The slope of a graph is the "rise over run" for straight line graphs.

The slope of \( y = x \) is constant, the same everywhere:

\[
m = \frac{\Delta y}{\Delta x} = \frac{y_f - y_0}{x_f - x_0} = \frac{3m - 1m}{3m - 1m} = 1
\]

For more general graphs, "rise over run" gives the average slope between \( x_0 \) and \( x_f \).

The exact slope at a point can be approximated as \( x_f \) and \( x_0 \) are brought closer together.

Consider a ball thrown up in the air from \( y_0 = 1m \) to \( y = 3m \) and back to \( y_f = 1m \).

The graph of the ball's height \( y \) versus the time since being thrown \( t \) is:

The slope of a position versus time graph is the rate of change of position, called velocity.

The ball reaches its maximum height at \( t = \frac{1}{2} t_f = 0.78 \, s \) (from observation).

The average velocity from \( t=0 \) to \( t = \frac{1}{2} t_f \) is

\[
\langle V \rangle = \frac{\Delta x}{\Delta t} = \frac{x_f - x_0}{t_f - t_0} = \frac{3m - 1m}{0.78s - 0s} = 3.83 \, m/s
\]

What is the average velocity from \( t_0 \) to \( t_f \)?

To get the exact velocity at any time \( t \) we take the derivative of position with respect to time

\[
\frac{d}{dt} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}
\]

The curve is a parabola \( y = y_0 + v_0 t + \frac{1}{2} at^2 \) where \( y_0 \) is initial height, and \( v_0 \) and \( a \) are constants.

\[
v = \frac{dy}{dt} = \frac{d}{dt}(y_0 + v_0 t + \frac{1}{2} at^2) = v_0 + at
\]

Now we see \( v_0 \) is the initial velocity, \( a \) is the slope of the \( V \) vs. \( t \) graph, the rate of change of velocity, called acceleration.

\[
a = \frac{dv}{dt}
\]

\[
\langle \dot{a} \rangle = \frac{\Delta a}{\Delta t}
\]

\[
g = 9.8 \, m/s^2
\]

In the absence of air resistance, the acceleration due to gravity is the same for all shapes and masses.