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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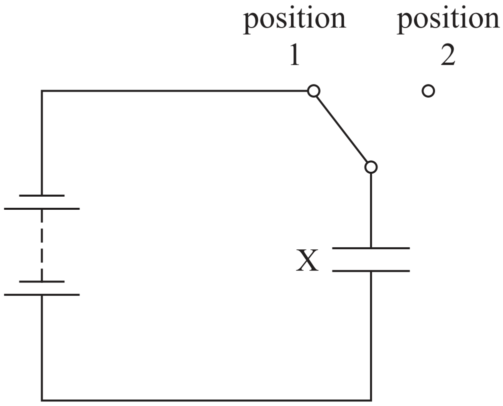
Pearson

Answer ALL questions.

1 The capacitance of an unknown capacitor can be determined using a method known as charge sharing. Some of the components needed for this method, including capacitor X of known capacitance, are shown in the circuit diagram.



(a) (i) Add a capacitor Y to the circuit diagram, so the switch can connect capacitor X either to the power supply or to capacitor Y.

(1)

(ii) Add a voltmeter to the circuit diagram to measure the potential difference (p.d.) across capacitor X.

(1)

(b) The photograph shows a voltmeter that could be used in this circuit.

(i) State the resolution of the voltmeter.

(1)

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(ii) The voltmeter can be adjusted so that more significant figures are shown.

Suggest a reason why the voltmeter does not need to be adjusted.

(1)

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(c) The capacitance C_Y of capacitor Y can be determined using the formula

$$C_Y = \left(\frac{V_1 - V_2}{V_2}\right) C_X$$

where

C_X is the capacitance of capacitor X

V_1 is the p.d. across capacitor X when the switch is in position 1

V_2 is the p.d. across capacitor X when the switch is in position 2.

Three students, A, B and C, tested the same capacitor Y using different known values of C_X. Their measurements are shown in the table.

Student	C_X / μF	V_1 / V	V_2 / V	C_Y / μF
A	0.10	6.00	0.38	
B	0.22	5.97	0.72	
C	0.33	5.98	1.07	

(i) Complete the table.

(2)

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(ii) Explain whether the calculated values of C_Y show that the students' results are repeatable.

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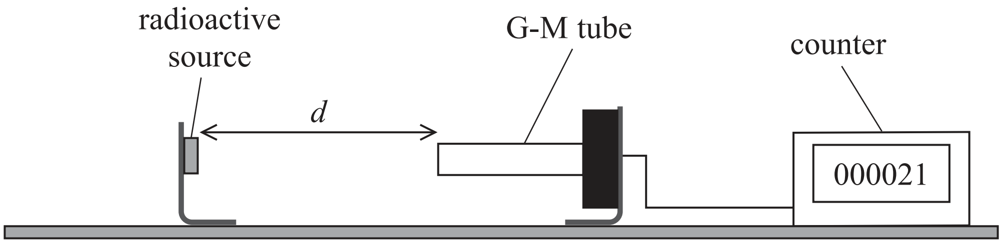
(Total for Question 1 = 8 marks)

2 The emission of radiation from a radioactive source can be investigated using the apparatus shown.



(a) A student suggests that the relationship between the count rate C of gamma radiation with distance d is given by

$$C = \frac{C_0}{d^2}$$

where C_0 is a constant.

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

(6)

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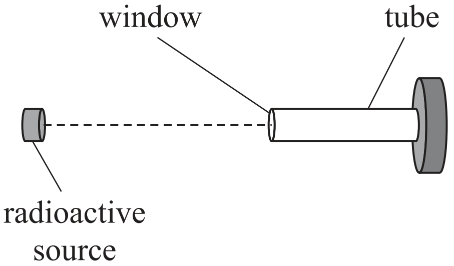
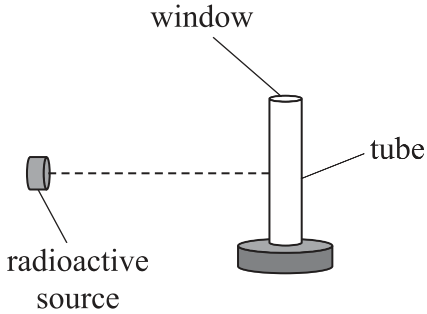
(b) The G-M tube is made from steel that is a few millimetres thick. The tube has a thin mica window at one end that allows all types of ionising radiation to enter.



Arrangement 1



Arrangement 2

The radioactive source emits both beta and gamma radiation.

Ionising radiation may be detected anywhere inside the tube.

Explain which arrangement would be more suitable to measure the counts from gamma radiation only.

(4)

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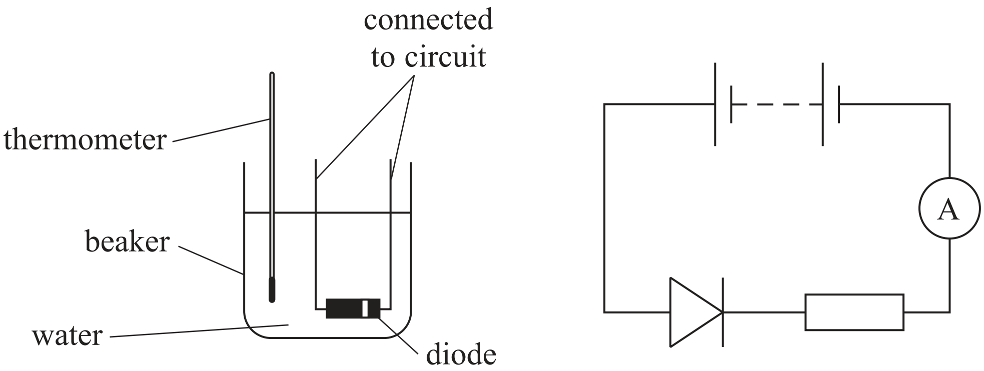
(Total for Question 2 = 10 marks)

3 A student investigated how the current in a diode varied with the temperature of the diode, using the apparatus shown.



(a) The student filled the beaker with hot water and recorded the current at different temperatures as the water cooled.

(i) Describe two techniques the student should use to ensure that the temperature measurement is valid.

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(ii) State one reason why repeat measurements are not appropriate for this investigation.

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(b) The relationship between the current I in the diode and the absolute temperature T of the diode is given by

$$I = I_0 e^{-qV/kT}$$

where

q is the charge of the charge carriers

V is the potential difference across the diode

k is the Boltzmann constant.

Explain why q can be determined from a graph of $\ln I$ against $1/T$.

(2)

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(c) The student recorded the following data.

T / K	I / mA		
298	3.49		
303	4.34		
308	5.26		
313	6.34		
318	7.58		
323	9.03		

(i) Plot a graph of $\ln I$ against $1/T$ on the grid opposite. Use the additional columns in the table to record your processed data.

(6)

(ii) The value of q can be determined using the formula

$$q = -\frac{\text{gradient} \times k}{V}$$

Use your graph to determine the value of q.

$V = 0.32\,\text{V}$

(3)

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q = ...

(Total for Question 3 = 14 marks)

Turn over ▶

4 A student investigated the stiffness of a metal rod. The rod had been formed into an L-shape as shown.

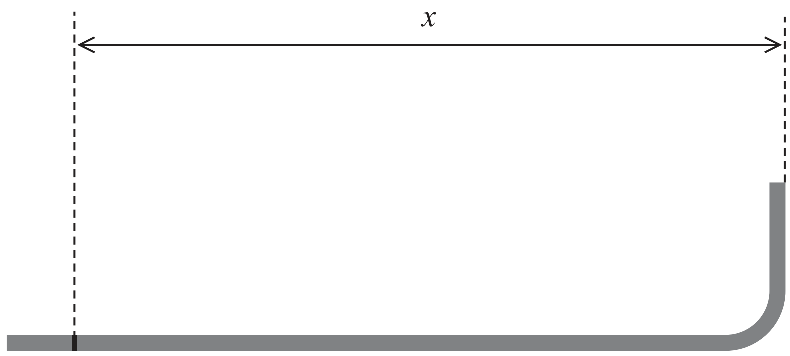

Diagram not to scale

(a) The student measured the distance x using a metre rule.

(i) Describe a method to measure x as accurately as possible, including any additional apparatus required.

You may add to the diagram to illustrate your answer.

(2)

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(ii) The student recorded x as 61.5 cm ± 0.1 cm.

Explain why the uncertainty was recorded as 0.1 cm.

(2)

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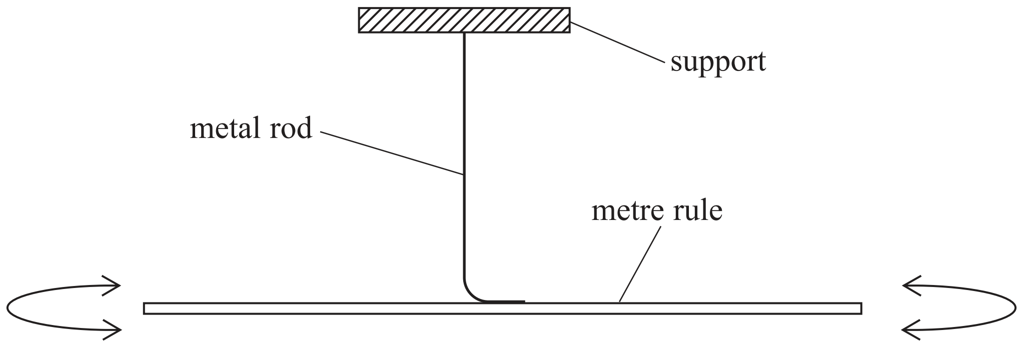
(b) The L-shaped rod was clamped to a support as shown. A metre rule was firmly attached to the rod.



The student gave the metre rule a small angular displacement causing the rod to twist. The metre rule performed angular oscillations about a vertical axis through the metal rod.

(i) Explain one technique the student should use when measuring the time period T of the oscillations.

(2)

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(ii) The student recorded the following measurements.

20*T* / s			
20.93	20.69	20.77	20.85

Calculate the mean value of T and its uncertainty.

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Mean value of T = ... ± ....

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(c) The shear modulus G of a metal is a measure of the metal's resistance to twisting forces. G can be determined using the formula

$$G = \frac{32\pi M w^2 x}{3d^4T^2}$$

where

M is the mass of the metre rule

w is the length of the metre rule

d is the diameter of the metal rod.

(i) Determine a value for G in $\mathrm{N\,m^{-2}}$.

$M = 0.115\,\mathrm{kg} \pm 0.001\,\mathrm{kg}$
$w = 1.000\,\mathrm{m} \pm 0.001\,\mathrm{m}$
$x = 61.5\,\mathrm{cm} \pm 0.1\,\mathrm{cm}$
$d = 2.35\,\mathrm{mm} \pm 0.03\,\mathrm{mm}$

(2)

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

(ii) Determine the percentage uncertainty in G.

(2)

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Percentage uncertainty = ...

(d) The student repeated the investigation with a rod made from a different metal. The student was told the metal could be brass, bronze or copper. The table shows the values of *G* for these metals.

Type of metal	G / GPa
Brass	40.0
Bronze	44.5
Copper	45.0

From the student's investigation $G = 42.1 \text{ GPa} \pm 6\%$.

Deduce whether the student can use this value of *G* to determine whether the rod is made from brass, bronze or copper.

Your answer should include calculations.

(4)

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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	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$	
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	$\varepsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	
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

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

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

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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 $F = 6\pi\eta r v$

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	$v = \sqrt{\dfrac{T}{\mu}}$
Intensity of radiation	$I = \dfrac{P}{A}$
Refractive index	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
	$n = \dfrac{c}{v}$
Critical angle	$\sin C = \dfrac{1}{n}$
Diffraction grating	$n\lambda = d\sin\theta$

Electricity

Potential difference	$V = \dfrac{W}{Q}$
Resistance	$R = \dfrac{V}{I}$
Electrical power, energy	$P = VI$
	$P = I^2R$
	$P = \dfrac{V^2}{R}$
	$W = VIt$
Resistivity	$R = \dfrac{\rho l}{A}$
Current	$I = \dfrac{\Delta Q}{\Delta t}$
	$I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Particle nature of light

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \dfrac{1}{2}mv^2_{max}$
de Broglie wavelength	$\lambda = \dfrac{h}{p}$

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Unit 4

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 $F = ma = \frac{mv^2}{r}$

$$F = m\omega^2 r$$

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

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	$\frac{1}{2}m<c^2> = \frac{3}{2}kT$

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	$v = H_0 d$

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