Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel International Advanced Level

Centre Number	Candidate Number

Tuesday 19 January 2021

Morning (Time: 1 hour 20 minutes) | Paper Reference **WPH16/01**

Physics

Advanced
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.
- Candidates may use a scientific calculator.

Advice

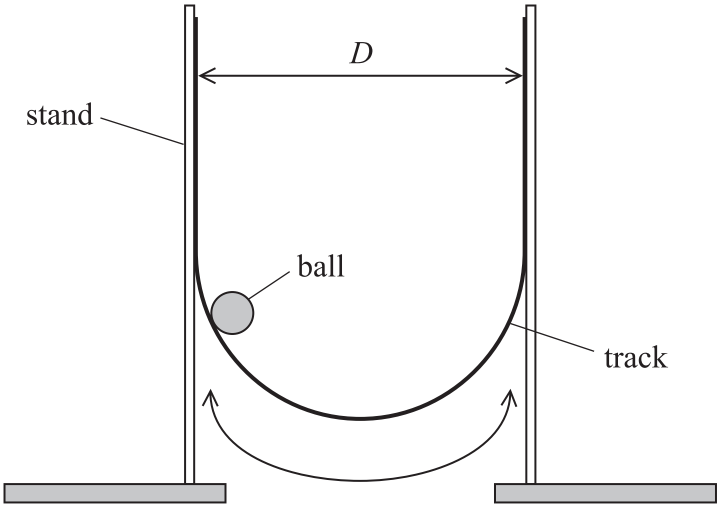
- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over

Pearson

Answer ALL questions.

1 A ball rolls along a U-shaped track. The ball oscillates in a vertical plane as shown.



(a) Describe how the time period of the oscillations should be measured to make the readings as accurate as possible.

(3)

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(b) Describe how a single measure of *D* should be made accurately.

(2)

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(c) A student determined the time period T for different values of the distance D.
She obtained the following results.

***D* / m**	0.235	0.335	0.445
***T* / s**	0.78	0.94	1.09

She predicts that for these oscillations

$$T \propto \sqrt{D}$$

Show that her results are consistent with this prediction.

(3)

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(Total for Question 1 = 8 marks)

2 Two identical capacitors were connected in series and charged. They were then discharged through a resistor and ammeter.
A student investigated how the current in the resistor varied as the capacitors discharged.

(a) Draw an appropriate circuit diagram for this investigation.

(3)

(b) State **one** safety precaution the student should take.

(1)

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(c) The student had a stopwatch.

Describe how the student should determine an accurate value for the total capacitance of the capacitors.

(6)

(d) The student repeated the investigation but used a data logger instead of a stopwatch and an ammeter.

Suggest why using a data logger would improve this investigation.

(2)

(Total for Question 2 = 12 marks)

3 When high energy electrons are incident on a sample of an isotope, a diffraction pattern is produced. The diffraction pattern can be used to determine the radius of a nucleus of the isotope.

The relationship between the radius r of a nucleus and the nucleon number A is

$$r = r_0 A^n$$

where r_0 is the radius of a proton and n is a constant.

(a) Explain why a graph of $\log r$ against $\log A$ can be used to determine a value for n.

(2)

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(b) The table shows the values of r for some different isotopes.

Isotope	A	r **/ fm**		
H-2	2	1.54		
He-4	4	1.92		
Be-9	9	2.47		
C-12	12	2.72		
O-16	16	3.00		
Mg-24	24	3.42		

(i) Plot a graph of $\log r$ against $\log A$ on the grid. Use the additional columns in the table to record your processed data.
You should **not** convert the values of r to metres.

(6)

(ii) Use your graph to determine the value of n.

(2)

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n = ...

(iii) Determine the value of r_0 and hence state the mathematical relationship between r and A.

(3)

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(Total for Question 3 = 13 marks)

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4 A cylindrical container is made from a transparent material. Two students want to determine the density of this material.

(a) The students need to make measurements to determine the volume of the transparent material. The external diameter of the container is approximately 10 cm.

Student A suggests measuring the external diameter with a metre rule.

Student B suggests placing a piece of string around the circumference of the container and then measuring this length of string with a metre rule.

Explain which of these measurements would have the least percentage uncertainty.

(2)

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(b) The students decide to use string to determine the circumference of the container. They measure the thickness t of the string using a micrometer screw gauge.

(i) Explain **two** techniques that could be used to make sure this measurement is as accurate as possible.

(2)

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(ii) The following measurements were obtained.

t / mm				
2.15	2.06	2.13	2.08	2.10

Calculate the mean value of t in mm and its uncertainty.

(2)

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mean t = ... mm ± .... mm

(c) The circumference C of the container can be determined using the formula

$$C = x - \pi t$$

where x is the length of string around the container.

(i) Calculate the value of C in cm.

$x = 25.8\,\text{cm} \pm 0.2\,\text{cm}$

(2)

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C = ... cm

(ii) Show that the uncertainty in C is approximately 0.2 cm.

(1)

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(d) The volume V of the transparent material is given by

$$V = \frac{C^2 L}{4\pi} - V_i$$

where L is the length of the container and V_i is the internal volume of the container.

Determine the value of V in cm^3 and its uncertainty.

$L = 19.90\,cm \pm 0.05\,cm$

$V_i = 810\,cm^3 \pm 5\,cm^3$

(4)

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$V =$ .... $cm^3 \pm$ .... cm^3

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(e) The table shows the densities of some common materials used to manufacture this type of container. Only borosilicate is safe to heat directly with a Bunsen burner.

Material	Soda glass	Borosilicate	Perspex
ρ / g cm^{-3}	2.52	2.23	1.18

The mass of the container was measured as 463 g ± 1 g.

Deduce whether the container is safe to heat directly with a Bunsen burner.

(4)

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(Total for Question 4 = 17 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

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

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

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

Young modulus $E = \dfrac{\sigma}{\varepsilon}$ where

Stress $\sigma = \dfrac{F}{A}$

Strain $\varepsilon = \dfrac{\Delta x}{x}$

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

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

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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	$\Delta E = c^2\Delta m$
Radio-active 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	$g = \dfrac{F}{m}$
Gravitational force	$F = \dfrac{Gm_1m_2}{r^2}$
Gravitational field	$g = \dfrac{Gm}{r^2}$
Gravitational potential	$V_{grav} = \dfrac{-Gm}{r}$
Stephan-Boltzman law	$L = \sigma T^4 A$
Wein's law	$\lambda_{\max} T = 2.898 \times 10^{-3}\ \mathrm{m\,K}$
Intensity of radiation	$I = \dfrac{L}{4\pi d^2}$
Redshift of electromagnetic radiation	$z = \dfrac{\Delta\lambda}{\lambda} \approx \dfrac{\Delta f}{f} \approx \dfrac{v}{c}$
Cosmological expansion	$v = H_0 d$

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