General Certificate of Education
Advanced Subsidiary Examination

# Physics A

# Data and Formulae Booklet

**DATA**
**FUNDAMENTAL CONSTANTS AND VALUES**

| *Quantity* | *Symbol* | *Value* | *Units* |
|---|---|---|---|
| speed of light in vacuo | $c$ | $3.00 \times 10^{8}$ | $m\ s^{-1}$ |
| permeability of free space | $\mu_o$ | $4\pi \times 10^{-7}$ | $H\ m^{-1}$ |
| permittivity of free space | $\varepsilon_o$ | $8.85 \times 10^{-12}$ | $F\ m^{-1}$ |
| magnitude of the charge of electron | $e$ | $1.60 \times 10^{-19}$ | C |
| the Planck constant | $h$ | $6.63 \times 10^{-34}$ | J s |
| gravitational constant | $G$ | $6.67 \times 10^{-11}$ | $N\ m^2\ kg^{-2}$ |
| the Avogadro constant | $N_A$ | $6.02 \times 10^{23}$ | $mol^{-1}$ |
| molar gas constant | $R$ | 8.31 | $J\ K^{-1}\ mol^{-1}$ |
| the Boltzmann constant | $k$ | $1.38 \times 10^{-23}$ | $J\ K^{-1}$ |
| the Stefan constant | $\sigma$ | $5.67 \times 10^{-8}$ | $W\ m^{-2}\ K^{-4}$ |
| the Wien constant | $\alpha$ | $2.90 \times 10^{-3}$ | m K |
| electron rest mass (equivalent to $5.5 \times 10^{-4}$ u) | $m_e$ | $9.11 \times 10^{-31}$ | kg |
| electron charge/mass ratio | $e/m_e$ | $1.76 \times 10^{11}$ | $C\ kg^{-1}$ |
| proton rest mass (equivalent to 1.00728 u) | $m_p$ | $1.67(3) \times 10^{-27}$ | kg |
| proton charge/mass ratio | $e/m_p$ | $9.58 \times 10^{7}$ | $C\ kg^{-1}$ |
| neutron rest mass (equivalent to 1.00867 u) | $m_n$ | $1.67(5) \times 10^{-27}$ | kg |
| gravitational field strength | $g$ | 9.81 | $N\ kg^{-1}$ |
| acceleration due to gravity | $g$ | 9.81 | $m\ s^{-2}$ |
| atomic mass unit (1u is equivalent to 931.5 MeV) | u | $1.661 \times 10^{-27}$ | kg |

**ASTRONOMICAL DATA**

| *Body* | *Mass/kg* | *Mean radius/m* |
|---|---|---|
| Sun | $1.99 \times 10^{30}$ | $6.96 \times 10^{8}$ |
| Earth | $5.98 \times 10^{24}$ | $6.37 \times 10^{6}$ |

**GEOMETRICAL EQUATIONS**

| | |
|---|---|
| *arc length* | $= r\theta$ |
| *circumference of circle* | $= 2\pi r$ |
| *area of circle* | $= \pi r^2$ |
| *surface area of cylinder* | $= 2\pi rh$ |
| *volume of cylinder* | $= \pi r^2 h$ |
| *area of sphere* | $= 4\pi r^2$ |
| *volume of sphere* | $= \frac{4}{3}\pi r^3$ |

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## AS FORMULAE

## PARTICLE PHYSICS

### Rest energy values

| *class* | *name* | *symbol* | *rest energy /MeV* |
|---|---|---|---|
| photon | photon | $\gamma$ | 0 |
| lepton | neutrino | $\nu_e$ | 0 |
| | | $\nu_\mu$ | 0 |
| | electron | $e^{\pm}$ | 0.510999 |
| | muon | $\mu^{\pm}$ | 105.659 |
| mesons | $\pi$ meson | $\pi^{\pm}$ | 139.576 |
| | | $\pi^0$ | 134.972 |
| | K meson | $K^{\pm}$ | 493.821 |
| | | $K^0$ | 497.762 |
| baryons | proton | p | 938.257 |
| | neutron | n | 939.551 |

### Properties of quarks

*antiquarks have opposite signs*

| *type* | *charge* | *baryon number* | *strangeness* |
|---|---|---|---|
| **u** | $+\frac{2}{3}e$ | $+\frac{1}{3}$ | 0 |
| **d** | $-\frac{1}{3}e$ | $+\frac{1}{3}$ | 0 |
| **s** | $-\frac{1}{3}e$ | $+\frac{1}{3}$ | -1 |

### Properties of leptons

| | *lepton number* |
|---|---|
| *particles*: $e^-$, $\nu_e$ ; $\mu^-$, $\nu_\mu$ | +1 |
| *antiparticles*: $e^+$, $\overline{\nu_e}$ ; $\mu^+$, $\overline{\nu_\mu}$ | –1 |

### Photons and energy levels

*photon energy* $E = hf = hc/\lambda$

*photoelectricity* $hf = \phi + E_{K\,(max)}$

*energy levels* $hf = E_1 - E_2$

*de Broglie wavelength* $\lambda = \frac{h}{p} = \frac{h}{mv}$

## ELECTRICITY

*current and pd* $I = \frac{\Delta Q}{\Delta t}$ $V = \frac{W}{Q}$ $R = \frac{V}{I}$

*emf* $\varepsilon = \frac{E}{Q}$ $\varepsilon = I(R + r)$

*resistors in series* $R = R_1 + R_2 + R_3 + \ldots$

*resistors in parallel* $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

*resistivity* $\rho = \frac{RA}{L}$

*power* $P = VI = I^2R = \frac{V^2}{R}$

*alternating current* $I_{rms} = \frac{I_0}{\sqrt{2}}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$

## MECHANICS

*moments* moment = $Fd$

*velocity and acceleration* $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

*equations of motion* $v = u + at$ $s = \frac{(u+v)}{2}t$

$v^2 = u^2 + 2as$ $s = ut + \frac{at^2}{2}$

*force* $F = ma$

*work, energy and power* $W = F s \cos\theta$

$E_K = \frac{1}{2} m v^2$ $\Delta E_p = mg\Delta h$

$P = \frac{\Delta W}{\Delta t}$, $P = Fv$

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

## MATERIALS

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

Hooke's law $F = k\,\Delta L$

*Young modulus* $= \frac{\text{tensile stress}}{\text{tensile strain}}$ $\text{tensile stress} = \frac{F}{A}$ $\text{tensile strain} = \frac{\Delta L}{L}$

*energy stored* $E = \frac{1}{2}F\Delta L$

## WAVES

*wave speed* $c = f\lambda$ *period* $T = \frac{1}{f}$

*fringe spacing* $w = \frac{\lambda D}{s}$ *diffraction grating* $d \sin\theta = n\lambda$

*refractive index of a substance s,* $n = \frac{c}{c_s}$

*for two different substances of refractive indices $n_1$ and $n_2$,*

*law of refraction* $n_1 \sin\theta_1 = n_2 \sin\theta_2$

*critical angle* $\sin\theta_c = \frac{n_2}{n_1}$ for $n_1 > n_2$