Constant Acceleration
$d = d_0 + v_0 t + \frac{1}{2}at^2$
$v = v_0 + at$
$v^2 = v_0^2 + 2a(\Delta x)$

Projectile Motion
$v_x(t) = v_{x0} = v_0 \cos\theta_0$
$x(t) = x_0 + v_0 \cos(\theta_i)t$
$v_y(t) = v_0 \sin\theta_i - gt$
$y(t) = y_0 + v_0 \sin(\theta_i)t + \frac{1}{2}at^2$
$v = v_{0y} - gt$
$v^2 = v_y^2 - 2ad$

Vectors with angles
$A_x = A\cos\theta$
$A_y = A\sin\theta$
$\tan\theta = \frac{A_y}{A_x}$
$\theta = \arctan\frac{A_y}{A_x}$

Angular Velocity
$s = r\theta$
$v = r\omega$
$v = \frac{2\pi r}{T}$
$\omega = \frac{v}{r}$
$\omega = \frac{d\theta}{dt} = \frac{2\pi}{T}$
$T = \frac{2\pi r}{v}$

Angular Acc.
$r =$ radius
$\alpha =$ acceleration $(\frac{rad}{s^2})$
$\omega =$ velocity $(\frac{rad}{s})$
$\alpha = \frac{\Delta\omega}{\Delta t}$
$s =$ arc length
$s = s_0 + v_0 t + \frac{1}{2}at^2$
$s = r\Delta\theta$
$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$
$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$
$\Delta\theta = \frac{w_f^2 - w_0^2}{2\alpha}$
$v_f = r\omega$
$v_f^2 = v_0^2 + 2a(\Delta s)$
$\omega_f^2 = \omega_0^2 + 2\alpha(\Delta\theta)$
$\omega_f = \omega_0 + \alpha\Delta t$
$a_c = \frac{v_f^2}{r}$ (centripetal)
$a_r = \omega^2 r$
$a_t = r\alpha$ (tangential)
$v_{ang} = \frac{r}{T}$
$a_{ang} = \frac{v_{ang}}{T}$
$a_{total} = \sqrt{a_t^2 + a_c^2}$
$\sum F_r = ma_c = \frac{1}{2}mv^2$

Work/Energy
$K =$ Kinetic Energy
$U =$ Potential Energy
Master equation
$\Delta E^m = -f_k d$
$K(U) = \frac{1}{2}mv^2$
$PE = mgd$
$W = PE + KE$
Conservation of Energy
$K_1 + U_1 = K_2 + U_2$
$U_{sp} = \frac{1}{2}kx^2$

Momentum
$p =$ Momentum
$J =$ Joules
$p = mv$
$F_{net} = \frac{dp}{dt}, m\frac{v}{dt}$
$F_{avg} = \frac{\Delta p}{\Delta t}$
Impulse $= \int F dt = J$

Collisions/Explosions
General Eq. (for inelastic, share common final velocity.):
$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$

- During inelastic collision, some KE goes to thermal.
- If KE is conserved, called perfectly elastic.
- Momentum is always conserved

KE in elastic collision (general, 2D):
$m_1\frac{v_{1i}^2}{2} + m_2\frac{v_{2i}^2}{2} = m_1\frac{v_{1f}^2}{2} + m_2\frac{v_{2f}^2}{2}$
KE in 1D: $v_{1i} - v_{2i} = v_{2f} - v_{1f}$
If needed to split to x/y components
$\theta = \tan^{-1}(\frac{v_y}{v_x})$
$v_f = \sqrt{v_y^2 + v_x^2}$

Friction
$f_k = \mu_k mg$
$\sum F_x = ma$
$\sum F_y = n - mg = 0$
$\overrightarrow{F_{net}} = \sum\overrightarrow{F_x} + \sum\overrightarrow{F_y}$
$a = \frac{f_{net}}{m}$
$\mu mg = ma$

Newton's Laws
$F = ma$
$\sum F = T - mg = ma$
$\sum F = ma + mg$
$\sum F = \frac{T - f_k}{m}$
$\sum F_{m_a + m_b} = (m_a + m_b)a$

Center of Mass
$x_{cm} = \frac{m_1 x_1 ...(+m_2 x_2)}{m_1 ...(+m_2)}$
$y_{cm} = \frac{m_1 y_1 ...(+m_2 y_2)}{m_1 ...(+m_2)}$
$r_{cm} = \frac{1}{M}\sum m_i x_i$
$K_{rot} = \frac{\omega^2}{2}\sum m_i r_i^2$

Rotation of a Rigid Body
Parallel-Axis Theorem
$I_{cm} = \frac{1}{12}ML^2$ (if at center.)
$I_A = I_{cm} + Md^2 \equiv \frac{1}{3}ML^2$
$K_{sys} = \frac{1}{2}L\omega^2$
$I = \sum m_i r_i^2, I = \int r^2 dm$
$\frac{1}{2}I\omega_1^2 + Mgy_{cm1} = \frac{1}{2}I\omega_0^2 + Mgycm0$

Torque
$t = rF\sin\varphi$
(-,cw : +,ccw)
$d = r\sin\varphi$
$\theta = \varphi - 90$
$t_g = Mgd \equiv t_g = Mgx_{cm}$
$t_{net} = I\alpha \equiv (\sum m_i r_i^2)\alpha$

Misc. Equations
$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$rpm -> rad\frac{rev}{min} \times \frac{2\pi rad \cdot min}{rev \cdot 60s}$
$rad -> rev = \frac{rad}{2\pi}$