Physics Formulas

This document was created by the *Guide to IJSO* team — a student-led initiative dedicated to supporting Junior Science Olympiad aspirants around the world. It contains a carefully curated and organized collection of essential formulas commonly used in Physics, covering key topics relevant to IJSO level preparation.

1. Mechanics

Kinematics

For all equations, the acceleration is constant.

$$s = v_0 t + \frac{1}{2} a t^2$$

$$v_f = v_0 + at$$

$$v_f^2 = v_0^2 + 2as$$

$$v_{avg} = \frac{v_f + v_0}{2}$$

Newton's laws of motion

F = force, a = acceleration, μ = friction coefficient

Newton's 2nd law : $F = ma$

Weight : $W = mg$

Static friction : $f_s \leq \mu_s N$

Kinetic friction : $f_k = \mu_k N$

Work, Energy, and Power

Work : $W = Fd\cos\theta$

Kinetic Energy : $KE = \frac{1}{2} m v^2$

Potential energy : $PE = mgh$

Conservation of energy : $initial\ energy = final\ energy$

Power : $P = \frac{W}{t}$

Power : $P = Fv$

Momentum and Collisions

MOMENTUM IS CONSERVED UNLESS AN EXTERNAL NET FORCE IS ACTING ON THE OBJECT!!!

Linear Momentum : $p = mv$

Impulse : $J = F\Delta t = \Delta p$

Rotational Motion

Angular displacement : $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

Angular velocity : $\omega = \omega_0 + \alpha t$

Rotational Kinetic Energy : $KE_{rot} = \frac{1}{2} I\omega^2$

Torque : $\tau = rF\,sin\theta$

Newton's 2nd law for rotation : $\tau = I\alpha$

Angular Momentum : $L = I\omega$

Torque : $\tau = \frac{dL}{dt}$

ANGULAR MOMENTUM IS CONSERVED UNLESS AN EXTERNAL NET FORCE IS ACTING ON THE OBJECT!!!

Circular Motion

Centripetal Force : $F_c = m\frac{v^2}{r}$

Centripetal Acceleration : $a_c = \frac{v^2}{r}$

Gravitation

Newton's law of Gravitation : $F = \frac{GMm}{r^2}$

Gravitational field : $g = \frac{GM}{r^2}$

Gravitational PE : $U = -\frac{GMm}{r}$

Orbital velocity : $V = \sqrt{\frac{GM}{r}}$

Escape Velocity : $V_e = \sqrt{\frac{2GM}{R}}$

where, R represents the radius of the celestial body.

Fluid Mechanics

Density : $\rho = \frac{M}{V}$

Pressure : $P = \frac{F}{A}$

Hydrostatic Pressure : $P = P_0 + \rho gh$ where, P_0 = atmospheric pressure.

Buoyant Force : $F_b = \rho V g$

Equation of Continuity : $A_1 V_1 = A_2 V_2$

Bernoulli's Equation : $P + \frac{1}{2}\rho v^2 + \rho gh = constant$

2. Waves and Oscillations

Hooke's Law : $F = -kx$

In simple harmonic motion (SMH):

- Displacement : x = $A\,cos\,(\omega t + \phi)$
- Velocity : v = $A\omega\,sin\,(\omega t + \phi)$
- Acceleration : v = $A\omega^2\,cos\,(\omega t + \phi)$
- Angular frequency : $\omega = \sqrt{\frac{k}{m}}$
- Period : $T = 2\pi\sqrt{\frac{m}{k}}$

Wave speed : $v = f\lambda$

Doppler Effect : $f' = \frac{v \pm v_o}{v \pm v_s}$

3. Optics

Snell's Law $: n_1 sin\theta_1 = n_2 sin\theta_2$

BE CAREFUL TO USE A PROPER SIGN CONVENTION!!

Mirror Equation $: \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

Lens Equation $: \frac{1}{f} = \frac{1}{d_i} - \frac{1}{d_o}$

Magnification $: M = |\frac{h_i}{h_o}| = |\frac{d_i}{d_o}|$

Lens Maker's Formula $: \frac{1}{f} = (\mu - 1)(\frac{1}{R_1} - \frac{1}{R_2})$

where μ is the refractive index of the material.

4. Thermodynamics

Thermal Expansion $: \Delta L = \alpha L_0 \Delta T$

Heat Transfer $: \Delta Q = mc\Delta T$

Change in State $: \Delta Q = mL$

First law of Thermodynamics $: \Delta U = \Delta Q - \Delta W$

Universal gas law $: \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

Ideal Gas law $: PV = nRT$

Work done by gas $: W = p\Delta V$

5. Electricity and Magnetism

Ohm's Law : $V = IR$

Resistance : $R = \rho \frac{L}{A}$

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

Capacitance : $C = \frac{Q}{V}$

Capacitance : $C = \frac{\epsilon_0 A}{d}$

Energy stored in a Capacitor : $U = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C}$

Magnetic Force for a Particle : $F = qvB\ sin\theta$

Magnetic Force in a Current : $F = BIL\ sin\theta$

6. Modern Physics

Energy of a Photon : $E = hf$

Photoelectric Effect : $E = hf - \phi$

De Broglie Wavelength : $\lambda = \frac{h}{p} = \frac{h}{mv}$

Mass-Energy equivalence : $E = mc^2$