JEE Formula Sheet

Physics · Chemistry · Mathematics — the essential formulas for JEE Main & Advanced. Print it, pin it, revise it daily.

PHYSICS

Kinematics

Velocity	$v = u + at$
Displacement	$s = ut + \frac{1}{2}at^2$
v–s relation	$v^2 = u^2 + 2as$
nth second	$s_n = u + (a/2)(2n - 1)$
Projectile range	$R = u^2 \sin 2\theta / g$
Max height	$H = u^2 \sin^2\theta / 2g$
Time of flight	$T = 2u \sin\theta / g$

Laws of Motion

Force	$F = ma = dp/dt$
Momentum	$p = mv$
Friction (max)	$f = \mu N$
Centripetal acc.	$a_c = v^2/r = \omega^2 r$
Centripetal force	$F_c = mv^2/r$

Work, Energy & Power

Work	$W = F \cdot d = Fd\cos\theta$
Kinetic energy	$KE = \frac{1}{2}mv^2$
Grav. PE	$U = mgh$
Spring PE	$U = \frac{1}{2}kx^2$
Power	$P = W/t = F \cdot v$
Work–energy thm	$W_{net} = \Delta KE$

Rotational Motion

Angular vel.	$\omega = 2\pi/T = 2\pi f$
Torque	$\tau = r \times F = rF\sin\theta = I\alpha$
Ring	$I = MR^2$
Disc	$I = \frac{1}{2}MR^2$
Solid sphere	$I = (2/5)MR^2$
Rod (centre)	$I = ML^2/12$
Ang. momentum	$L = I\omega$
Rotational KE	$KE = \frac{1}{2}I\omega^2$

Gravitation

Newton's law	$F = Gm_1 m_2 / r^2$
Surface g	$g = GM/R^2$
Orbital velocity	$v = \sqrt{(GM/r)}$
Escape velocity	$v = \sqrt{(2GM/R)} = \sqrt{(2gR)}$
Kepler's 3rd	$T^2 \propto r^3$
Grav. PE	$U = -GMm/r$

Simple Harmonic Motion

Displacement	$x = A\sin(\omega t + \varphi)$
Spring period	$T = 2\pi\sqrt{(m/k)}$
Pendulum	$T = 2\pi\sqrt{(L/g)}$
Velocity	$v = \omega\sqrt{(A^2 - x^2)}$
Acceleration	$a = -\omega^2 x$
Total energy	$E = \frac{1}{2}m\omega^2 A^2$

Heat & Thermodynamics

Ideal gas	$PV = nRT$
First law	$\Delta U = Q - W$
Work (isobaric)	$W = P\Delta V$
Work (isotherm.)	$W = nRT \ln(V_2/V_1)$
Carnot efficiency	$\eta = 1 - T_2/T_1$
Mayer's relation	$C_p - C_v = R$
Heat ratio	$\gamma = C_p/C_v$
Adiabatic	$PV^\gamma = \text{constant}$

Waves & Sound

Wave speed	$v = f\lambda$
On a string	$v = \sqrt{(T/\mu)}$
Sound in gas	$v = \sqrt{(\gamma RT/M)}$
Doppler	$f' = f(v \pm v_o)/(v \mp v_s)$
Beats	$f_{beat} = \lvert f_1 - f_2 \rvert$

Electrostatics

Coulomb's law	$F = kq_1 q_2 / r^2$
Coulomb const.	$k \approx 9\times10^9\ N\cdot m^2/C^2$
Field	$E = F/q = kQ/r^2$
Potential	$V = kQ/r$
Capacitance	$C = Q/V = \varepsilon_0 A/d$
Energy stored	$U = \frac{1}{2}CV^2 = Q^2/2C$
Series	$1/C = 1/C_1 + 1/C_2$
Parallel	$C = C_1 + C_2$

Current Electricity

Ohm's law	$V = IR$
Resistance	$R = \rho L/A$
Power	$P = VI = I^2R = V^2/R$
Series	$R = R_1 + R_2$
Parallel	$1/R = 1/R_1 + 1/R_2$
Drift	$I = nAev_d$

Magnetism & EMI

Force on charge	$F = qvB\sin\theta$
Force on wire	$F = BIL\sin\theta$
Long wire	$B = \mu_0 I / 2\pi r$
Solenoid	$B = \mu_0 nI$
Faraday's law	$\varepsilon = -d\Phi/dt$
Inductor EMF	$\varepsilon = -L(dI/dt)$
Reactance	$X_L = \omega L,\ X_C = 1/\omega C$
Resonance	$\omega = 1/\sqrt{(LC)}$
RMS voltage	$V_{rms} = V_0/\sqrt{2}$

Optics

Mirror	$1/v + 1/u = 1/f$
Lens	$1/v - 1/u = 1/f$
Lensmaker	$1/f = (n-1)(1/R_1 - 1/R_2)$
Power	$P = 1/f$ (dioptre)
Snell's law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
Critical angle	$\sin\theta_c = 1/n$
YDSE fringe	$\beta = \lambda D/d$

Modern Physics

Photon energy	$E = hf = hc/\lambda$
Photoelectric	$KE_max = hf - \varphi$
de Broglie	$\lambda = h/p = h/mv$
Bohr energy	$E_n = -13.6/n^2$ eV
Bohr radius	$r_n = 0.529\ n^2$ Å
Mass–energy	$E = mc^2$
Radioactivity	$N = N_0\ e^{-\lambda t}$
Half-life	$t_{½} = 0.693/\lambda$

PHYSICAL CHEMISTRY

Mole Concept

Moles	$n = \text{mass}/M = N/N_A$
Avogadro	$N_A = 6.022\times10^{23}$
Molarity	$M = \text{mol solute / L soln}$
Molality	$m = \text{mol solute / kg solvent}$
Mole fraction	$x = n_i / n_{total}$

Gaseous State

Ideal gas	$PV = nRT$
Gas constant	$R = 0.0821\ L\cdot atm/mol\cdot K$
Van der Waals	$(P + an^2/V^2)(V - nb) = nRT$
Dalton's law	$P_total = \Sigma P_i$
Graham's law	$\text{rate} \propto 1/\sqrt{M}$
RMS speed	$v_{rms} = \sqrt{(3RT/M)}$

Thermodynamics

First law	$\Delta U = q + w$
Enthalpy	$\Delta H = \Delta U + \Delta n_g\ RT$
Gibbs energy	$\Delta G = \Delta H - T\Delta S$
Equilibrium	$\Delta G^\circ = -RT \ln K$
Entropy	$\Delta S = q_rev / T$
Spontaneity	$\Delta G < 0$

Chemical & Ionic Equilibrium

Equil. constant	K_c = [products]/[reactants]
Kp – Kc	$K_p = K_c (RT)^{\Delta n}$
pH	$pH = -\log[H^+]$
pH + pOH	pH + pOH = 14
Henderson	$pH = pK_a + \log([salt]/[acid])$
Ka·Kb	$K_a \times K_b = K_w = 10^{-14}$

Electrochemistry

Cell EMF	$E_{cell} = E_{cath} - E_{anode}$
Nernst (298K)	$E = E° - (0.059/n) \log Q$
Gibbs-EMF	$\Delta G = -nFE$
Faraday's law	m = (M/nF)·It
Faraday const.	F = 96500 C/mol

Chemical Kinetics

Rate law	Rate = $k[A]^m[B]^n$
First order	$k = (2.303/t) \log([A_0]/[A])$
1st-order t½	$t_{½} = 0.693/k$
Zero order	$[A] = [A_0] - kt$
Zero-order t½	$t_{½} = [A_0]/2k$
Arrhenius	$k = A\, e^{-E_a/RT}$

MATHEMATICS

Algebra & Progressions

Quadratic roots	$x = (-b \pm \sqrt{(b^2 - 4ac)}) / 2a$
Sum of roots	$\alpha + \beta = -b/a$
Product of roots	$\alpha\beta = c/a$
AP nth term	$a_n = a + (n-1)d$
AP sum	$S_n = (n/2)(2a + (n-1)d)$
GP nth term	$a_n = ar^{n-1}$
GP sum	$S_n = a(r^n - 1)/(r - 1)$
GP infinite	$S_\infty = a/(1 - r)$, $\lvert r\rvert<1$
Binomial term	$T_{r+1} = C(n,r)\, a^{n-r}\, b^r$

Trigonometry

Identity	$\sin^2\theta + \cos^2\theta = 1$
Identity	$1 + \tan^2\theta = \sec^2\theta$
Sum	$\sin(A\pm B) = \sin A \cos B \pm \cos A \sin B$
Sum	$\cos(A\pm B) = \cos A \cos B \mp \sin A \sin B$
Double angle	$\sin 2\theta = 2 \sin\theta \cos\theta$
Double angle	$\cos 2\theta = 1 - 2\sin^2\theta$
Sine rule	$a/\sin A = b/\sin B = 2R$
Cosine rule	$c^2 = a^2 + b^2 - 2ab \cos C$

Differentiation

Power	$d/dx(x^n) = nx^{n-1}$
Sine / Cosine	$(\sin x)' = \cos x$, $(\cos x)' = -\sin x$
Tangent	$(\tan x)' = \sec^2 x$
Exp / Log	$(e^x)' = e^x$, $(\ln x)' = 1/x$
Product rule	$(uv)' = u'v + uv'$
Quotient rule	$(u/v)' = (u'v - uv')/v^2$
Chain rule	$dy/dx = (dy/du)(du/dx)$

Integration

Power	$\int x^n\,dx = x^{n+1}/(n+1) + C$
Reciprocal	$\int (1/x)\,dx = \ln\lvert x\rvert + C$
Exponential	$\int e^x\,dx = e^x + C$
Sine / Cosine	$\int \sin x\,dx = -\cos x$, $\int \cos x\,dx = \sin x$
Secant²	$\int \sec^2 x\,dx = \tan x + C$

Coordinate Geometry

Distance	$d = \sqrt{((x_2-x_1)^2 + (y_2-y_1)^2)}$
Slope	$m = (y_2-y_1)/(x_2-x_1)$
Point-slope	$y - y_1 = m(x - x_1)$
Point-line dist.	$\lvert ax_0+by_0+c\rvert \,/\, \sqrt{(a^2+b^2)}$
Circle	$(x-h)^2 + (y-k)^2 = r^2$
Parabola	$y^2 = 4ax$
Ellipse	$x^2/a^2 + y^2/b^2 = 1$
Ellipse ecc.	$e = \sqrt{(1 - b^2/a^2)}$
Hyperbola ecc.	$e = \sqrt{(1 + b^2/a^2)}$

Vectors

Magnitude	$\lvert a\rvert = \sqrt{(a_1{}^2 + a_2{}^2 + a_3{}^2)}$
Dot product	$a\cdot b = \lvert a\rvert\lvert b\rvert \cos\theta$
Cross product	$\lvert a\times b\rvert = \lvert a\rvert\lvert b\rvert \sin\theta$
Projection	$(a\cdot b)/\lvert b\rvert$