

**Paper Reference(s) 9PH0/01**  
**Pearson Edexcel Level 3 GCE**

**Physics**

**Advanced**

**PAPER 1: Advanced Physics I**

**Friday 24 May 2024 – Morning**

**Time: 1 hour 45 minutes**

**Data, Formulae and Relationships**  
**Booklet**

**DO NOT RETURN THIS BOOKLET  
WITH THE QUESTION PAPER.**

**Acceleration of free fall**

$$g = 9.81 \text{ m s}^{-2} \quad (\text{close to Earth's surface})$$

**Boltzmann constant**

$$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$$

**Coulomb law constant**

$$k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

**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**

$$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$$

**Turn over**

**Gravitational field strength**

$$g = 9.81 \text{ N kg}^{-1} \quad (\text{close to Earth's surface})$$

**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**

$$u = 1.66 \times 10^{-27} \text{ kg}$$

**Turn over**

# 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

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

$$\text{moment of force} = Fx$$

## Momentum

$$p = mv$$

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Turn over

## **Mechanics continued.**

### **Work, energy and power**

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

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

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

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

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

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

**Turn over**

# Electric circuits

## Potential difference

$$V = \frac{W}{Q}$$

## Resistance

$$R = \frac{V}{I}$$

## Electrical power and energy

$$P = VI$$

$$P = I^2R$$

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

$$W = VIt$$

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Turn over

## Electric circuits continued.

### Resistivity

$$R = \frac{\rho l}{A}$$

### Current

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nqvA$$

# Materials

## Density

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

## Stokes' law

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

## Hooke's law

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

## Young modulus

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

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

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

## Elastic strain energy

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

Turn over



# Waves and Particle Nature of Light

## Wave speed

$$v = f\lambda$$

## Speed of a transverse wave on a string

$$v = \sqrt{\frac{T}{\mu}}$$

## Intensity of radiation

$$I = \frac{P}{A}$$

## Power of a lens

$$P = \frac{1}{f}$$

$$P = P_1 + P_2 + P_3 + \dots$$

## Thin lens equation

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

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Turn over

## Waves and Particle Nature of Light continued.

### Magnification for a lens

$$m = \frac{\text{image height}}{\text{object height}} = \frac{v}{u}$$

### Diffraction grating

$$n\lambda = d \sin \theta$$

### Refractive index

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$n = \frac{c}{v}$$

### Critical angle

$$\sin C = \frac{1}{n}$$

### Photon model

$$E = hf$$

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Turn over

## Waves and Particle Nature of Light continued.

### Einstein's photoelectric equation

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

### de Broglie wavelength

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

## 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

$$v = \omega r$$

$$T = \frac{2\pi}{\omega}$$

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

$$a = \frac{v^2}{r}$$

$$a = r\omega^2$$

$$F = mr\omega^2$$

# Fields

## Coulomb's law

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

## Electric field strength

$$E = \frac{F}{Q}$$

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

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

## Electric potential

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

## Capacitance

$$C = \frac{Q}{V}$$

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Turn over

**Fields continued.**

**Energy stored in a capacitor**

$$W = \frac{1}{2} QV$$

$$W = \frac{1}{2} CV^2$$

$$W = \frac{1}{2} \frac{Q^2}{C}$$

**Capacitor discharge**

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

$$I = I_0 e^{-t/RC}$$

$$V = V_0 e^{-t/RC}$$

$$\ln Q = \ln Q_0 - \frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{t}{RC}$$

$$\ln V = \ln V_0 - \frac{t}{RC}$$

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**Turn over**

**Fields continued.**

**In a magnetic field**

$$\mathbf{F} = BIl \sin \theta$$

$$\mathbf{F} = Bqv \sin \theta$$

**Faraday's and Lenz's laws**

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

**Root-mean-square values**

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

$$I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$$

**Nuclear and particle physics**

**In a magnetic field**

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

**Turn over**

# Thermodynamics

## Heating

$$\Delta E = mc\Delta\theta$$

$$\Delta E = L\Delta m$$

## Molecular kinetic theory

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

$$pV = \frac{1}{3} Nm \langle c^2 \rangle$$

## Ideal gas equation

$$pV = NkT$$

## Stefan-Boltzmann law

$$L = \sigma AT^4$$

$$L = 4\pi r^2 \sigma T^4$$

## Wien's law

$$\lambda_{\max} T = 2.898 \times 10^{-3} \text{ m K}$$

Turn over



**Space**

**Intensity**

$$I = \frac{L}{4\pi d^2}$$

**Redshift of electromagnetic radiation**

$$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$$

**Cosmological expansion**

$$v = H_0 d$$

**Turn over**

# Nuclear radiation

## Mass-energy

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

## Radioactive decay

$$A = \lambda N$$

$$\frac{dN}{dt} = -\lambda N$$

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$N = N_0 e^{-\lambda t}$$

$$A = A_0 e^{-\lambda t}$$

# Gravitational fields

## Gravitational force

$$F = \frac{Gm_1m_2}{r^2}$$

## Gravitational field strength

$$g = \frac{Gm}{r^2}$$

## Gravitational potential

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

# 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

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

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