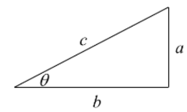
Physical constants: $g = 9.81\ \frac{\text{m}}{\text{s}^2}$ $G = 6.67 \times 10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}$

Trigonometry: $\cos\theta = \frac{\text{adj}}{\text{hyp}} = \frac{b}{c}$; $\sin\theta = \frac{\text{opp}}{\text{hyp}} = \frac{a}{c}$; $\tan\theta = \frac{\text{opp}}{\text{adj}} = \frac{a}{b}$



Pythagorean theorem: $a^2 + b^2 = c^2$ sum of angles in a triangle = 180°

Quadratic equation: $ax^2 + bx + c = 0$ Solution: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Circle: circumference $C = 2\pi r$; area: $A = \pi r^2$

Area of a triangle: $A = \frac{1}{2} b \cdot h$

Volume: sphere: $V = \frac{4}{3}\pi \cdot r^3$; cylinder: $V = \pi \cdot r^2 \cdot h$; rectangular box: $V = l \cdot w \cdot h$

Uncertainty in a measured quantity f, which has an average value $f_{av} = \frac{1}{N}\sum_{i=1}^{N} f_i$:

Average deviation: $\delta f = \frac{\sum_{i=1}^{N} |f_i - f_{\text{av}}|}{N} = \frac{|f_1 - f_{\text{av}}| + |f_2 - f_{\text{av}}| + |f_3 - f_{\text{av}}| + \cdots + |f_N - f_{\text{av}}|}{N}$

Propagation of uncertainty in a calculated quantity f: $\delta f = f_{\text{max}} - f_{\text{best}}$

Displacement: $\Delta x = x_f - x_i$ $\Delta\theta = \theta_f - \theta_i$ $\Delta\vec{r} = \vec{r}_f - \vec{r}_i$

Velocity: $v_{av,x} = \frac{\Delta x}{\Delta t}$ $\omega_{av} = \frac{\Delta\theta}{\Delta t}$ $\vec{v} = \frac{\Delta\vec{r}}{\Delta t}$

Acceleration: $a_{av,x} = \frac{\Delta v_x}{\Delta t}$ $\alpha_{av} = \frac{\Delta\omega}{\Delta t}$ $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$

If acceleration is constant then:

$$x_f = x_i + v_{ix}(t_f - t_i) + \frac{1}{2}a_x(t_f - t_i)^2$$
$$v_{fx} = v_{ix} + a_x(t_f - t_i)$$
$$v_{fx}^2 = v_{ix}^2 + 2a_x(x_f - x_i)$$
$$v_{av,x} = \frac{1}{2}(v_{fx} + v_{ix}) = \frac{\Delta x}{\Delta t}$$

$$y_f = y_i + v_{iy}(t_f - t_i) + \frac{1}{2}a_y(t_f - t_i)^2$$
$$v_{fy} = v_{iy} + a_y(t_f - t_i)$$
$$v_{fy}^2 = v_{iy}^2 + 2a_y(y_f - y_i)$$
$$v_{av,y} = \frac{1}{2}(v_{fy} + v_{iy}) = \frac{\Delta y}{\Delta t}$$

$$\theta_f = \theta_i + \omega_i(t_f - t_i) + \frac{1}{2}\alpha(t_f - t_i)^2$$
$$\omega_f = \omega_i + \alpha(t_f - t_i)$$
$$\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$$
$$\omega_{av} = \frac{1}{2}(\omega_f + \omega_i) = \frac{\Delta\theta}{\Delta t}$$

Arc length: $s = r\theta$

Radial (centripetal) acceleration: $a_{cp} = \frac{v^2}{r} = r\omega^2$

Tangential velocity: $v_t = r\omega = \frac{2\pi r}{T}$ tangential acceleration: $a_t = \frac{\Delta v_t}{\Delta t} = r\frac{\Delta\omega}{\Delta t} = r\alpha$

Torque: $\tau = \pm r \cdot F_\perp$ $F_\perp$ is the component of $\vec{F}$ perpendicular to $\vec{r}$.

$\tau = \pm rF\ \sin\theta$

Newton's Second Law:

$m\vec{a} = \vec{F}_{net}$ $I\vec{\alpha} = \vec{\tau}_{net}$

$m\vec{a} = \sum\vec{F}$ $I\vec{\alpha} = \sum\vec{\tau}$

Translational Equilibrium: $0 = \vec{F}_{net} = \sum\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots$

Rotational Equilibrium: $0 = \vec{\tau}_{net} = \sum\vec{\tau} = \vec{\tau}_1 + \vec{\tau}_2 + \vec{\tau}_3 + \cdots$

Moment of Inertia: $I = \sum_{i=1}^{N} m_i r_i^2$ (only for N **point** masses)

Weight: $W = mg$

Friction: $0 \le f_s \le f_{s,max}$ $f_{s,max} = \mu_s N$

$f_k = \mu_k N$

Spring: $F_{sp} = -kx$

Universal Gravitation: $F = G\frac{m_1 m_2}{r^2}$

Center of mass: $X_{cm} = \dfrac{m_1x_1 + m_2x_2 + \cdots + m_Nx_N}{m_1 + m_2 + \cdots + m_N} = \dfrac{\sum m_i x_i}{\sum m_i}$; $Y_{cm} = \dfrac{\sum m_i y_i}{\sum m_i}$

Work: $W = Fd\cos\theta = F_\parallel d$ $W_{total} = \Delta K$ $W = \tau\Delta\theta$

$W_{nc} = \Delta K + \Delta U$ $W_{nc} = E_f - E_i$

Kinetic Energy: $K = \frac{1}{2}mv^2$ $K = \frac{1}{2}I\omega^2$

Rolling: $v_{cm} = \omega r$

Potential Energy: weight: $U_g = mgy$

spring: $U_{sp} = \frac{1}{2}kx^2$

universal gravitation: $U_{grav} = -G\frac{m_1 m_2}{r}$

Mechanical Energy: $E = K + U$

Conservation of Mechanical Energy: $\sum E_{initial} = \sum E_{final}$

Power: $P = F\ v\ \cos\theta = F_\parallel\ v$

Impulse: $\vec{I} = \vec{F}_{av} \cdot (\Delta t) = \Delta\vec{p}$

Momentum:

Translational (single particle) $\vec{p} = m\vec{v}$

Angular momentum (rigid body) $\vec{L} = I\vec{\omega}$

System of particles: $\vec{p}_{total} = \sum \vec{p} = \vec{p}_1 + \vec{p}_2 + \vec{p}_3 + \cdots$ $\vec{L}_{total} = \sum \vec{L} = \vec{L}_1 + \vec{L}_2 + \vec{L}_3 + \cdots$

Conservation of linear momentum $\vec{p}_{total,initial} = \vec{p}_{total,final}$ or $\sum \vec{p}_{initial} = \sum \vec{p}_{final}$

Conservation of angular momentum $\vec{L}_{total,initial} = \vec{L}_{total,final}$ or $\sum \vec{L}_{initial} = \sum \vec{L}_{final}$

Simple Harmonic Motion**:**

$a = -\omega^2 x$ $x(t) = A\cos\{\omega t\}$ $\omega = \frac{2\pi}{T} = 2\pi f$

$v(t) = -\omega A \sin\{\omega t\}$

$a(t) = -\omega^2 A \cos\{\omega t\}$

mass/spring: $F_{sp} = -kx$ $U_{sp} = \frac{1}{2}kx^2$ $T = 2\pi\sqrt{\frac{m}{k}}$

$E = K + U = \frac{1}{2}kA^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

damped mass/spring: $\vec{F} = -b\vec{v}$ $x_{\max} = Ae^{-\frac{t}{\tau}}$ $\tau = \frac{2m}{b}$

simple pendulum: $T = 2\pi\sqrt{\frac{L}{g}}$

Waves:

$I = \frac{\text{Power}}{\text{Area}} = \frac{P}{A}$ spherical waves, point source: $I = \frac{P}{4\pi r^2}$

harmonic traveling waves: $y(x,t) = A\cos\left\{2\pi\left(\frac{x}{\lambda} \pm \frac{t}{T}\right)\right\}$ $v = \lambda f = \frac{\lambda}{T}$

transverse waves, taut string: $v = \sqrt{\frac{F_T}{\mu}}$ $\mu = \frac{\text{mass}}{\text{length}}$

Sound:

$\beta = (10.0\ \text{dB})\log\left(\frac{I}{I_0}\right)$, $I_0 = 1 \times 10^{-12}\ \frac{\text{W}}{\text{m}^2}$ $\beta_2 - \beta_1 = (10.0\ \text{dB})\log\left(\frac{I_2}{I_1}\right)$

Standing Waves:

Taut string fixed at both ends, or sound wave in an open-open or closed-closed tube:

$\lambda_n = \frac{2L}{n}$ and $f_n = nf_1$ where $n = 1, 2, 3, 4, 5, \ldots$ and $f_1 = \frac{v}{2L}$

Sound wave in an open-closed tube:

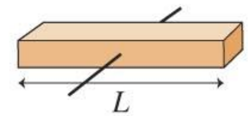
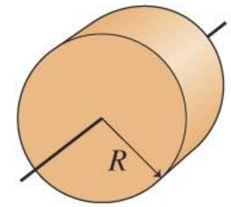
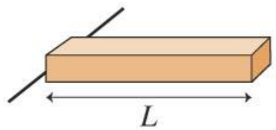
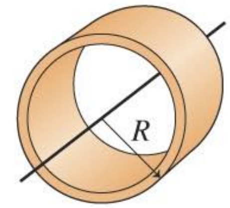
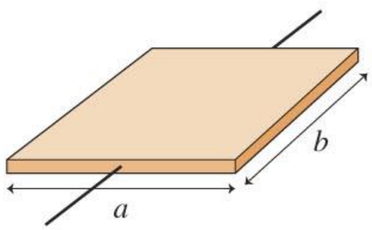
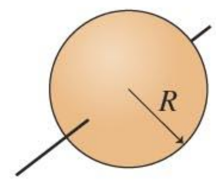
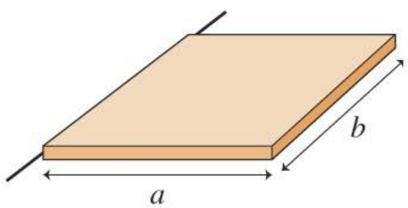
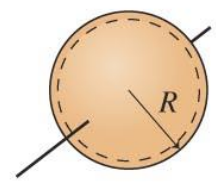
$\lambda_n = \frac{4L}{n}$ and $f_n = n f_1$ where $n = 1, 3, 5, \ldots$ and $f_1 = \frac{v}{4L}$

Interference: Constructive $\Delta d = n\lambda$ $n = 0, 1, 2, 3, \ldots$

Destructive $\Delta d = (n+1/2)\,\lambda$ $n = 0, 1, 2, 3, \ldots$

Beats: $f_{beat} = |f_1 - f_2|$

TABLE 7.4 Moments of inertia of objects with uniform density and total mass M

Object and axis	Picture	I	Object and axis	Picture	I
Thin rod (of any cross section), about center		$\frac{1}{12}ML^2$	Cylinder or disk, about center		$\frac{1}{2}MR^2$
Thin rod (of any cross section), about end		$\frac{1}{3}ML^2$	Cylindrical hoop, about center		MR^2
Plane or slab, about center		$\frac{1}{12}Ma^2$	Solid sphere, about diameter		$\frac{2}{5}MR^2$
Plane or slab, about edge		$\frac{1}{3}Ma^2$	Spherical shell, about diameter		$\frac{2}{3}MR^2$