11 Physics Mechanics formula list

Notation	$\vec{a} = a_x i + a_y j + a_z k$
Magnitude	$\vec{a} = \lvert\vec{a}\rvert = \sqrt{a_x^2 + a_y^2 + a_z^2}$
Dot Product	$\vec{A} \cdot \vec{B} = \lvert\vec{A}\rvert\lvert\vec{B}\rvert \cos \emptyset$
Cross Product	$\vec{A} \times \vec{B} = \lvert\vec{A}\rvert\lvert\vec{B}\rvert \sin\theta$
Mechanical energy	$E = U + K.$ Conserved if forces are conservative in nature.
Power	$P_{av} = \frac{\Delta w}{\Delta t}, P_{inst} = \vec{F} \cdot \vec{v}$
Centre of mass:	$x_{cm} = \frac{\sum x_i m_i}{\sum m_i}$
Triangle(CM = Centroid)	$y_c = \frac{h}{3}$
Semicircular ring	$y_c = \frac{2r}{\pi}$
Semicircular disc	$y_c = \frac{4r}{3\pi}$
Hemispherical shell	$y_c = \frac{r}{2}$
Solid Hemisphere	$y_c = \frac{3r}{8}$
Motion of the CM	$M = \sum m_i$
Impulse	$J = \int F\, dt = \Delta p$

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Angular velocity	$\vec{\omega} = \frac{d\theta}{dt}, \quad \vec{v} = \vec{\omega} \times \vec{r}$
Angular accel	$\vec{\alpha} = \frac{d\vec{\omega}}{dt}, \quad \vec{a} = \vec{\alpha} \times \vec{r}$
Motion in a straight line with constant a:	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 - u^2 = 2as$
Relative Velocity	$\overrightarrow{v_{AB}} = \overrightarrow{v_A} - \overrightarrow{v_B}$
Projectile Motion	$T = \frac{2u\sin\theta}{g},$ $R = \frac{u^2 \sin 2\theta}{g}, \quad H = \frac{u^2 \sin^2\theta}{2g}$
Linear momentum	$\vec{p} = m\vec{v}$
Newton's first law	inertial frame
Newton's second law	$\vec{F} = \frac{d\vec{p}}{dt}, \quad \vec{F} = m\vec{a}$
Newton's third law	$\overrightarrow{F_{AB}} = -\overrightarrow{F_{BA}}$
Frictional force	$f_{static,\ max} = \mu_s N, \ f_{kinetic} = \mu_k N$
Banking angle	$\frac{v^2}{rg} = \tan\theta, \quad \frac{v^2}{rg} = \frac{\mu + \tan\theta}{1 - \mu\tan\theta}$
Centripetel force	$F_c = \frac{mv^2}{r}, \quad a_c = \frac{v^2}{r}$

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Pseudo force

$$F_{pseudo} = -ma_0, \quad F_{centrifugal} = -\frac{mv^2}{r}$$

Conical pendulum

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

Work

$$W = \vec{F}.\vec{S} = FS\cos\theta, \quad W = \int \vec{F}.d\vec{S}$$

Kinetic energy

$$K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$$

Potential energy

$F = -\frac{\partial U}{\partial x}$ for conservative forces.

$$U_{gravitational} = mgh, \quad U_{spring} = \frac{1}{2}kx^2$$

Work- energy theorem

$$W = \Delta K$$

Rotation about an axis with constant α:

$$\theta = \omega t + \frac{1}{2}\alpha t^2, \;\; \omega^2 - \omega_0^2 = 2\alpha\theta$$

Moment of Inertia

$$I = \int r^2 dm$$

Theorem of Parallel Axes

$$I_{\parallel} = I_{cm} + md^2$$

Theorem of Perp. Axes

$$I_z = I_x + I_y$$

Radius of Gyration

$$k = \frac{\sqrt{I}}{m}$$

Angular Momentum

$$\vec{L} = \vec{r} \times \vec{p}, \quad \vec{L} = I\vec{\omega}$$

Torque

$$\vec{\tau} = \vec{r} \times \vec{F}, \qquad \vec{\tau} = \frac{d\vec{L}}{dt}, \qquad \vec{\tau} = I\vec{\alpha}$$

Conservation of L

$$\frac{d\vec{L}}{dt} = 0 \implies L = const.$$

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Equilibrium condition	$\sum F = 0, \quad \sum r = 0$
Kinetic Energy	$K_{rot} = \frac{1}{2} I\omega^2$
Gravitational force	$F = G\frac{m_1 m_2}{r^2}$
Potential energy	$U = \frac{GM_m}{r}$
Gravitational acceleration	$g = \frac{GM}{R^2}$
Variation of g with depth	$g_{inside} \approx g\ (1 - \frac{h}{R})$
Variation of g with height	$g_{outside} \approx g\ (1 - \frac{2h}{R})$
Hooke's law	$F = -kx$ (for small elongation x.)
Acceleration	$a = \frac{d^2y}{dt^2} = -\frac{k}{m}x = -\omega^2 x$
Time period	$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$
Displacement	$x = A \sin(\omega t + \emptyset)$
Velocity	$v = A\omega \cos(\omega t + \emptyset) = \pm\omega\sqrt{A^2} - x^2$
Potential energy	$U = \frac{1}{2}kx^2$
Kinetic energy	$K = \frac{1}{2}mv^2$
Total energy	$E = U + K = \frac{1}{2}m\omega^2 A^2$

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Simple pendulum

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

Physical Pendulum

$$T = 2\pi\sqrt{\frac{I}{mgl}}$$

Torsional Pendulum

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

Springs in series

$$\frac{1}{k_{eq}} = \frac{1}{k_1} + \frac{1}{k_2}$$

Spring in parallel

$$k_{eq} = k_1 + k_2$$

Modulus of rigidity

$$y = \frac{\frac{F}{A}}{\frac{\Delta l}{t}}, \quad B = -V\frac{\Delta P}{\Delta V}, \quad \eta = \frac{F}{A\theta}$$

Compressibility

$$K = \frac{1}{B} = -\frac{1}{V}\frac{dV}{dP}$$

Poisson's ratio

$$\sigma = \frac{lateral\ strain}{longitudinal\ strain} = \frac{\Delta D/D}{\Delta l/l}$$

Elastic energy

$$U = \frac{1}{2}\ stress \times strain \times volume$$

Surface tension

$$S = \frac{F}{l}$$

Surface energy

$$U = SA$$

Excess pressure in bubble

$$\Delta p_{air} = \frac{2S}{R}, \Delta p_{soap} = \frac{4S}{R}$$

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Capillary rise	$h = \frac{2S\cos\theta}{rpg}$
Hydrostatic pressure	$p = pgh$
Buoyant force	$F_B = pVg =$ Weight of displaced liquid
Equation of continuity	$A_1 v_1 = A_2 v_2$
Bernoulli's equation	$p + \frac{1}{2}pv^2 + pgh =$ constant
Torricelli's theorem	$v_{efflux} = \sqrt{2}gh$
Viscous force	$F = -\eta A \frac{dv}{dx}$
Stoke's law	$F = 6\pi\eta rv$
Poiseuilli's equation	$\frac{\text{Volume flow}}{\text{time}} = \frac{\pi pr^4}{8\eta l}$
Terminal Velocity	$v_t = \frac{2r^2(\rho - \sigma)g}{g\eta}$