

For use in exams from the June 2016 Series onwards

DATA - FUNDAMENTAL CONSTANTS AND VALUES

| Quantity | Symbol | Value | Units |
|--|-----------------|---------------------------|-----------------------------------|
| speed of light in vacuo | c | 3.00×10^8 | m s^{-1} |
| permeability of free space | μ_0 | $4\pi \times 10^{-7}$ | H m^{-1} |
| permittivity of free space | ϵ_0 | 8.85×10^{-12} | F m^{-1} |
| magnitude of the charge of electron | e | 1.60×10^{-19} | C |
| the Planck constant | h | 6.63×10^{-34} | J s |
| gravitational constant | G | 6.67×10^{-11} | $\text{N m}^2 \text{kg}^{-2}$ |
| the Avogadro constant | N_A | 6.02×10^{23} | mol^{-1} |
| molar gas constant | R | 8.31 | $\text{J K}^{-1} \text{mol}^{-1}$ |
| the Boltzmann constant | k | 1.38×10^{-23} | J K^{-1} |
| the Stefan constant | σ | 5.67×10^{-8} | $\text{W m}^{-2} \text{K}^{-4}$ |
| the Wien constant | α | 2.90×10^{-3} | m K |
| electron rest mass (equivalent to 5.5×10^{-4} u) | m_e | 9.11×10^{-31} | kg |
| magnitude of electron charge/mass ratio | $\frac{e}{m_e}$ | 1.76×10^{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 | $\frac{e}{m_p}$ | 9.58×10^7 | 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 | 1.661×10^{-27} | kg |

ALGEBRAIC EQUATION

quadratic equation $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

ASTRONOMICAL DATA

| Body | Mass/kg | Mean radius/m |
|-------|-----------------------|--------------------|
| Sun | 1.99×10^{30} | 6.96×10^8 |
| Earth | 5.97×10^{24} | 6.37×10^6 |

GEOMETRICAL EQUATIONS

arc length = $r\theta$

circumference of circle = $2\pi r$

area of circle = πr^2

curved surface area of cylinder = $2\pi rh$

area of sphere = $4\pi r^2$

volume of sphere = $\frac{4}{3}\pi r^3$

Particle Physics

| Class | Name | Symbol | Rest energy/MeV |
|---------|-------------|-----------|-----------------|
| photon | photon | γ | 0 |
| lepton | neutrino | ν_e | 0 |
| | | ν_μ | 0 |
| | electron | e^\pm | 0.510999 |
| | muon | μ^\pm | 105.659 |
| mesons | π meson | π^\pm | 139.576 |
| | | π^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: | $e^+, \bar{\nu}_e, \mu^+, \bar{\nu}_\mu$ | -1 |

Photons and energy levels

photon energy $E = hf = \frac{hc}{\lambda}$
photoelectricity $hf = \phi + E_{k(\max)}$
energy levels $hf = E_1 - E_2$
de Broglie Wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

Waves

wave speed $c = f\lambda$ *period* $f = \frac{1}{T}$
first harmonic $f = \frac{1}{2l} \sqrt{\frac{T}{\mu}}$
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 $n_1 > n_2$

Mechanics

moments *moment* = Fd
velocity and acceleration $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$
equations of motion $v = u + at$ $s = \left(\frac{u+v}{2}\right)t$
 $v^2 = u^2 + 2as$ $s = ut + \frac{at^2}{2}$
force $F = ma$
force $F = \frac{\Delta(mv)}{\Delta t}$
impulse $F \Delta t = \Delta(mv)$
work, energy and power $W = F s \cos \theta$
 $E_k = \frac{1}{2} m v^2$ $\Delta E_p = mg\Delta h$
 $P = \frac{\Delta W}{\Delta t}$, $P = Fv$
efficiency = $\frac{\text{useful output power}}{\text{input power}}$

Materials

density $\rho = \frac{m}{V}$ *Hooke's law* $F = k \Delta L$
Young modulus = $\frac{\text{tensile stress}}{\text{tensile strain}}$ *tensile stress* = $\frac{F}{A}$
tensile strain = $\frac{\Delta L}{L}$
energy stored $E = \frac{1}{2} F \Delta L$

Electricity

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

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

resistors in series $R_T = R_1 + R_2 + R_3 + \dots$

resistors in parallel $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$

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

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

