Chapter 9 Equations

Static Equilibrium:

$\Sigma F_x = \Sigma F_y = \Sigma F_z = 0, \qquad \Sigma\tau = 0, \qquad \tau = rF sin\theta.$

Chapter 8 Equations

Rotational coordinates:

$1 \text{ rev} = 2\pi \text{ radians} = 360°, \qquad \omega = 2\pi f, \quad f = \frac{1}{T}, \qquad \bar{\omega} = \frac{\Delta\theta}{\Delta t}, \qquad \bar{\alpha} = \frac{\Delta\omega}{\Delta t}, \qquad \Delta\theta = \bar{\omega}\Delta t.$

Linear coordinates vs. rotation coordinates and radius:

$l = \theta r, \qquad v = \omega r, \qquad a_{\tan} = \alpha r, \qquad a_R = \omega^2 r,$ (must use radians in these).

Constant angular acceleration:

$\omega = \omega_0 + \alpha t, \qquad \theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2, \qquad \bar{\omega} + \frac{1}{2}(\omega_0 + \omega), \qquad \omega^2 = \omega_0^2 + 2\alpha\Delta\theta.$

Torque & Dynamics:

$\tau = rF\sin\theta, \qquad I = \Sigma mr^2, \qquad \tau_{\text{net}} = I\alpha, \qquad L = I\omega, \qquad \Delta L = \tau_{\text{net}}\Delta t, \qquad \text{KE}_{\text{rotation}} = \frac{1}{2}I\omega^2.$

Rotational Inertias about centers:

$I = MR^2,$	$I = \frac{1}{2}MR^2,$	$I = \frac{2}{5}MR^2,$	$I = \frac{1}{12}ML^2.$
hoop	solid cylinder	sphere	thin rod

Chapter 7 Equations

Momentum & Impulse:

momentum $\vec{p} = m\vec{v}, \qquad$ impulse $\Delta\vec{p} = \vec{F}_{\text{ave}}\,\Delta t.$

Conservation of Momentum:

(2-body collision): $m_A\vec{v}_A + m_B\vec{v}_B = m_A\vec{v'}_A + m_B\vec{v'}_B.$

1D elastic collision–conservation of energy:

$\frac{1}{2}m_A v_A^2 + \frac{1}{2}m_B v_B^2 = \frac{1}{2}m_A v_A'^2 + \frac{1}{2}m_B v_B'^2,$ or $v_A - v_B = -(v_A' - v_B').$

Center of Mass:

$x_{\text{cm}} = \frac{m_1x_1 + m_2x_2 + \ldots}{m_1 + m_2 + \ldots}, \qquad v_{\text{cm}} = \frac{m_1v_1 + m_2v_2 + \ldots}{m_1 + m_2 + \ldots}.$

Chapter 6 Equations

Work & Kinetic & Potential Energies:

$W = Fd\cos\theta, \qquad \text{KE} = \frac{1}{2}mv^2, \qquad \text{PE}_{\text{gravity}} = mgy, \quad F_{\text{gravity}} = -mg. \qquad \text{PE}_{\text{spring}} = \frac{1}{2}kx^2, \quad F_{\text{spring}} = -kx.$

Conservation or Transformation of Energy:

"work-KE theorem" $\Delta\text{KE} = W_{\text{net}},$ **or use conservation law**: $\Delta\text{KE} + \Delta\text{PE} = W_{\text{NC}}. \qquad E_2 = E_1 + W_{\text{NC}}.$

Power:

$P_{\text{ave}} = \frac{W}{t},$ or use $P_{\text{ave}} = \frac{\text{energy}}{\text{time}}.$

(over)

Chapter 5 Equations

Centripetal Acceleration:

$a_R = \frac{v^2}{r}$, towards the center of the circle.

Circular motion:

speed $v = \frac{2\pi r}{T} = 2\pi r f$, frequency $f = \frac{1}{T}$, where T is the period of one revolution.

Gravitation:

$F = G\frac{m_1 m_2}{r^2}$; $\quad g = \frac{GM}{r^2}$, $\quad$ where $G = 6.67 \times 10^{-11}$ Nm^2/kg^2;

Orbits:

$\frac{v^2}{r} = g = \frac{GM}{r^2}$; $\quad v = \sqrt{\frac{GM}{r}}$.

Chapter 4 Equations

Newton's Second Law:

$\vec{F}_{\text{net}} = m\vec{a}$, which means $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$.

Static friction (magnitude):

$f_s \leq \mu_s N$ or $F_{\text{fr}} \leq \mu_s F_N$.

Kinetic or sliding friction (magnitude):

$f_k = \mu_k N$ or $F_{\text{fr}} = \mu_k F_N$.

Gravitational force near Earth:

$F_G = mg$, downward.

Acceleration Equations

$\bar{v} = \frac{\Delta x}{\Delta t}$, $\quad \Delta x = x - x_0$, $\quad$ slope of $x(t) = v(t)$.

$\bar{a} = \frac{\Delta v}{\Delta t}$, $\quad \Delta v = v - v_0$, $\quad$ slope of $v(t) = a(t)$.

For constant acceleration in one-dimension:

$\bar{v} = \frac{1}{2}(v_0 + v)$, $\quad v = v_0 + at$, $\quad x = x_0 + v_0 t + \frac{1}{2}at^2$, $\quad v^2 = v_0^2 + 2a(x - x_0)$.

Vectors

Written $\vec{V}$ or $\mathbf{V}$, described by magnitude=V, direction=θ or by components (V_x, V_y).

$V_x = V\cos\theta$, $\quad V_y = V\sin\theta$,

$V = \sqrt{V_x^2 + V_y^2}$, $\quad \tan\theta = \frac{V_y}{V_x}$. $\quad$ θ is the angle from $\vec{V}$ to $+x$-axis.

Addition: $\mathbf{A} + \mathbf{B}$, head to tail. $\quad$ Subtraction: $\mathbf{A} - \mathbf{B}$ is $\mathbf{A} + (-\mathbf{B})$, $\quad -\mathbf{B}$ is $\mathbf{B}$ reversed.

Trig summary

$\sin\theta = \frac{\text{(opp)}}{\text{(hyp)}}$, $\quad \cos\theta = \frac{\text{(adj)}}{\text{(hyp)}}$, $\quad \tan\theta = \frac{\text{(opp)}}{\text{(adj)}}$, $\quad \text{(opp)}^2 + \text{(adj)}^2 = \text{(hyp)}^2$.

$\sin\theta = \sin(180° - \theta)$, $\quad \cos\theta = \cos(-\theta)$, $\quad \tan\theta = \tan(180° + \theta)$, $\quad \sin^2\theta + \cos^2\theta = 1$.