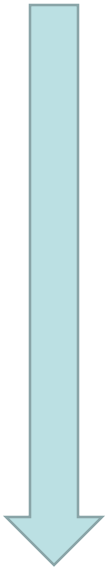
Kinematics in One Dimension: Describing Motion

- Vector / Scaler Quantities
- Displacement, Velocity, Acceleration
- Graphing Motion
- Average Velocity & Acceleration
- Instantaneous Velocity & Acceleration
- Free Falling Bodies
- Velocity & Displacement using Integration

Kinematics in One Dimension
Describing Motion

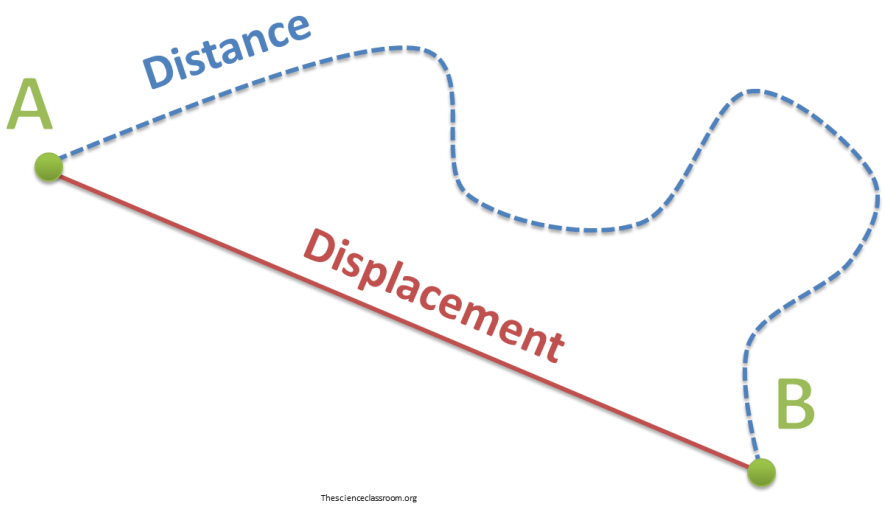
- Vector Quantity
  - –Has Magnitude & Direction
    - **Ex: Force-You must push or pull in a certain direction.**
    - Push can be considered positive Direction
    - Pull –negative direction



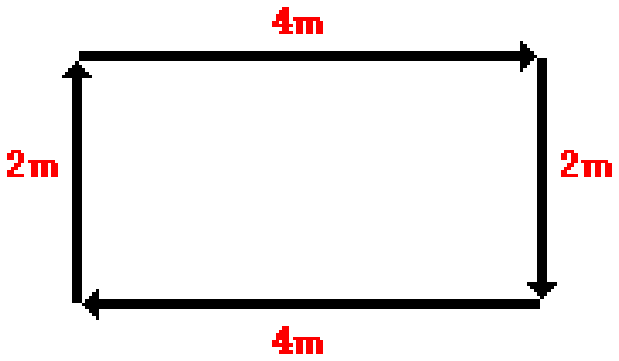
- Scaler Quantity
  - –Magnitude only
  - –Ex: mass-10 kg is 10 kg

Motion=change in position

- Distance
  - Scaler Quantity
- Total Length
  - Always Positive



- Displacement
  - Vector quantity
  - Measured from start position to final position
  - Can be positive or negative.



Rate of Change in Position

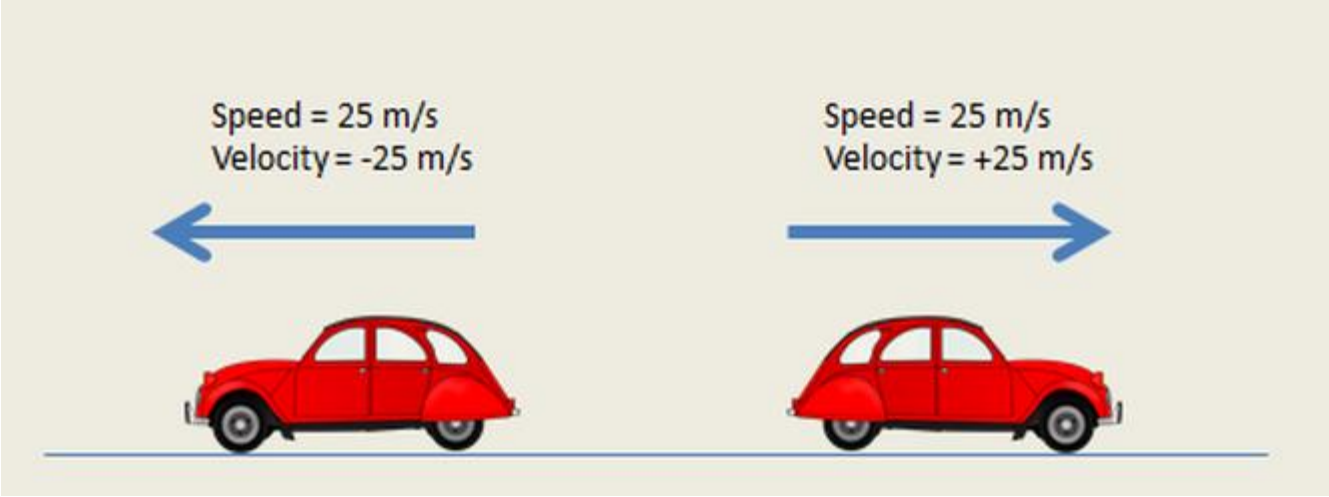
Speed

- Scaler quantity
- Magnitude only

Velocity

- Vector Quantity
- Magnitude & Direction

$$v_{\text{av}} = \frac{d_2 - d_1}{t_2 - t_1} = \frac{\Delta d}{\Delta t}$$



Rate of Change of Velocity

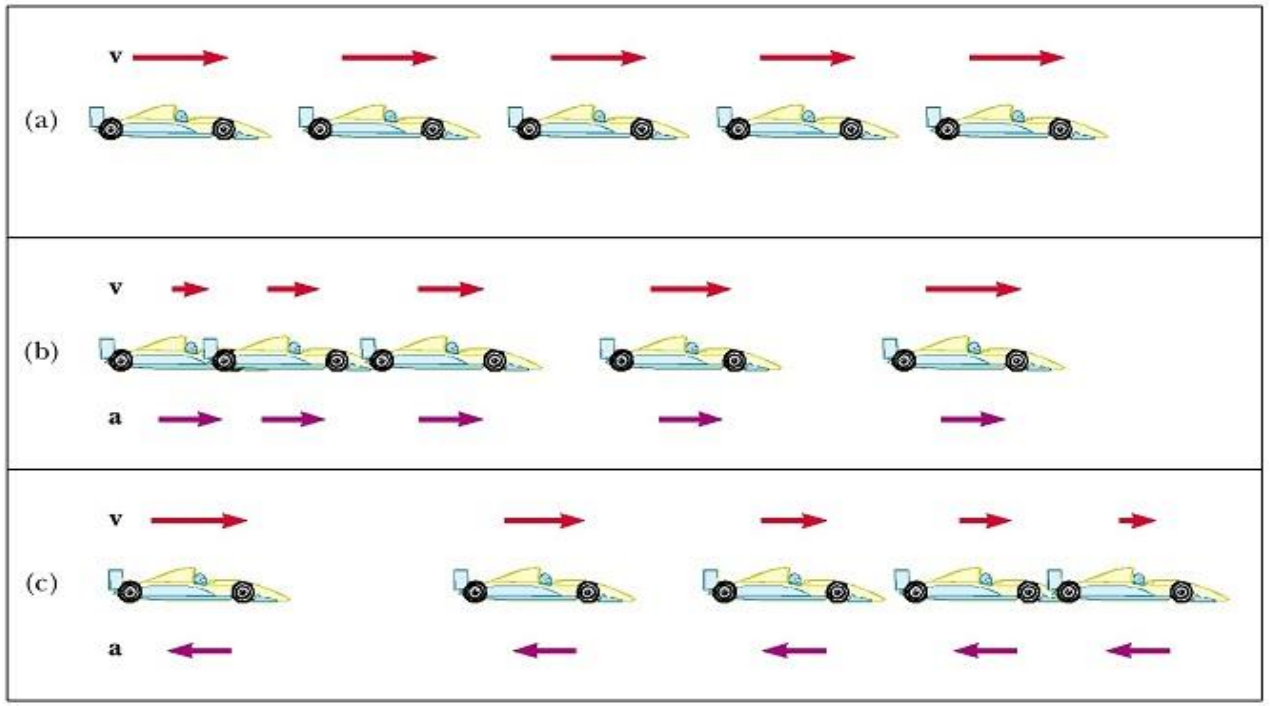
Acceleration

- Vector Quantity

Deceleration

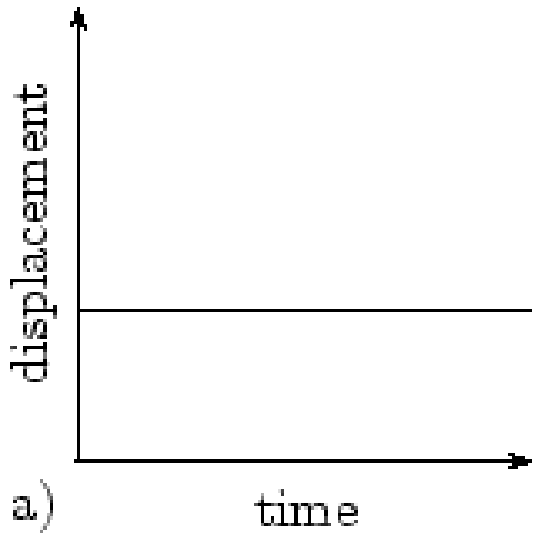
- Slowing down
- Scaler quantity

$$a_{\text{av}} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

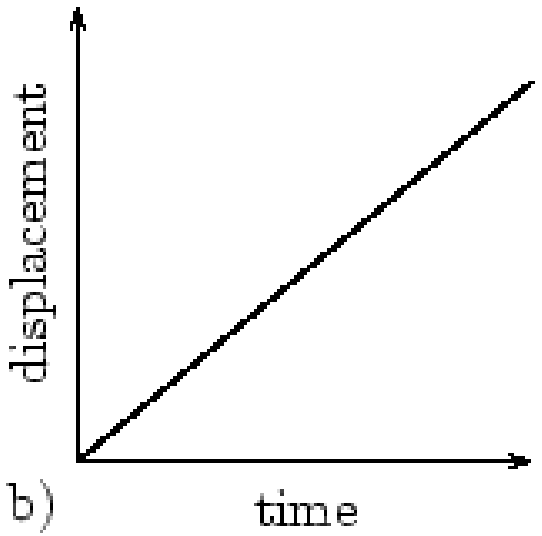


Graphing Motion

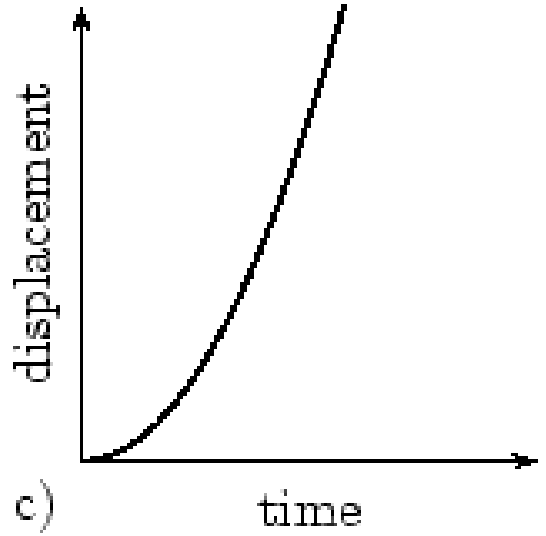
- Displacement vs. Time
  - Slope = velocity



$v = 0$



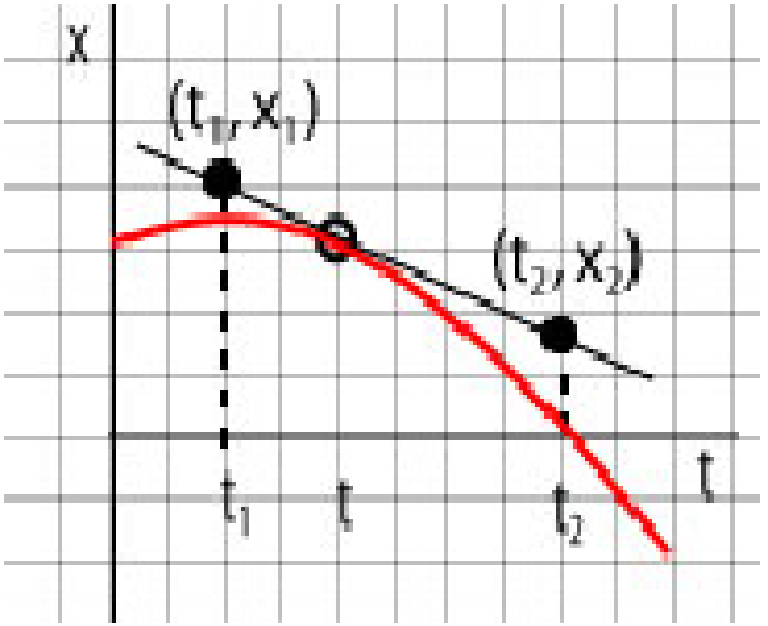
$d = vt + d_i$



$d = \frac{1}{2} at^2 + v_i t + d_i$

Displacement vs. Time
Slope = velocity
Instantaneous Velocity

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$



Displacement vs. Time
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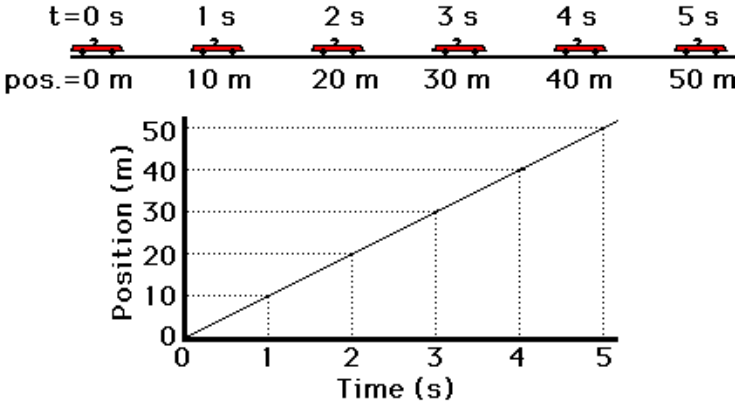
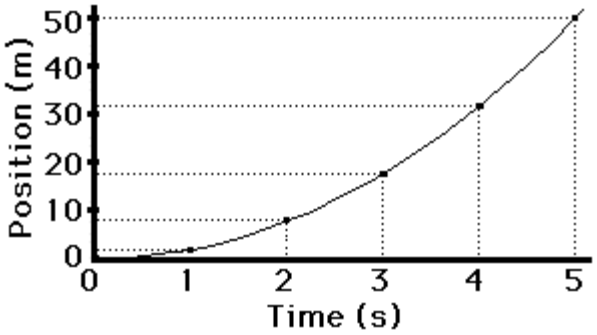




$$d = vt + d_i$$

$$\frac{dx}{dt} = v$$

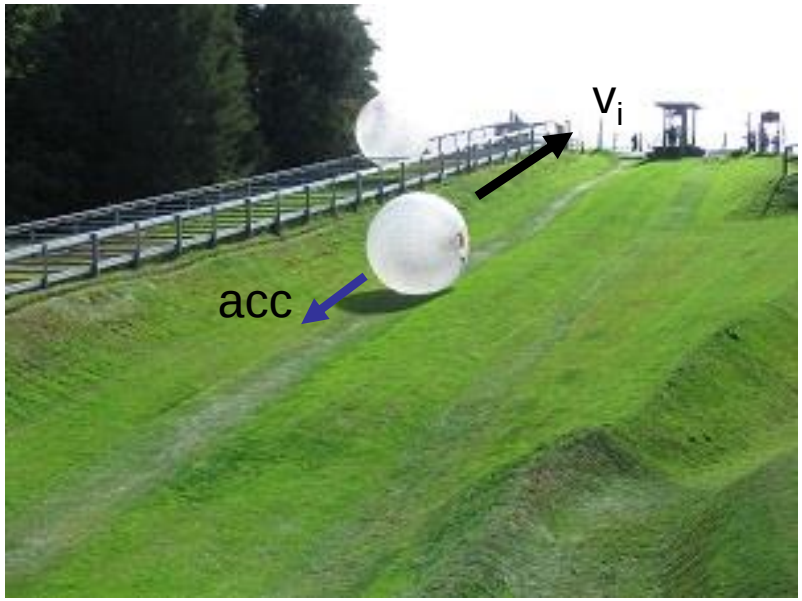
$$d = \tfrac{1}{2} at^2 + v_i t + d_i$$

$$\frac{dx}{dt} = v = at + v_i$$

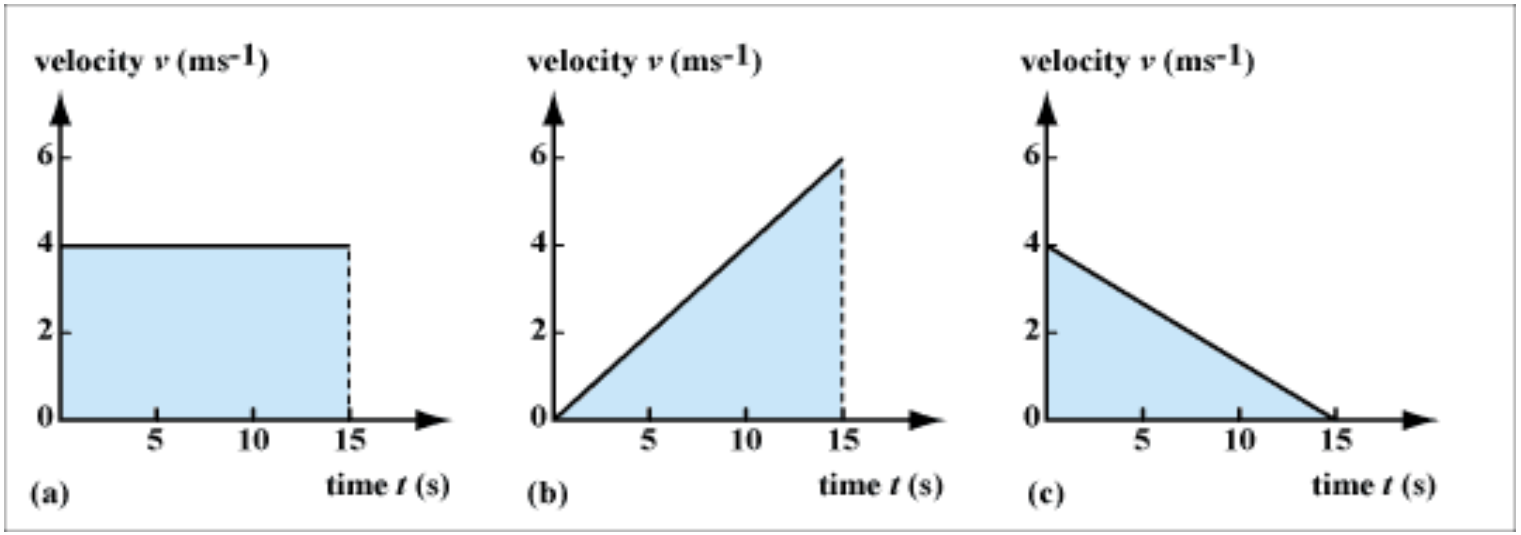
EXAMPLE:

A ball rolls up a ramp with initial velocity of 5.0 m/s and an acceleration of 2.5 m/s^2 directed down the ramp.

A. Write an equation to describe the motion.
B. Sketch a d/t graph of the motion of the ball.
C. What is the average velocity after 1.5s
D. What is the instant velocity after 1.5 seconds?
E. What is the maximum displacement of the ball?



Graphing Motion
velocity-time graphs



$v = at + v_i$ Slope of v/t graph = acceleration

$d = \frac{1}{2}(v_i + v_f)t$ Area of v/t graph = displacement

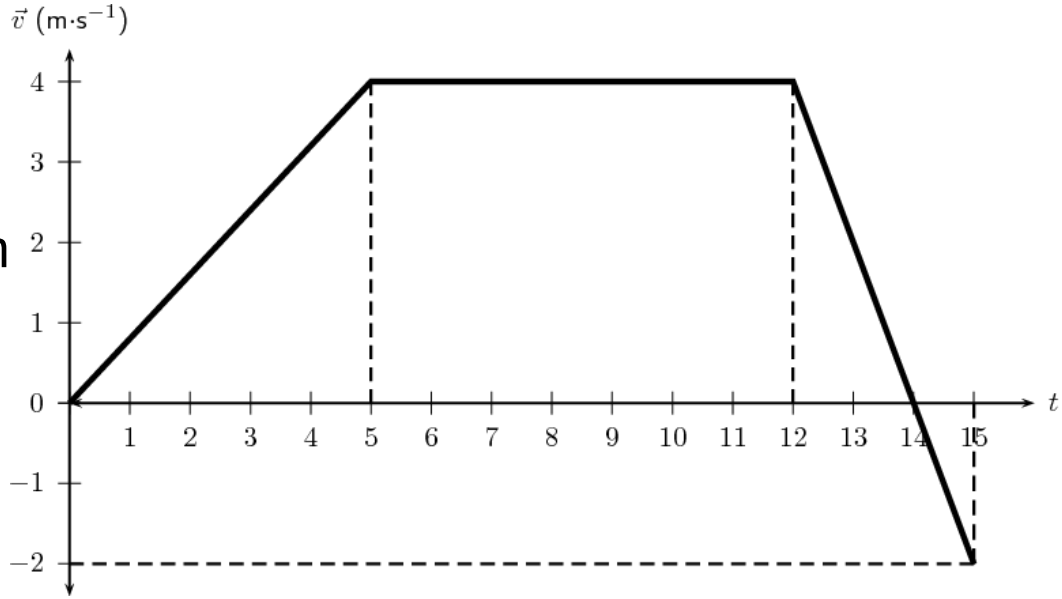
EXAMPLE:

A car skids to a stop with initial velocity of 15.0 m/s and an acceleration of 3.0 m/s^2

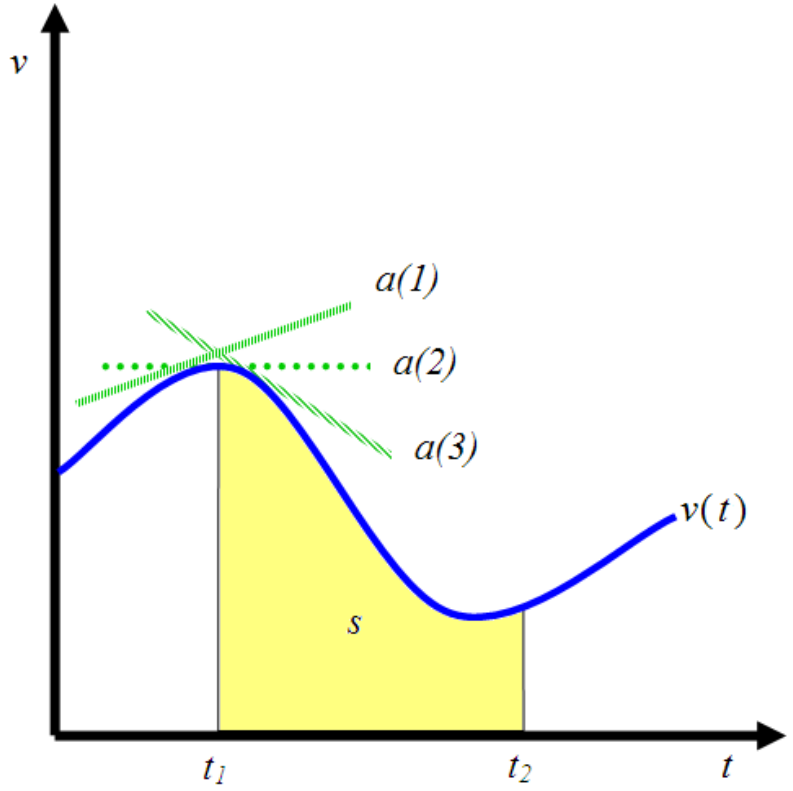
A. Write velocity equation to describe the motion.
B. Sketch a v/t graph of the motion of the car.
C. What is the velocity of the car after 2.0 seconds?
D. What is the displacement of the car after 2.0s?

Example:

A. Describe the motion shown in the graph
B. What is the acceleration from 0-5 seconds
C. What is the acceleration from 12-15 seconds
D. What is the displacement from 0 – 12 seconds
E. When does the direction change?



Graphing Motion
velocity-time graphs



Slope = Acceleration

$$a_x = \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt}$$

EXAMPLE:

The velocity of a fish is given by the equation:

$v = -2.5t^2 + 4t + 1$

A. Sketch a graph for the velocity of the fish
B. Write an equation for the acceleration of the fish
C. Sketch a graph of the acceleration of the fish
D. What is the velocity when the acceleration is a zero?

EXAMPLE:

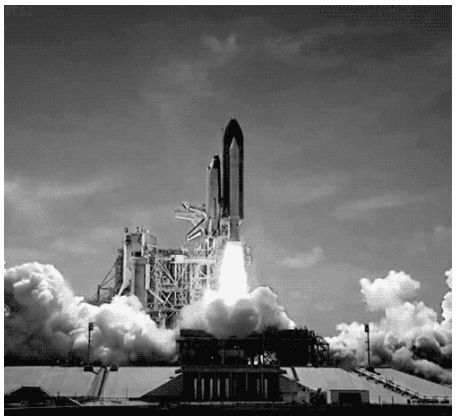
The velocity of a duck is given by the equation:

$$d = 4t^3 - 2t^2 + 4t$$

A. Sketch a graph for the displacement of the duck
B. Write an equation for the velocity of the duck
C. Sketch a graph of the velocity of the duck
D. Write an equation for the acceleration of the duck
E. Sketch a graph of the acceleration of the duck

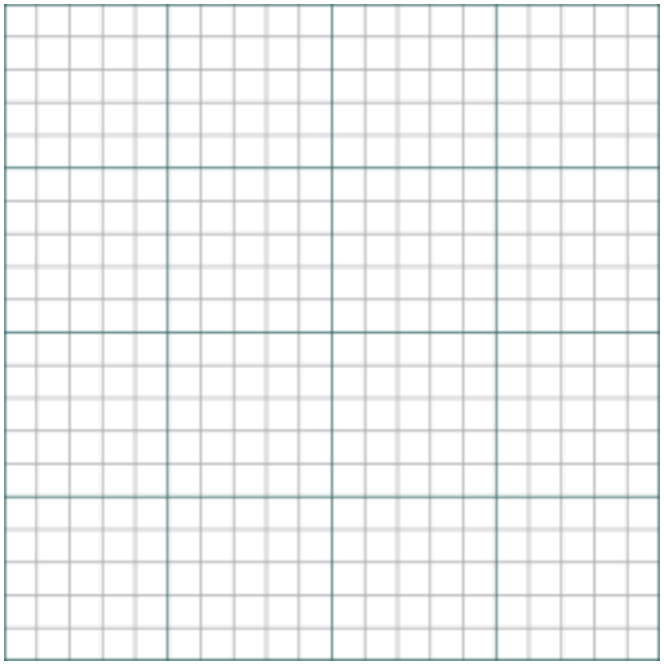
USING GRAPHS TO SOLVE PROBLEMS

1. Read Problem
2. Sketch Graph
3. Use Graph to determine equations(s)
4. Determine strategy to solve problems



A rocket is fired straight up with an acceleration of 4.5 m/s^2. The engines fire for 10 seconds. It then continues upward until it comes to rest at maximum height. The chute then opens and it falls back to the ground at constant speed of 5 m/s.

A. What is the maximum height?
B. How long is it in the air?



During the Olympics 100m. A runner accelerated to maximum speed in 5.0 seconds then runs at a constant speed for the remaining time. The runners time was 10.5 seconds.

A. What was the runners top speed?

B. What was the runners acceleration for the first 5 seconds?

FREE FALLING OBJECTS

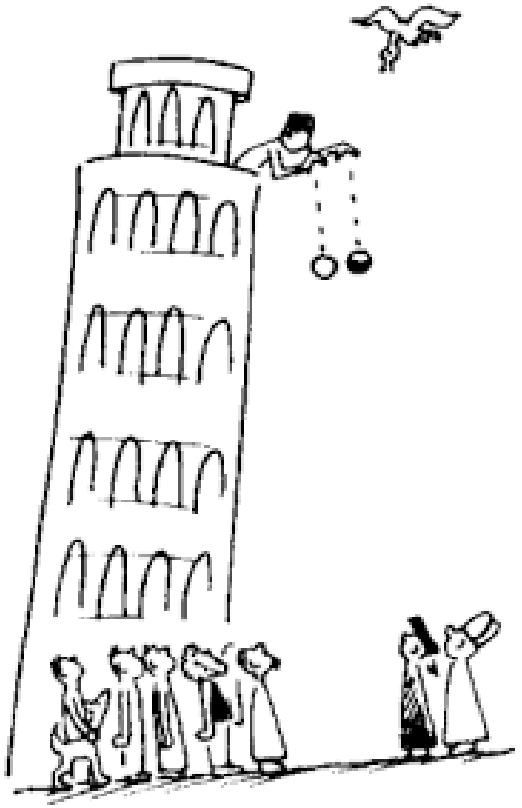
Acceleration due to gravity

Constant for all objects

$a = g = 9.8\ m/s^2$ downward

Can be positive or negative depending on reference frame

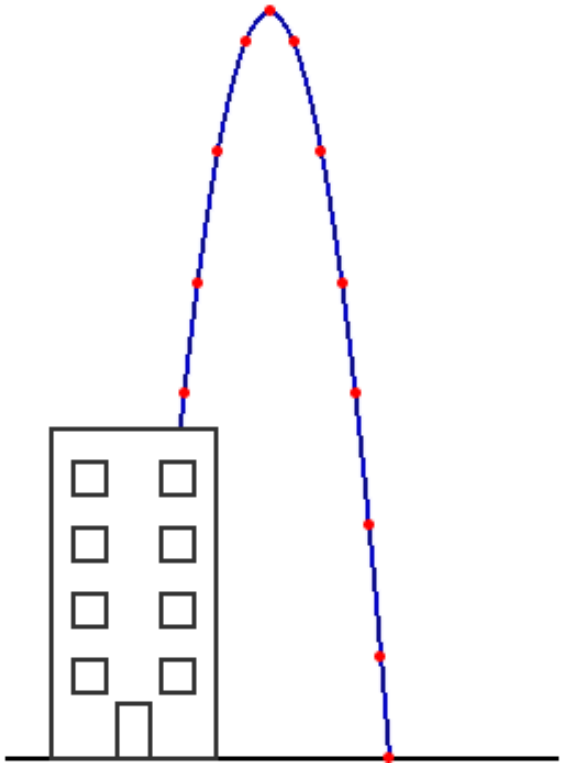
$32\ ft/s^2$



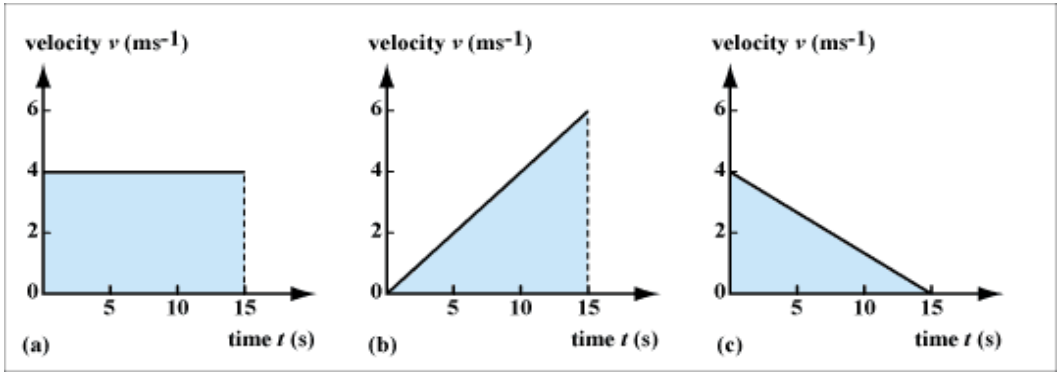
FREE FALLING OBJECTS

A rock thrown upwards with velocity of 15 m/s from the top of a building 20 m high.

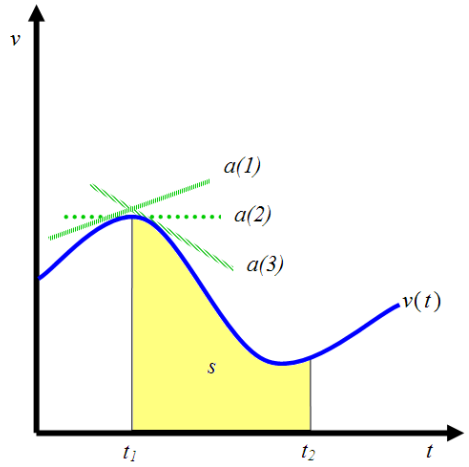
- How long is it in the air?
  - Is there a change in direction?
  - Vi = ?
  - D = ?
  - a =
- What is its final speed?
  - Vi = ?
  - a =
  - Vf =



Displacement using a velocity time graph.

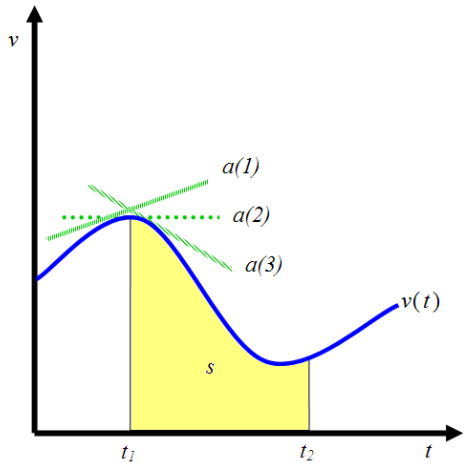


$$d = \tfrac{1}{2}(v_i + v_f)t$$



$$x = \int_0^t v_x \, dt$$

Displacement using a velocity time graph.



$$x = \int_0^t v_x dt$$

$$\int Ax^n = \frac{A}{n+1} x^{(n\ +\ 1)} + C$$

$$\int 5x^3 = \frac{5}{3+1} x^{(3\ +\ 1)} + C = \frac{5}{4} x^4 + C$$

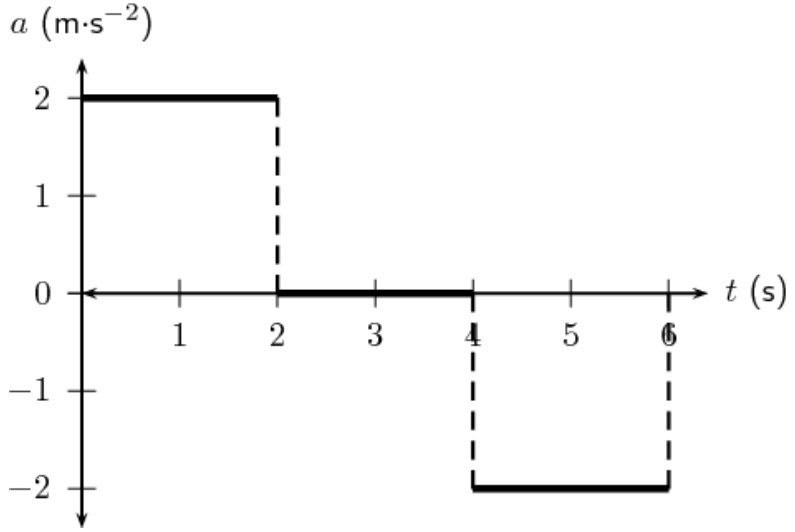
C is a constant = to initial displacement, or you must solve for it.

The velocity of a car is given by the equation ($v=6x^2-2$)

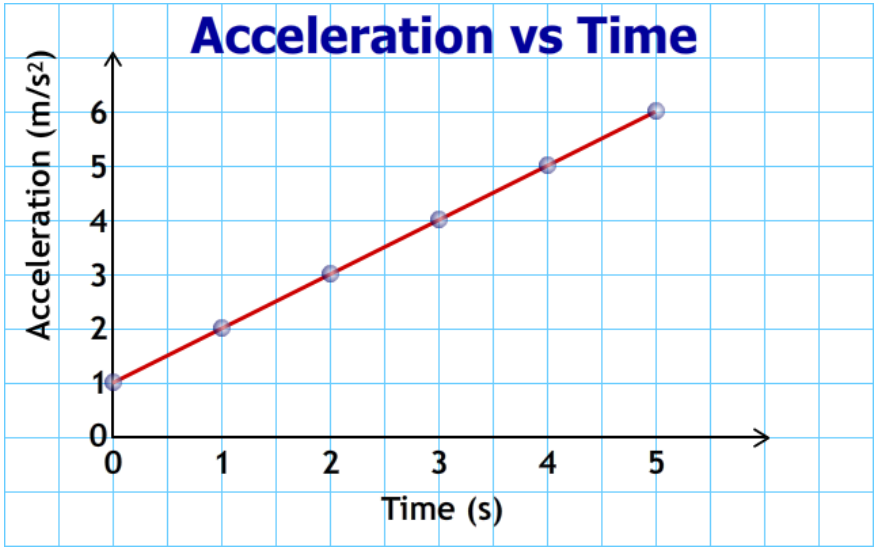
The displacement at ($t=3$) is ($d=20m$)

- Write an equation to determine the displacement of the car?
- Where is the car at ($t=8.0$) seconds?
- What is the acceleration of the car?

Velocity using an *acceleration vs. time* graph



$$v = at + v_i$$



$$v_x = \int_0^t a_x \, dt$$

The acceleration of a bullet is given by the equation ($a = 9x^2 + 4x$).

The displacement and velocity at ($t = 0$) is (0)

A. Write an equation to determine the Velocity of the bullet?
B. What is the velocity at $t = 2s$?
C. Write an equation to determine the displacement of the bullet?
D. What is the displacement at $t = 2s$?