Kinematics

$$x = \left(\frac{v_0 + v_f}{2}\right)t \qquad v_f^2 = v_0^2 + 2ax$$

$$x = v_o t + \tfrac{1}{2}at^2 \qquad v_f = v_0 + at$$

For freefall, use $a=g$

Quadratic equation $\quad x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Simple trig functions

$$\sin\theta = \frac{opp}{hyp} \qquad \tan\theta = \frac{opp}{adj} = \frac{\sin\theta}{\cos\theta}$$

$$\cos\theta = \frac{adj}{hyp}$$

Motion in two dimensions—apply kinematics to <u>both</u> x and y motions separately and use trig or Pythagorean for final answer: $c = \sqrt{x^2 + y^2}$

Projectile motion

Time of falling from rest $\quad t = \sqrt{\dfrac{2y}{g}}$

Time of flight of projectile $\quad T = \dfrac{2v_0 \sin\theta}{g}$

Range of projectile $\quad R = \dfrac{v_0^2 \sin 2\theta}{g}$

Maximum height of projectile $\quad y_{max} = y_0 - \dfrac{v_0^2 \sin^2\theta}{2g}$

Forces: Spring force $F = -kx$

Gravitational force $\quad F = \dfrac{Gm_1 m_2}{r^2}$

$$F_{net} = ma \qquad F_N = mg\cos\theta$$

$$F_g = mg \qquad F_f = \mu F_N$$

For equilibrium conditions

$\Sigma F_x = 0$ <u>and</u> $\Sigma F_y = 0$

Uniform circular motion

$a_c = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2} = 4\pi^2 r f^2 = \omega^2 r$ $\omega = \frac{v}{r} = 2\pi f = \frac{2\pi}{T}$ $f = 1/T$

$v = \frac{2\pi r}{T} = 2\pi r f = \omega r$ $F_c = \frac{mv^2}{r} = ma_c$

F_c can be supplied by any other force

Kepler's Law $\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$ Gravitational acceleration $g = \frac{GM}{R^2} = \frac{4}{3}G\pi R\rho$

Density $\rho = \frac{3g}{4\pi RG}$ Gravity comparisons $g_{planet} = g_{Earth}\frac{difference(m)}{difference(r^2)}$

Work and Energy $W = Fx\cos\theta$ $Kinetic = ½mv^2$

$W_{spring} = ½Fx = ½kx^2$ $Potential = mgh$

Conservation of Energy $KE_0 + PE_0 = KE_f + PE_f$

With friction: $KE_0 + PE_0 = KE_f + PE_f + W_{fr}$ ($W_{fr} = \mu mgx \cos\theta$)

Power $P = \frac{W}{t} = Fv$

Momentum $p = mv$

Impulse = $m\Delta v$ or $v\Delta m$

Collisions: Elastic $m_1v_1 + m_2v_2 = m_1v_3 + m_2v_4$

Inelastic $m_1v_1 + m_2v_2 = (m_1 + m_2)v_3$

Rotational Kinematics

$\theta = \left(\frac{\omega_0 + \omega_f}{2}\right)t$ $\omega_f = \omega_0 + \alpha t$

$\theta = \omega_0 t + ½\alpha t^2$ $\omega_f^2 = \omega_0^2 + 2\alpha\theta$

Torque and Rotational Inertia

$\tau = rF\sin\phi = I\alpha$ $I_{\text{point mass or ring}} = mr^2$ $I_{\text{cylinder or disk}} = ½\, mr^2$

$I_{\text{sphere}} = {}^2/_5\, mr^2$

Rotational equilibrium

$\Sigma\tau = 0$

Angular Momentum

L = $I\omega$ Conservation of L → $I_0\omega_o = I_f\omega_f$

Kinetic Energy of rotation $KE = {}^1/_2\, I\omega^2$

Remember!! Energy is conserved in totality of all forms!