

Please check the examination details below before entering your candidate information

Candidate surname

Other names

**Pearson Edexcel**  
**International**  
**Advanced Level**

Centre Number

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Candidate Number

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**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 ►

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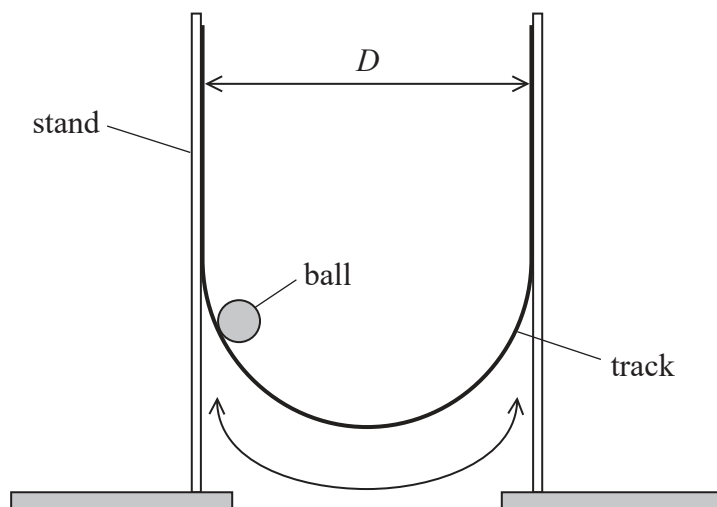
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Pearson

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.

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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.

$D / \text{m}$	0.235	0.335	0.445
$T / \text{s}$	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)

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(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)

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**(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	$A$	$r / \text{fm}$		
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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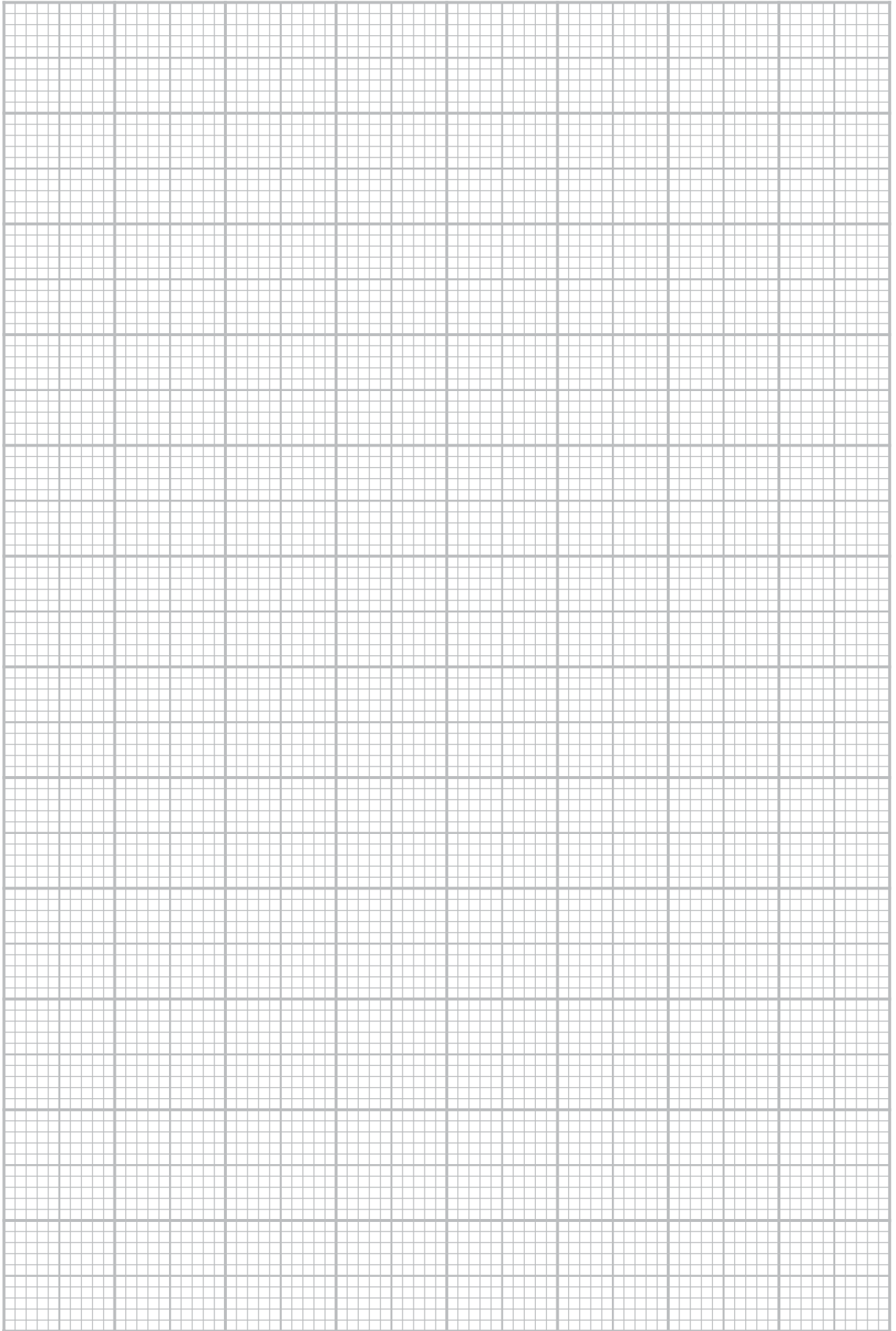
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(iii) Determine the value of  $r_0$  and hence state the mathematical relationship between  $r$  and  $A$ .

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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.

$t / \text{mm}$				
2.15	2.06	2.13	2.08	2.10

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

(2)

mean  $t = \dots\dots\dots$  mm  $\pm \dots\dots\dots$  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)

$C = \dots\dots\dots$  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  $\text{cm}^3$  and its uncertainty.

$$L = 19.90 \text{ cm} \pm 0.05 \text{ cm}$$

$$V_i = 810 \text{ cm}^3 \pm 5 \text{ cm}^3$$

(4)

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$$V = \dots\dots\dots \text{cm}^3 \pm \dots\dots\dots \text{cm}^3$$



- (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
$\rho / \text{g cm}^{-3}$	2.52	2.23	1.18

The mass of the container was measured as  $463 \text{ g} \pm 1 \text{ g}$ .

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

(4)

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(Total for Question 4 = 17 marks)

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**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	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
Coulomb's law constant	$k = 1/4\pi\epsilon_0$ $= 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	
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

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

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

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

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

$$P = VI$$

$$P = I^2R$$

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

$$W = VIt$$

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

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

de Broglie wavelength

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



**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

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

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

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

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

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

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

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



*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  $V_{grav} = \frac{-Gm}{r}$

Stephan-Boltzman law  $L = \sigma T^4 A$

Wein'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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