Introductory Mechanics Concepts

1. Motion

Acceleration → Velocity → Position, Integrate to get from acceleration to position

For constant acceleration integrating gives you the kinematic equations

$$x = x_0 + v_{x0}t + \frac{a_x}{2}t^2$$
$$v_x = v_{x0} + a_x t$$
$$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$$

2. Newton's Laws

First law – inertia – body at rest or in motion stays at rest or in motion

Second law – $\sum \vec{F} = m\vec{a} = \frac{d\vec{p}}{dt}$

Third law – every action has an equal and opposite reaction, $F_{12} = -F_{21}$

3. Momentum

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

$\Delta\vec{p} = 0$ if momentum is conserved

Impulse-momentum theorem $\vec{I} = \Delta\vec{p} = \vec{F}\Delta t$

4. Energy

$W = \int \vec{F} \cdot d\vec{x} = \Delta K$

$U_g = mgh$

$U_s = \frac{1}{2}kx^2$

$K = \frac{1}{2}mv^2$

Work-Kinetic energy theorem, $W = \Delta K$

$\Delta E = 0$ if energy is conserved or ΔE-W$_f = 0$ if not

5. Angular Motion, Momentum, and Energy

$\omega = v/r$

$\omega = \frac{2\pi}{T} = 2\pi f$

$\vec{\tau} = \vec{r} \times \vec{F} = \frac{d\vec{L}}{dt}$

$\sum \tau = 0$ and $\sum \vec{F} = 0$ for static equilibrium

$\vec{L} = \vec{r} \times \vec{p} = I\omega$, here the I is inertia

Inertia calculation, $I = \rho \int r^2 dV$

6. Harmonic Oscillator

$x = Asin(\omega t)$

$\omega = \sqrt{\frac{k}{m}}$

$E = \frac{1}{2}kA^2$ for simple harmonic oscillator

7. Miscellaneous

Gravity, $F = GMm/r^2$

Pressure is force per area, $P = \frac{F}{A}$

Fluids – continuity equation, $Av =$ constant

Fluids – Bernoulli equation, $P + \rho gh + \frac{\rho v^2}{2} =$ constant

$v = \sqrt{\frac{T}{\mu}}$ velocity of particle on wave

$v = \lambda f = \frac{2\pi f}{k}$ velocity of wave where k in this instance is the wave number

Doppler effect, $f_{approach} = \frac{f_{actual}}{1 - \frac{v_{source}}{v_{sound}}}$ for a moving source that is approaching the observer

$f_{approach} = (1 + \frac{v_{observer}}{v_{sound}}) f_{actual}$ for a moving observer approaching a source

$\lambda = 2L/n$, n=1, 2, 3… for standing waves