Periodic Motion : A (amplitude), T (period), ω (angular speed), f (frequency), always **positive** (convention). $f = 1/T \quad \omega = 2\pi/T = 2\pi f$

Restoring force $F = -kx \;\rightarrow\; \omega = \sqrt{k/m} \quad f = \frac{1}{2\pi}\sqrt{k/m} \quad T = 2\pi\sqrt{m/k}$

$x = A\cos(\omega t + \phi) \quad v_x = \frac{dx}{dt} = -\omega A \sin(\omega t + \phi) \quad a_x = \frac{dv_x}{dt} = -\omega^2 A\cos(\omega t + \phi) = -\omega^2 x$

Initial conditions: $x_o, v_{ox} \;\rightarrow\; \phi = arctan(-\frac{v_{ox}}{\omega x_o}) \quad A = \sqrt{(x_o)^2 + \frac{v_{ox}^2}{\omega^2}}$

$E = \frac{1}{2}mv_x^2 + \frac{1}{2}kx^2 = const = \frac{1}{2}kA^2 \;|\; v_x = \pm\sqrt{\frac{k}{m}}\sqrt{A^2 - x^2} \;|\; v_{max} = \sqrt{\frac{k}{m}}A = \omega A \;|\; a_{max} = \omega^2 A$

Pendula: (simple) $\omega = \sqrt{g/L}$ (physical) $\omega = \sqrt{(mgd)/I}$

Damped Oscillations: $\Sigma F_x = -kx - bv_x$: $x(t) = Ae^{-(\frac{b}{2m})t}\cos(\omega' t + \phi)$ where $\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$.
Note ω' is less than ω. Underdamped (decaying oscillations): $b < 2\sqrt{km}$. Critically damped (no oscillations): $b = 2\sqrt{km}$. Overdamped (no osc.): $b > 2\sqrt{km}$.

Mechanical Waves : k (wave number), λ (wavelength) always **positive** (convention). $k = 2\pi/\lambda$

Wave function for sinusoidal wave traveling in +X direction:

$y(x,t) = A\sin[\omega(\frac{x}{v} - t)] = A\sin[2\pi f(\frac{x}{v} - t)] = A\sin[2\pi(\frac{x}{\lambda} - \frac{t}{T})] = A\sin(kx - \omega t)$

$v_y(x,t) = -A\omega\cos(kx - \omega t) \quad a_y(x,t) = -A\omega^2\sin(kx - \omega t)) = -\omega^2 y(x,t)$

wave speed: $v = \lambda f = \omega/k = \lambda/T$ to the right.

(Traveling in $-X$ direction : replace $-$ with $+$ in the cos and sin terms.)

Transverse waves on a wire/string: $v = \sqrt{F/\mu}$ F is tension in wire, $\mu = M/L$ of wire
Wave power: $P_{avg} = 2\pi^2\mu v f^2 A^2 = \frac{1}{2}\sqrt{\mu F}\omega^2 A^2$

Standing waves: $y(x,t) = 2A\sin(kx)\cos(\omega t)$

Sound Waves : Longitudinal (pressure) wave. Human range: 20 Hz to $20,000$ Hz

Speed of sound in air: $v = \sqrt{B/\rho} \;|\; v \approx (331 + 0.60T)$ for T in $deg\ C$ (343 m/s at $20^o\ C$)

Displacement: $D(x,t) = A\sin(kx - \omega t)$ | Pressure: $\Delta P = -\Delta P_{max}\cos(kx - \omega t)$
where: $\Delta P_{max} = BAk = \rho v^2 Ak = 2\pi\rho v Af$

Intensity (power/area): $I = 2\pi^2\rho v A^2 f^2 \quad I = (\Delta P_{max})^2/(2v\rho)$
Intensity in decibels: $\beta = 10\log_{10}(I/I_o)$ where $I_o = 1\times10^{-12}\ W/m^2$

Stringed Instruments: $\lambda_n = \frac{2L}{n} = v/f_n$ and $f_n = n(\frac{v}{2L})$ for $n = 1,2,3,...$ where $v = \sqrt{F_T/\mu}$

Wind instrument (open pipe): $\lambda_n = \frac{2L}{n}$ and $f_n = n(\frac{v}{2L})$ (for $n = 1,2,3...$)
Wind instrument (closed pipe): $\lambda_n = \frac{4L}{n}$ and $f_n = n(\frac{v}{4L})$ (for $n = 1,3,5,...$)

Interference (beats) : $f_{avg} = \frac{1}{2}(f_1 + f_2) \quad f_{beat} = |f_2 - f_1|$
Constructive interference: path difference $d = n\lambda$; destructive if $d = (n + \frac{1}{2})\lambda$

Doppler Effect (using **this book's** conventions) : $f' = f\cdot(v \pm v_{obs})/(v \mp v_{src})$ where v = sound speed, v_{obs} = observer speed and v_{src} = source speed. Upper sign if moving towards, lower sign if moving away (**separate analysis for each term**)
Circle: $area = \pi r^2$ || **Sphere** : $area = 4\pi r^2 \quad volume = \frac{4}{3}\pi r^3$ || **Cylinder** $volume = \pi r^2 L$
$\rho_{air} = 1.2\ kg/m^3 \quad \rho_{water} = 1000\ kg/m^3 \quad \rho_{steel} = 7800\ kg/m^3 \quad B_{air} = 1.41\times10^5 N/m^2$
$Pressure = Force/Area$