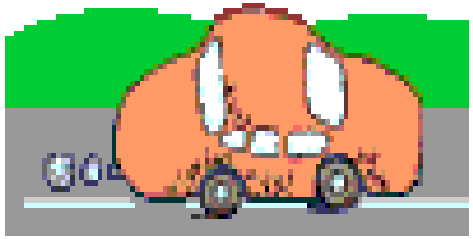
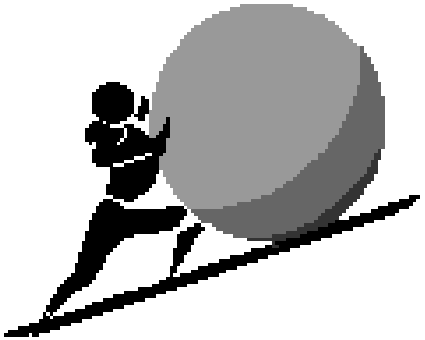
Speed



Inertia

Newton's Laws of Motion



FORCE

Velocity

Acceleration

What Is Motion?

- Motion is when an object changes place or position. To properly describe motion, you need to use the following:
- Start and end position?
- Movement relative to what?
- How far did it go?
- In what direction did it go?

Speed

- Speed is a description of motion.
- It is how fast an object moves.
- In other words speed is how much time it takes for an object to move from one position to another.

- Any change over time is a rate.
- Therefore, <u>speed is the rate of change in position, or rate of motion.</u>

Ways To Calculate Speed

•**Constant speed** is when you are traveling at the same rate of speed, such as 55 mph constantly on a highway (Speed that does not vary over a period of time).

•**Average speed** is taking the total distance traveled, and dividing by the total time it takes. Used for calculations that involve changing speed.

•**Instantaneous speed** is the speed at any one given point in time.

- When dealing with varying speeds, the best way to describe speed is average speed.

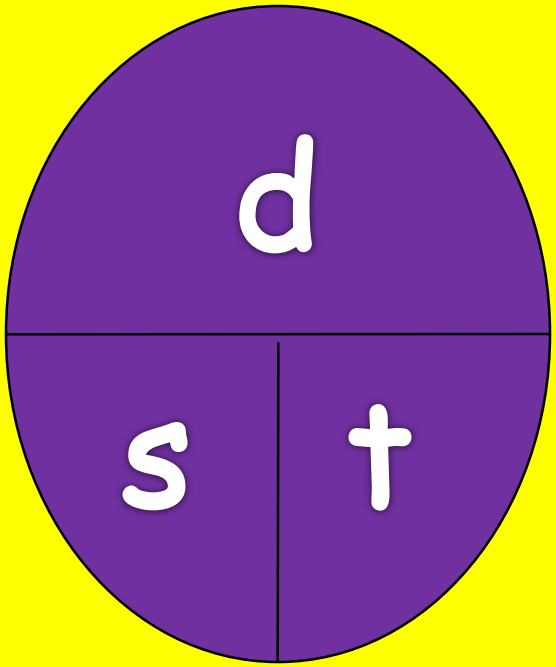
To calculate speed there is a simple formula.

$$s = \frac{d}{t}$$

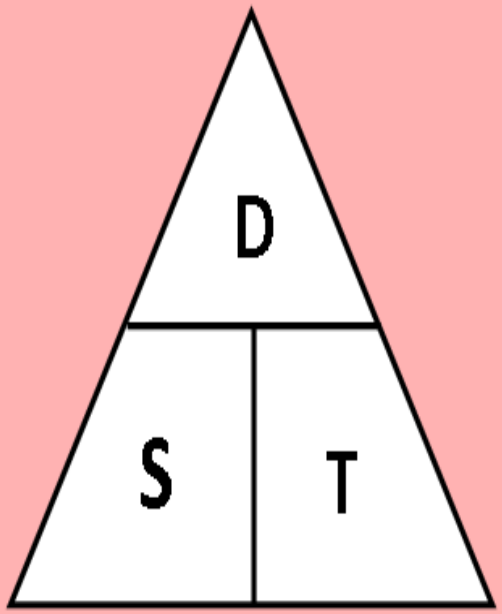
s = speed
d = distance
t = time

Standard units will be m/s

Remember to cover up the Letter you are solving for.



Speed Distance Time



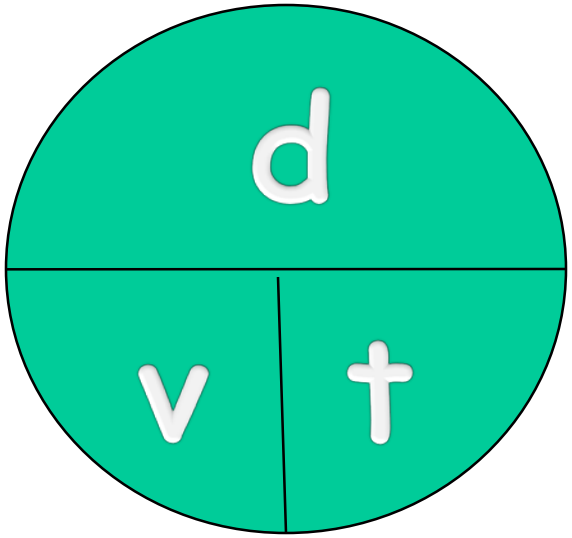
$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$\text{Distance} = \text{Speed} \times \text{Time}$$

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$

Velocity is similar to speed, however it includes speed and direction.

Ex: 55 m/s north
34 mph southwest
250 m/s down



v = velocity
d = distance
t = time

- ***Standard unit will be m/s with direction.***

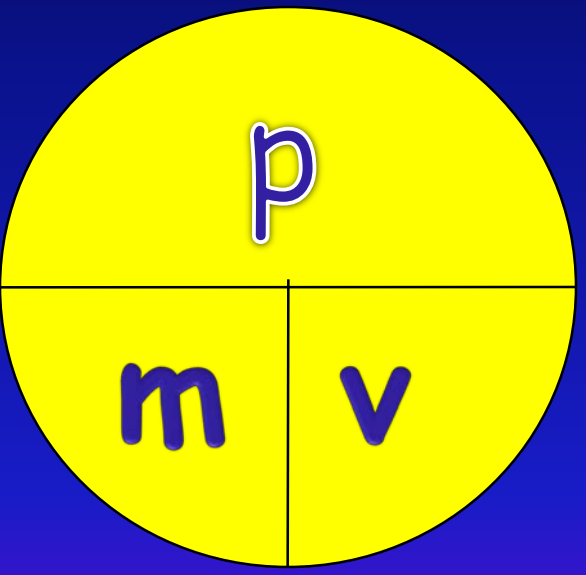
Velocity

MOMENTUM

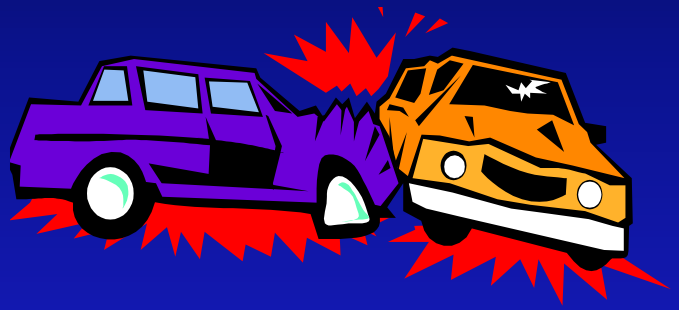
- If I were to roll a toy truck towards you, you could easily stop it.
- However, if I were to start a semi-truck rolling towards you at the same speed, it would be more difficult to stop even though they are rolling at the same speed. WHY?

Momentum is the property a moving object has due to its mass and velocity.

Formula for Momentum: $p = mv$



p = momentum
m = mass
v = velocity



Momentum can be transferred from one object to another.
Ex: car crash or two pool balls

Units will be $\frac{kg \times m}{s}$ with direction

1. Calculate the speed for a car that went a distance of 130 miles in 2 hours time.

a. 75mph

b. 65 mph

c. 70 mph

d. 80 mph

2. How much time does it take for a car traveling east on I-20 going 45 miles per hour to travel a distance of 90 miles?

a. 1 hr.

b. 2 hrs.

c. 36 hrs.

d. 3 hrs.

1. Calculate the speed for a car that went a distance of 130 miles in 2 hours time.

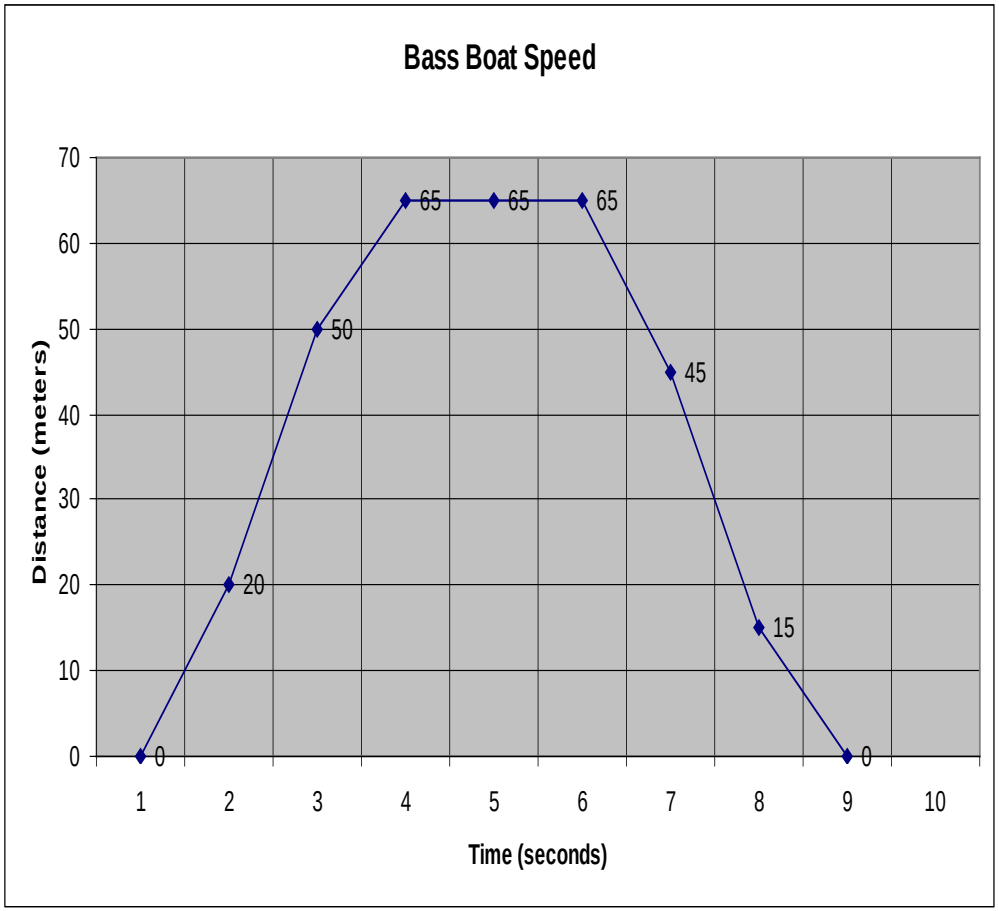
b. 65mph S=d/t S=130mi/2hr S=65mph

2. How much time does it take for a car traveling east on I-20 going 45 miles per hour to travel a distance of 90 miles?

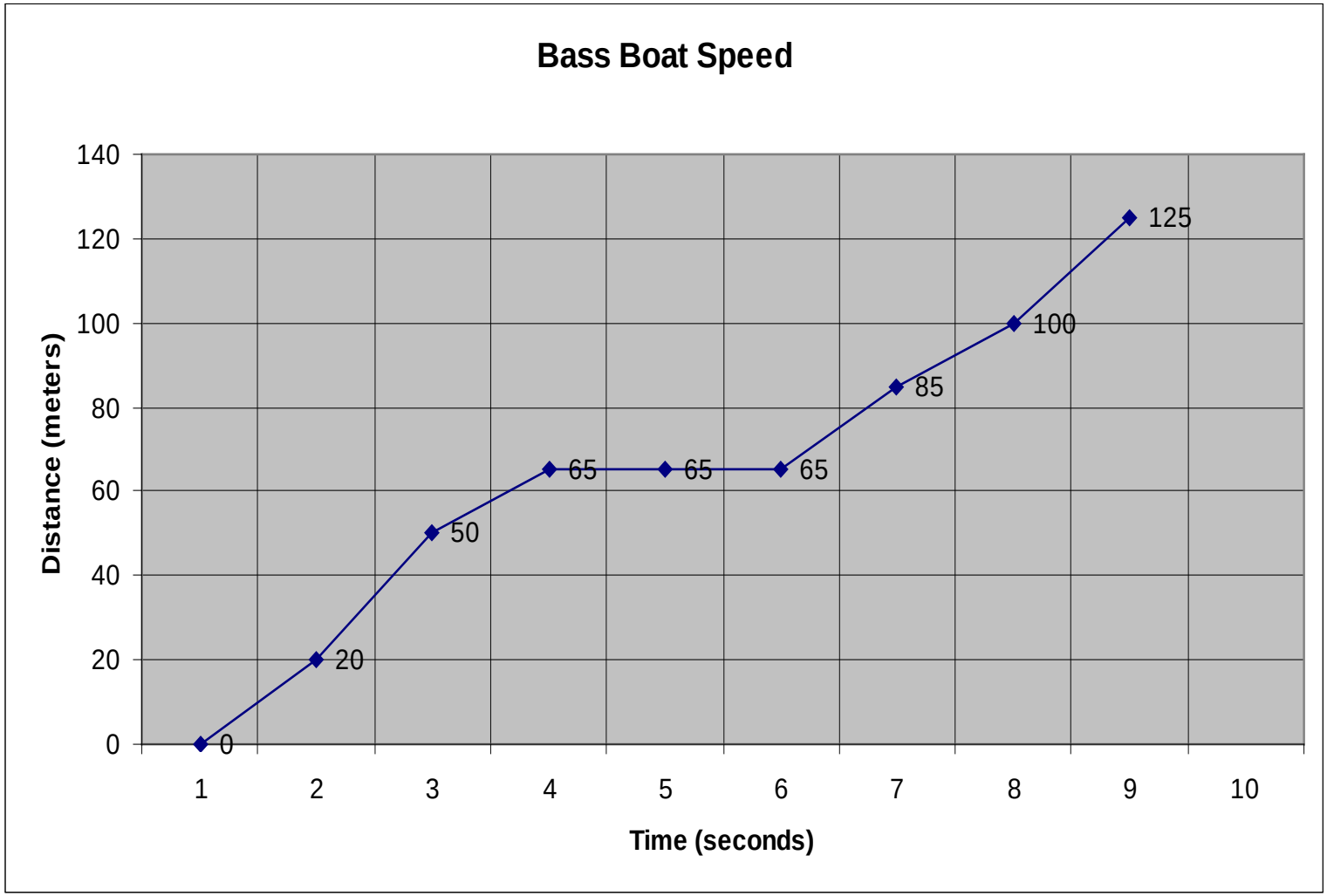
t=d/s t=90mi/45mph t=2hrs. B. 2hrs.

Graphing Speed

- Speed is usually graphed using a line graph, and it depicts the distance and time.
- Time is the independent variable, and thus is ALWAYS on the x-axis.
- Distance is the dependent variable, and is ALWAYS on the y-axis.

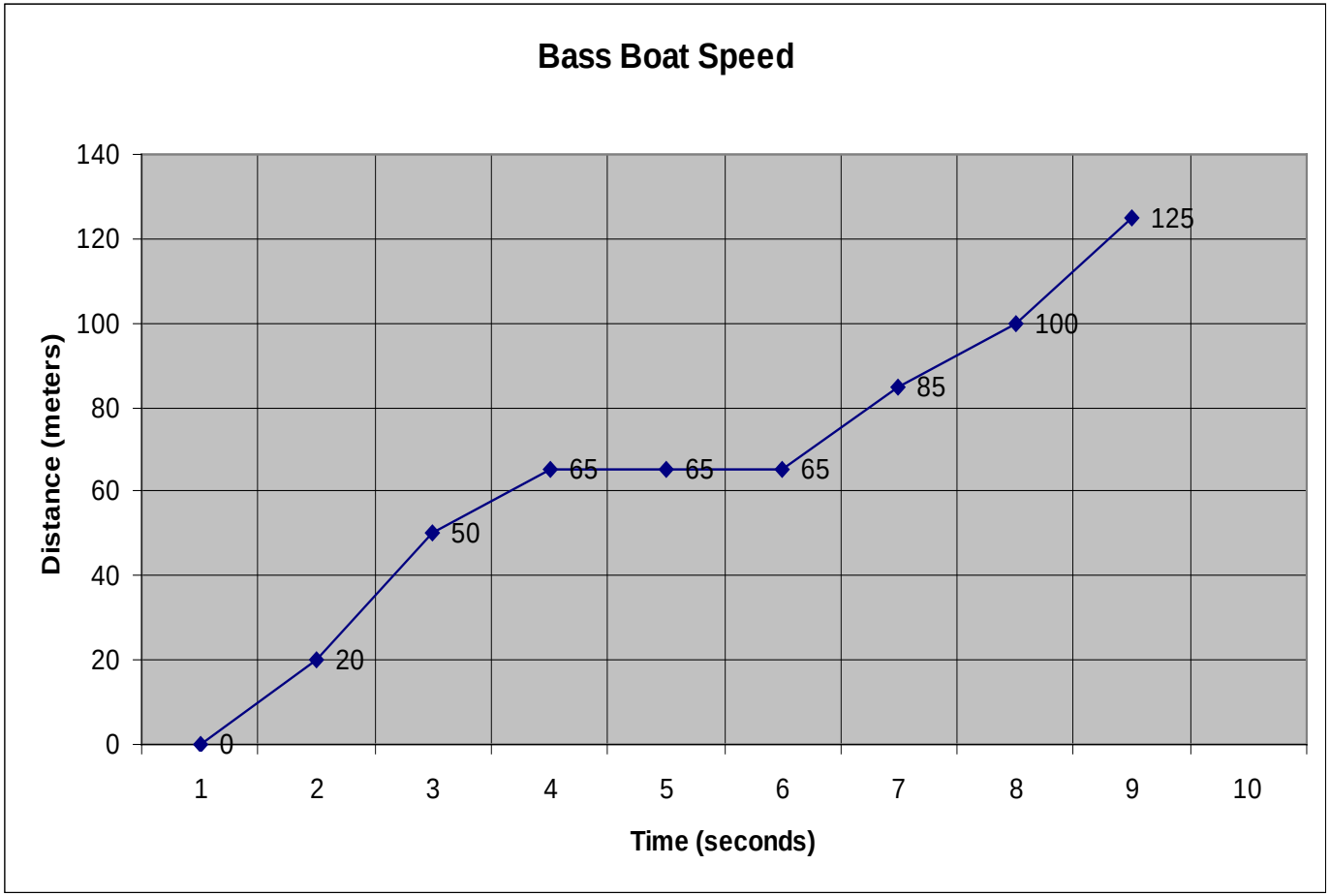


Average Speed



What is the AVERAGE speed of the bass boat depicted in the graph?

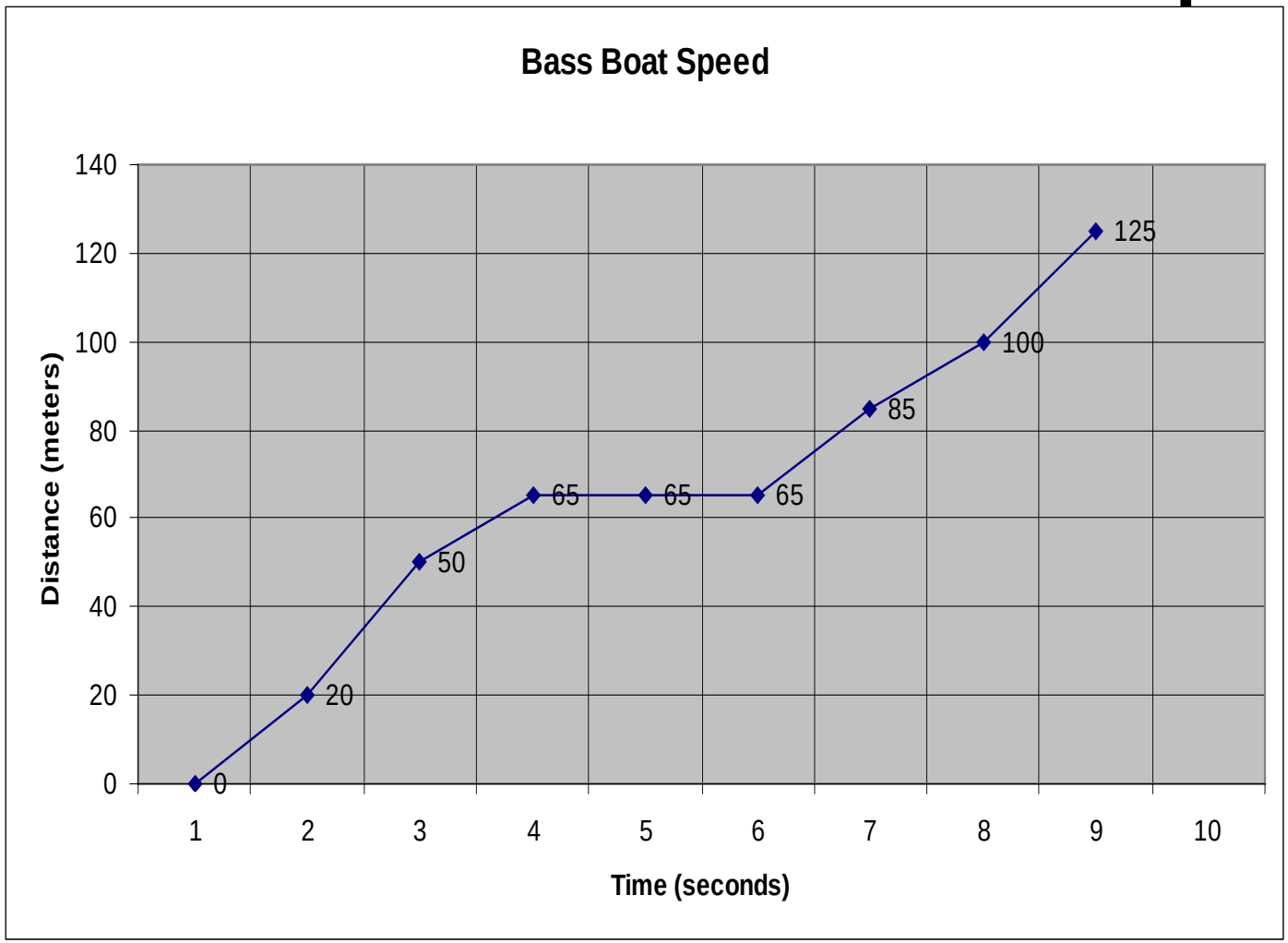
Average Speed



<u>Average speed</u> is taking the total distance traveled (0 to 125 meters), and dividing by the total time (1 to 9 seconds) it takes.

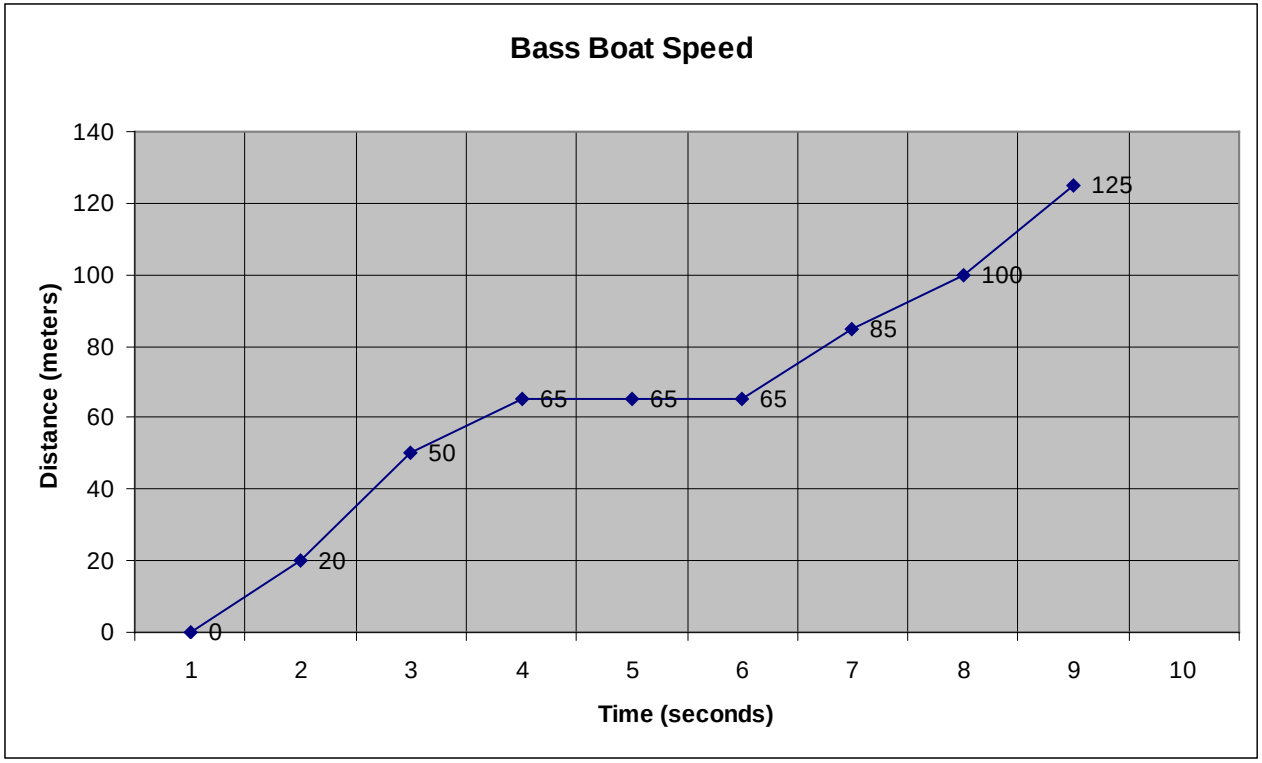
Average Speed = $\frac{\text{125 meters}}{\text{8 seconds}}$ = 15.6 m/s

Instantaneous Speed



What is the instantaneous speed of the bass boat at t=7 seconds?

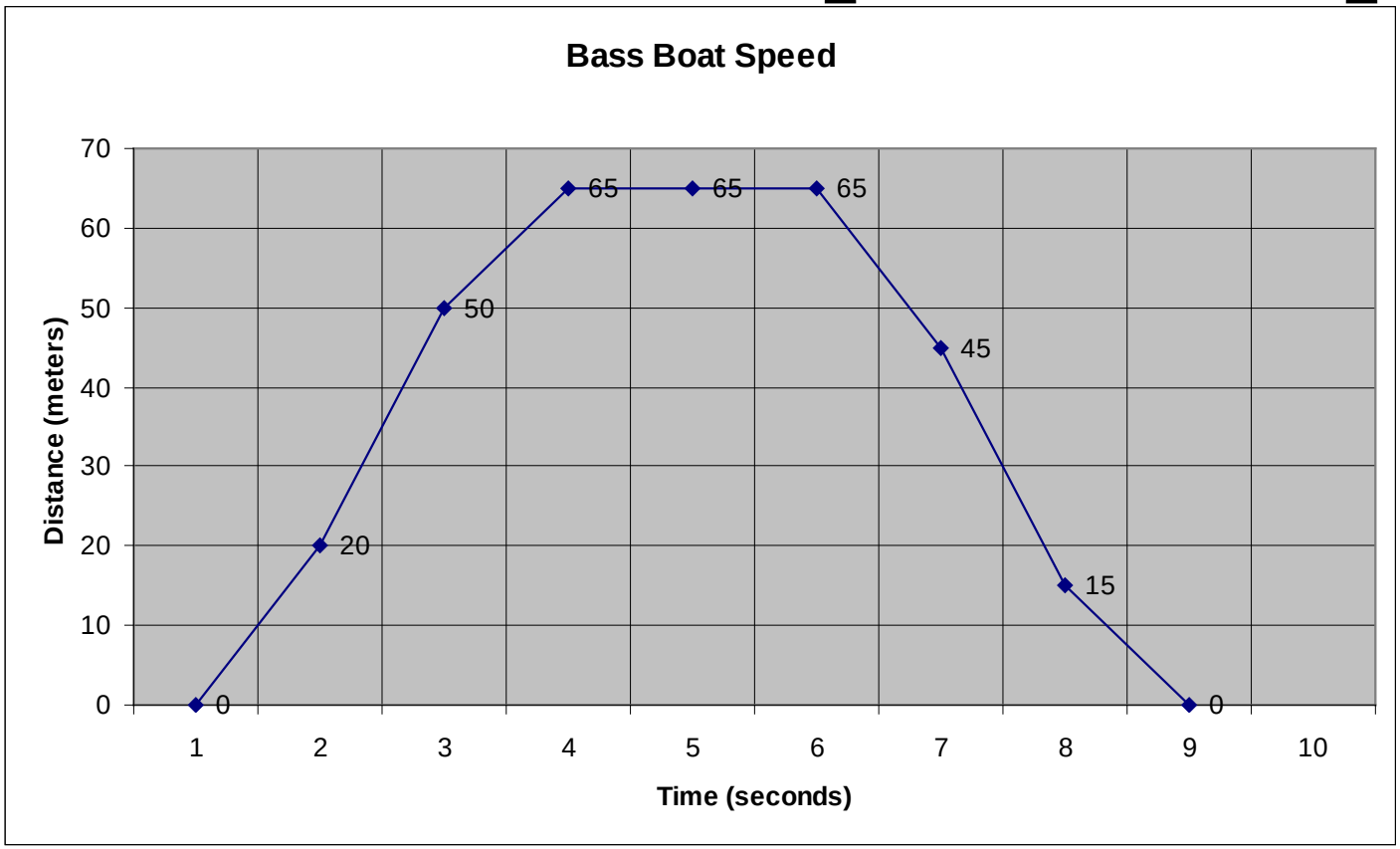
Instantaneous Speed



Instantaneous Speed = $\frac{\text{85 meters}}{\text{7 seconds}}$ = 12.1 m/s

Instantaneous speed is speed at any given point in time. At 7 seconds, the distance is 85 meters; therefore the IS is

Speed Graphs



- In what time period is the bass boat speeding up?
- In what time period is the bass boat slowing down?
- When is the speed NOT changing?

Velocity Problem

Indicate which of the following are velocities:

a. 125 cm/sec
b. 30 km/h northwest
c. 350m/sec north
d. 520 km/h

Velocity Problem

Indicate which of the following are velocities:

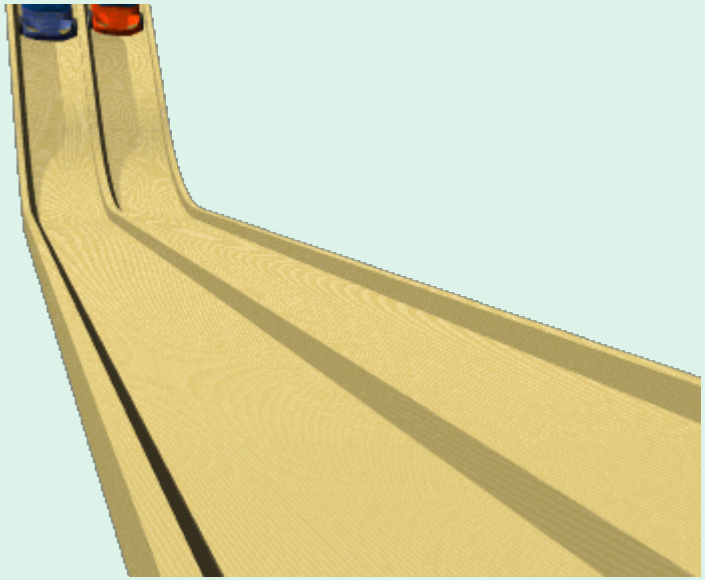
a. 125 cm/sec

b. 30 km/h northwest

c. 350m/sec north

d. 520 km/h

Acceleration



- Acceleration is the rate of change of velocity. A change in velocity can be either a change in speed, or direction, or both.
- Deceleration is when acceleration has a negative value.

Acceleration

Acceleration is the rate of change of velocity.

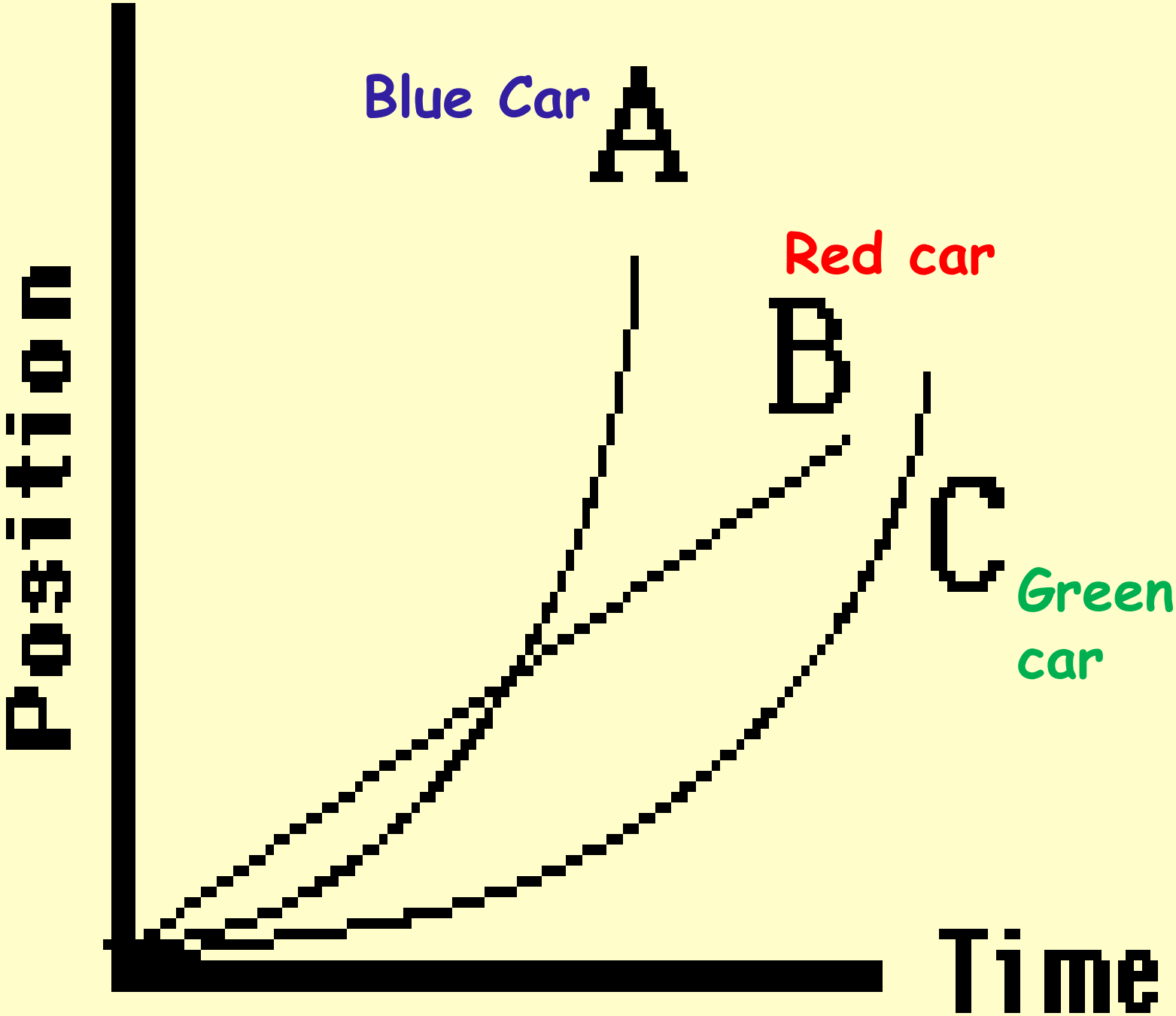
Acceleration is the measure of both the rate of change and direction.

Ex: if a car goes around a curve, its direction changes. This will cause a change in velocity, even if the speed stays the same. Therefore, acceleration occurs with a change in direction or a change in speed.

- As a final test of your understanding, consider the position-time graph on the next screen.

- Each one of the three lines on the position-time graph corresponds to the motion of one of the three cars.

- Match the appropriate line to the particular color of car.


Blue Car
A
Red car
B
C
Green car
Position
Time

Acceleration depends on both change in velocity and the time interval.

- Time interval is the amount of time that passed while the change in velocity was taking place.

$$a = \frac{V_f - V_i}{t}$$

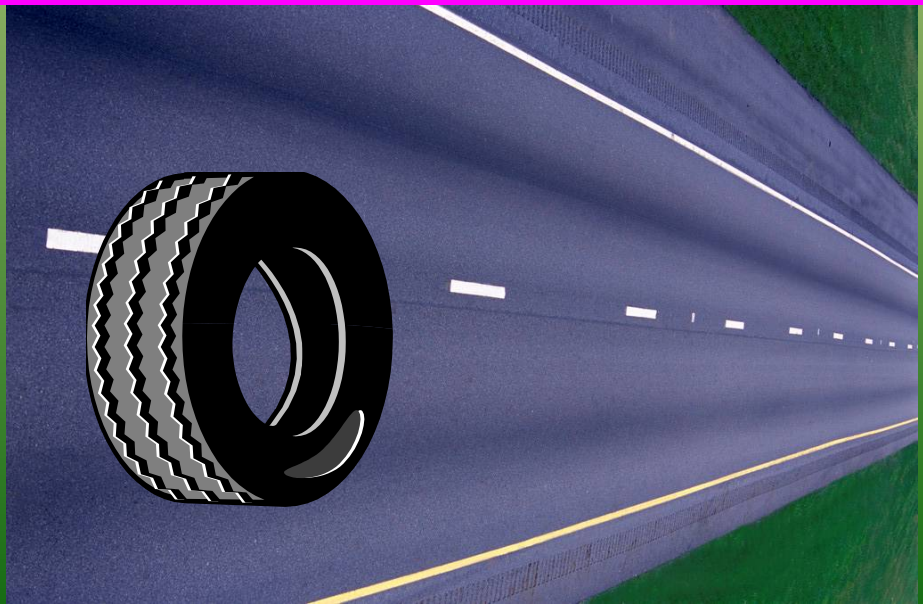
a = acceleration
Vf = final velocity
Vi = initial velocity
t = time

Units will be m/s/s OR m/s^2

Centripetal Force

Centripetal force is a force that causes a moving object to move in a curved or circular path (fights inertia).

Ex: This force is the force between the tires and the pavement.



Acceleration Math Problem

- A jet starts at rest at the end of a runway and reaches a speed of 80 m/s in 20 s. What is its acceleration?

Acceleration Math Problem

- A jet starts at rest at the end of a runway and reaches a speed of 80 m/s in 20 s. What is its acceleration?

- Acceleration (a) = $\frac{\text{final velocity } (v_f) - \text{initial velocity } (v_i)}{\text{time (sec)}}$

- $a = \frac{80 \text{ m/s} - 0 \text{ m/s}}{20 \text{ sec}} = 4 \text{ m/s}^2$

A skateboarder is moving in a straight line at a speed of 3 m/s and comes to a stop in 2 sec. What is his acceleration?

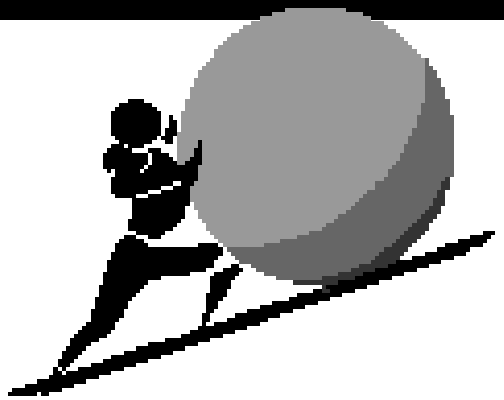
$$a = \frac{0\ m/s\ -\ 3\ m/s}{2\ m/s} = -1.5\ m/s^2$$

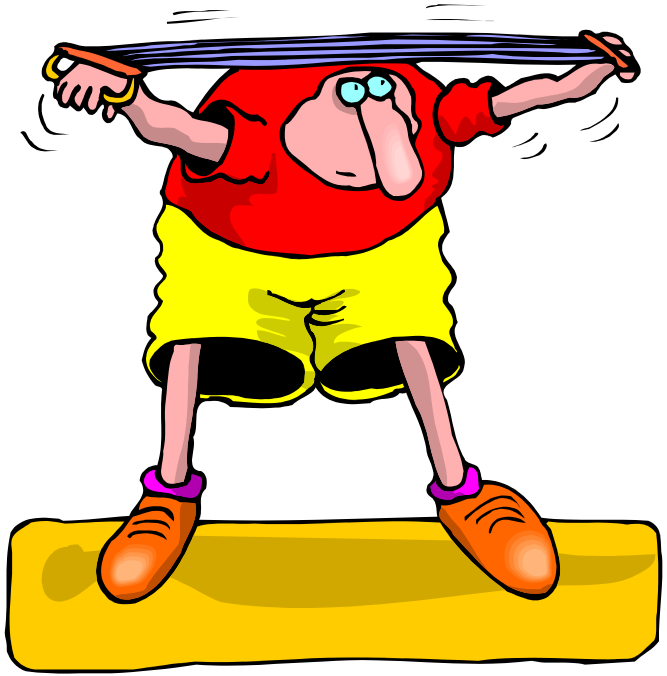
Forces

- **A force is a push or a pull**

Examples

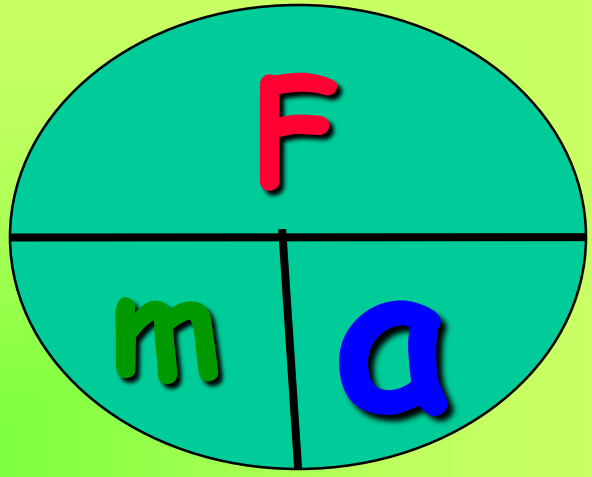
1. punching the wall
2. Force the floor exerts on your feet
3. pulling, pushing, stretching, squeezing, bending, and falling





F = force
m = mass
a = acceleration

$F = ma$



The SI unit of force is the Newton, named in honor of **Isaac Newton**.

One Newton of force is the amount of force needed to cause a one kilogram mass to accelerate at a rate of 1 m/s^2.

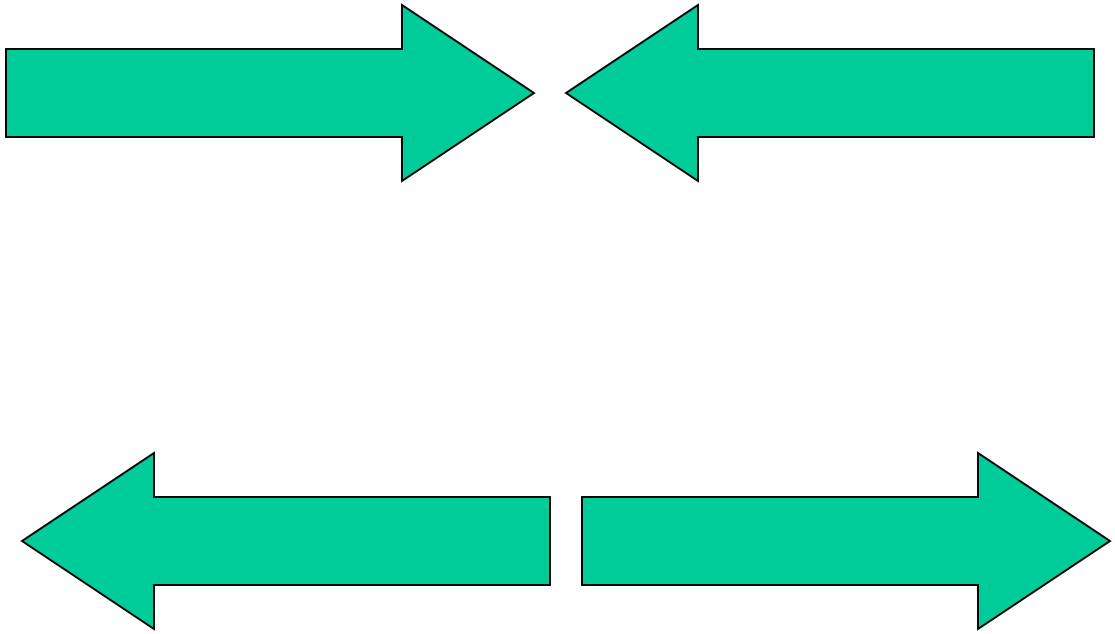
Force

- Can cause a change in motion
- Can cause a change in velocity
- Can cause acceleration
- There can be no acceleration without a force

Net Force

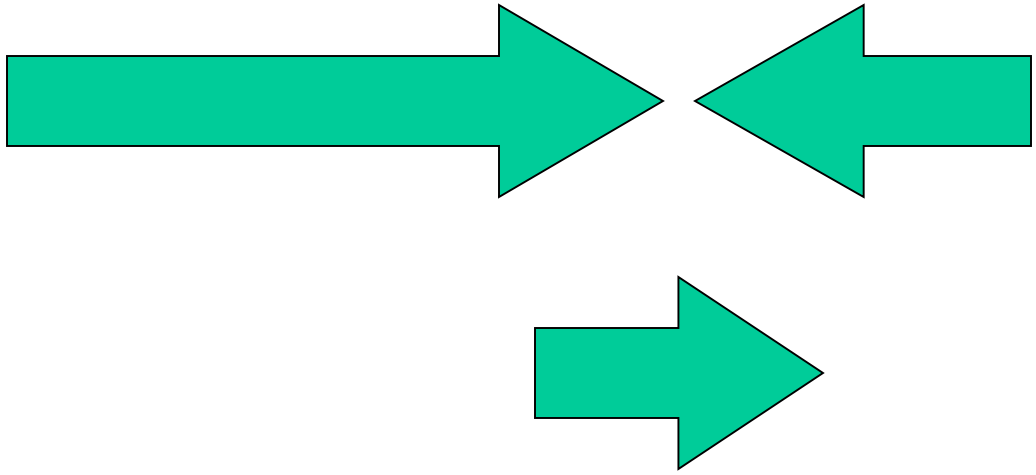
- **Usually many forces are acting at the same time**
- **Balanced Forces cancel out and give a net force of zero**
- **Balanced forces can not cause a change in motion**

Balanced Forces



Unbalanced Forces

- The forces don’t cancel out
- Unbalanced cause a change in motion
- Act as one force



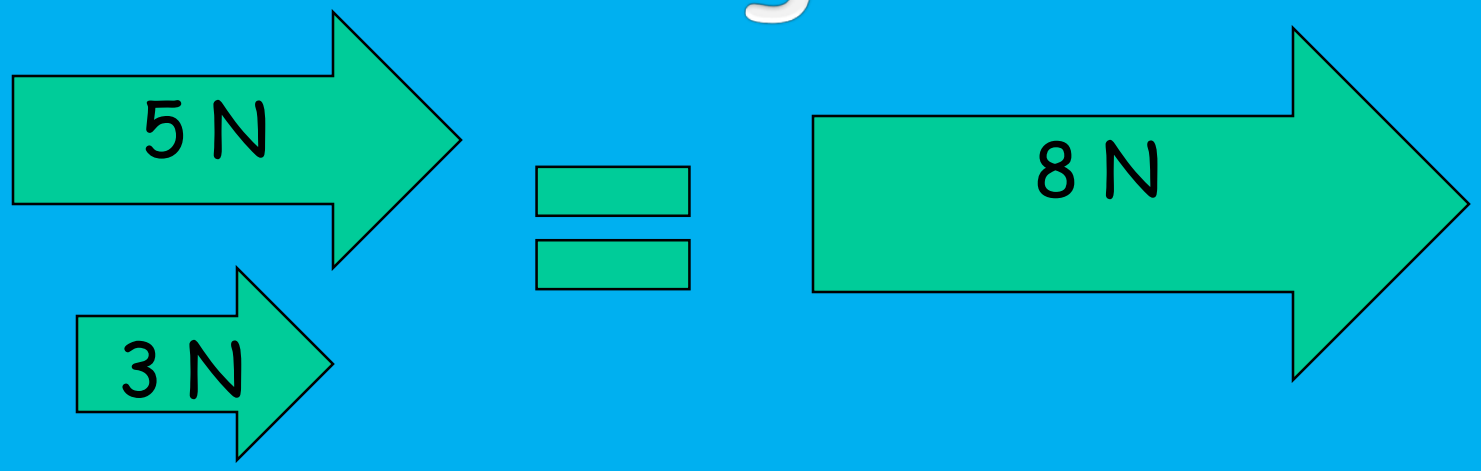
Forces act in a particular direction

Many times there is a combining force

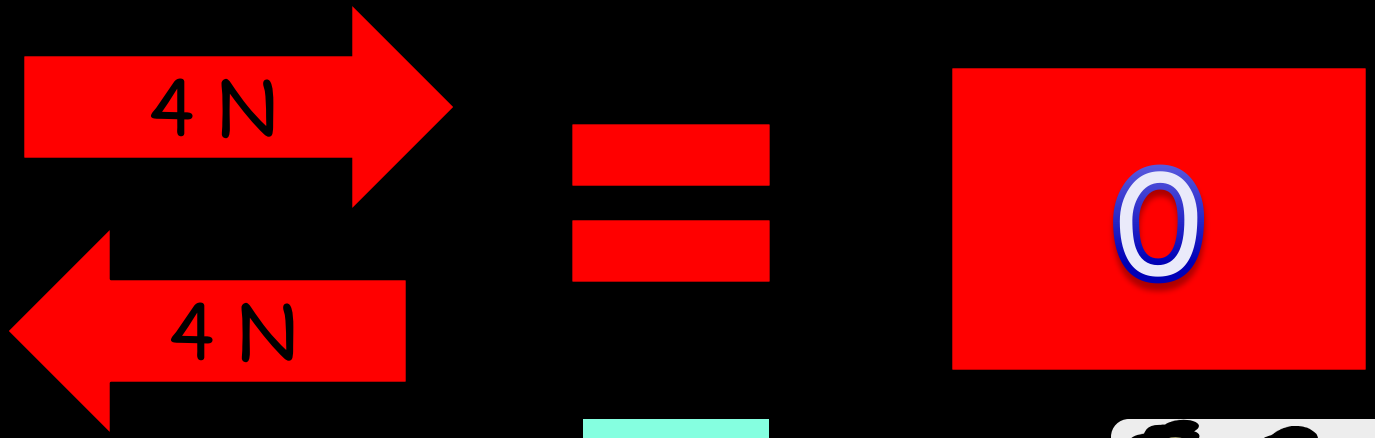
Force is measured in Newtons (N).

A Newton (N) is a $\frac{kg \times m}{s^2}$

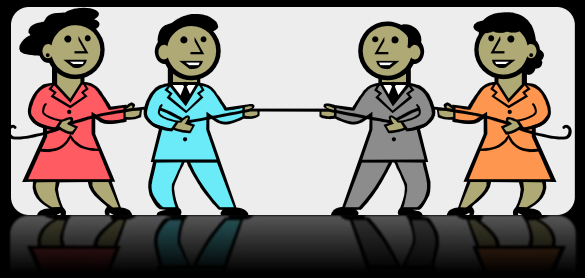
Combining forces

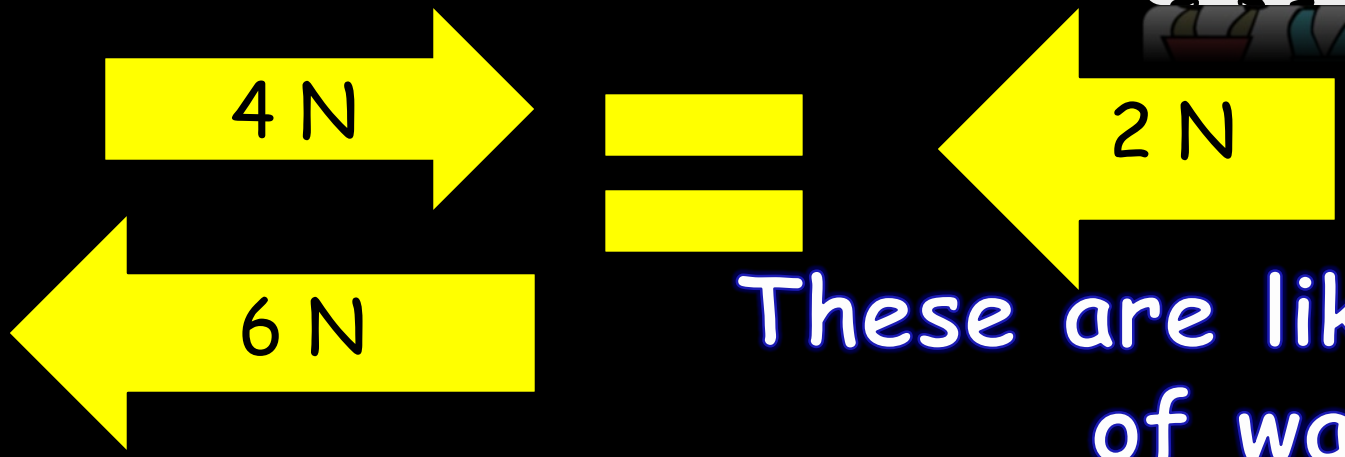


Sometimes forces oppose each other



or





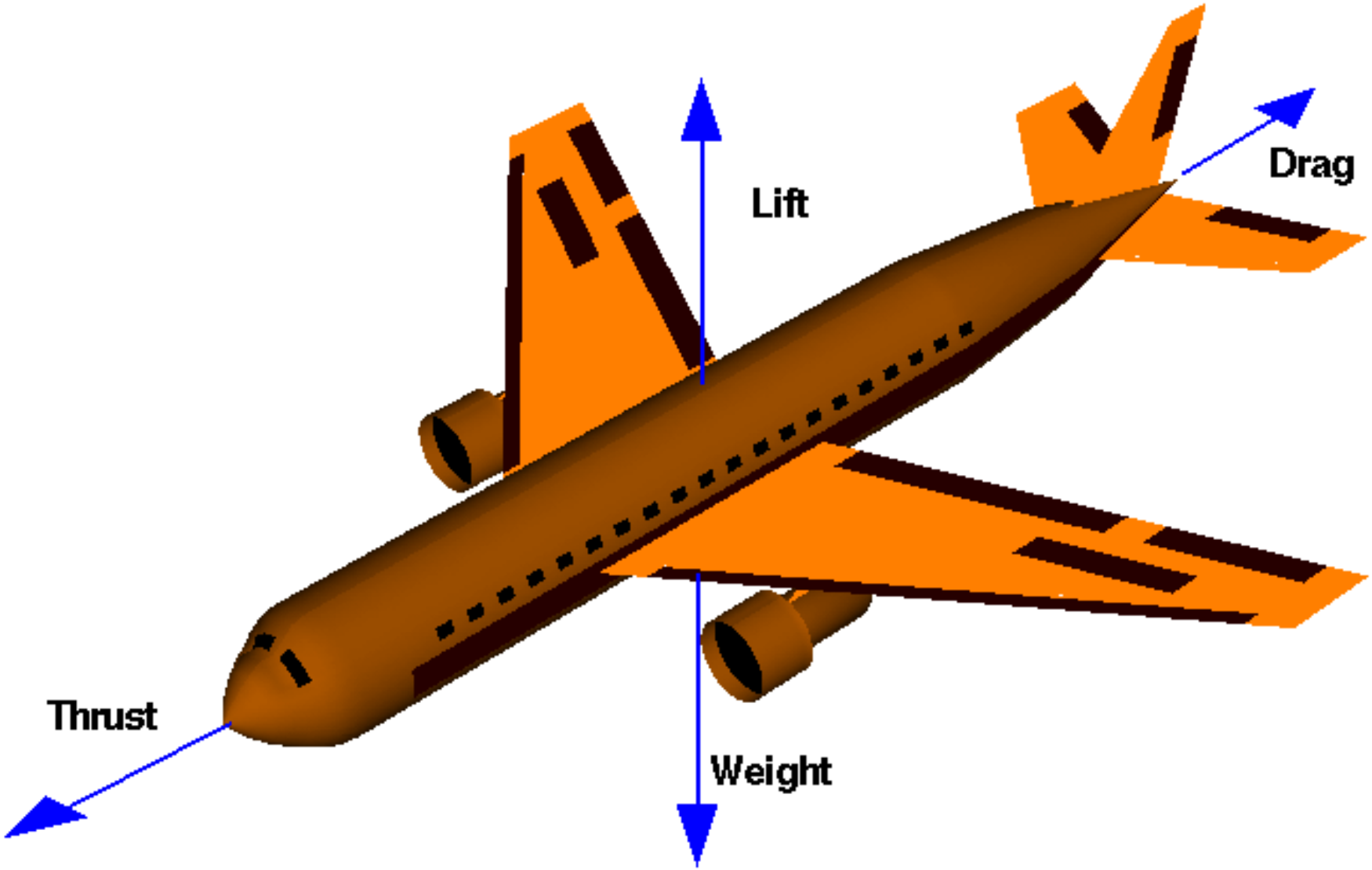
These are like a tug of war


balanced forces
100 N
100 N


truck moves in this direction
bigger force
100 N
unbalanced forces
smaller force
60 N

Four Forces on an Airplane

Glenn Research Center



How much force is needed to accelerate a 66 kg skier at 2 m/sec^2?

F=ma

F=66kg x 2m/sec^2 F=132 kg m/s^2 (Newton)

What is the force on a 1000 kg elevator that is falling freely at 9.8 m/sec^2?

F=ma

F=1000x 9.8 m/sec^2 F=9,800 kg m/s^2 (Newton)

The mass of a large car is 1000 kg. How much force would be required to accelerate the car at a rate of 3 m/sec^2?

F=ma

F=1500x3m/sec^2 f F=4500 Newton

Types of Forces

Inertia

Tendency of an object to resist a change in its motion

FRICTION

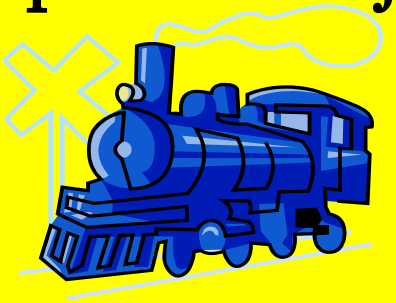
Force that opposes motion between two Surfaces that are touching one another

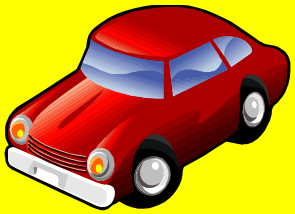
Would the bowling ball and the golf ball have the same inertia?

NO…why?

The more massive an object is, the greater its inertia…

And the greater an objects inertia is, the greater the force required to put the object in motion





FRICTION

Characteristics

1. Friction acts parallel to the surfaces in contact and in the direction opposite to the motion of the object
2. Friction depends on the nature of the materials in contact and the smoothness of their surfaces.

Effects of Gravity

Gravity – force that one object exerts on another

Amount of gravity depends on two things:

- their masses
- distance between the 2 objects

Earth's gravity causes a falling object to accelerate At 9.8 m/s^2

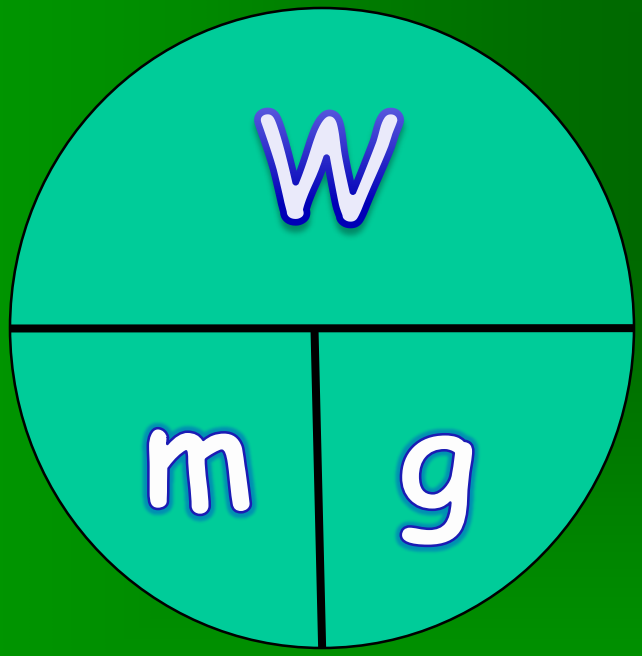
Weight – Depends on the amount of gravity

Weight is measured in Newtons (N).

WEIGHT

weight = mass x acceleration of gravity

$$W = mg$$



Air resistance

Force that air exerts on an object

Amount of Air resistance depends on:

1. Speed
2. Size
3. Shape
4. density

Terminal Velocity

Highest velocity that will be reached by a falling object.

- As an object falls, air resistance will gradually increase until it balances with the pull of gravity

- Since there is a balancing of forces, acceleration will stop. The object will continue to fall, but at the constant, final velocity

You measure a bag of apples as weighing 85 N on a scale and it on a surface of the earth with a 9.8 N/kg gravitational force. How massive is the bag of apples?

M=w/g

M=85 N/9.8 kg/N M=8.67 kg

If you were to carry the bag of apples to the surface of the moon, where the gravitational field is only 1.67 N/kg, how much would the apples weigh?

W=m x g

W=8.67kg x 1.67 N/kg W=14.48 N