## Kinematics 2D Motion

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|---|---|
| $V = V_0 + at$ | $V_0$ = Initial velocity of object<br>$V$ = Final velocity of object<br>$a$ = Acceleration of object<br>$t$ = Time |
| $V^2 = V_0^2 + 2a\Delta x$ | $V_0$ = Initial velocity of object<br>$V$ = Final velocity of object<br>$a$ = Acceleration of object<br>$\Delta x$ / $\Delta y$ = Change in position |
| $\Delta x = V_0 t + \tfrac{1}{2}at^2$ | $\Delta x$ / $\Delta y$ = Change in position<br>$V_0$ = Initial velocity<br>$t$ = Time<br>$a$ = Acceleration |
| $F = ma$ | $F$ = Force from object<br>$m$ = Mass of object<br>$a$ = Acceleration of object |
| $F_f = \mu N$ | $F_f$ = Force of friction<br>$\mu$ = Coefficient of friction<br>$N$ = Normal force |

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

## Momentum

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|---|---|
| $F\Delta t = \Delta p = mV - mV_0$ | $F\Delta t = \Delta p$ = Impulse<br>$mV$ = Final momentum<br>$mV_0$ = Initial momentum |

$$mV_{before} - mV_{0\,before} = mV_{after} - mV_{0\,after}$$

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<br>$F$ = Force applied<br>$d$ = Distance travelled |

## Energy (cont)

| | |
|---|---|
| $W = \Delta KE = \tfrac{1}{2}mV^2 - \tfrac{1}{2}mV_0^2$ | $W$ = Work done<br>$m$ = Mass of object<br>$V$ = Final velocity<br>$V_0$ = Initial velocity |
| $U_g = mgh$ | $U_g$ = Work done by gravity<br>$m$ = Mass<br>$g$ = Gravity<br>$h$ / $d$ = Height or distance traveled |
| $F_S = kx$ | $F_S$ = Force of spring (Restored Force)<br>$k$ = Spring coefficient<br>$x$ = Distance from equilibrium |
| $W_S = U_S = \tfrac{1}{2}kx^2$ | $W_S$ = Work done by spring<br>$k$ = Spring coefficient<br>$x$ = Distance from equilibrium |
| $KE = \tfrac{1}{2}mV^2$ | $KE$ = Kinetic Energy<br>$m$ = Mass<br>$v$ = Velocity of object |
| $KE + U_g + U_S =$ $KE + U_g + U_S + W$ | $KE$ = Kinetic Energy (is the object moving?)<br>$U_g$ = Work done by gravity (is the object above where you set x = 0?)<br>$U_S$ = Work done by spring (is a spring involved?)<br>$W$ = 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 | |
|---|---|
| $\omega = \omega_0 + \alpha t$ | $\omega_0$ = Angular initial velocity<br>$\omega$ = Angular final velocity<br>$\alpha$ = Angular acceleration<br>$t$ = Time |
| $\omega^2 = \omega_0^2 + 2\alpha\theta$ | $\omega_0$ = Angular initial velocity<br>$\omega$ = Angular final velocity<br>$\alpha$ = Angular acceleration<br>$\theta$ = Angular change in position |
| $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$ | $\theta$ = Angular change in position<br>$\omega_0$ = Angular initial velocity<br>$t$ = Time<br>$\alpha$ = Angular acceleration |
| $V_T = r\omega$ | $V_T$ = Tangential (Linear) velocity<br>$r$ = Radius<br>$\omega$ = Angular final velocity |
| $a_T = r\alpha$ | $a_T$ = Tangential (Linear) acceleration<br>$r$ = Radius<br>$\alpha$ = Angular acceleration |
| $a_C = V_T^2 / r$ | $a_C$ = Centripetal acceleration<br>$V_T$ = Tangential (Linear) velocity<br>$r$ = Radius |
| $a_r = r\omega^2$ | $a_r$ = Radial Acceleration<br>$r$ = Radius<br>$\omega$ = Angular velocity |

| Rotational Motion (cont) | |
|---|---|
| $\tau = F\perp d$ | $\tau$ = Torque<br>$F\perp$ = Perpendicular Forces<br>$d$ = Distance from Pivot Point |
| $I = \Sigma mr^2$ | $I$ = Moment of Inertia (Rotational Moment / Rotational Intertia)<br>$\Sigma mr^2$ = Total of each Mass x Radius Squared |
| $KE_C = 1/2(I)\omega^2$ | $KE_C$ = Kinetic Circular Energy<br>$I$ = Moment of Inertia (Rotational Moment / Rotational Intertia)<br>$\omega$ = Angular velocity |
| $\tau = I\alpha$ | $\tau$ = Torque<br>$I$ = Moment of Inertia (Rotational Moment / Rotational Intertia)<br>$\alpha$ = Angular acceleration |
| $KE_R = 1/2\ I_P\omega^2 = 1/2(I_{COM} + mh^h)\omega^2 = 1/2(m(V_{COM})^2) + 1/2 I\omega^2$ | $KE_R$ = Kinetic Rolling Energy<br>$1/2(m(V_{COM})^2)$ = Sliding Equation<br>$1/2 I\omega^2$ = 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.