

Kinematics 2D Motion

$$V = V_0 + at$$

V_0 = Initial velocity of object
 V = Final velocity of object
 a = Acceleration of object
 t = Time

$$V^2 = V_0^2 + 2a\Delta x$$

V_0 = Initial velocity of object
 V = Final velocity of object
 a = Acceleration of object
 $\Delta x / \Delta y$ = Change in position

$$\Delta x = V_0t + \frac{1}{2}at^2$$

$\Delta x / \Delta y$ = Change in position
 V_0 = Initial velocity
 t = Time
 a = Acceleration

$$F = ma$$

F = Force from object
 m = Mass of object
 a = Acceleration of object

$$F_f = \mu N$$

F_f = Force of friction
 μ = Coefficient of friction
 N = Normal force

Note: Some formulas may involve BOTH the x and y directions, as well as incorporate other formulas outside kinematics.

Momentum

$$F\Delta t = \Delta p = m\mathbf{v} - m\mathbf{v}_0$$

$F\Delta t = \Delta p$ = Impulse
 $m\mathbf{v}$ = Final momentum
 $m\mathbf{v}_0$ = Initial momentum

$$m\mathbf{v}_{\text{before}} - m\mathbf{v}_{0\text{before}} = m\mathbf{v}_{\text{after}} - m\mathbf{v}_{0\text{after}}$$

Note: Momentum is ALWAYS conserved. You may need to note that the momentum before is equal to the momentum after.

Energy

$$W = Fd$$

W = Work done
 F = Force applied
 d = Distance travelled

Energy (cont)

$$W = \Delta KE = \frac{1}{2}mV^2 - \frac{1}{2}mV_0^2$$

W = Work done
 m = Mass of object
 V = Final velocity
 V_0 = Initial velocity

$$U_g = mgh$$

U_g = Work done by gravity
 m = Mass
 g = Gravity
 h / d = Height or distance traveled

$$F_s = kx$$

F_s = Force of spring (Restored Force)
 k = Spring coefficient
 x = Distance from equilibrium

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

W_s = Work done by spring
 k = Spring coefficient
 x = Distance from equilibrium

$$KE = \frac{1}{2}mV^2$$

KE = Kinetic Energy
 m = Mass
 v = Velocity of object

$$KE + U_g + U_s = KE + U_g + U_s + W$$

KE = Kinetic Energy (is the object moving?)
 U_g = Work done by gravity (is the object above where you set $x = 0$?)
 U_s = Work done by spring (is a spring involved?)
 W = Friction (did energy go to friction?)

Note: Energy is **SOMETIMES** conserved depending on the situation. **Inelastic** collisions cannot apply the conservation of energy because of the loss of energy. However, you can apply the conservation of energy for **elastic** collisions.



Rotational Motion

$$\omega = \omega_0 + \alpha t$$

ω_0 = Angular initial velocity
 ω = Angular final velocity
 α = Angular acceleration
 t = Time

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

ω_0 = Angular initial velocity
 ω = Angular final velocity
 α = Angular acceleration
 θ = Angular change in position

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

θ = Angular change in position
 ω_0 = Angular initial velocity
 t = Time
 α = Angular acceleration

$$v_T = r\omega$$

v_T = Tangential (Linear) velocity
 r = Radius
 ω = Angular final velocity

$$a_T = r\alpha$$

a_T = Tangential (Linear) acceleration
 r = Radius
 α = Angular acceleration

$$a_C = v_T^2 / r$$

a_C = Centripetal acceleration
 v_T = Tangential (Linear) velocity
 r = Radius

$$a_r = r\omega^2$$

a_r = Radial Acceleration
 r = Radius
 ω = Angular velocity

Rotational Motion (cont)

$$\tau = F_{\perp}d$$

τ = Torque
 F_{\perp} = Perpendicular Forces
 d = Distance from Pivot Point

$$I = \sum mr^2$$

I = Moment of Inertia (Rotational Moment / Rotational Intertia)
 $\sum mr^2$ = Total of each Mass x Radius Squared

$$KE_C = \frac{1}{2}I\omega^2$$

KE_C = Kinetic Circular Energy
 I = Moment of Inertia (Rotational Moment / Rotational Intertia)
 ω = Angular velocity

$$\tau = I\alpha$$

τ = Torque
 I = Moment of Inertia (Rotational Moment / Rotational Intertia)
 α = Angular acceleration

$$KE_R = \frac{1}{2}I_P\omega^2 = \frac{1}{2}(I_{COM} + mh^2)\omega^2 = \frac{1}{2}m(V_{COM})^2 + \frac{1}{2}I\omega^2$$

KE_R = Kinetic Rolling Energy
 $\frac{1}{2}m(V_{COM})^2$ = Sliding Equation
 $\frac{1}{2}I\omega^2$ = Rotation Equation

$$l = mr\omega$$

l = Momentum of a particle

$$L = I\omega$$

L = Momentum of a rigid body (not a particle)

NOTE:

- You may need to consider that $\omega = d\theta / dt$ and $\alpha = d\omega / dt$.
- Account for all objects rotating the pivot point when calculating I .
- Momentum is **ALWAYS** conserved.

