PHYSICS FORMULAS MEETLEARN.COM

Advanced Level Physics

PHYSICS USEFULA DATA

USEFUL DATA

Constants of Nature	Symbol	Value
speed of light in vacuum	c	3×10^{8} m s^{-1}
gravitational constant	G	6.67×10^{-11} N m^{2} kg^{-2}
Planck constant	h	6.62×10^{-34} J s
permittivity of free space	ε_0	8.85×10^{-12} F m^{-1}
permeability of free space	μ_0	$4\pi \times 10^{-7}$ H m^{-1}
elementary charge	e	1.6×10^{-19} C
electron mass	m_e	9.11×10^{-31} kg
mass of proton	m_p	1.0078 u
mass of neutron	m_N	1.0087 u
1 atomic mass unit, amu	u	931 MeV
1 atomic mass unit, amu	u	1.66×10^{-27} kg
roton mass	m_p	1.67×10^{-27} kg
utron mass	m_n	1.675×10^{-27} kg
ogadro constant	N_A	6.02×10^{23} mol^{-1}
tzmann constant	k	1.38×10^{-23} J K^{-1}
r gas constant	R	8.31 J K^{-1} mol^{-1}

Useful quantities	Value
typical radius of an atom	$\sim 10^{-10}$ m
typical radius of a nucleus	$\sim 10^{-15}$ m
mean radius of the Earth	6.38×10^{6} m
mass of the Earth	5.974×10^{24} kg
gravitational field strength close to the surface of Earth	9.81 N kg^{-1}
acceleration due gravity close to the surface of Earth	9.81 m s^{-2}
atmospheric pressure at sea level	1.01×10^{5} Pa
pressure due to 10 m of water	~1 atmosphere
mass of the Moon	7.35×10^{22} kg
gravitational field strength close to the surface of Moon	1.62 N kg^{-1}
mean radius of the Sun	6.96×10^{8} m
power output of the Sun	3.9×10^{26} W
1 electronvolt (1 eV)	1.60×10^{-19} J
1 kilowatt hour (1 kWh)	3.6×10^{6} J

Useful quantities	Value
absolute zero temperature	- 273.15°C or 0 K
density of mercury	1.36×10^{4} kg m^{-3}
density of water	1.00×10^{3} kg m^{-3}
density of atmosphere at stp	1.29 kg m^{-3}
specific heat capacity of water	4.19×10^{3} J kg^{-1} K^{-1}
specific heat of fusion of water	3.34×10^{5} J kg^{-1}
specific heat of vaporisation of water	2.26×10^{6} J kg^{-1}
triple point of water	273.16 K
ice point	273.15 K
speed of sound in air at stp	3.34×10^{2} m s^{-1}
typical drift velocity of electrons	$\sim 10^{-3}$ m s^{-1}
$1/4\pi\varepsilon_0$	9×10^{9} F m^{-1}
π^2	~10
1 year	$\sim \pi \times 10^{7}$ s
1 light year (1 ly)	9.46×10^{15} m

MECHANICS

USEFUL FORMULAE AND RELATIONSHIPS

Mechanics

Upthrust = weight of displaced liquid	
Instantaneous velocity	$V_{ins} = \frac{ds}{dt}$
Momentum, p	$p = mv$
Change in pe close to Earth	$\Delta pe = mg\Delta h$
Uniformly accelerated motion	$v = u + at$ $s = ut + ½ at^2$ $v^2 = u^2 + 2a.s$
Work	$\Delta W = F.\Delta s$ $W = \int F.ds$
Angular speed	$\omega = \frac{\Delta\theta}{\Delta t} = \frac{v}{r}$
Period, T	$T = \frac{1}{f}$ $\omega = 2\pi f$, $\omega = \frac{2\pi}{T}$
simple harmonic motion	$a = -\omega^2 r$ $r = r_0 \sin \omega t$ $v = r_0 \omega \cos \omega t$ $T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{m}{k}}$

Average speed, v	$V = \frac{\text{distance travelled}}{\text{time taken}}$
Average velocity, v_{av} Average acceleration, a_{av}	$V_{av} = \frac{\Delta s}{\Delta t}$ $a_{av} = \frac{\Delta v}{\Delta t}$
Instantaneous acceleration	$a = \frac{dv}{dt}$
Kinetic energy	$ke = \frac{1}{2} mv^2$
Resultant force	$\Sigma F = ma$ $\sum F = \frac{\Delta p}{\Delta t}$
Power	$P = F.v$ $= \frac{\Delta W}{\Delta t}$
Centripetal acceleration	$a_c = r\omega^2 = \frac{v^2}{r}$
Moment of F about O from point p (r)	Moment = r x F
Torque	$\Gamma = \mathbf{r} \times \mathbf{F}$
Simple harmonic motion	$ke = \frac{1}{2}m(r_o \omega \cos \omega t)^2$ $= \frac{1}{2}m(r_o^2 - r^2)\omega^2$ $= \frac{1}{2}m(r_o \omega \sin \omega t)^2$ $= \frac{1}{2}m\omega^2 r^2$

ENERGETICS

Energetics

Thermometry	$\theta = \frac{X_\theta - X_0}{X_{100} - X_0} \times 100\ ^\circ C$
Mass-energy equivalent	$\Delta E = c^2 \Delta m$
Energy for change of state	$\Delta Q = mL$
Electricity	$I = \frac{dQ}{dt} = nAQv$
Resistors in series	$R_{total} = R_1 + R_2 + R_3 + \ldots$
Thermal energy transfer	$\Delta Q = mc\Delta\theta$
Electrical energy converted	$E = IVt$
First law of thermodynamics	$\Delta Q = \Delta U + \Delta W$
Rate of heat transfer by conduction	$\frac{dQ}{dt} = -kA \frac{\Delta T}{\Delta l}$
$R = \frac{V}{I} = \frac{\rho l}{A}$	$R_\theta = R_0(1 + \alpha\theta)$
Resistors in parallel	$R^{-1}_{total} = R_1^{-1} + R_2^{-1} + R_3^{-1} + \ldots$

Matter

Density $(\rho) = \frac{m}{V}$	Hooke's law, $F = k\Delta x$ Work done $= \frac{1}{2} F \Delta x = \int F dx$
$pV = nRT = \frac{mRT}{M}$	$p = \frac{1}{3}\rho \overline{c^2}$ $\overline{ke} = \frac{3}{2}kT$, $R = kN_A$
$\Delta p = \rho g \Delta h$ $p = \frac{F}{A}$	$E = \frac{stress}{strain}$, $stress = \frac{F}{A}$, $strain = \frac{\Delta l}{l}$
$\frac{dN}{dt} = -\lambda N$, $T_{1/2} = \frac{\ln 2}{\lambda}$	$N = N_0 e^{-\lambda t}$

FIELDS

Fields

Newton's law of gravitation	$F = \frac{Gm_1m_2}{r^2}\hat{r}$ $g = \frac{F}{m} = \frac{Gm}{r^2}$
$ke = \frac{Gm_1m_2}{2r}$ $ME = -\frac{Gm_1m_2}{2r}$ $pe = -\frac{Gm_1m_2}{r}$	
Capacitors in parallel	$C_{total} = C_1 + C_2 + C_3 \ldots$
Charging a capacitor	$Q = Q_o e^{-\frac{t}{\tau}}, \tau = CR$
$F_{magnetic} = BIl = Bqv$	$B_{solenoid} = \mu_o nI$
$\varepsilon_{back} = -L\frac{dI}{dt}, \Delta\varphi = L\Delta I$ $\varepsilon_{back} = -M\frac{dI}{dt}, \Delta\varphi = M\Delta I$	
Transformer	$\frac{\varepsilon_s}{\varepsilon_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$
$I = I_o \sin 2\pi_r ft$,	$V = V_o \sin 2\pi ft$

Coulomb's law	$F = \frac{Q_1Q_2}{4\pi\varepsilon_o r^2}\hat{r}$ $E = \frac{F}{Q}$ $E = -\frac{\Delta V}{\Delta r}$
$\Delta V = \frac{\Delta W}{Q}$ $C = \frac{Q}{V} = \frac{\varepsilon_r\varepsilon_o A}{d}$	$W = ½CV^2$
Capacitors in series	$C^{-1}_{total} = C_1^{-1} + C_2^{-1} + C_3^{-1} \ldots$
$V = V_o e^{-\frac{t}{CR}}$	$I = I_o e^{-\frac{t}{CR}}$
$\varphi = BA$	Induced emf = Blv
$B_{longwire} = \frac{\mu_o I}{2\pi r}$ $\frac{F}{l} = \frac{\mu I_1 I_2}{2\pi r}$	Induced emf = $-\frac{N\Delta\varphi}{\Delta t}$
$I_r = \frac{I_o}{\sqrt{2}}$ $V_r = \frac{V_o}{\sqrt{2}}$	$f_{resonance} = \frac{1}{2\pi\sqrt{LC}}$
$P_{av} = I_rV_r = ½ I_oV_o$	

WAVES

Wave phenomena	
$c = f\lambda$, $n_1 \sin\theta_1 = n_2 \sin\theta_2$,	
$\frac{\lambda_1}{\lambda_2} = \frac{c_1}{c_2} = \frac{n_2}{n_1}$ $f_1 - f_2 = f_B = \frac{1}{t}$	$n_1 \sin\theta_c = n_2$ $C = \sqrt{\frac{T}{M}} = \sqrt{\frac{E}{\rho}} = \sqrt{\frac{\gamma P}{\rho}}$, $C = \frac{1}{\sqrt{\mu\varepsilon}}$
observer toward source $f_o = \frac{v + u_o}{v} f_s$	observer away from source $f_o = \frac{v - u_o}{v} f_s$
$E = hf$, $ke_{max} = hf - \varphi$	
Young 2-slit $y = \frac{\lambda}{a} D$ source approach observer $f_o = \frac{v}{v - u_s} f_s$	$I = \frac{power}{4\pi r^2}$ source receding observer $f_o = \frac{v}{v + u_s} f_s$
observer and source moving in the same direction $f_o = \frac{v - u_o}{v - u_s} f_s$	observer and source moving in the opposite direction $f_o = \frac{v - u_o}{v + u_s} f_s$

RELATIVITY

Relativistic Mechanics

Energy, $E = mc^2$.

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$ and hence $$E = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$$

where m_0 is rest mass, m is relativistic mass, v is velocity of particle and c velocity of light in vacuum.

kinetic energy, E_k

$$E_k = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} m_0 c^2 - m_0 c^2$$

Momentum

$$p = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} m_0 v$$

Energy and Momentum

$$E = \frac{1}{\sqrt{1 - \frac{p^2 c^2}{E^2}}} m_0 c^2, \quad E^2 - p^2 c^2 = m^2 c^4 = \text{cons tan t.}$$

Relativistic and classical (newtonian) mechanics

If $v <<<$ ke $= \frac{1}{2} m_0 v^2$ and $p = m_0 v$ as in classical mechanics.