**Definition of velocity and acceleration**

Objects accelerate only if they interact with other objects.

Perpendicular components of the motion of an object are independent.

The horizontal part of the acceleration never affects the vertical part of the velocity.

The vertical part of the acceleration never affects the horizontal part of the velocity.

This theory predicts the motion of all objects. You have tested it in the lab.

**Straight line (1-D) motion**

**Projectiles (2-D)**

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The vertical part of the acceleration never affects the horizontal part of the velocity.

**Theory of Motion**

**Circular (2-D)**

**Example**

While on a vacation you find an old fort probably built in the 16th century. Large stone walls rise vertically from the shore to protect the fort from cannon fire from pirate ships. Walking around on the ramparts, you find the fort's cannons mounted such that they fire horizontally out of holes near the top of the walls facing the ocean. Leaning out of one of these gun holes, you drop a rock which hits the ocean 3.0 seconds later. You wonder how close a pirate ship would have to sail to the fort to be in range of the fort's cannon? Of course you realize that the range depends on the velocity that the cannonball leaves the cannon. That muzzle velocity depends, in turn, on how much gunpowder was loaded into the cannon. For fun, you decide to calculate the muzzle velocity necessary to hit a pirate ship 300 meters from the base of the fort.

**Focus**

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**Plan**

**Unknowns**

Find \( v_o \)

\[ v_o = \frac{x_f}{t_f} \]

No additional unknowns! We're done.

**Execute**

Find \( v_o \)

\[ v_o = \frac{300 \text{ m}}{3.0 \text{ s}} = 100 \text{ m/s} \]

Evaluate

Units are correct for a velocity

Speed of a fast car is about 100 km/hr

\[ 100 \text{ km/hr} \left( \frac{1000 \text{ m}}{1 \text{ km}} \right) \left( \frac{1 \text{ hr}}{3600 \text{ s}} \right) = 28 \text{ m/s} \]

so cannon ball is faster than a car

Speed of a jet is about 1000 km/hr = 280 m/s

so cannon ball is slower than a jet

Cannon ball speed is not unreasonable.