Chapter 8

Motion and Forces

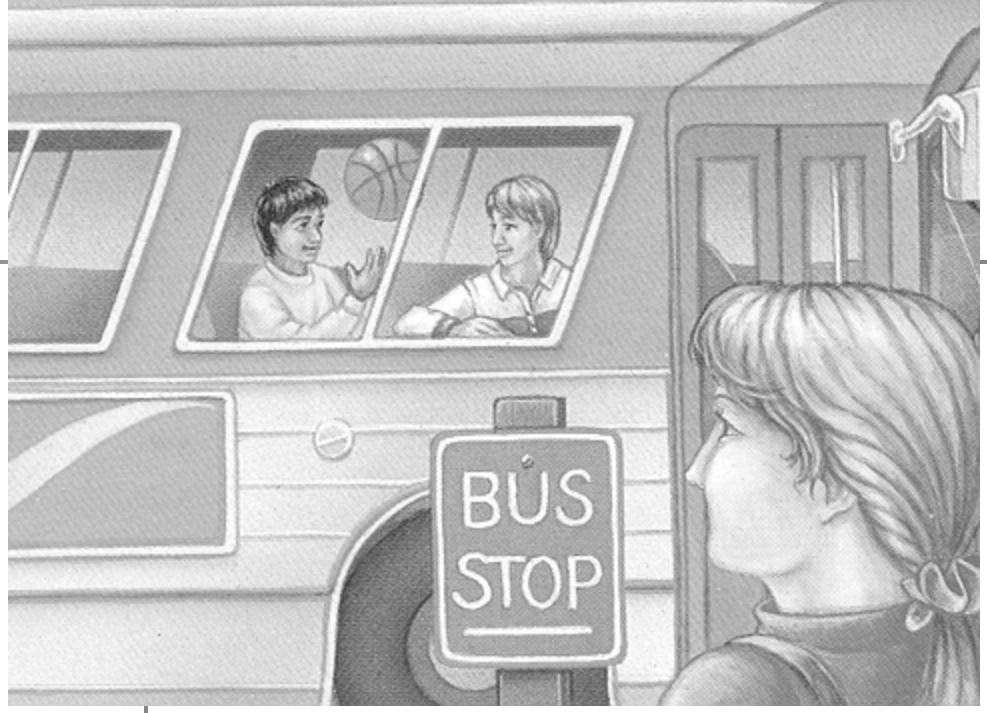
Reference Frame

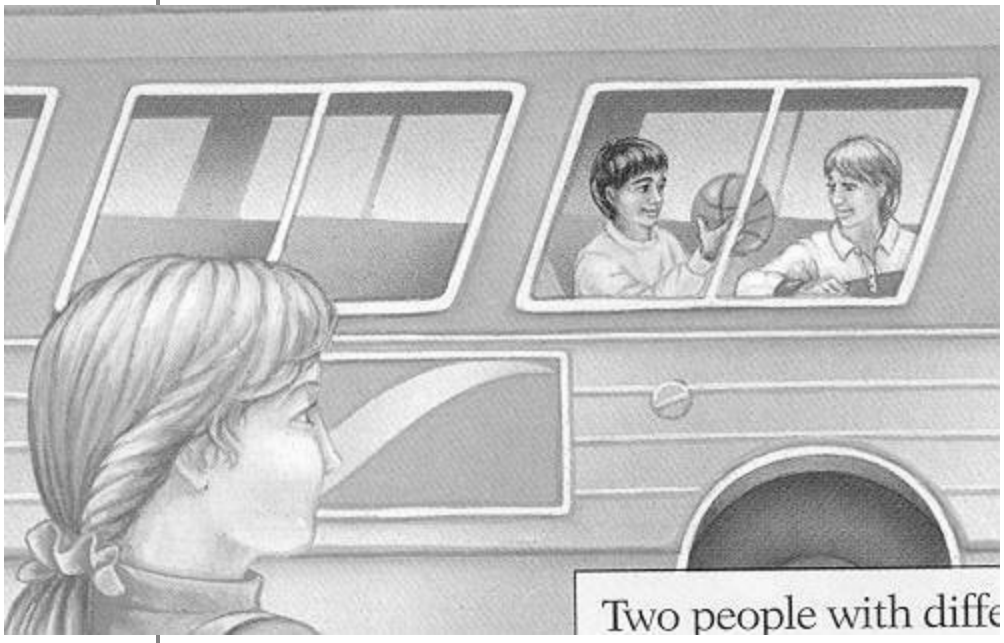
- Clues are often given by looking at other objects in your surroundings
- Normally you think of walls or signs as not moving, or as being stationary objects
- When you do this you use the walls or signs as a frame or reference

Reference Frame

- Object that you assume is fixed in place
- Reference frames also move relative to each other which may cause confusion
- The perception of motion depends on the observer’s frame of reference

- Describe the motion observed by one of the boys in the drawing, how does the motion appear to be different to the other boy?





- Imagine you are the girl observing the bus, describe the motion of each object that you can see

Frame of Reference

- How would the earth's movement appear to astronauts?
- What are up and down directions to the astronauts? Why?
- What do you use as your frame of reference most of the time?

Measuring Motion

- How do you describe motion taking place?
- To describe motion you discuss speed
- Speed is the distance an object travels per unit of time
- To calculate its speed you divide the distance it travels by the time it travels

Measuring Motion

- Speed is sometimes expressed in kilometers per hour
- Or meter per second
- An objects speed doesn’t indicate all there is to know about its motion
- An objects speed together with its direction of motion is called velocity

Measuring Motion

- People often use the word speed when they mean velocity
- Since a moving object always travels in some direction, velocity is a more precise term for describing motion
- Meteorologists use wind velocity measurements to help predict weather

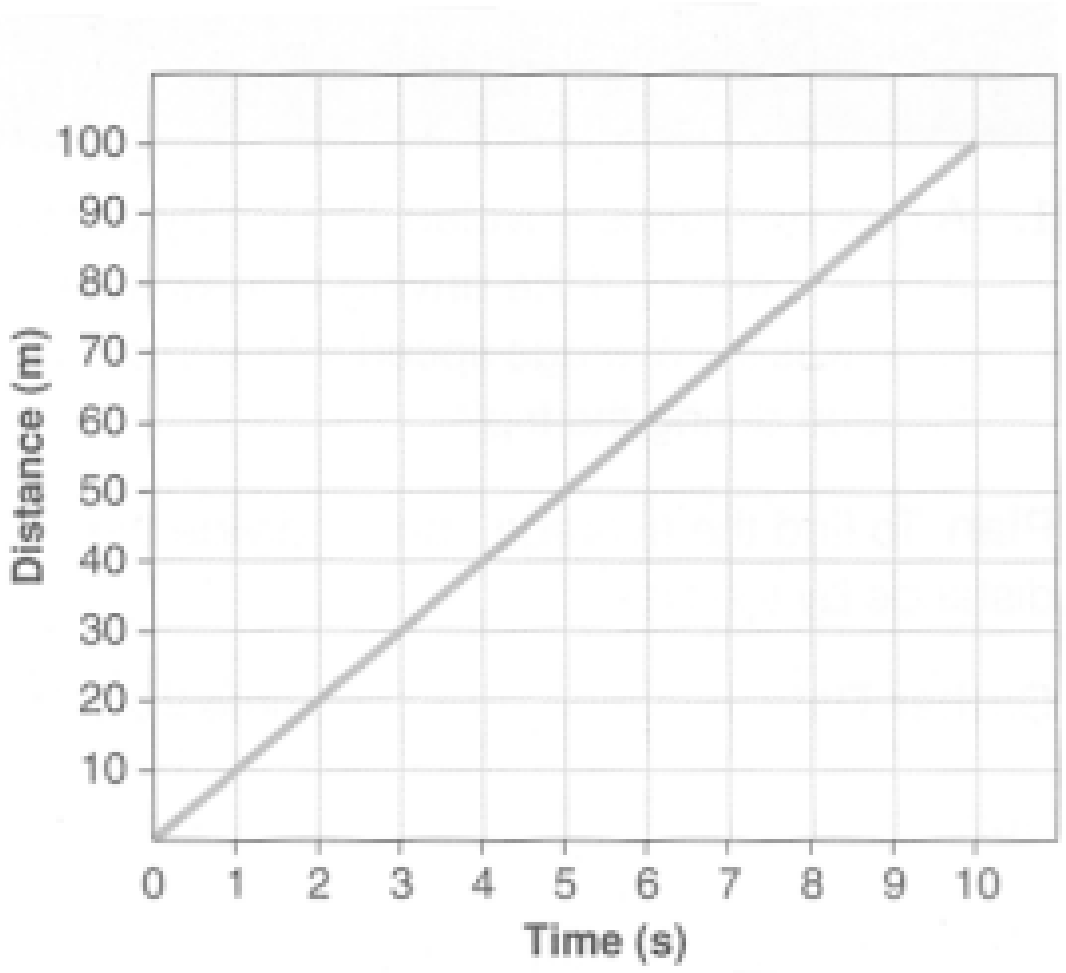
Constant speed

- A moving object that doesn’t change it’s speed travels at constant speed
- Constant speed means equal distances are covered in an equal amount of time
- Suppose you and a friend want to run around a track at constant speed for half an hour

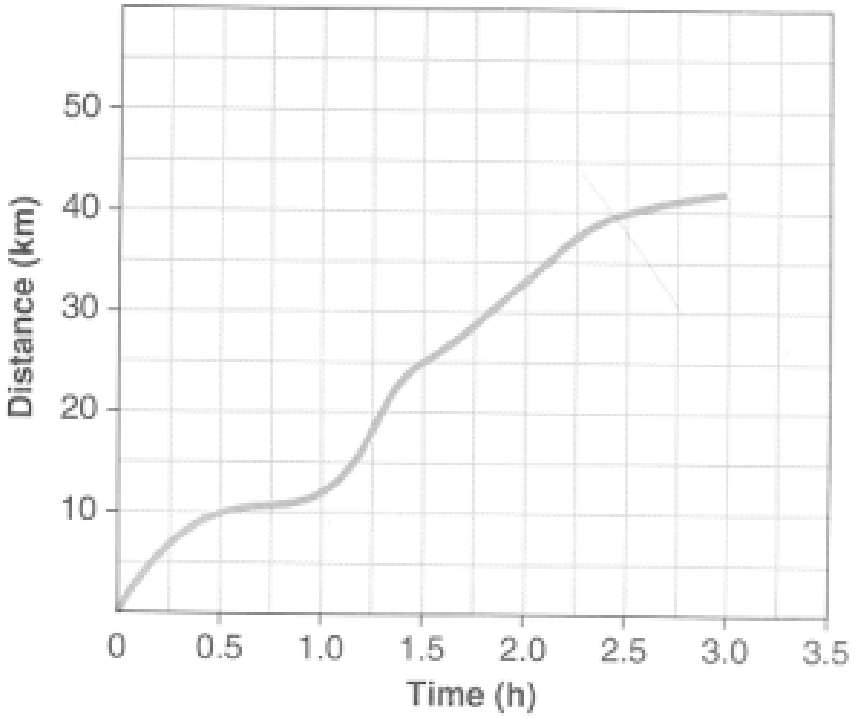
Constant speed

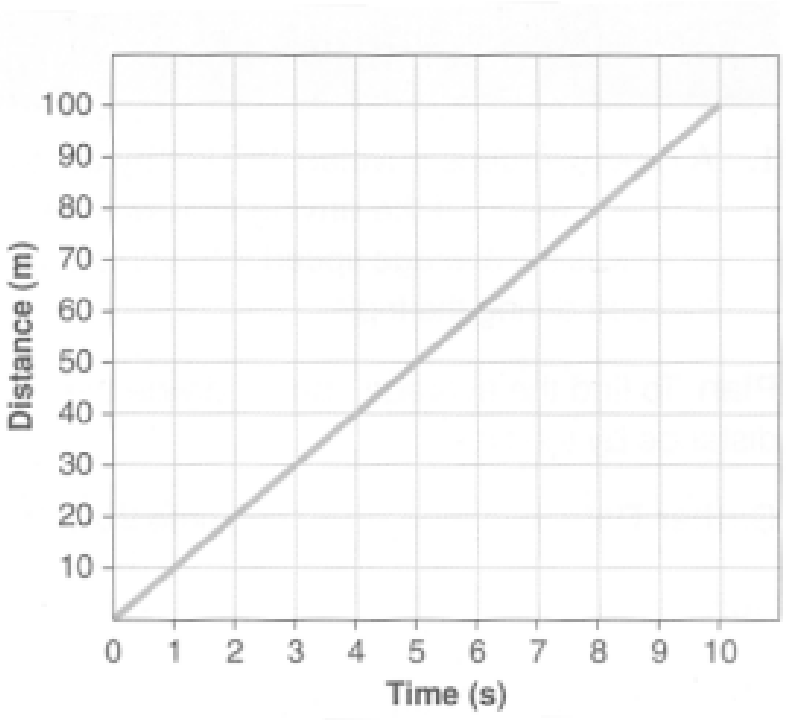
- How can you check to see if your speed is constant?
- Your measurement can be even more accurate if you measure how long it takes to travel very short distances of equal length
- If all the times are the same they must be constant.

- How does this graph display speed?



- Why are these graphs different?
- How was the motion different?





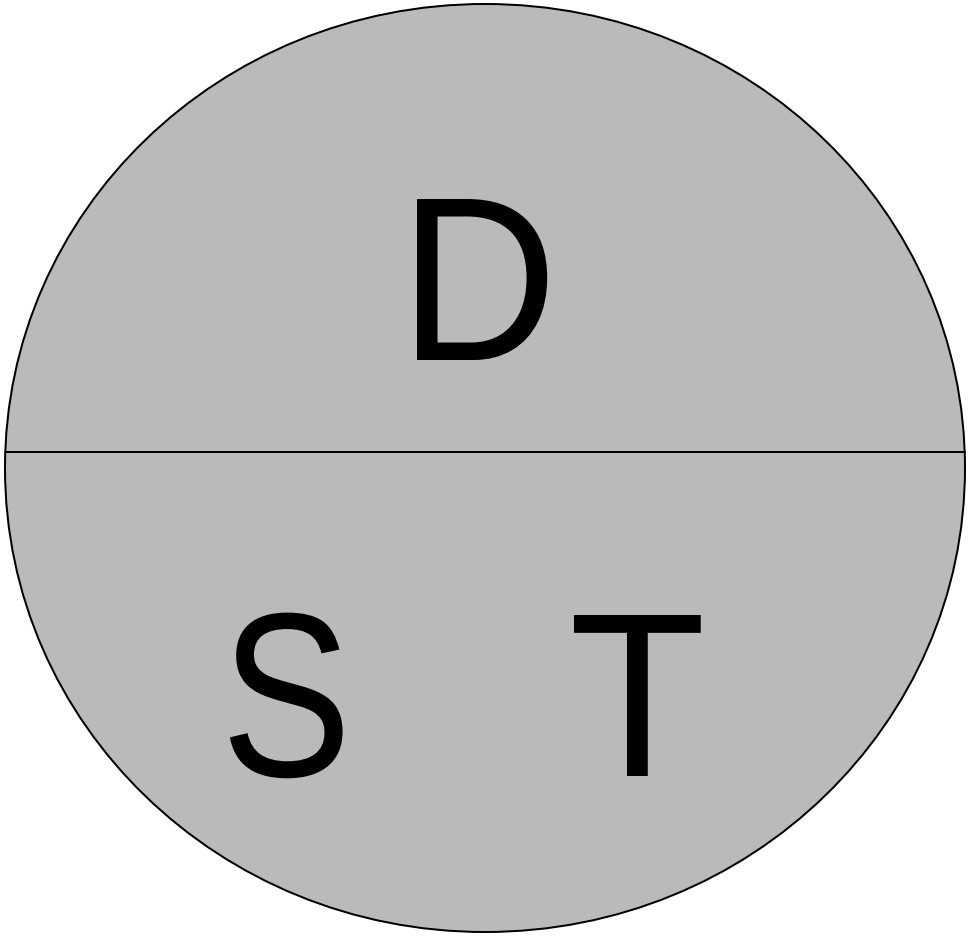
Average Speed

- Average speed is equal to the total distance of the course divided by the runner's total timer.

Calculating Speed

- Speed = $\frac{\text{Distance}}{\text{Time}}$
- If a runner travels 100 m in 10 seconds what was his average speed?
- Probably not constant
- Can solve for the other pieces too
- Distance = speed x time
- Time = $\frac{\text{Distance}}{\text{Speed}}$

Cover the one you're looking for



Practice

- A car race is 500 km long. It takes the winner 2.5 hours to complete it. How was he going?
- It is 320 km to Las Vegas. If you average 80 km/hr, how long will it take you to get there?
- You are going on a trip. You average 80 km/hr for 6 hours. How far did you go?

Velocity

- Is both speed and direction.
- 40 km/hr = speed
- 40 km/hr west = velocity
- Can change velocity two ways
- Change speed
- Or change directions

Momentum

- A truck is harder to stop than a car
- Mass affects motion
- Momentum = mass x velocity
- Symbol is p
- $p = mv$
- Units kg·m/s
- Has direction just like velocity

Calculating Momentum

- A 75 kg man is traveling 10 km/hr west. What is his momentum?
- A 0.25 kg ball is moving at 160 km/hr toward home plate. What is its momentum?

Law of Conservation of Momentum

- The total amount of momentum in a system is conserved.
- Add up all the momentum
- Take into account the direction.
- Used to predict motion of cars after a collision

Change in Velocity

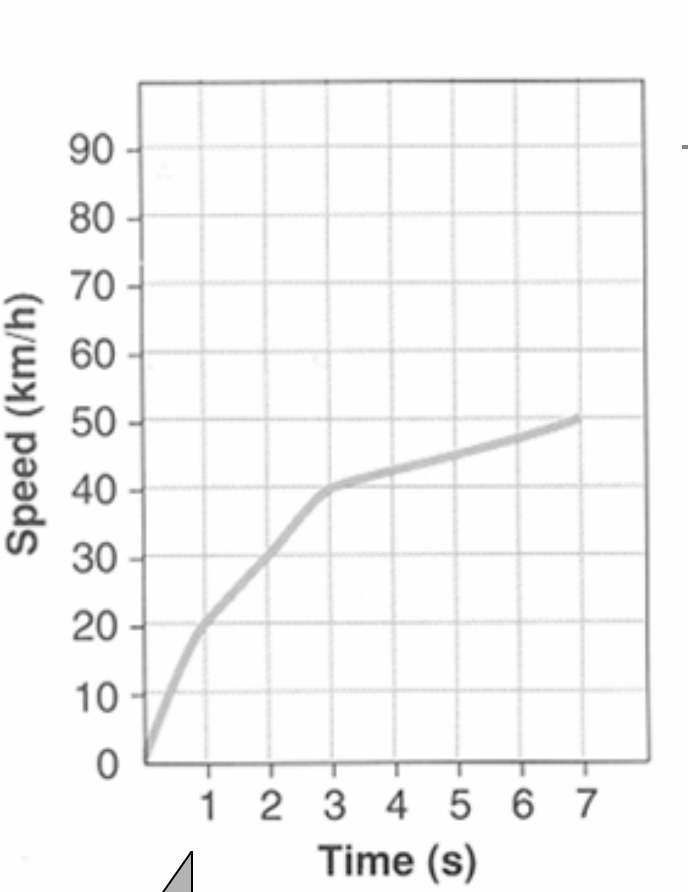
- Each time you take a step you are changing the velocity of your body.
- You are probably most familiar with the velocity changes of a moving bus or car.
- The rate at which velocity changes occur is called acceleration.

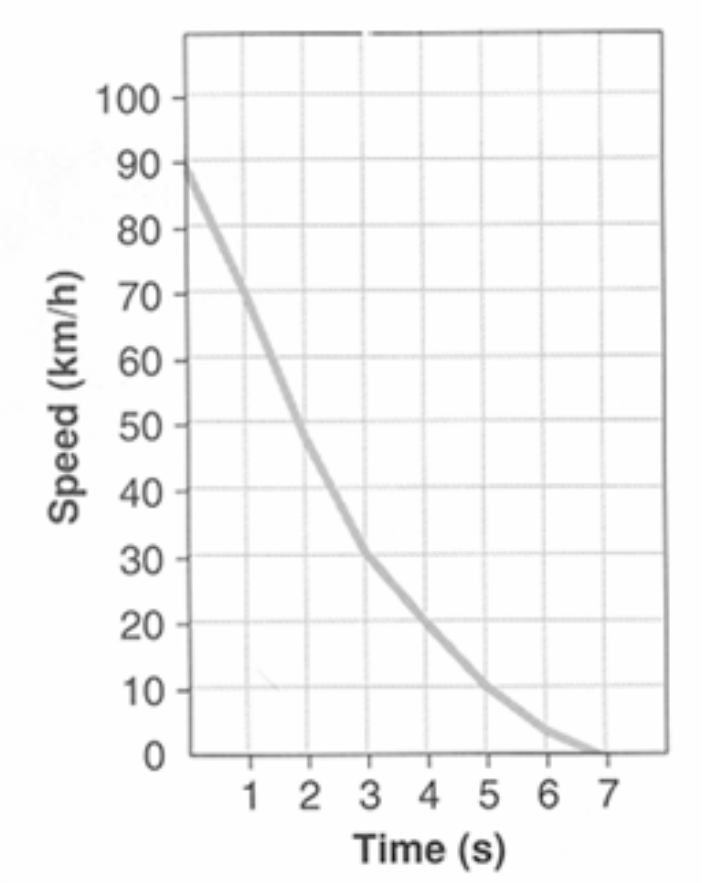
$$\text{Acceleration} = \frac{\text{final velocity - starting velocity}}{\text{time}}$$

$$\text{Change in velocity} = \text{final velocity} - \text{starting velocity}$$

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

Positive acceleration





Negative acceleration

Acceleration

- Any change in velocity is acceleration, even if the speed of the object remains the same.
- When ever an object changes how it moves, the velocity changes.
- A change in direction is a change in velocity, and acceleration.

Motion in a circle

- An object moving in a circle or a curve is constantly changing direction.
- Centripetal = acceleration towards the center of the circle.

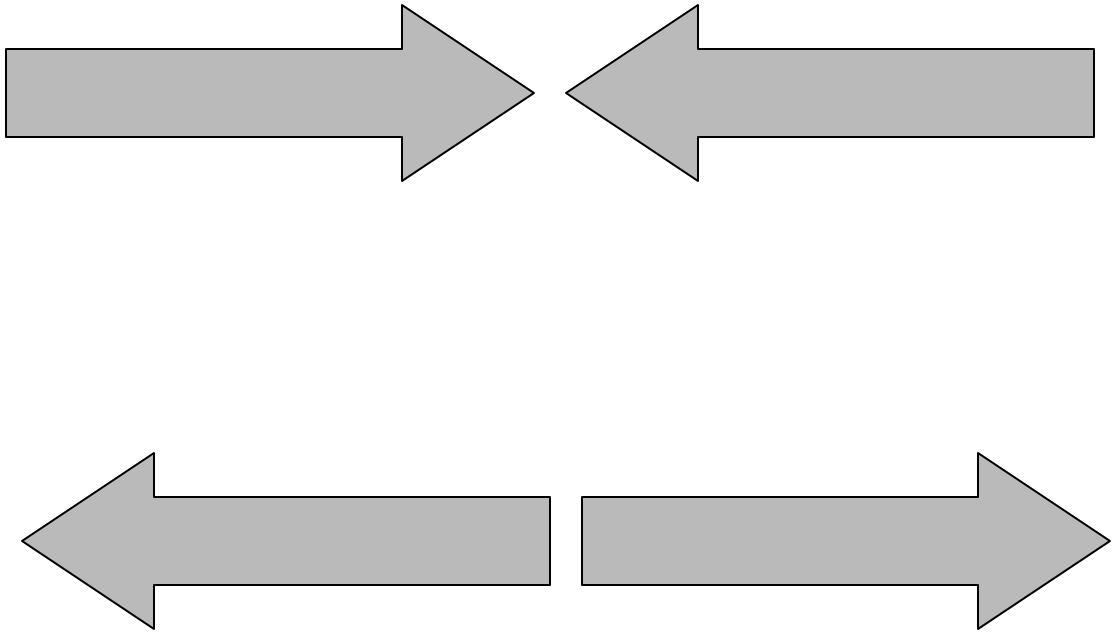
Force

- A push or a pull
- 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

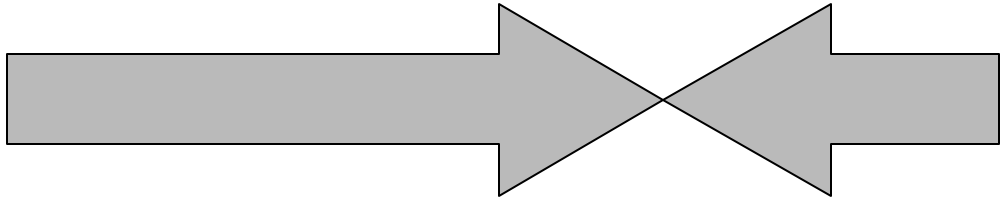
- Usually many forces are acting at the same time
- Have to add up these forces to see whether they add up or cancel out.
- Balanced Forces cancel out and give a net force of zero
- Balanced forces can not cause a change in motion
- Like a tug of war

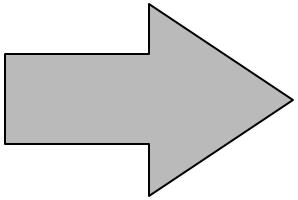
Balanced Forces



Unbalanced Forces

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





Friction

- A force between two objects that opposes motion
- A ball will not roll forever
- It will slow down because it rubs against the ground
- The friction causes a negative acceleration
- To keep a car moving at a constant speed, you need to keep applying a force

Friction

- Friction can keep an object from moving
- Rougher surfaces have greater friction
- Smoother surfaces have less friction
- Larger surface area has more friction
- Greater weight has more friction
- Sliding friction is greater than rolling friction.

Friction

- Friction affects every object on the earth.
- Why we use oil and bearings
- Without friction you wouldn’t be able to walk without slipping and falling down.

Air Resistance

- The force of the air against a moving object
- Increases as the velocity of the motion increases
- The size and shape of the object also effect the air resistance
- Larger surface area more resistance
- Car designers try to minimize it
- Overcoming air resistance uses more fuel

Gravity

- A force of attraction between objects
- Can act at a distance, they don’t have to touch
- The strength of the force depends on the mass of the objects and the distance
- You multiply the masses together
- Gravity is a weak force
- The masses need to be large to be noticed

Gravity

- Like the size of planet
- And divide by the distance squared
- Twice as far is one quarter as strong
- Three times is one ninth as strong

Newton's Laws of Motion

- An object at rest stays at rest until an outside force causes it to move.
- An object in motion continues to move in the same direction at the same speed until a force stops it or changes its direction.
- So, an object at rest will stay at rest, and an object in motion will remain in motion unless acted by an outside force.
- Newton's First Law of Motion

Inertia

- An object at rest stays at rest until an outside force causes it to move.
- An object in motion continues to move in the same direction until a force stops it or changes its direction.
- So, an object at rest will stay at rest, and an object in motion will remain in motion unless acted by an outside force.

Inertia

- Inertia: the tendency of an object to remain at rest or in motion until acted upon by an external force.
- Friction is an outside force that resists motion when two surfaces come in contact.
- The surfaces can be between two objects or between an object and air or water.

Second Law of Motion

- Acceleration depends on the mass of the object and the unbalanced force applied
- F = m x a
- more mass, harder to accelerate
- more force, faster acceleration
- Newton is the unit of force
- equal the force needed to change the velocity of a 1 kg mass by 1 m/s^2

Free fall

- When the force of gravity is the only force acting on an object
- If there was no air, all objects would fall at the same speed
- The acceleration caused by gravity is 9.8 m/s^2
- Called g
- Is the same for all objects

Weight

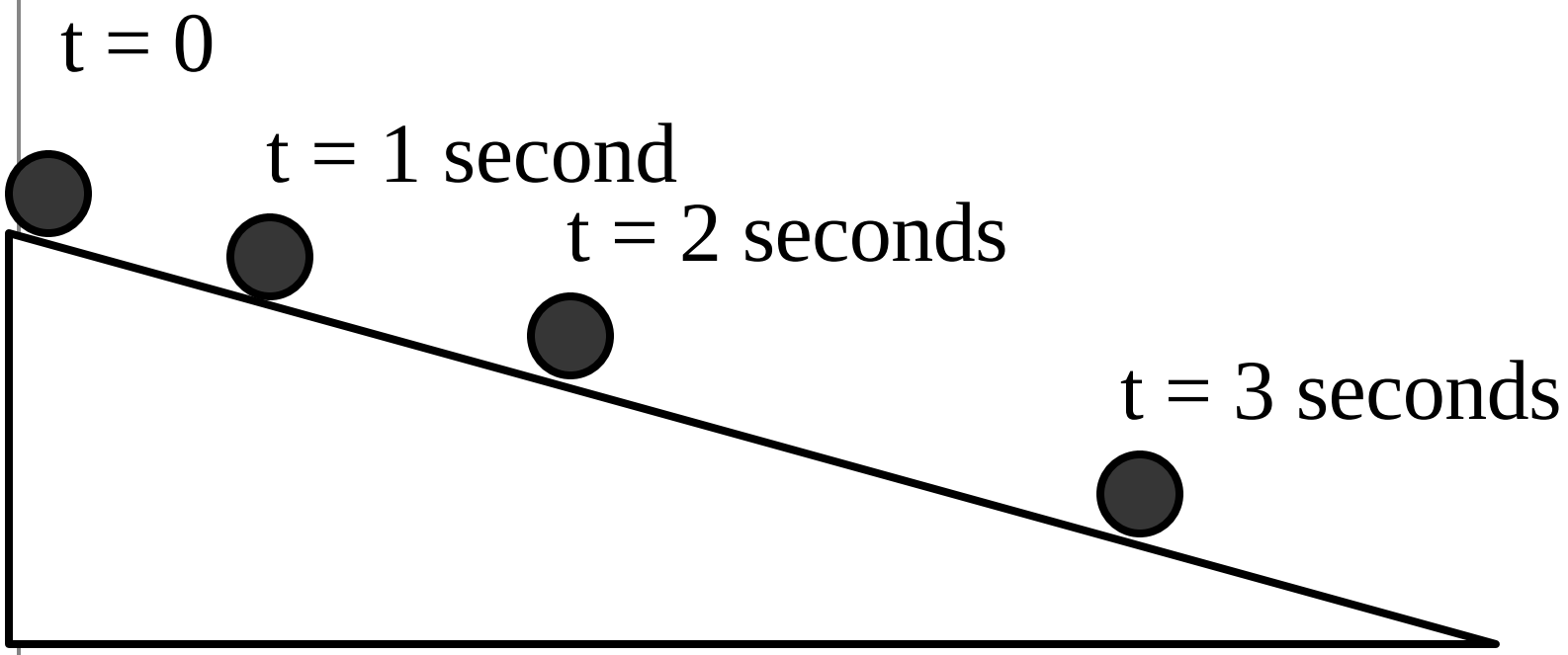
- The force of gravity on an object.
- $F = m \times a$
- $W = m \times g$
- Larger mass, larger weight
- Astronauts in orbit in the shuttle are falling with the same acceleration as the shuttle
- There is apparent weightlessness
- Different planets different values of g, so you would weigh different amounts

How Things Fall

Galileo

- 1600’s
- Studied how things fell
- Didn’t have a good clock
- Rolled balls down an inclined plane
- Found that the speed increased as it rolled down the ramp

Galileo



Galileo

- Same things happen when things fall
- Didn’t drop things from Tower of Pisa

Falling

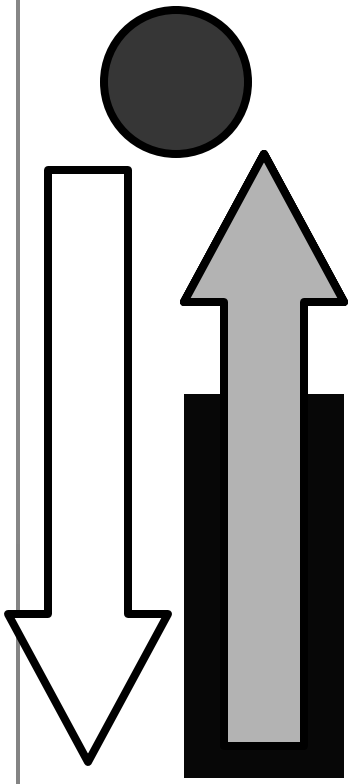
- Things accelerate
- acceleration needs a force
- caused by gravity
- Doesn’t depend on mass
- 9.8 m/s^2
- After 1 second falling at 9.8 m/s
- After 2 seconds 19.6 m/s
- 3 seconds 29.4 m/s

Falling

- Air resistance will increase as it falls faster
- An upward force on the object
- Eventually gravity will balance with air resistance
- Reaches terminal velocity - highest speed reached by a falling object.

Terminal velocity

- Force of gravity is constant

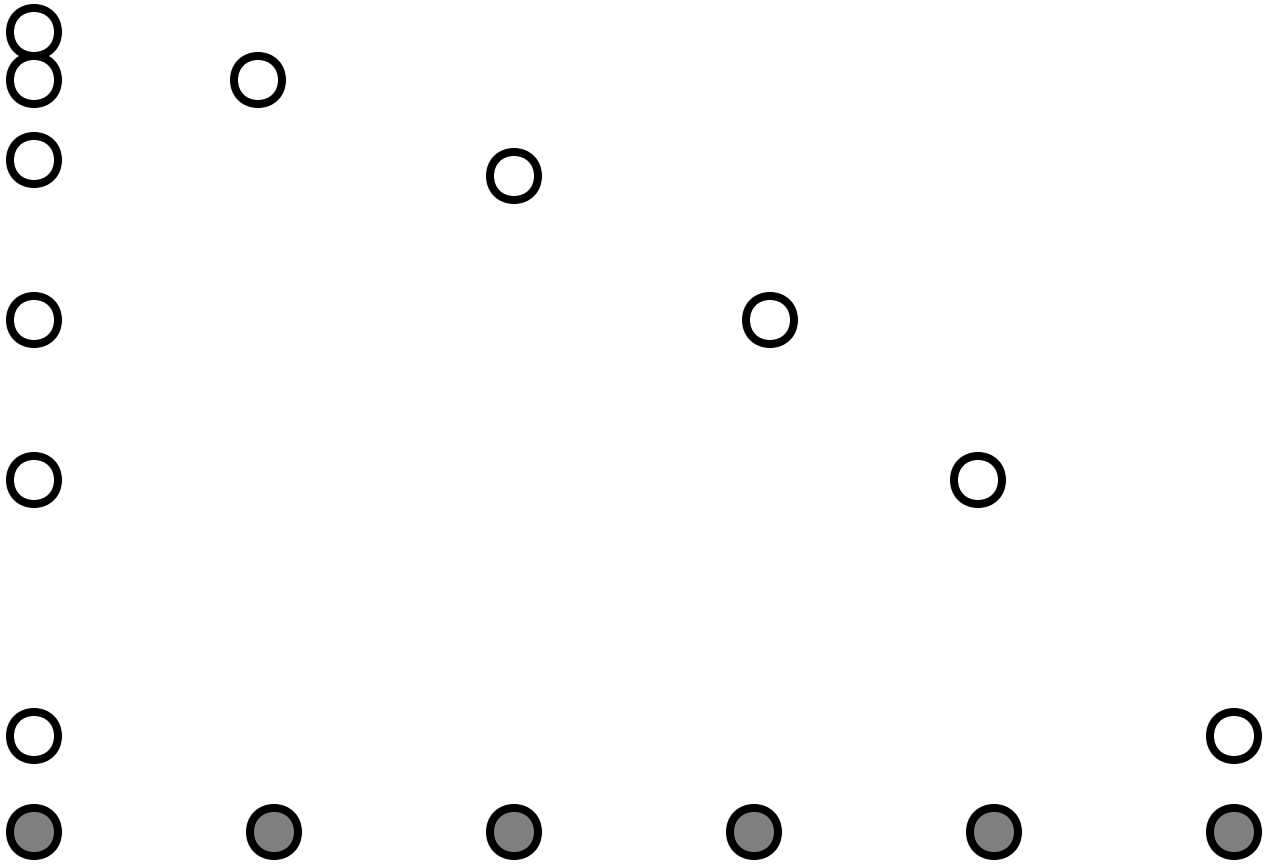


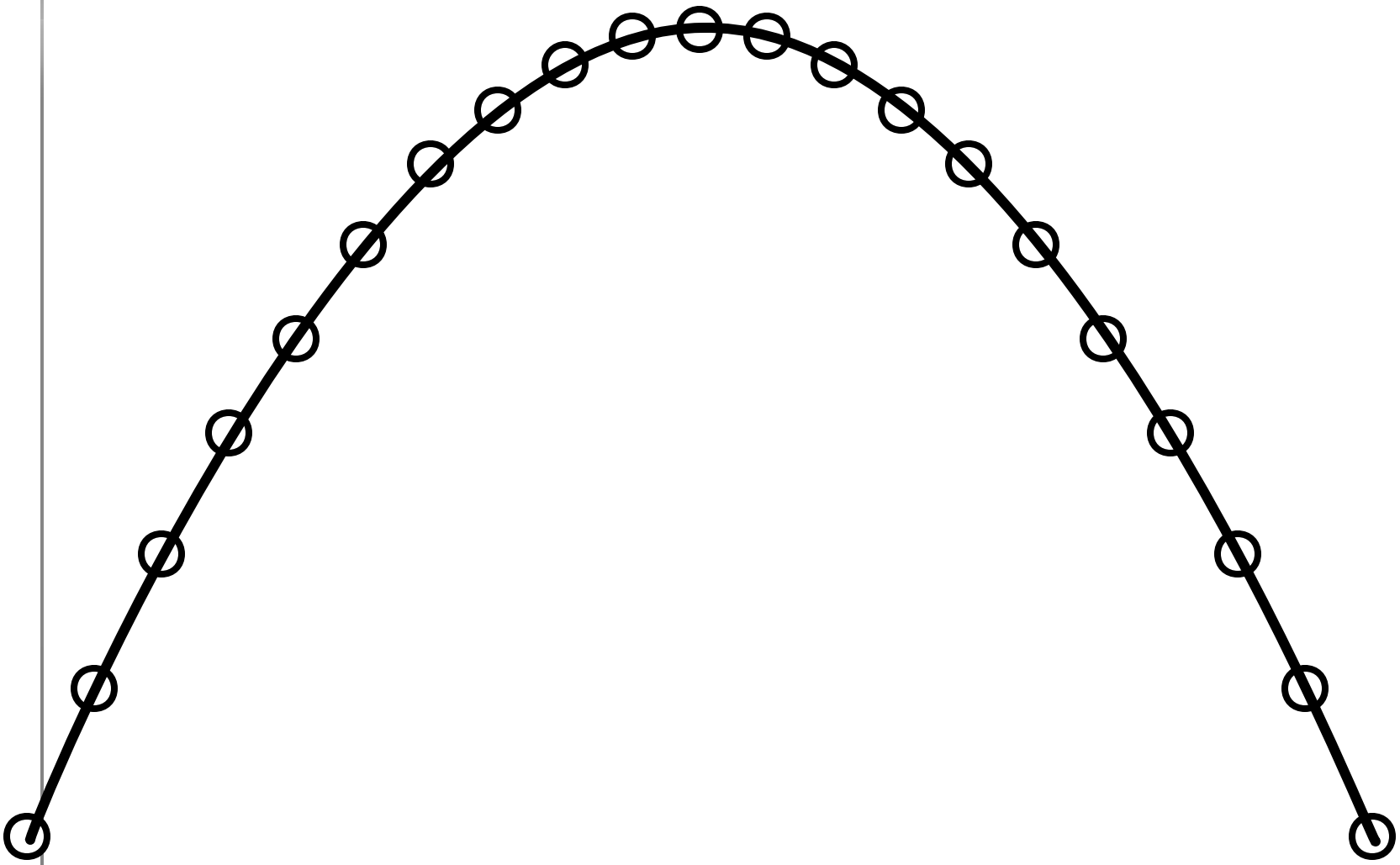
- **air resistance increases as you speed up**
- **until the force is equal**
- **Equal forces, no acceleration**
- **constant velocity terminal velocity**

Motion in Two Directions

- Things can move sideways and vertically at the same time
- If no force other than gravity acts,
- the sideways velocity will remain the same
- The vertical velocity will change
- Gives a curved path
- Parabola

Motion in two directions





Third Law of Motion

- For every force, there is an equal and opposite force
- For every action there is an equal and opposite reaction.
- Rockets
- gases get pushed out
- Rocket moves forward
- Skating

- http://www.cath-mem.org/physics/contents.htm
- http://www.physicsclassroom.com/mmedia/index.html
- http://webphysics.ph.msstate.edu/jc/library/8-2a/pendel5.htm
- http://jersey.uoregon.edu/vlab/Cannon/
- http://www.phy.ntnu.edu.tw/java/projectileOrbit/projectileOrbit.html