20 g

(3)

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Efficiency = ...

(Total for Question 1 = 11 marks)

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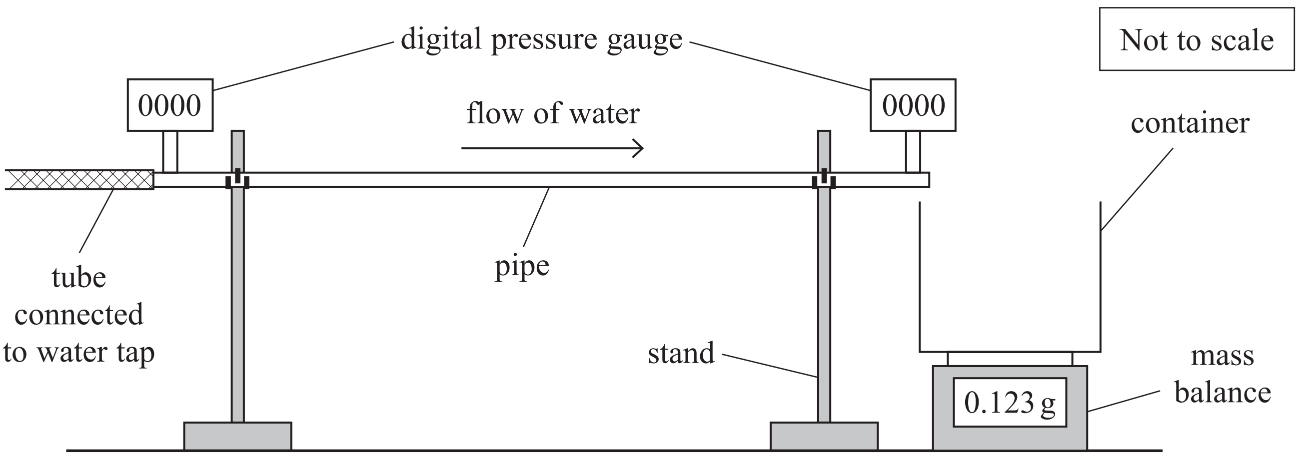
2 A student investigated the flow of water through a horizontal pipe using the apparatus shown.



The mass M of water leaving the pipe in a time t is given by the formula

$$M = \frac{\pi \rho P r^4 t}{8 \eta L}$$

where
ρ = density of water
P = pressure difference between the ends of the pipe
r = internal radius of the pipe
η = viscosity of water
L = distance between digital pressure gauges

(a) Show that the formula gives the unit for η as $\mathrm{N\,s\,m^{-2}}$.

(2)

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(b) The student used a metre rule to measure L and a stopwatch to measure t.
He adjusted the water tap to give a constant flow of water.

Describe a method to determine an accurate value for η.

Your method should use a suitable graph.

(6)

(c) The mass balance can be connected to a data logger. The data logger records the mass shown on the balance.

Give **two** reasons why using a data logger would improve this investigation.

(2)

(Total for Question 2 = 10 marks)

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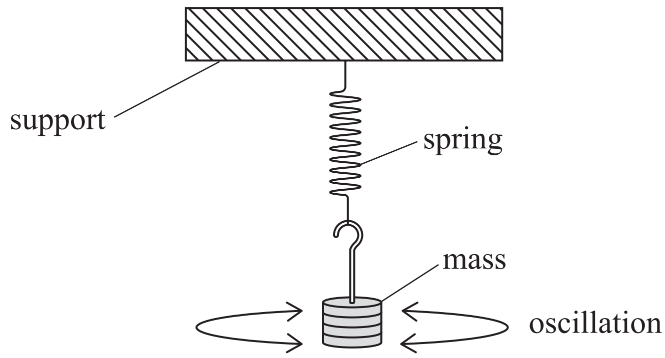
3 A student investigated the rotational oscillations of a mass on a spring, using the apparatus shown.



When the mass is displaced through a small angle, the mass performs rotational oscillations about a vertical axis through the spring.

(a) The student used a stopwatch to determine the time period T of the rotational oscillations.

Describe how the student should determine an accurate value for T.

(3)

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(b) The student predicted that the relationship between T and the mass M was of the form

$$T = aM^b$$

where a and b are constants.

(i) Explain how a graph of $\log T$ against $\log M$ can be used to determine the value of b.

(2)

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(ii) The student varied M and determined the corresponding values of T. She recorded the following data.

M / kg	T / s		
0.200	1.46		
0.300	1.86		
0.400	2.14		
0.500	2.36		
0.600	2.63		
0.700	2.88		

Plot a graph of $\log T$ against $\log M$ on the grid opposite.

Use the additional columns for your processed data.

(6)

(iii) Determine the gradient of the graph.

(3)

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Gradient = ...

(iv) Determine the value of a.

(3)

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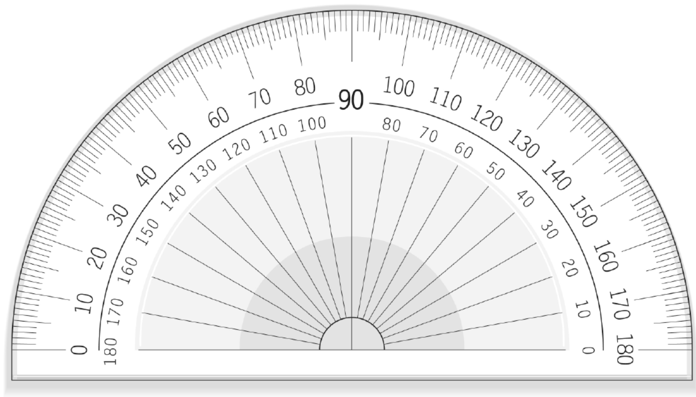
a = ...

(Total for Question 3 = 17 marks)

4 A student made measurements of the plastic protractor shown.



(Source: © Natsmith1/Shutterstock)

(a) (i) The student used a micrometer screw gauge to measure the thickness *t* of the plastic protractor.

Explain **one** technique she should use when measuring *t*.

(2)

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(ii) The student determined a value of *t* as 1.41 mm.

Explain why a micrometer screw gauge is an appropriate instrument for this measurement.

Your answer should include a calculation.

(2)

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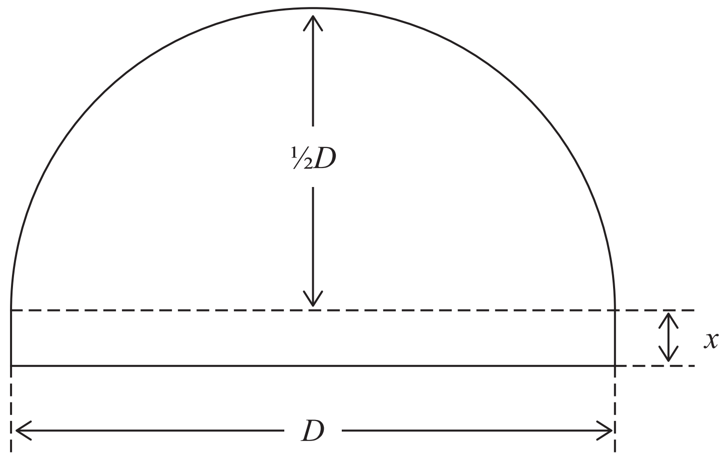
(b) The student determined the volume V of the plastic protractor from the measurements shown.



The student recorded the following measurements.

$D = 10.10\,\text{cm} \pm 0.05\,\text{cm}$
$x = 4.5\,\text{mm} \pm 0.1\,\text{mm}$
$t = 1.40\,\text{mm} \pm 0.02\,\text{mm}$

(i) Show that V is about $6.2\,\text{cm}^3$.

(2)

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(ii) Show that the uncertainty in V is about $0.2\,\text{cm}^3$.

(4)

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(c) The student determined the density of the plastic as $1.04\,g\,cm^{-3}$ with a percentage uncertainty of 3%.

The accepted value of the density of Perspex is $1.18\,g\,cm^{-3}$.

Explain whether the student's measurements suggest that the protractor could be made of Perspex.

Your answer should include a calculation.

(2)

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(Total for Question 4 = 12 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	$\lambda = \frac{h}{p}$

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	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{V}{d}$
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 $\mathcal{E} = \frac{-d(N\phi)}{dt}$

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

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

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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	$L = \sigma A T^4$
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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