EQUATIONS AND CONSTANTS FOR GRADE 12 PHYSICS

These equations are meant to make doing homework and exams a bit easier. They are **not** an excuse for not learning the course material. If you don't know what these equations mean and how to use them, they will not help you at all. Vector quantities are expressed in **bold fonts**.

KINEMATICS (constant acceleration):

$$\mathbf{v} = \frac{\Delta \mathbf{d}}{\Delta t} \qquad \Delta \mathbf{d} = \mathbf{v}_1 \Delta t + \frac{1}{2}\mathbf{a}\Delta t^2 \qquad \Delta \mathbf{d} = \frac{\mathbf{v}_1 + \mathbf{v}_2}{2}\Delta t \qquad v_2^2 = v_1^2 + 2a\Delta d$$

$$\mathbf{a} = \frac{\Delta \mathbf{v}}{\Delta t} \qquad \Delta \mathbf{d} = \mathbf{v}_2 \Delta t - \frac{1}{2}\mathbf{a}\Delta t^2 \qquad \mathbf{v}_2 = \mathbf{v}_1 + \mathbf{a}\Delta t$$

SYMMETRIC PROJECTILE MOTION:

Time of flight: $t_{\text{tot}} = \dfrac{2v_i \sin(\theta)}{g}$ Range: $R = \dfrac{v_i^2 \sin(2\theta)}{g}$ Max height: $h_{\max} = \dfrac{v_i^2 \sin^2(\theta)}{2g}$

UNIFORM CIRCULAR MOTION:

$\mathbf{a}_c \perp \mathbf{v}$ $a_c = \dfrac{v^2}{r}$ $F_c = ma_c$ $T = \dfrac{2\pi r}{v}$ $f = \dfrac{1}{T}$ Bank angle, no friction: $\tan\theta = \dfrac{v^2}{rg}$

NEWTON'S LAWS, MOMENTUM, IMPULSE, KINETIC ENERGY:

$$\mathbf{F}_{\text{net}} = m\mathbf{a} = \frac{\Delta \mathbf{p}}{\Delta t} \qquad \mathbf{F}_{\text{A on B}} = -\mathbf{F}_{\text{B on A}} \qquad \mathbf{p} = m\mathbf{v} \qquad \mathbf{J} = \Delta\mathbf{p} = \mathbf{F}_{\text{ave}}\Delta t \qquad W = Fd\cos\theta \qquad K = \frac{1}{2}mv^2$$

COLLISIONS:

$\mathbf{p}_A + \mathbf{p}_B = \mathbf{p}'_A + \mathbf{p}'_B$

$K_A + K_B = K'_A + K'_B$ (elastic)

FRICTION:

Static: $\max F_s = \mu_s F_N$

Kinetic: $F_k = \mu_k F_N$

SPRING:

Hooke's Law: $\mathbf{F} = k\mathbf{x}$

Elastic Potential: $U_e = \dfrac{1}{2}kx^2$

VELOCITIES AND ENERGIES IN ORBIT (m orbiting M):

$$v_{\text{escape}} = \sqrt{\frac{2GM}{r}} \qquad K_{\text{orbit}} = \frac{GMm}{2r} = \frac{1}{2}mv_{\text{orbit}}^2 \qquad E_{\text{tot}} = K_{\text{orbit}} + U_g = -\frac{GMm}{2r} = -K_{\text{orbit}}$$

$$v_{\text{orbit}} = \sqrt{\frac{GM}{r}} \qquad U_{\text{orbit}} = -\frac{GMm}{r} = -2K_{\text{orbit}} \qquad \frac{T^2}{r^3} = \text{constant}$$

FORCE FIELDS:

$$F_g = \frac{Gm_1m_2}{r^2} \qquad U_g = -\frac{Gm_1m_2}{r} \qquad g = \frac{Gm_s}{r^2} \qquad \mathbf{F}_g = m\mathbf{g}$$

$$F_q = \frac{kq_1q_2}{r^2} \qquad U_q = \frac{kq_1q_2}{r} \qquad E = \frac{kq_s}{r^2} \qquad \mathbf{F}_q = q\mathbf{E}$$

$$F_M = qvB\sin\theta \qquad F_M = IlB\sin\theta \qquad V = \frac{kq_s}{r} \qquad E = \frac{\Delta V}{d}\ \text{(Parallel plate)}$$

SINGLE-SLIT DIFFRACTION:

Bright fringes: $\pm\left(m + \dfrac{1}{2}\right)\lambda = W\sin\theta$ $y_m = \left(m + \dfrac{1}{2}\right)\dfrac{\lambda L}{W}$

Dark fringes: $\pm m\lambda = W\sin\theta$ $y_m = \dfrac{m\lambda L}{W}$ for $m = 1, 2, 3, \cdots$

DOUBLE-SLIT INTERFERENCE & DIFFRACTION GRATING:

Bright fringe: $\pm n\lambda = d\sin\theta$ Dark: $\pm\left(n+\frac{1}{2}\right)\lambda = d\sin\theta$ $\lambda \approx \frac{\Delta y d}{x}$

REFRACTION:

$n_1\sin\theta_1 = n_2\sin\theta_2$ $n = \frac{c}{v}$

OPTICAL RESOLUTION: (θ in radians)

Rectangular aperture: $\theta_{\min} = \frac{\lambda}{W}$

Circular aperture: $\theta_{\min} = \frac{1.22\lambda}{D}$

UNIVERSAL WAVE EQUATION:

$v = f\lambda$

SPECIAL RELATIVITY:

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}} \qquad \Delta t = \gamma\Delta t_o \qquad L = \frac{L_o}{\gamma} \qquad m = \gamma m_0 \qquad K = mc^2 - m_0c^2$$

QUANTUM MECHANICS:

$$E = hf \qquad K_{\max} = \begin{cases} hf - \varphi & \text{if } hf > \varphi \\ 0 & \text{otherwise} \end{cases} \qquad p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda} \qquad \lambda = \frac{h}{mv} \qquad \sigma_p\sigma_x \geq \frac{1}{2}\hbar \qquad \hbar = \frac{h}{2\pi}$$

USEFUL CONSTANTS:

Acceleration due to gravity	$g = 9.81\ \mathrm{m/s^2}$ (near surface of Earth)
Gravitational constant	$G = 6.674 \times 10^{-11}\ \mathrm{N\,m^2/kg^2}$
Coulomb's constant	$k = 8.988 \times 10^{9}\ \mathrm{N\,m^2/C^2}$
Electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
Proton rest mass	$m_p = 1.673 \times 10^{-27}$ kg
Elementary charge	$e = 1.602 \times 10^{-19}$ C
Speed of light	$c = 2.998 \times 10^{8}$ m/s
Planck's Constant	$h = 6.626 \times 10^{-34}$ J s
Mass of Earth	5.972×10^{24} kg
Radius of Earth	6.371×10^{6} m
Mass of Sun	1.989×10^{30} kg
Radius of sun	6.957×10^{8} m
Mass of Moon	7.348×10^{22} kg
Radius of Moon	1.737×10^{6} m
Earth-to-moon distance	3.844×10^{8} m (centre to centre)

CONVERSION TO SI UNITS:

Electron volt	$1\ \mathrm{eV} = 1.602 \times 10^{-19}$ J
Kilowatt-hour	$1\ \mathrm{kW\,h} = 3.6 \times 10^{6}$ J
Kilometres per hour	$1\ \mathrm{km/h} = 0.278\ \mathrm{m/s}$, $1\ \mathrm{m/s} = 3.6\ \mathrm{km/h}$
Light year	$1\ \mathrm{ly} = 9.461 \times 10^{15}$ m

MATHEMATICAL FORMULAS:

Circumference of a circle	$C = 2\pi r$
Area of a circle	$A = \pi r^2$
Volume of a sphere	$V = \frac{4}{3}\pi r^3$
Density	$\rho = m/V$
Small-angle approximation	$\tan\theta \approx \sin\theta \approx \theta$ (θ in radians)

UNIT PREFIXES:

tera	10^{12}	T
giga	10^{9}	G
mega	10^{6}	M
kilo	10^{3}	k
centi	10^{-2}	c
milli	10^{-3}	m
micro	10^{-6}	µ
nano	10^{-9}	n