NJIT Physics 102 Formula Sheet

Chapter 1: Mathematics Formulas, Unit Conversions

Quadratic formula: $ax^2 + bx + c = 0$, $x = \left(-b \pm \sqrt{b^2 - 4ac}\right)/(2a)$

Unit conversions: 1 mile = 5,280 ft = 1.609 km

1 inch = 2.54 cm

1 kg = 2.2 lbs

Chapter 2: One-Dimensional Motion

Displacement: $\Delta x = x_f - x_0$

Constant velocity: $x_f = x_0 + vt$ or $\Delta x = vt$

Constant acceleration: $v_f = v_0 + at$

$\Delta x = v_0 t + \frac{1}{2}at^2$

$v_f^2 = v_0^2 + 2a\Delta x$

$v_f + v_0 = 2\Delta x/t$

$\Delta x = v_f t - \frac{1}{2}at^2$

Average velocity: $v_{\text{avg}} = (x_f - x_0)/(t_f - t_0)$

Average speed: speed = (total distance)/(elapsed time)

Average acceleration: $a_{\text{avg}} = (v_f - v_0)/(t_f - t_0)$

Acceleration due to gravity: $g = 9.8\ \text{m/s}^2$

Chapter 3: Vectors and Two-Dimensional Motion

Vector magnitude: $|\vec{A}| = \sqrt{A_x^2 + A_y^2}$ or $\sqrt{A_x^2 + A_y^2 + A_z^2}$

Vector direction: $\theta = \tan^{-1}\frac{A_y}{A_x}$, add 180° if necessary

Vector components: $A_x = |\vec{A}|\cos\theta$

$A_y = |\vec{A}|\sin\theta$

Projectile motion, horizontal: $\Delta x = v_{0,x}t$

Projectile motion, vertical: $v_{f,y} = v_{0,y} + at$

$\Delta y = v_{0,y}t + \frac{1}{2}at^2$

$v_{f,y}^2 = v_{0,y}^2 + 2a\Delta y$

$\Delta y = v_{f,y}t - \frac{1}{2}at^2$

Projectile range: $R = v^2\sin(2\theta)/g$

Chapter 4: Forces

First Law: $\vec{F}_{\text{net}} = 0 \longleftrightarrow$ constant velocity

Second Law: $\vec{F}_{\text{net}} = m\vec{a}$

Third Law: $\vec{F}_{12} = -\vec{F}_{21}$

Kinetic and static friction: $f_k = \mu_k F_N$ and $f_s \le \mu_s F_N$

Normal force: $F_N = mg$ on horizontal surface,

$F_N = mg\cos\theta$ on incline

(in the absence of other forces)

Chapter 5: Circular Motion

speed: $v = 2\pi r/T$

RPM: $v = \text{RPM's} \times 2\pi r/60$

Radial acceleration: $a_{\text{rad}} = v^2/r$ or $4\pi^2 r/T^2$

Nonuniform motion: $|a_{\text{tot}}| = \sqrt{a_{\text{rad}}^2 + a_{\text{tan}}^2}$

Chapter 6: Work and Energy

Work done by a constant force: $W = Fd\cos\theta$

Kinetic energy: $K = \frac{1}{2}mv^2$

Work-energy theorem: $W_{\text{tot}} = K_2 - K_1 = \Delta K$

Power: $P = \Delta W/\Delta t$

$P = F\,v$

Hooke's Law: $F = -k(x_f - x_0)$

Work done by a spring: $W = \frac{1}{2}k(x_f^2 - x_0^2)$

Work done by gravity: $W = -mg\Delta y$

Gravitational potential energy: $U_g = mgh$

Elastic potential energy: $U_E = \frac{1}{2}kx^2$

Conservation: $(K + U_g + U_E)_0 + W_{\text{NC}} = (K + U_g + U_E)_f$

Chapter 7: Momentum, Impulse, and Collisions

Momentum: $\vec{p} = m\vec{v}$

Force and momentum: $\vec{F} = (\vec{p}_f - \vec{p}_0)/\Delta t$ or $\Delta\vec{p}/\Delta t$

Impulse: $\vec{J} = \vec{p}_f - \vec{p}_0 = m(\vec{v}_f - \vec{v}_0) = \vec{F}\Delta t$

Conservation: $m_A\vec{v}_A + m_B\vec{v}_B + \ldots = m_A\vec{v}_A{}' + m_B\vec{v}_B{}' + \ldots$

($\vec{v}_A{}'$, $\vec{v}_B{}'$ are post-collision final velocities)

Completely inelastic collision: $m_A\vec{v}_A + m_B\vec{v}_B = (m_A + m_B)\vec{v}_f$

1-D Elastic collision: $v_A + v_A' = v_B + v_B'$

Center of mass: $x_{\text{CM}} = (m_1x_1 + m_2x_2 + \ldots)/(m_1 + m_2 + \ldots)$

Chapter 8: Rotational Motion, Part 1

Angular displacement: $\Delta\theta = \theta_f - \theta_0$

Constant velocity: $\theta_f = \theta_0 + \omega t$ or $\Delta\theta = \omega t$

Kinematics: $\omega_f = \omega_0 + \alpha t$

$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$\omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta$

$\omega_f + \omega_0 = 2\Delta\theta/t$

Velocity: $\omega_{\text{avg}} = (\theta_f - \theta_0)/(t_f - t_0)$

Acceleration: $\alpha_{\text{avg}} = (\omega_f - \omega_0)/(t_f - t_0)$

Angular $\rightarrow$ tangential: $\Delta s = r\Delta\theta$, $v = r\omega$, $a = r\alpha$

No-slip condition: $v_{\text{cm}} = R\omega$

Chapter 8: Rotational Motion, Part 2

Rotational KE:	$K_{\rm rot} = \frac{1}{2} I\omega^2$
CM Moment of Inertia:	Point mass, mr^2. Disk, $\frac{1}{2}mR^2$. Ring, mR^2. Spherical shell, $\frac{2}{3}mR^2$. Sphere, $\frac{2}{5}mR^2$. Rod (about center), $\frac{1}{12}mL^2$
Parallel axis theorem:	$I = I_{\rm CM} + md^2$
Torque (magnitude):	$\tau = rF\sin\theta$
Newton's 2nd Law:	$\tau_{\rm net} = I\alpha$
Translational/rotational energy:	$K = \frac{1}{2}mv_{\rm cm}^2 + \frac{1}{2}I_{\rm cm}\omega^2$
Work done by constant torque:	$W = \tau\Delta\theta$
Work-energy theorem:	$W_{\rm tot} = \frac{1}{2}I\omega_f^2 - \frac{1}{2}I\omega_0^2$
Angular momentum:	$\vec{L} = I\vec{\omega}$ (rigid body rotating about axis)
Conservation of angular momentum:	$I_A\omega_A + I_B\omega_B = I'_A\omega'_A + I'_B\omega'_B$ (primes indicate 'final')

Chapter 9: Static Equilibrium

Static equilibrium conditions:	$\vec{F}_{\rm net} = 0$ $\tau_{\rm net} = 0$ about any point

Chapter 5: Gravitation

Gravitational constant:	$G = 6.67 \times 10^{-11}$ N·m^2/kg^2
Mass of the Earth:	$M_E = 5.97 \times 10^{24}$ kg
Radius of the Earth:	$R_E = 6.38 \times 10^6$ m
Force of gravity:	$F_G = GMm/r^2$
Local acceleration due to gravity:	$g = GM_E/R_E^2$
Orbits:	$v = 2\pi r/T$ $v^2 = GM/r$ $T^2 = 4\pi^2 r^3/(GM)$

Updated 2025-02-18 23:21:55