Class 11 Physics Formula Sheet

1 Units and Measurement

SI base units: metre, kilogram, second, ampere, kelvin, mole, candela

Dimensions	$F : [\mathrm{MLT^{-2}}],\ E : [\mathrm{ML^2T^{-2}}],\ P : [\mathrm{ML^2T^{-3}}]$
Sig. figs (×, ÷)	Result keeps the fewest significant figures
Sig. figs (+, −)	Result keeps the fewest decimal places
Dim. analysis	Every term has the same dimensions

2 Motion in a Straight Line

Equations of motion (constant a)	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Velocity, acceleration	$v = \dfrac{dx}{dt},\quad a = \dfrac{dv}{dt}$
Relative velocity	$v_{AB} = v_A - v_B$
Free fall	$a = g \approx 9.8\ \mathrm{m\,s^{-2}}$ (downward)

3 Motion in a Plane

Resultant of $\vec{A}$, $\vec{B}$	$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$ $\tan\alpha = \dfrac{B\sin\theta}{A + B\cos\theta}$ (α: angle with $\vec{A}$)
Projectile: time of flight	$T = \dfrac{2u\sin\theta}{g}$
Maximum height	$H = \dfrac{u^2\sin^2\theta}{2g}$
Horizontal range	$R = \dfrac{u^2\sin 2\theta}{g},\ R_{\max} = \dfrac{u^2}{g}$ at $\theta = 45^\circ$
Trajectory	$y = x\tan\theta - \dfrac{gx^2}{2u^2\cos^2\theta}$
Uniform circular motion	$v = \omega r,\ a_c = \dfrac{v^2}{r} = \omega^2 r,\ \omega = \dfrac{2\pi}{T} = 2\pi\nu$

4 Laws of Motion

Second law	$F = \dfrac{dp}{dt} = ma,\ p = mv$
Impulse	$J = F\,\Delta t = \Delta p$
Momentum conservation	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
Friction	$f_s \le \mu_s N,\ f_k = \mu_k N$
Circular motion, level road	$v_{\max} = \sqrt{\mu_s Rg}$
Banked road	$v_o = \sqrt{Rg\tan\theta}$ (no friction) $v_{\max} = \sqrt{Rg\,\dfrac{\mu_s + \tan\theta}{1 - \mu_s\tan\theta}}$

5 Work, Energy and Power

Work	$W = \vec{F}\cdot\vec{d} = Fd\cos\theta$
Kinetic energy	$K = \frac{1}{2}mv^2 = \dfrac{p^2}{2m}$
Work–energy theorem	$W_{\text{net}} = K_f - K_i$
Potential energy	$U = mgh$; spring: $U = \frac{1}{2}kx^2,\ F = -kx$
Power	$P = \dfrac{dW}{dt} = \vec{F}\cdot\vec{v};\ 1\ \mathrm{hp} = 746\ \mathrm{W}$
Elastic collision (m_2 at rest)	$v_1 = \dfrac{(m_1 - m_2)\,u_1}{m_1 + m_2},\ v_2 = \dfrac{2m_1u_1}{m_1 + m_2}$

6 System of Particles and Rotational Motion

Centre of mass	$X = \dfrac{\sum m_i x_i}{M}$
Torque	$\vec{\tau} = \vec{r}\times\vec{F},\ \tau = rF\sin\theta$
Angular momentum	$\vec{L} = \vec{r}\times\vec{p},\ \vec{\tau} = \dfrac{d\vec{L}}{dt}$
Rigid body	$L = I\omega,\ \tau = I\alpha,\ K = \frac{1}{2}I\omega^2,\ P = \tau\omega$
Rotational kinematics	$\omega = \omega_0 + \alpha t,\ \omega^2 = \omega_0^2 + 2\alpha\theta$ $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$
Conservation of L	$I_1\omega_1 = I_2\omega_2$ (no external torque)
Moment of inertia (central axis; ⊥ to ring, disc, rod)	Ring MR^2 · disc $\frac{1}{2}MR^2$ · thin rod $\frac{1}{12}ML^2$ Solid sphere $\frac{2}{5}MR^2$ · hollow sphere $\frac{2}{3}MR^2$

7 Gravitation

Newton's law	$F = \dfrac{Gm_1m_2}{r^2}$
Surface gravity	$g = \dfrac{GM_E}{R_E^2}$
Height h ($h \ll R_E$) / depth d	$g(h) = g\left(1 - \dfrac{2h}{R_E}\right),\ g(d) = g\left(1 - \dfrac{d}{R_E}\right)$
Potential energy	$U = -\dfrac{GMm}{r}$
Escape speed	$v_e = \sqrt{\dfrac{2GM_E}{R_E}} = \sqrt{2gR_E} \approx 11.2\ \mathrm{km\,s^{-1}}$
Satellite, orbit radius r	$v_o = \sqrt{\dfrac{GM_E}{r}},\ T = 2\pi\sqrt{\dfrac{r^3}{GM_E}}$ Total energy $E = -\dfrac{GM_Em}{2r}$
Kepler's third law	$T^2 \propto a^3$

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8 Mechanical Properties of Solids

Stress, strain	$\text{stress} = \dfrac{F}{A},\ \text{strain} = \dfrac{\Delta L}{L}$
Young's modulus	$Y = \dfrac{F/A}{\Delta L/L} = \dfrac{FL}{A\,\Delta L}$
Bulk modulus	$B = -\dfrac{p}{\Delta V/V},\ \text{compressibility } k = \dfrac{1}{B}$
Shear modulus	$G = \dfrac{F/A}{\Delta x/L} = \dfrac{F}{A\theta}$
Poisson's ratio	$\sigma = \dfrac{\text{lateral strain}}{\text{longitudinal strain}}$

9 Mechanical Properties of Fluids

Pressure at depth	$P = P_a + \rho g h$
Continuity	$A_1 v_1 = A_2 v_2$
Bernoulli	$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$
Speed of efflux	$v = \sqrt{2gh}$ (Torricelli)
Viscosity, Stokes' law	$F = \eta A \dfrac{dv}{dx},\ F = 6\pi\eta a v$
Terminal velocity	$v_t = \dfrac{2a^2(\rho - \sigma)g}{9\eta}$
Excess pressure	Drop $\dfrac{2S}{r}$, soap bubble $\dfrac{4S}{r}$
Capillary rise	$h = \dfrac{2S\cos\theta}{\rho g a}$

10 Thermal Properties of Matter

Temperature scales	$t_F = \frac{9}{5}t_C + 32,\ T = t_C + 273.15$
Thermal expansion	$\dfrac{\Delta l}{l} = \alpha_l \Delta T,\ \dfrac{\Delta V}{V} = \alpha_V \Delta T,\ \alpha_V = 3\alpha_l$
Heat	$Q = mc\,\Delta T$; latent heat $Q = mL$
Conduction	$H = KA\dfrac{T_C - T_D}{L}$
Radiation	$H = e\sigma A T^4$; Wien: $\lambda_m T = b$
Newton's law of cooling	$\dfrac{dT}{dt} = -k\,(T - T_s)$

CONSTANTS

$G = 6.67 \times 10^{-11}\ \text{N m}^2\text{ kg}^{-2}$	$R = 8.314\ \text{J mol}^{-1}\text{ K}^{-1}$
$k_B = 1.38 \times 10^{-23}\ \text{J K}^{-1}$	$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$
$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\text{ K}^{-4}$	$b = 2.9 \times 10^{-3}\ \text{m K}$ (Wien)
$g = 9.8\ \text{m s}^{-2}$	$R_E = 6.37 \times 10^{6}\ \text{m}$

11 Thermodynamics

First law	$\Delta Q = \Delta U + \Delta W,\ \Delta W = P\,\Delta V$
Isothermal work	$W = nRT\ln\dfrac{V_2}{V_1}$
Adiabatic	$PV^\gamma = \text{constant},\ W = \dfrac{nR(T_1 - T_2)}{\gamma - 1}$
Specific heats	$C_p - C_v = R,\ \gamma = \dfrac{C_p}{C_v}$
Heat engine	$\eta = \dfrac{W}{Q_1} = 1 - \dfrac{Q_2}{Q_1}$; Carnot: $\eta = 1 - \dfrac{T_2}{T_1}$
Refrigerator	$\alpha = \dfrac{Q_2}{W}$

12 Kinetic Theory

Ideal gas	$PV = nRT = Nk_BT$
Pressure	$P = \frac{1}{3}n\,m\,\overline{v^2}$ (n = molecules per volume)
Energy, rms speed	$\overline{KE} = \frac{3}{2}k_BT,\ v_{\text{rms}} = \sqrt{\dfrac{3k_BT}{m}} = \sqrt{\dfrac{3RT}{M}}$
Equipartition	$\frac{1}{2}k_BT$ per degree of freedom
Monatomic / diatomic	$C_v = \frac{3}{2}R,\ \gamma = \frac{5}{3}$ / $C_v = \frac{5}{2}R,\ \gamma = \frac{7}{5}$ (rigid)
Mean free path	$l = \dfrac{1}{\sqrt{2}\,n\pi d^2}$

13 Oscillations

SHM	$x = A\cos(\omega t + \phi),\ a = -\omega^2 x$
Speed at x	$v = \omega\sqrt{A^2 - x^2},\ v_{\max} = \omega A$
Time period	Spring $T = 2\pi\sqrt{\dfrac{m}{k}}$, pendulum $T = 2\pi\sqrt{\dfrac{L}{g}}$
Energy	$E = \frac{1}{2}kA^2 = \frac{1}{2}m\omega^2A^2$

14 Waves

Wave equation	$y = a\sin(kx - \omega t + \phi)$ $k = \dfrac{2\pi}{\lambda},\ \omega = 2\pi\nu,\ v = \nu\lambda = \dfrac{\omega}{k}$
Speed of waves	String $v = \sqrt{\dfrac{T}{\mu}}$; sound (Laplace) $v = \sqrt{\dfrac{\gamma P}{\rho}}$
String, both ends fixed	$\nu_n = \dfrac{nv}{2L},\ n = 1, 2, 3, \ldots$
Pipe closed at one end	$\nu = \dfrac{(2n-1)v}{4L},\ n = 1, 2, \ldots$ (odd harmonics)
Pipe open at both ends	$\nu_n = \dfrac{nv}{2L}$
Beats	$\nu_{\text{beat}} = \nu_1 - \nu_2$

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