Kinematics - Analyzing motion under the condition of constant acceleration

Honors Physics

Kinematic Symbols

x,y	**Displacement**
t	**Time**
v_o	**Initial Velocity**
v	**Final Velocity**
a	**Acceleration**
g	**Acceleration due to gravity**

Kinematic #1

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

$$\boxed{v = v_o + at}$$

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 m/s	v = ?
a = 2.40 m/s/s	
t = 5 s	

$$v = v_o + at$$

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

$$v = 13.5\, m/s$$

Kinematic #2

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

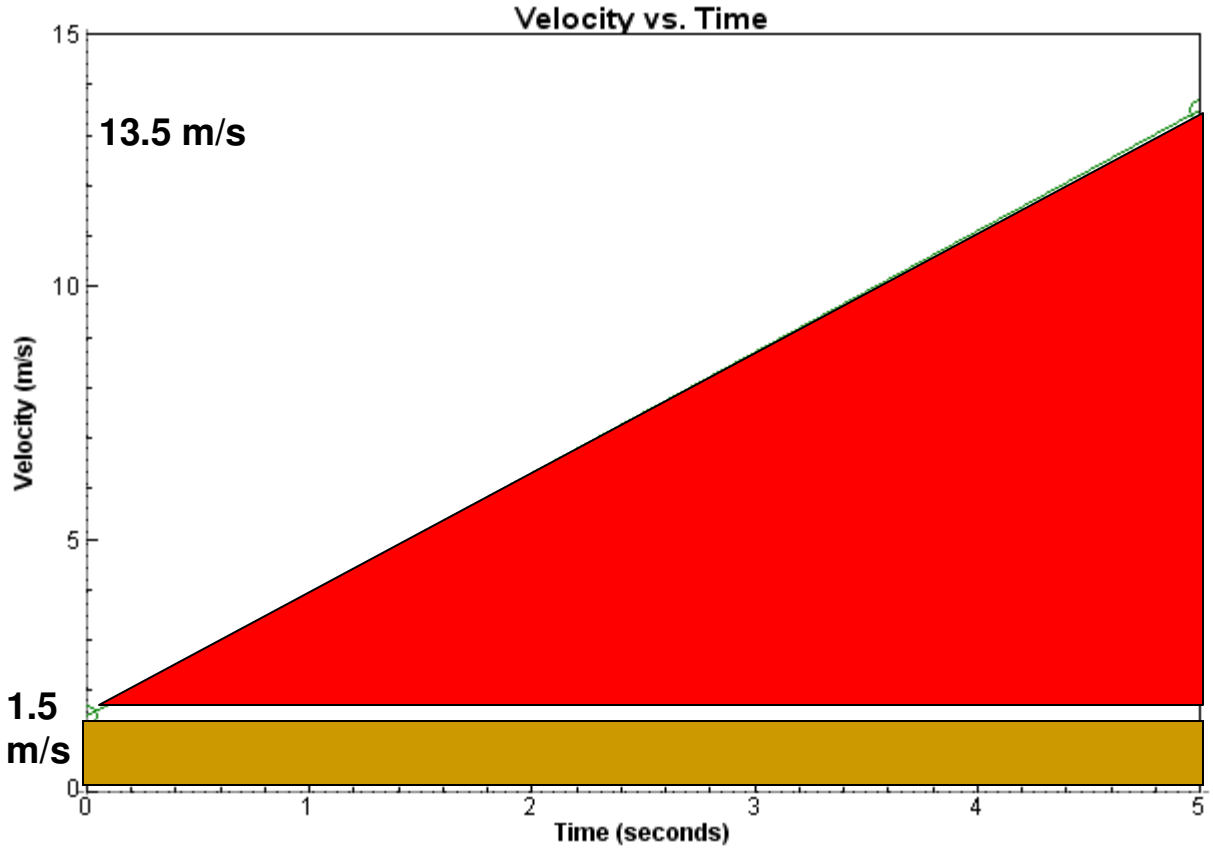
b) How <u>far</u> did the boat travel during that time?

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

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

$$x = 37.5\ m$$

Does all this make sense?



$$A = bh \rightarrow A = (5)(1.5)$$

$$A = 7.50\ m$$

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

$$A = 30\ m$$

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 m/s	x = ?
a = -3.5 m/s/s	
V = 0 m/s	

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

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

$$-144 = -7x$$

$$x = 20.57\ m$$

Common Problems Students Have

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

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

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.

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

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

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

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 m/s	a = ?
x = 2.5 m	
V = 43.5 m/s	

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

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

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

$$a = 378.45\ m/s^2$$

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 m/s	t = ?
x = 35 m	
a = 2.00 m/s/s	

Which variable is NOT given and NOT asked for?

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

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

$$t = 5.92\ s$$

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 m/s	a = ?
v = 25 m/s	
t = 6s	

Which variable is NOT given and NOT asked for?

$$v = v_o + at$$

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

$$a = 2.08\ m/s^2$$

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 m/s	y = ?
g = -9.8 m/s^2	
t = 5.78 s	

Which variable is NOT given and NOT asked for?

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

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

$$y = -163.7\ m$$

$$h = 163.7\ m$$