Physics Fundamentals

FORMULA SHEET

The essential equations across mechanics, thermodynamics, waves, electromagnetism & modern physics

Classical Mechanics

Concept	Formula	Variables
Velocity / Acceleration	$v = \Delta x/\Delta t \quad a = \Delta v/\Delta t$	x position (m), v velocity (m/s), a acceleration (m/s^2), t time (s)
Kinematics (constant a)	$v = v_0 + at$	v_0 initial velocity; used when acceleration is constant
Displacement	$x = x_0 + v_0t + \frac{1}{2}at^2$	x_0 initial position (m)
Velocity–displacement	$v^2 = v_0^2 + 2a\Delta x$	no time needed
Newton's Second Law	$F = ma$	F force (N), m mass (kg)
Weight	$W = mg$	g = 9.81 m/s^2 near Earth's surface
Momentum / Impulse	$p = mv \quad J = F\Delta t = \Delta p$	p momentum (kg·m/s), J impulse (N·s)
Work	$W = Fd\cos\theta$	d distance (m), θ angle between F and motion
Kinetic Energy	$KE = \frac{1}{2}mv^2$	energy of motion (J)
Gravitational PE	$PE = mgh$	h height (m)
Power	$P = W/t = Fv$	P power (W)
Universal Gravitation	$F = Gm_1m_2/r^2$	G = 6.674×10^{-11} $N\cdot m^2/kg^2$, r separation (m)
Projectile Range	$R = v^2\sin(2\theta)/g$	level ground, launch angle θ
Centripetal Acceleration	$a_c = v^2/r$	circular motion of radius r
Hooke's Law	$F = -kx$	k spring constant (N/m), x displacement (m)

Thermodynamics

Concept	Formula	Variables
Specific Heat	$Q = mc\Delta T$	Q heat (J), c specific heat (J/kg·K), ΔT temp change (K)
Latent Heat	$Q = mL$	L latent heat of fusion/vaporization (J/kg)
Ideal Gas Law	$PV = nRT$	R = 8.314 J/(mol·K), n moles, T in K
First Law of Thermodynamics	$\Delta U = Q - W$	ΔU internal energy change; W work done by gas
Thermal Expansion	$\Delta L = \alpha L_0\Delta T$	α coefficient of linear expansion (1/K)
Carnot Efficiency	$\eta = 1 - T_c/T_h$	max efficiency; temps in K

Waves & Optics

Concept	Formula	Variables
Wave Speed	$v = f\lambda$	f frequency (Hz), λ wavelength (m)
Period & Frequency	$T = 1/f$	T period (s)
Pendulum Period	$T = 2\pi\sqrt{(L/g)}$	L length (m); small-angle swing
Mass–Spring Period	$T = 2\pi\sqrt{(m/k)}$	simple harmonic motion
Index of Refraction	$n = c/v$	c speed of light; v speed in medium
Snell's Law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$	refraction at a boundary
Doppler Effect	$f' = f(v \pm v_o)/(v \mp v_s)$	v_o observer, v_s source speed; signs toward = up

Electricity & Magnetism

Concept	Formula	Variables
Ohm's Law	$V = IR$	V voltage (V), I current (A), R resistance (Ω)
Electrical Power	$P = IV = I^2R = V^2/R$	P in watts (W)
Coulomb's Law	$F = kq_1q_2/r^2$	$k = 8.99\times10^9$ N·m^2/C^2, q charge (C)
Electric Field	$E = F/q = kQ/r^2$	E field strength (N/C)
Capacitance	$C = Q/V$	C capacitance (F)
Resistors in Series	$R = R_1 + R_2 + \ldots$	currents equal, voltages add
Resistors in Parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$	voltages equal, currents add
Magnetic Force	$F = qvB \sin\theta$	B field (T); on a moving charge

Modern Physics

Concept	Formula	Variables
Mass–Energy Equivalence	$E = mc^2$	$c = 3.00\times10^8$ m/s
Photon Energy	$E = hf$	$h = 6.626\times10^{-34}$ J·s
de Broglie Wavelength	$\lambda = h/p$	matter waves; p momentum
Time Dilation	$\Delta t = \Delta t_0/\sqrt{(1 - v^2/c^2)}$	Δt_0 proper time
Photoelectric Effect	$KE_{max} = hf - \varphi$	φ work function of the metal (J)