Kinematics – How things Move

Time
$\Delta t = t_f - t_i$

Distance
$\Delta d = d_f - d_i$

Velocity
$\Delta v = v_f - v_i$

Average Velocity

$$v = \frac{\Delta d}{\Delta t}$$

Average Acceleration

$$a = \frac{\Delta v}{\Delta t}$$

Speed is the absolute value of velocity.

Speed vs. Velocity

Speed is a scalar – has magnitude

Velocity is a vector – has magnitude and direction

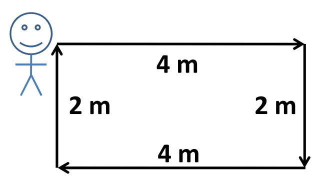
$$\textbf{Speed} = \frac{\text{Distance Traveled}}{\text{Time of Travel}}$$

$$\textbf{Velocity} = \frac{\text{Displacement}}{\text{Time of Travel}}$$

Displacement = Δ position

Speed vs. Velocity

Example: You travel a distance of 12 meters in 24 seconds along the following path. What is your speed and your velocity?



$$\textbf{Speed} = \frac{12 \text{ m}}{24 \text{ s}} = 0.5 \text{ m/s} \qquad \textbf{Velocity} = \frac{0 \text{ m}}{24 \text{ s}} = 0 \text{ m/s}$$

Acceleration

Acceleration – A change in velocity over time

This can be a change in speed
Ex. Speeding up or slowing down

This can be a change in direction
Ex. Making a turn, even at constant speed

You can "feel" when acceleration happens when a car changes speeds or makes sharp turns

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Motion Sign Conventions

	+	-
d	Forward/Up	Backward/Down
v	Move Forward	Move Reverse
a	Speeding Up or Slowing Down In Reverse	Slowing Down or Speeding Up In Reverse

Motion Equations

$$\Delta d = v_i t + \tfrac{1}{2} a t^2$$

$$v_f = v_i + a t$$

$$v_f^2 = v_i^2 + 2 a d$$

d - displacement
a - acceleration
t - time

v_f - final velocity
v_i - initial velocity
v_i is often written v_o

2 More Motion Equations

$$\Delta d = v_f\,t - \tfrac{1}{2}\,a\,t^2$$

$$\Delta d = \tfrac{1}{2}\,(v_i + v_f)\,t$$

From combining the other equations
we can remove some variables.
These can be helpful!!

Free Fall

Falling objects have acceleration due to gravity .

- Equations use g for a
- Down is negative

Ex: $\Delta d = v_i\,t + \tfrac{1}{2}\,g\,t^2$

$g = -9.8\ \text{m/s}^2$

Use the following table to organize information
Fill in all given information
Use equations to find unknowns one by one

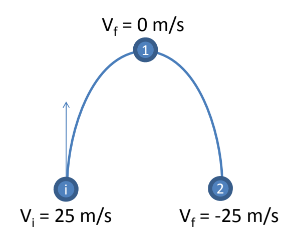
v_f	
v_i	
a	
d	
t	

A foul ball is hit straight up into the air with a speed of 25m/s. How high does it go and how long is it in the air?

First!! - Draw a picture and determine what two points to use

Point 1 is the maximum height (and half flight time).

	Initial to Point 1
v_f	0 m/s – Assumed
v_i	25 m/s - Given
a	-9.8 m/s² - Given
d	
t	

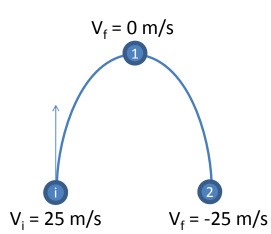


Use equations to find unknowns
To find max height, use an equation with only d as an unknown

$$\mathbf{v_f^2 = v_i^2 + 2\,a\,d}$$

$$d = \frac{v_f^2 - v_i^2}{2\,a} = \frac{(0\text{m/s})^2 - (25\ \text{m/s})^2}{2\,(-9.8\ \text{m/s}^2)} = 31.9\ \text{m}$$

	Initial to Point 1
v_f	0 m/s – Assumed
v_i	25 m/s - Given
a	-9.8 m/s² - Given
d	31.9 m
t	

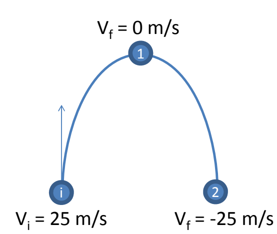


To find total flight time, use an equation with only t as an unknown
Use assumptions from Point 2 for data.

$$\mathbf{v_f = v_i + a\,t}$$

$$t = \frac{v_f - v_i}{a} = \frac{-25\ \text{m/s} - 25\ \text{m/s}}{-9.8\ \text{m/s}^2} = 5.1\ \text{s}$$

	Initial to Point 2
v_f	-25 m/s – Assumed
v_i	25 m/s - Given
a	-9.8 m/s² - Given
d	0 m – Assumed
t	5.1 s



A car traveling 4,5 m/s speeds up to 22 m/s in 8 s. What distance did this take place?

$V_f = 22\ m/s$

$V_i = 4{,}5\ m/s$

$a = $ (2,2 m/s²)

$d = $ (106 m)

$t = 8\ s$

$\Delta d = V_i t + \frac{1}{2} a t^2$

$V_f = V_i + a t$

$V_f = V_i + a t$

$\frac{V_f - V_i}{t} = a = \frac{22\ m/s - 4{,}5\ m/s}{8\ s} = 2{,}2\ m/s^2$

$\Delta d = (4{,}5\ m/s)(8\ s) + \frac{1}{2}(2{,}2\ m/s^2)(8\ s)^2$

$\Delta d = 106{,}4\ m$

or

$V_f^2 = V_i^2 + 2ad$

$\frac{V_f^2 - V_i^2}{2a} = d = \frac{(22\ m/s)^2 - (4{,}5\ m/s)^2}{(2)(2{,}2\ m/s^2)}$

$d = 105{,}4\ m$

A rocket is launched with an initial velocity of 50 m/s straight up. At what time(s) will the rocket be at 100 m

Hint $a = -9{,}8\ m/s^2$

V_f

V_i 50 m/s

a −9,8 m/s²

d 100 m

t

$\Delta d = V_i t + \frac{1}{2} a t^2$

$100 = 50\ m/s\ t + \frac{1}{2}(-9{,}8) t^2$

$t = \frac{-50 \pm \sqrt{50^2 - (4)(-60)(-4{,}9)}}{2(-100)}$

$t = 2{,}73$ and $7{,}47\ s$

Max Height?

$V_f = 0\ m/s$

$V_i = 50\ m/s$

$a = -9{,}8$

$d = ?$

$t = ?$

$V_f^2 = V_i^2 + 2ad$

$\frac{V_f^2 - V_i^2}{2a} = d$

$\frac{-(50\ m/s)^2}{2(-9{,}8)\ m/s^2} = 127{,}6\ m$