

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 ►

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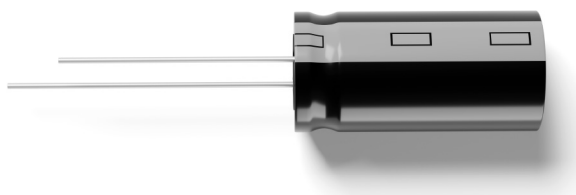
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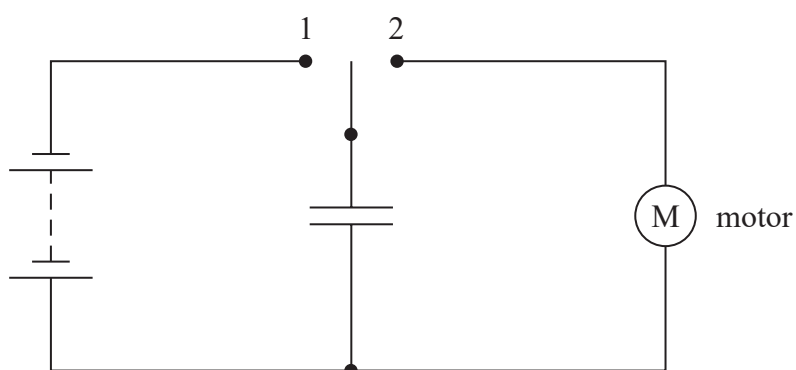
Answer ALL questions.

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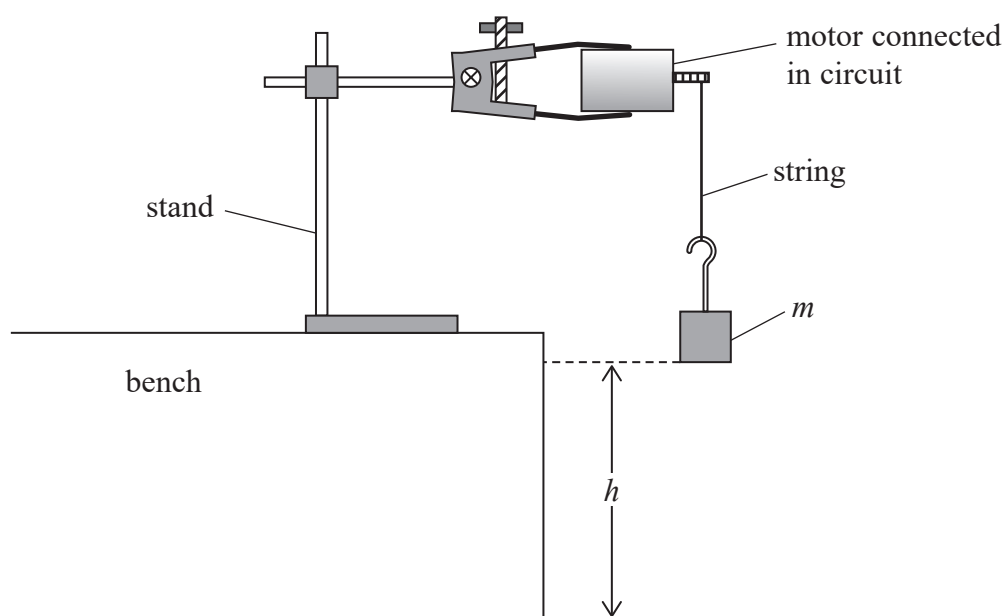
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(b) The student used the switch in position 1 to charge the capacitor.

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
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- (i) Calculate the mean value of h .

(1)

Mean value of h =

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

(2)

Percentage uncertainty =

- (iii) Determine the efficiency of the electric motor.

maximum potential difference across capacitor = 6 V

capacitance of capacitor = 4700 μF

$m = 20 \text{ g}$

(3)

Efficiency =

(Total for Question 1 = 11 marks)



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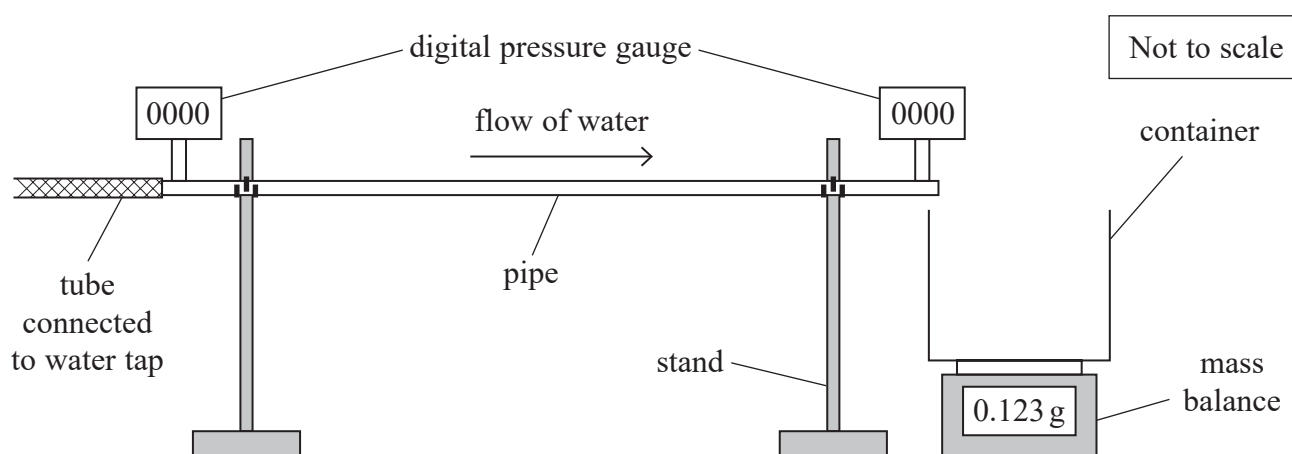
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- 2 A student investigated the flow of water through a horizontal pipe using the apparatus shown.



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 Ns m^{-2} .

(2)

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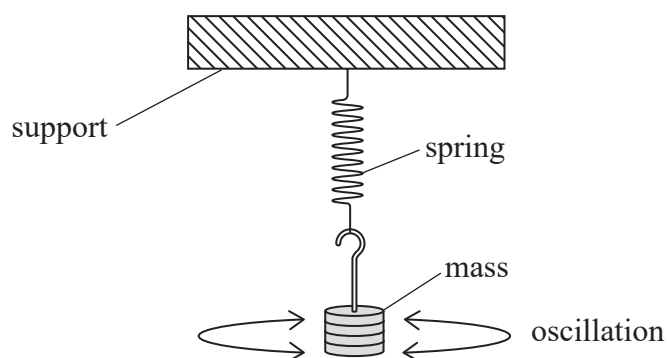
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- 3 A student investigated the rotational oscillations of a mass on a spring, using the apparatus shown.



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)

- (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)



- (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)

Gradient =

- (iv) Determine the value of a .

(3)

$a = \dots\dots\dots$

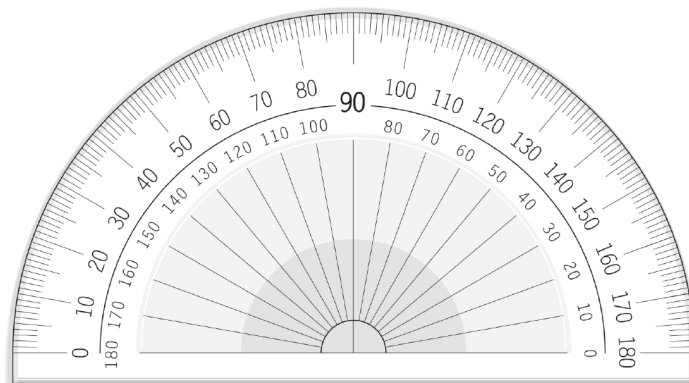


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(Total for Question 3 = 17 marks)



- 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)

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

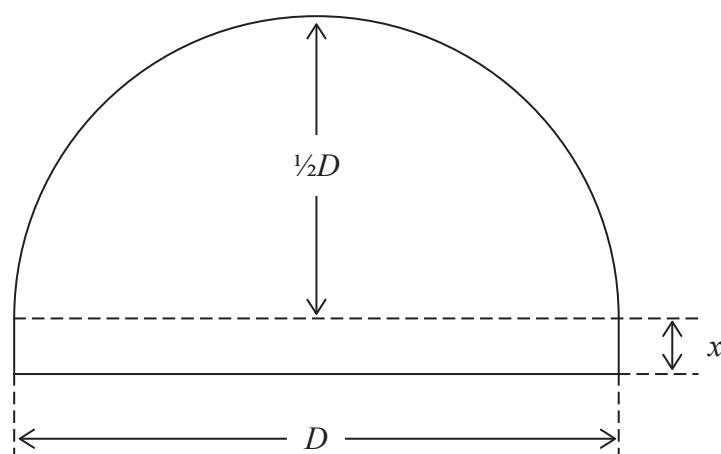
Explain why a micrometer screw gauge is an appropriate instrument for this measurement.

Your answer should include a calculation.

(2)



- (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 cm^3 .

(2)

- (ii) Show that the uncertainty in V is about 0.2 cm^3 .

(4)

- (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)

(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	$k = 1/4\pi\epsilon_0$ $= 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	
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	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
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

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

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

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

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

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

Stokes' law

$$F = 6\pi\eta rv$$

Hooke's law

$$\Delta F = k\Delta x$$

Elastic strain energy

$$\Delta E_{\text{el}} = \frac{1}{2}F\Delta x$$

Young modulus

$$E = \frac{\sigma}{\varepsilon} \text{ where}$$

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

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

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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

$$P = VI$$

$$P = I^2 R$$

$$P = \frac{V^2}{R}$$

$$W = VIt$$

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

$$hf = \phi + \frac{1}{2}mv_{\max}^2$$

de Broglie wavelength

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



Unit 4*Further mechanics*

Impulse

$$F\Delta t = \Delta p$$

Kinetic energy of a non-relativistic particle

$$E_k = \frac{p^2}{2m}$$

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

$$F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$$

$$E = \frac{Q}{4\pi\epsilon_0 r^2}$$

$$E = \frac{V}{d}$$

Electrical potential

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

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

$$\mathcal{E} = \frac{-d(N\phi)}{dt}$$

Nuclear and particle physics

In a magnetic field

$$r = \frac{p}{BQ}$$

Mass-energy

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

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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

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

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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