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# Kinematics - Analyzing motion under the condition of constant acceleration

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Honors Physics

# Kinematic Symbols

<b>x,y</b>	<b>Displacement</b>
<b>t</b>	<b>Time</b>
<b>v<sub>o</sub></b>	<b>Initial Velocity</b>
<b>v</b>	<b>Final Velocity</b>
<b>a</b>	<b>Acceleration</b>
<b>g</b>	<b>Acceleration due to gravity</b>

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# Kinematic #1

$$a = \frac{\Delta v}{\Delta t} \rightarrow \frac{v - v_o}{t} \quad v - v_o = at$$

$$v = v_o + at$$

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# Kinematic #1

**Example:** A boat moves slowly out of a marina (so as to not leave a wake) with a speed of 1.50 m/s. As soon as it passes the breakwater, leaving the marina, it throttles up and accelerates at 2.40 m/s/s.

a) How fast is the boat moving after accelerating for 5 seconds?

What do I know?	What do I want?
$v_o = 1.50 \text{ m/s}$	$v = ?$
$a = 2.40 \text{ m/s/s}$	
$t = 5 \text{ s}$	

$$v = v_o + at$$

$$v = (1.50) + (2.40)(5)$$

$$v = 13.5 \text{ m/s}$$

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## Kinematic #2

$$x = v_{ox}t + \frac{1}{2}at^2$$

b) How far did the boat travel during that time?

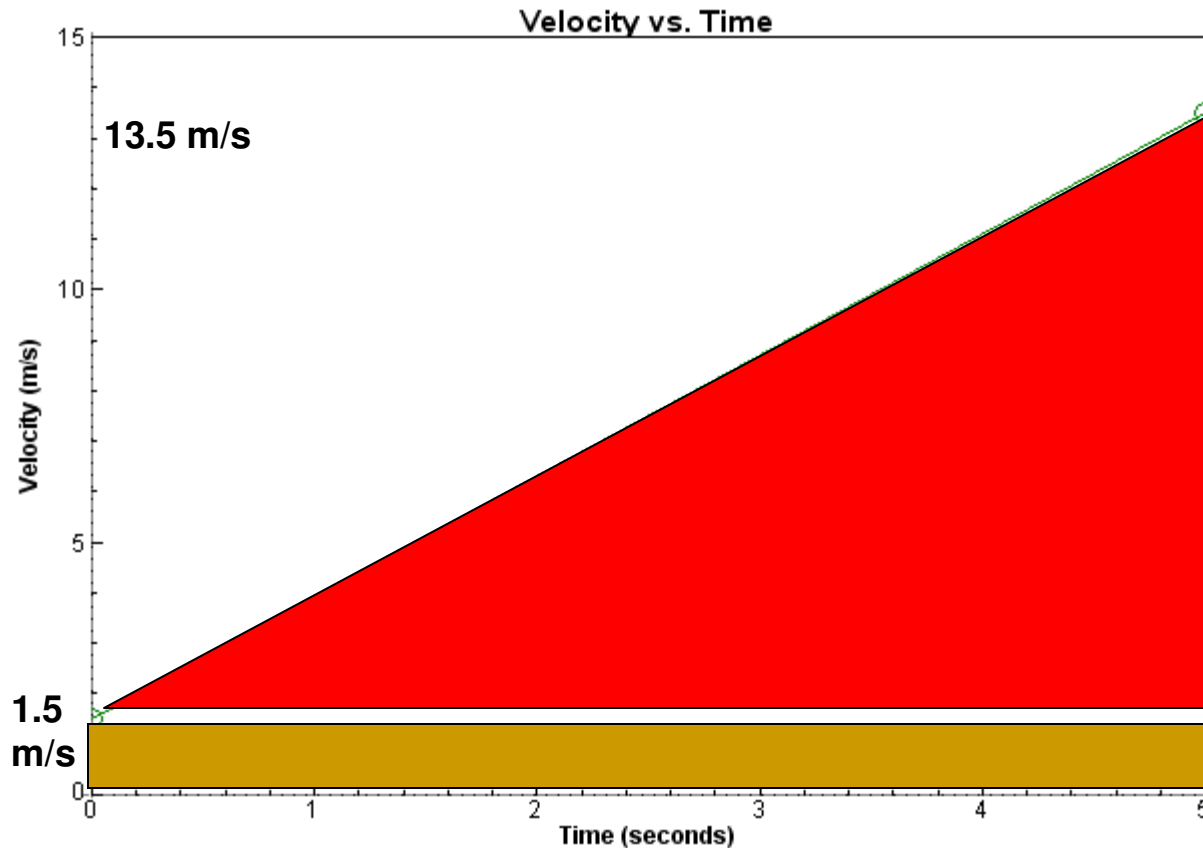
$$x = v_{ox}t + \frac{1}{2}at^2$$

$$x = (1.5)(5) + \frac{1}{2}(2.40)(5^2)$$

$$x = 37.5 \text{ m}$$

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# Does all this make sense?



$$A = bh \rightarrow A = (5)(1.5)$$
$$A = 7.50 \text{ m}$$

$$A = \frac{1}{2}bh \rightarrow \frac{1}{2}(5)(12)$$
$$A = 30 \text{ m}$$

**Total displacement = 7.50 + 30 = 37.5 m = Total AREA under the line.**

# Kinematic #3

$$v^2 = v_o^2 + 2ax$$

**Example:** You are driving through town at 12 m/s when suddenly a ball rolls out in front of your car. You apply the brakes and begin decelerating at 3.5 m/s/s.

How far do you travel before coming to a complete stop?

What do I know?	What do I want?
$v_o = 12 \text{ m/s}$	$x = ?$
$a = -3.5 \text{ m/s/s}$	
$V = 0 \text{ m/s}$	

$$v^2 = v_o^2 + 2ax$$

$$0 = 12^2 + 2(-3.5)x$$

$$-144 = -7x$$

$$x = 20.57 \text{ m}$$

# Common Problems Students Have

**I don't know which equation to choose!!!**

<b>Equation</b>	<b>Missing Variable</b>
$v = v_o + at$	x
$x = v_{ox}t + \frac{1}{2}at^2$	v
$v^2 = v_o^2 + 2ax$	t



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## Kinematics for the VERTICAL Direction

All 3 kinematics can be used to analyze one dimensional motion in either the X direction OR the y direction.

$$v = v_o + at \rightarrow v_y = v_{oy} + gt$$

$$x = v_{ox}t + \frac{1}{2}at^2 \rightarrow y = v_{oy}t + \frac{1}{2}gt^2$$

$$v^2 = v_{ox}^2 + 2ax \rightarrow v_y^2 = v_{oy}^2 + 2gy$$

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# Examples

A pitcher throws a fastball with a velocity of 43.5 m/s. It is determined that during the windup and delivery the ball covers a displacement of 2.5 meters. This is from the point behind the body to the point of release. Calculate the acceleration during his throwing motion.

What do I know?	What do I want?
$v_o = 0 \text{ m/s}$	$a = ?$
$x = 2.5 \text{ m}$	
$V = 43.5 \text{ m/s}$	

Which variable is NOT given and NOT asked for? TIME

$$v^2 = v_o^2 + 2ax$$

$$43.5^2 = 0^2 + 2a(2.5)$$

$$a = 378.45 \text{ m/s}^2$$

# Examples

How long does it take a car at rest to cross a 35.0 m intersection after the light turns green, if the acceleration of the car is a constant 2.00 m/s/s?

What do I know?	What do I want?
$v_o = 0 \text{ m/s}$	$t = ?$
$x = 35 \text{ m}$	
$a = 2.00 \text{ m/s/s}$	

Which variable is NOT given and NOT asked for?

$$x = v_{ox}t + \frac{1}{2}at^2$$

$$35 = (0) + \frac{1}{2}(2)t^2$$

$$t = 5.92 \text{ s}$$

# Examples

**A car accelerates from 12.5 m/s to 25 m/s in 6.0 seconds. What was the acceleration?**

What do I know?	What do I want?
$v_o = 12.5 \text{ m/s}$	$a = ?$
$v = 25 \text{ m/s}$	
$t = 6\text{s}$	

**Which variable is NOT given and NOT asked for?**

$$v = v_o + at$$

$$25 = 12.5 + a(6)$$

$$a = 2.08 \text{ m/s}^2$$

# Examples

**A stone is dropped from the top of a cliff. It is observed to hit the ground 5.78 s later. How high is the cliff?**

What do I know?	What do I want?
$v_{oy} = 0 \text{ m/s}$	$y = ?$
$g = -9.8 \text{ m/s}^2$	
$t = 5.78 \text{ s}$	

**Which variable is NOT given and NOT asked for?**

$$y = v_{oy}t + \frac{1}{2}gt^2$$

$$y = (0)(5.78) - 4.9(5.78)^2$$

$$y = -163.7 \text{ m}$$

$$h = 163.7 \text{ m}$$