Forces, Motion and Inertia

Describing Motion

- **Motion** is change in an object's position over time.
- **Motion** is sometimes difficult to describe…if you are standing still a car that passes by may appear to go very fast. However, from the perspective of the person driving the car…it may not seem fast at all!

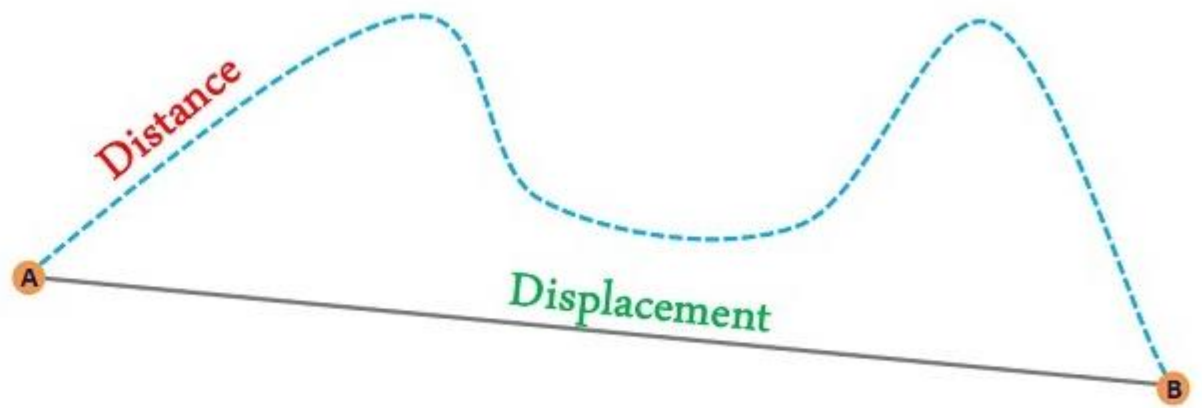
Motion

- To make sense of motion…we use **Reference Points**!
  - A Reference point is a stationary object, such as a tree, sign, dead body, a line in the road that you use to see if you are moving.
  - We use the Reference Point…because it is motionless…to determine the position, direction and speed of motion.

Motion

Distance vs. Displacement:

Distance: the length of a path between two points.
Displacement: the length from the starting point to the ending point. (shortest path)



- **Position** refers to an object's location relative to a reference point. Is it in front, behind, next to, beside, across from and so forth…
- **Direction** is the line or path along which an object moves.
- **Speed** is a measure of the distance traveled per unit of time.

Motion

- To calculate an object's speed, you MUST know the distance traveled and the time it took the object to travel that distance.

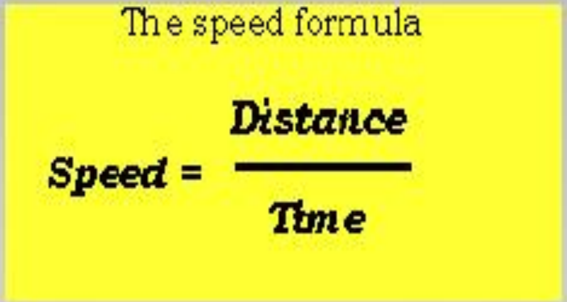
The formula (I know…you hate math) is:

The speed formula

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

Speed

- Fast Motorcycle: Bike travels 120 miles in .5 hour



  - Speed = 120 miles / .5 hour = 240 mph (miles per hour)

Computing Speed…Example

- Fast Runner: Sprinter runs 100 meters in 5 seconds:

The speed formula

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

  - Speed = 100 meters / 5 seconds = 20 meters per second

- Most objects do not move at a constant, unchanging speed…even a car that went 100 miles in 2 hours still had to come to a complete stop if the car approached a red light.
- When you use the speed formula, you are calculating the AVERAGE SPEED of an object.

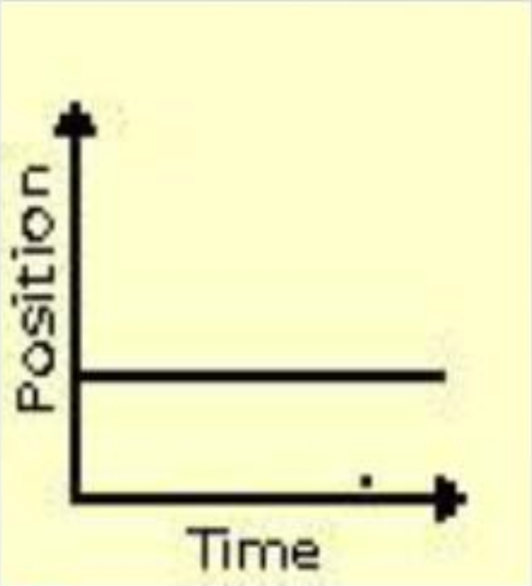
The speed formula

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

Velocity

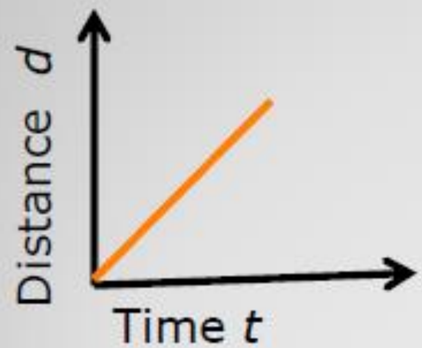
- **Velocity** is speed with some more additional information about the moving object.
  - I can say that an object is going 100 mph…but I am giving no indication of the **DIRECTION** that object is moving…unless I give you the object's velocity!
  - **Velocity** is **SPEED** in a particular **DIRECTION!**
    - SPEED = 60 mph VELOCITY = 60 mph north
    - SPEED = 90 kmh VELOCITY = 90 kmh south

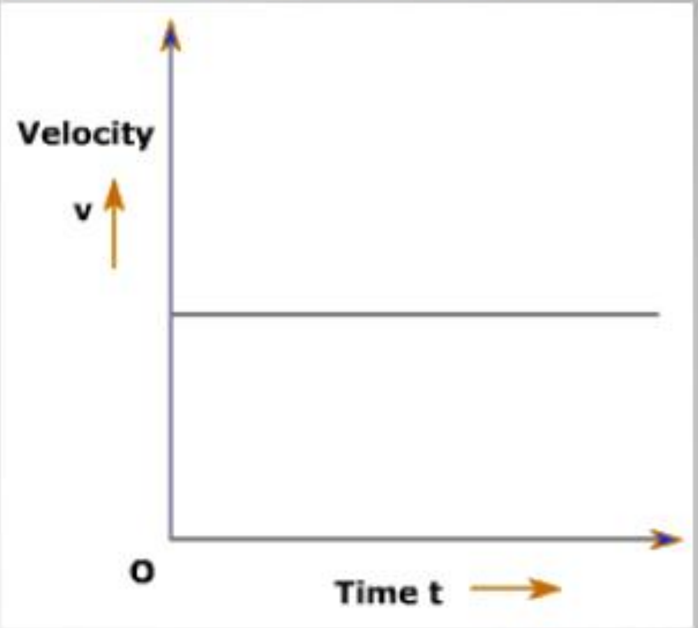
- We will use graphs to represent motion. One type of graph relates distance and time. The graph below is for a parked car. Notice the horizontal line…it is horizontal because the car is not moving.



Graphing Motion

- This graph shows a car moving at a CONSTANT velocity. Notice the straight line moving horizontally. This tells us that the car is not speeding up or slowing down.



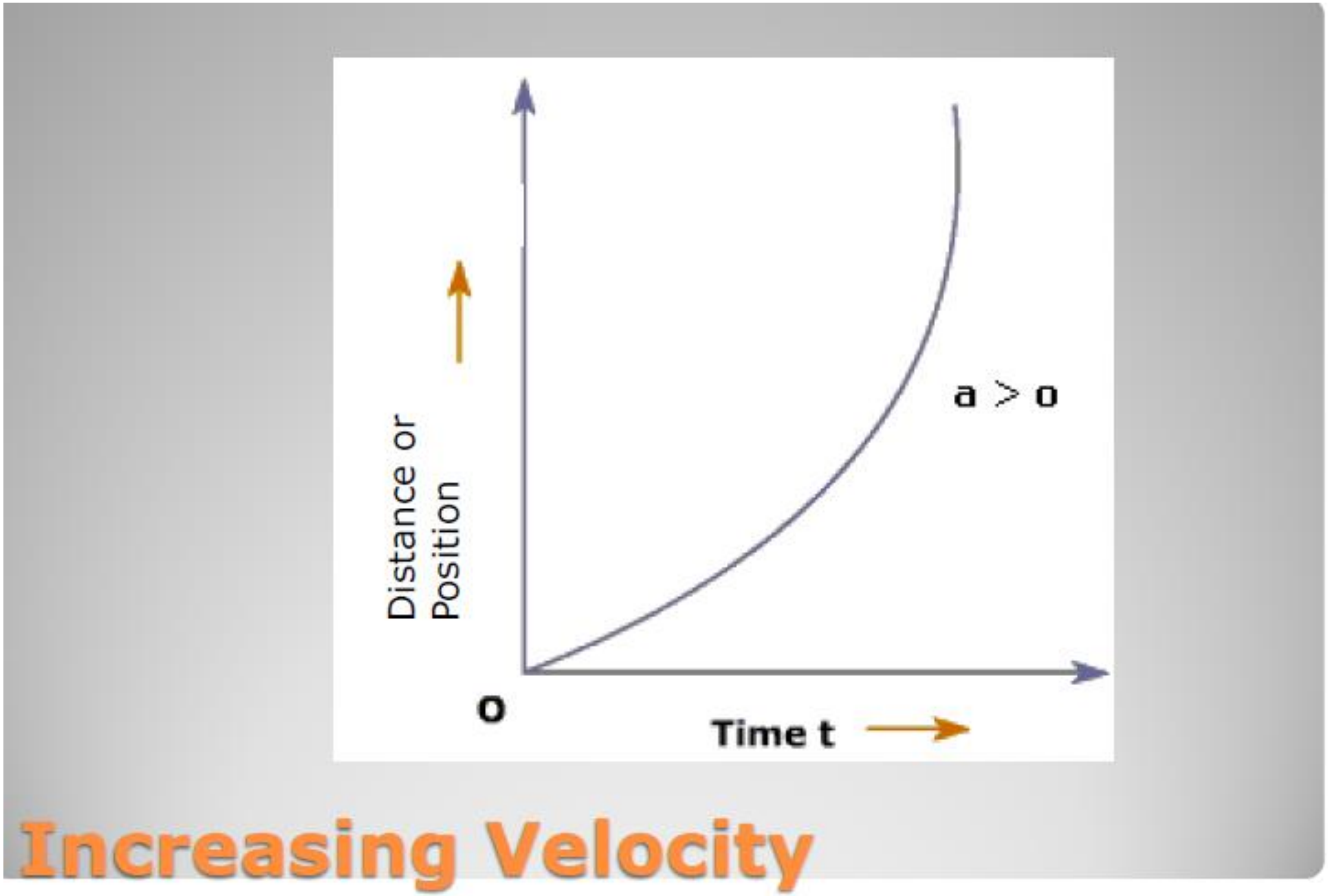


Graphing Motion

- Velocity can change in 3 ways:
  - Change direction
  - Speed up
  - Slow down

Acceleration = The rate of change in velocity, or the change in velocity per unit of time.

Acceleration is not about whether someone or something is moving fast. Instead, acceleration has to do with **CHANGING** how fast and object is moving.


Distance or Position
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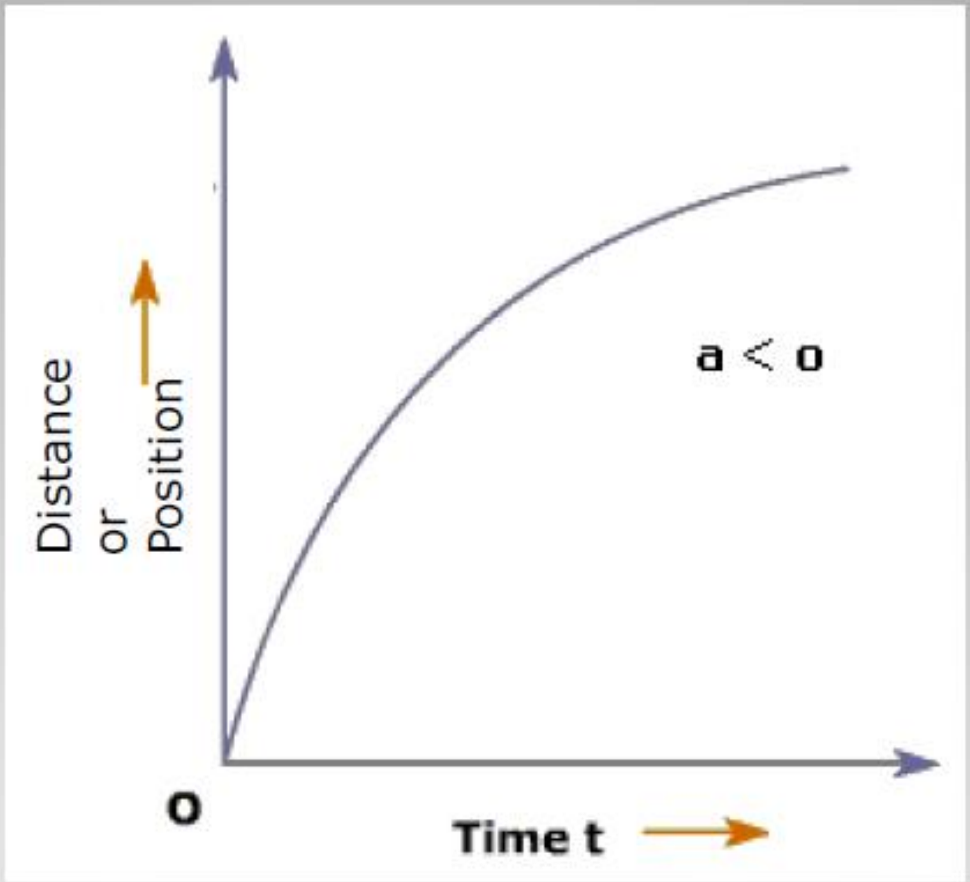
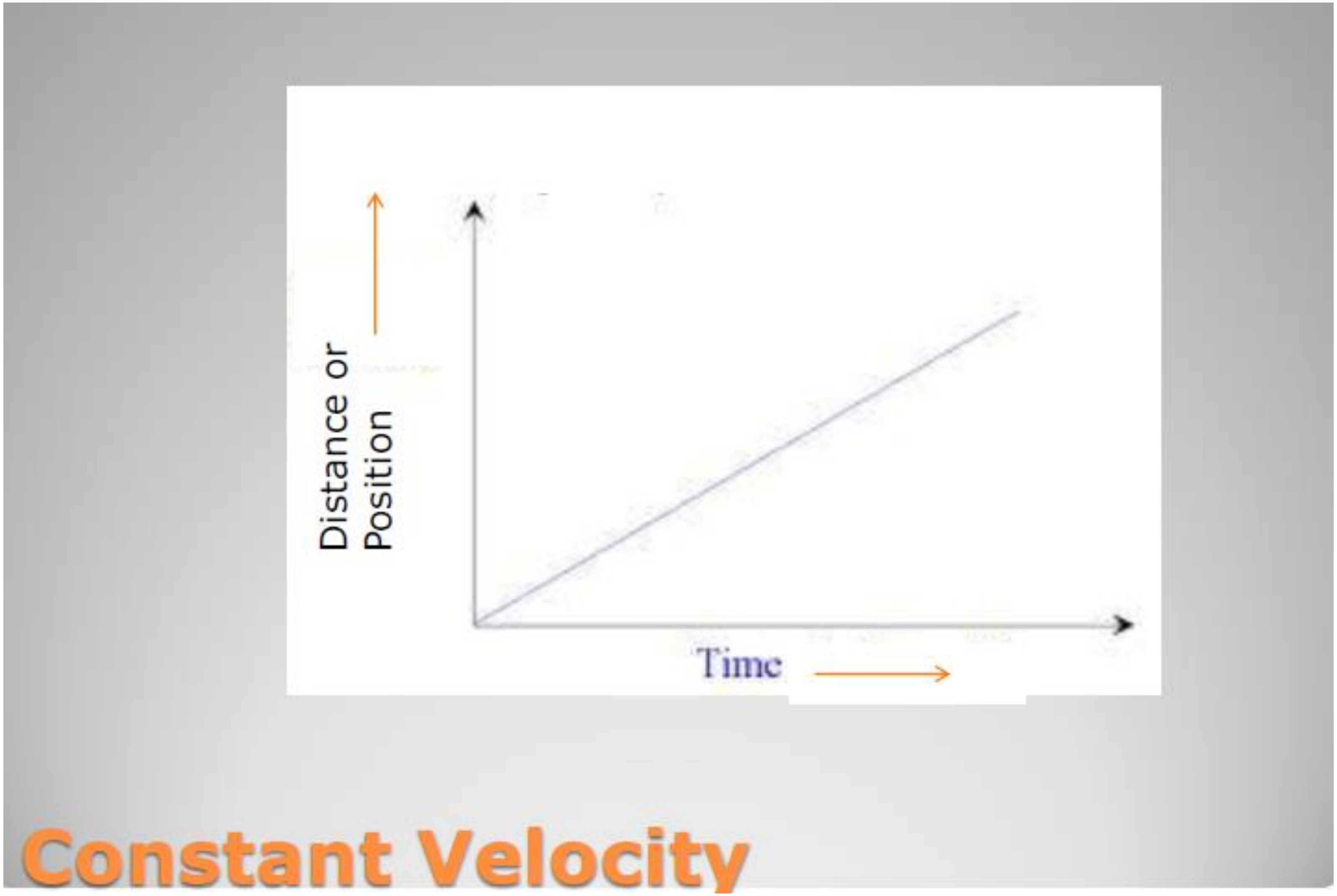
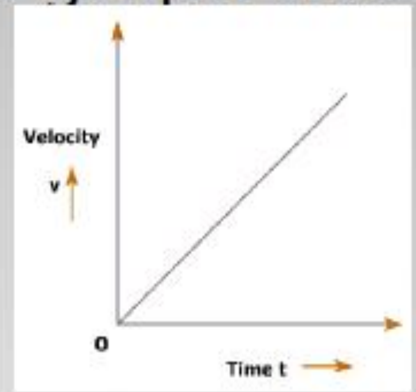
o
Time t
Increasing Velocity



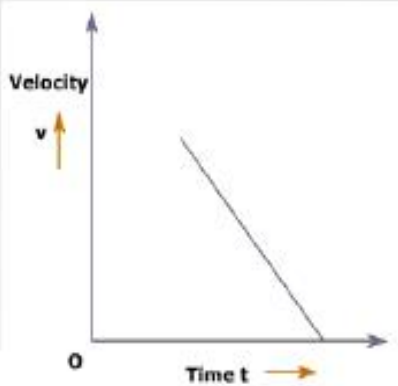
Decreasing Velocity


Distance or Position
Time
Constant Velocity

- When acceleration is **Increasing**, we say it is **Positive** and its graph has an upward angled line.



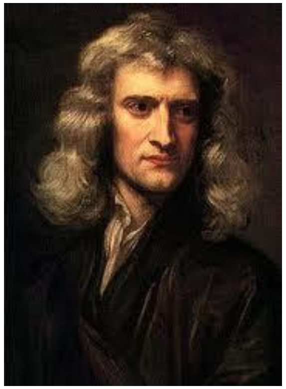
- When acceleration is **Decreasing**, we say it is **Negative** and its graph has a downward angled line.



Acceleration

Isaac Newton

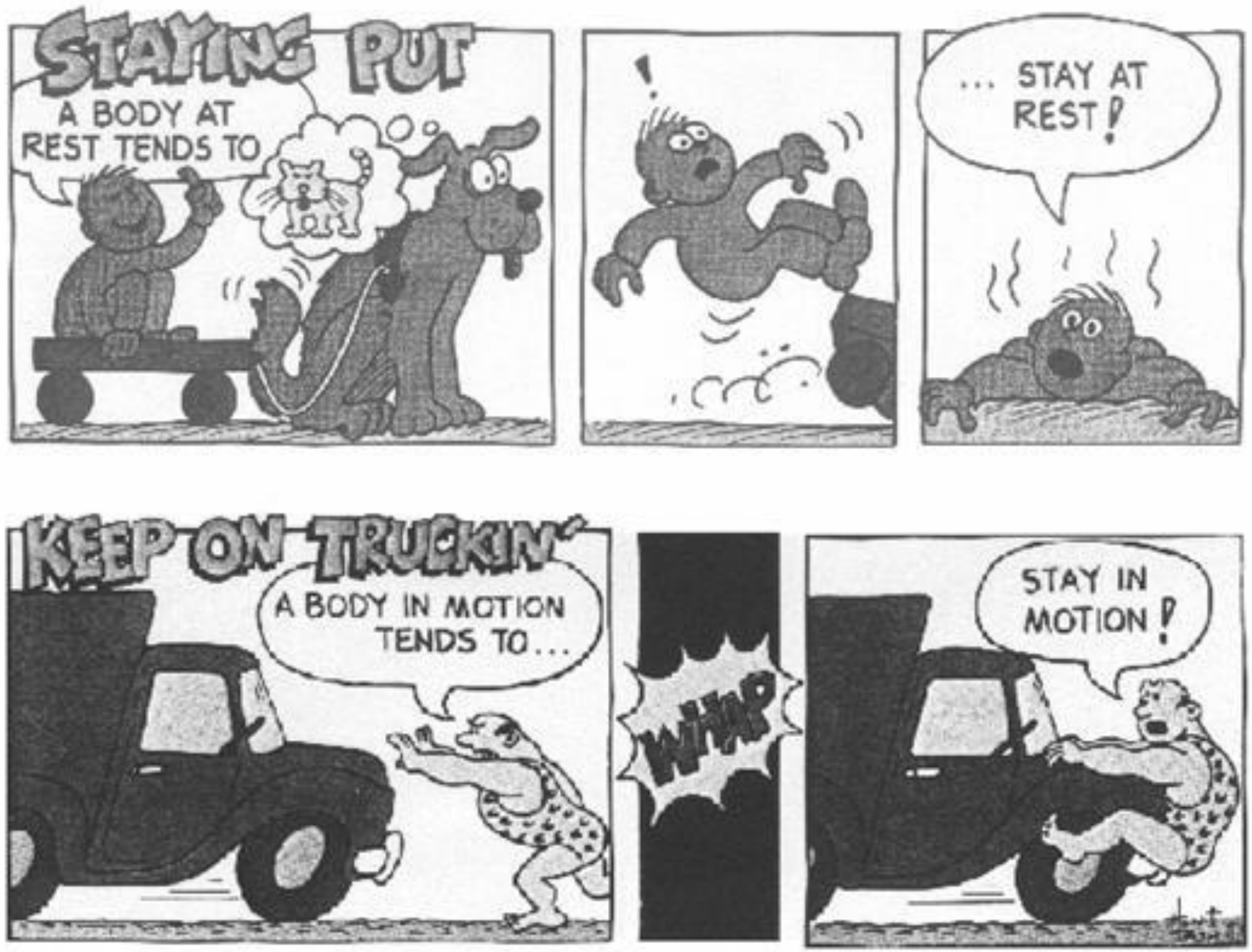
- Newton spent his time studying the behavior of objects in MOTION.
- His conclusion…anything in motion is going to follow 1 of the 3 basic **Laws of Motion**.



Newton's 1st law of Motion

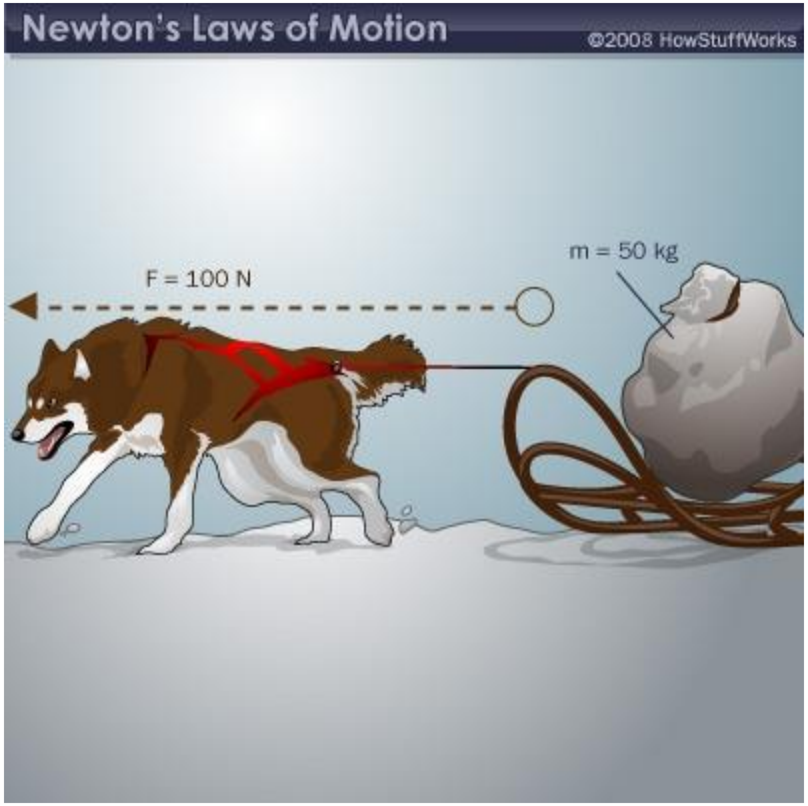
Law 1: An object at rest remains at rest, and an object in motion remains in motion at the constant speed and in a straight line unless acted on by an unbalanced force.

- This law brings us to the discussion of **INERTIA**…the tendency of an object to resist change in its motion.
- Inertia is based on **MASS**…the greater the mass, the greater the inertia.


STAYING PUT
A BODY AT REST TENDS TO
... STAY AT REST!
KEEP ON TRUCKIN'
A BODY IN MOTION TENDS TO...
WHAP
STAY IN MOTION!

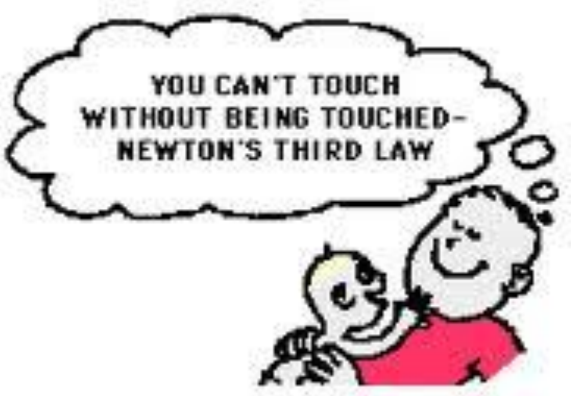
Newton's 2nd law of Motion

- **2nd Law:** The FORCE required to change the motion of an object depends on two factors – mass and acceleration.
  - Simply: Force = mass x acceleration
  - Also: Acceleration = Force / Mass
  - When a force is applied to an object, it can either speed up (positive acceleration), slow down (negative acceleration) or change directions.



Newton's 3rd Law of Motion

- **3rd Law:** For every action, there is an equal and opposite reaction.
- Forces act in pairs, When two objects interact, one force acts on the first object and the other force acts on the second object
  - The size of both forces are the same…but in opposite directions.



Newton's 3rd Law of Motion

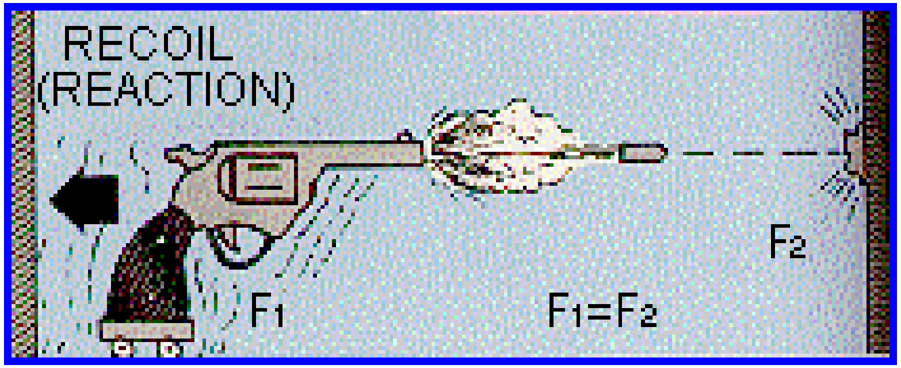
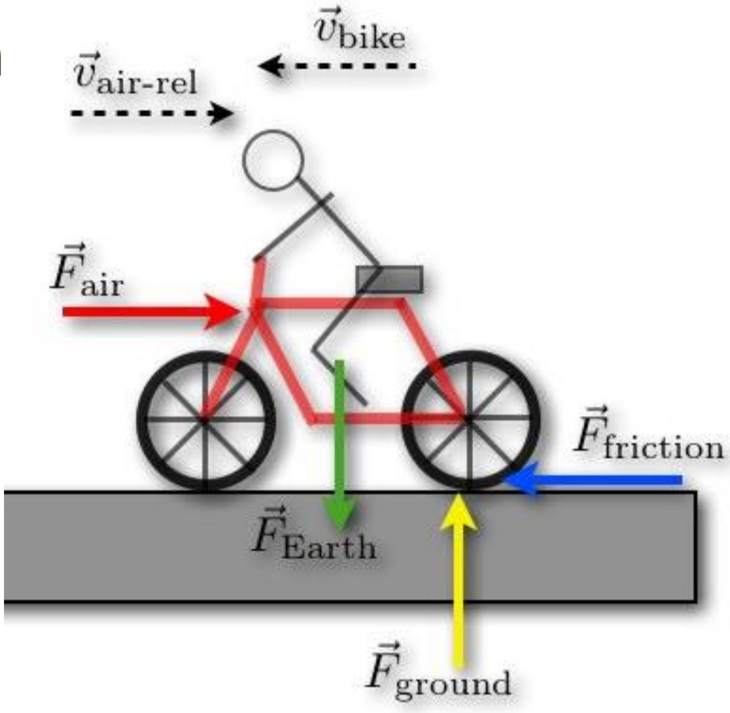


Figure 4-3 Example of Newton's third law of motion

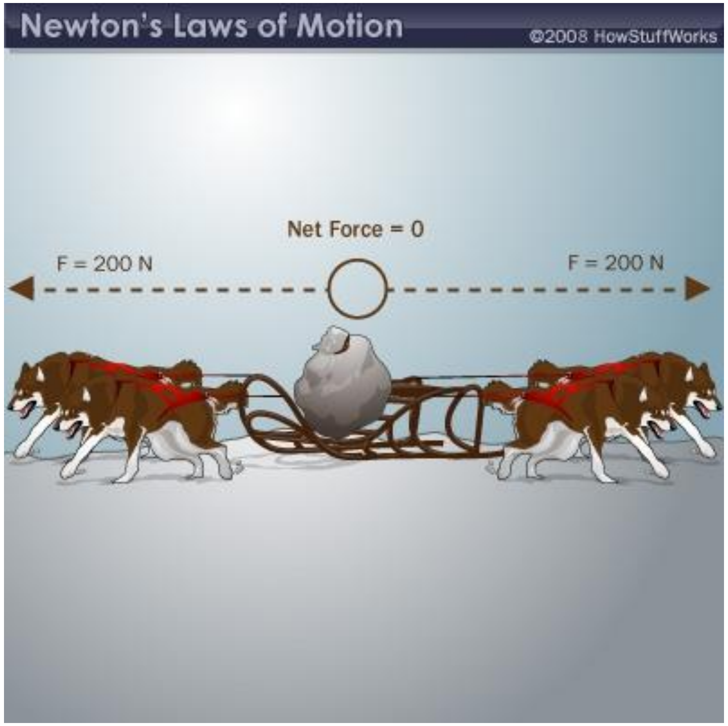
- Usually, more than one force is acting on an object at a time. Forces can act in the same direction…thus working together. Or forces can act in different directions…thus, canceling each other out.



- **Net Force** = The sum (total) of all the forces acting on the object.

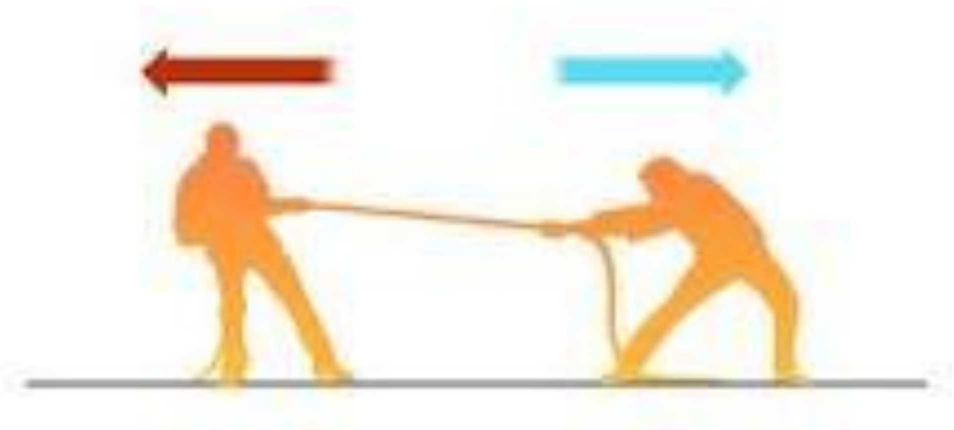
Balanced Force

- **Balanced forces** produce a net force that equals zero.
  - When forces are balanced, there is no change in motion. When balanced forces act on an object in motion, the object keeps moving at the same velocity.
  - When balanced forces act on an object that is still…the object does not move.



Unbalanced Forces

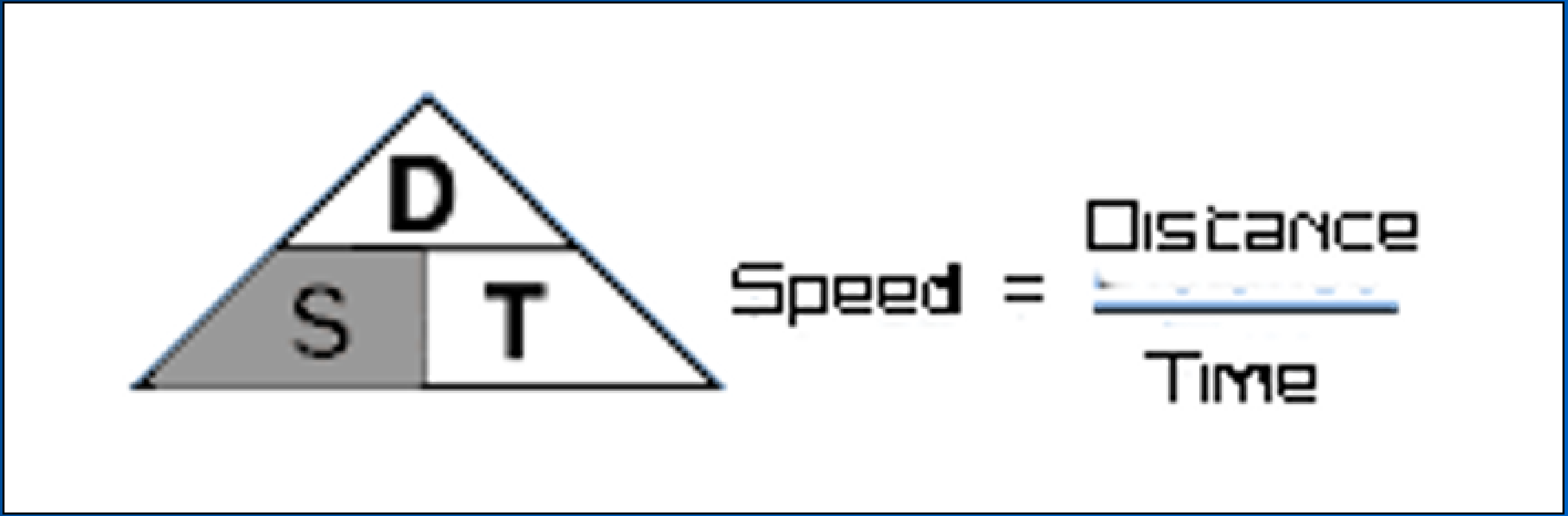
- **Unbalanced forces** produce a net force that is greater than zero.
  - The object acted on moves in the direction of the greater force.



Speed, Distance, Time Formulas

Calculating Speed

Given Distance & Time



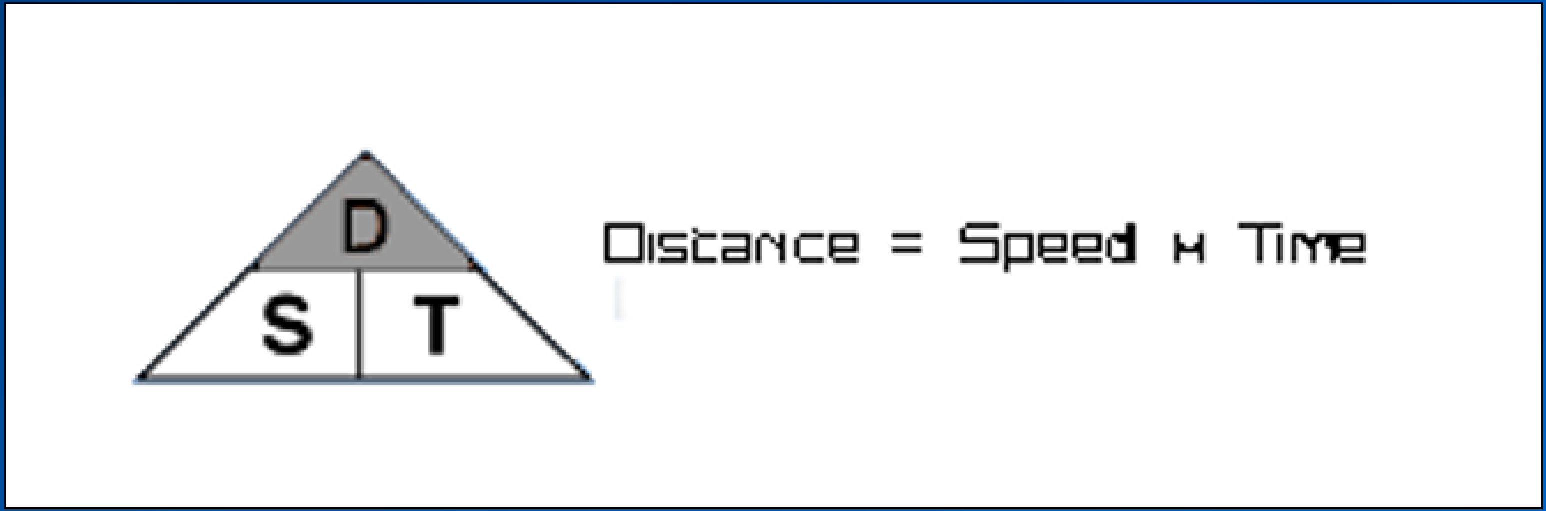
Divide Distance by Time

Distance ÷ Time = Speed

Speed = Distance ÷ Time

Calculating Distance

Given Speed & Time

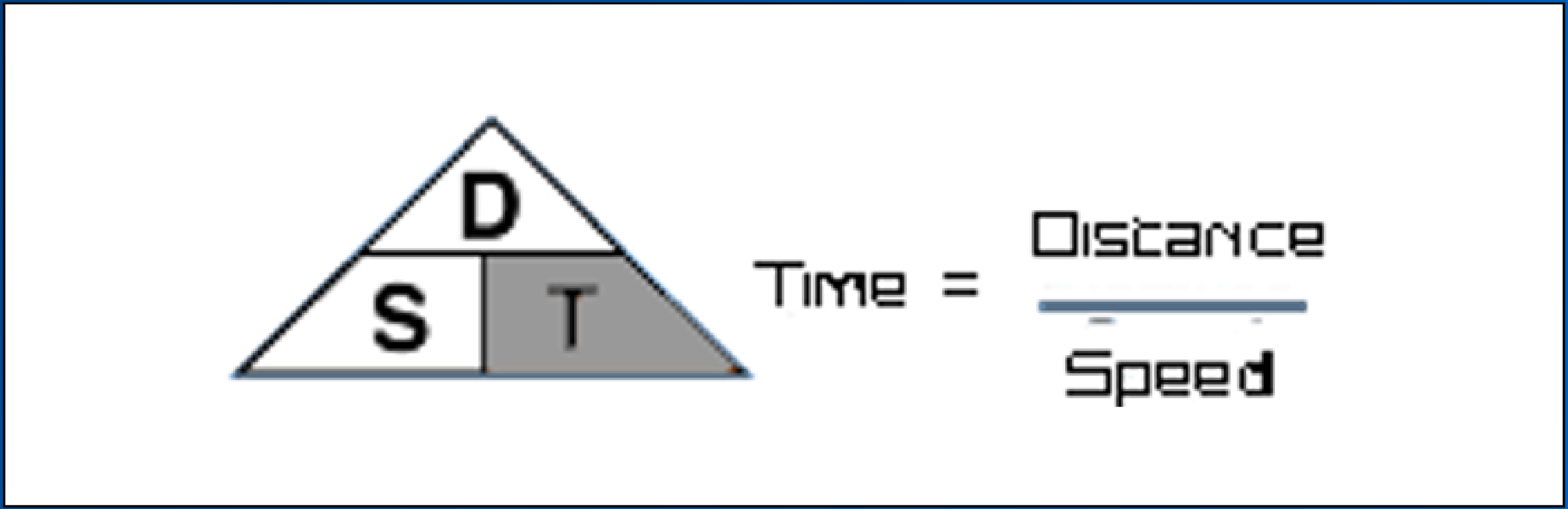


Multiply Speed and Time

Distance = Speed X Time

Speed X Time = Distance

Calculating Time
Given Distance and Speed



Divide Distance by Time

Distance ÷ Speed = Time

Time = Distance ÷ Speed