Newton's Laws of Motion

1. A body at rest will remain at rest a body in motion will remain in motion unless acted upon by an external force \( \sum \vec{F} = 0 \)

2. The net sum of forces accelerates an object by an amount proportional to its mass and in the direction of the net forces. \( \sum \vec{F} = m\vec{a} \)

3. For every action there is an opposite and equal reaction. Action reaction pairs never act on the same object \( \vec{F}_A \text{ on } B = -\vec{F}_B \text{ on } A \)

Equations of motion in 2 or 1 dimension are given below. These apply only when the acceleration is constant, gravitational acceleration is an example of a constant \( a \). The time \( t \) is the quantity that is common to both dimensions for 2-D problems.

\[
\begin{align*}
\vec{v}_{\text{average}} &= \frac{\vec{x}_f - \vec{x}_i}{\Delta t}, & \vec{v}_{\text{inst}} &= \lim_{\Delta t \to 0} \frac{\vec{x}_f - \vec{x}_i}{\Delta t} = \frac{d\vec{x}}{dt} = \int d\vec{v} = \int a(t) \, dt \\
\vec{a}_{\text{average}} &= \frac{\vec{v}_f - \vec{v}_i}{\Delta t}, & \vec{a}_{\text{inst}} &= \lim_{\Delta t \to 0} \frac{\vec{v}_f - \vec{v}_i}{\Delta t} = \frac{d\vec{v}}{dt} = \int d\vec{a} = \int \vec{a}(t) \, dt
\end{align*}
\]

Equations of motion that apply generally

For projectile motion in the plane

\[
\begin{align*}
\vec{v}_{\text{approx}} &= \vec{v}_0 + \vec{a}_g t \\
\vec{x}_{\text{approx}} &= \vec{x}_0 + \vec{v}_0 t + \frac{1}{2} \vec{a}_g t^2
\end{align*}
\]

Force due to spring is given by: \( \vec{F}_{\text{Spring}} = -k\vec{x} \)

Use FBD for spring problems, the sign of the force should be clear from the diagram.