



# Forces



# Aristotle

- Aristotle believed in two types of motion, Natural and violent.
- He felt all objects have a natural motion that would happen spontaneously.
  - Smoke rising, balls falling
- Violent motions were things that moved objects in a different direction than their natural motion and required a force.
- Earth was in its natural resting place in the center of the universe of course!

# Galileo

- Copernicus discussed the idea that the Earth was orbiting around the central sun, this had consequences if you liked Aristotle.
- Galileo realized that no force was necessary to keep objects moving if there was no friction.
- He demonstrated these ideas by using incline planes.
- Galileo showed how things move through experiment, but failed to explain why.

# Newton

- Newton came up with three laws of motion.
- Newton's First Law is the Law of Inertia
- Inertia is the objects resistance to a change in motion.
- Newton's 1<sup>st</sup> Law is stated "an object in motion will tend to stay in motion while an object at rest will stay at rest."
- Newton realized that a force is needed to start the motion of a resting object, and another force is needed to slow down a moving object.
- Implications? (the moving Earth!)

# Mass

- Mass is the quantity of matter in an object, or a measure of its inertia.
- Weight is a measure of how that mass is effected by a force of gravity.
- Weight varies, mass does not!
- Volume is the amount of space that mass occupies.



# Newton's Second Law

- Newton's second law is the law of force and acceleration.
- If an object is at rest and a force is put on the object, the object begins to move.
- This change in velocity means it was accelerated.
- Newton's law states that acceleration is directly proportional to the net force applied, and inversely proportional to the mass of the object.

# Forces

- The unit for force is a Newton (N) which can also be written as a  $\text{kg m/s}^2$ .
- $F=ma$  where  $F$  is the force,  $m$  is the mass, and  $a$  is the acceleration.
- A 1 kg object on earth would experience a force of 9.8 N (10 N), which is its weight.
- Force is a vector quantity, so the same rules as velocity vectors apply.

# Net Force and Equilibrium

- Once you add all of the force vectors, the resultant is the net force and will describe which direction the object will accelerate in.
- If all of the forces cancel out, then the object is in a state of equilibrium, and no acceleration will be felt by the object.
- The force that keeps you from falling through the floor (support force) even though you are acted on by gravity is called the Normal Force.
- It is a real force pushing against your feet!



# Friction

- Friction is created by the interaction between the molecules of the moving object and the surface it is laying on.
- The frictional force always works opposite the direction of motion.
- If the force on an object is not causing any acceleration of that object, then the force of friction is equal to the force applied to the object.
- Once more force is applied than the force of friction, the object will begin to move.

# Friction cont.

- The acceleration of the moving object can be found by subtracting out the force of friction from the force moving the object to get the net force.
- The force of friction can be found by the following equation:  $f = \mu F_N$
- $f$  = force of friction
- $\mu$  = coefficient of friction (known for each element)
- $F_N$  = normal force

# Air resistance

- Air resistance is the frictional force of air molecules reacting with fast moving objects.
- Air resistance will cause the objects acceleration to decrease as the objects velocity increases.
- Terminal velocity is where the force of gravity on an object is equaled by the air resistance and no longer accelerates.
- This is why the feather falls slower than the bowling ball. (What would happen in a vacuum?)

# Tension

- Suspended objects create a tension in the material that they are hung by.
- Each portion of the rope, spring, etc. carries a portion of the load. This creates tension.
- As the angle between the supports increases, the tension increases as well.
- In order to suspend something from a completely horizontal rope creates an infinite tension, that's why all things deflect (even steel beams!)



# Statics

- Statics is the study of the forces on an object that is not moving.
- If an object is hung, then its weight is divided evenly between the different supports if they are all at the same angle.
- The x and y components of the forces must perfectly cancel out in order for there to be no motion.
- This is part of what engineers look at when constructing buildings and bridges to ensure that at different positions, the structure will be safe.



# Pressure

- Pressure is the measurement of the amount of force per unit of area.
- $P = F/A$
- Where P is the pressure
- F is the force in Newtons
- A is the area in  $m^2$ .
- Units for pressure are  $N/m^2$ .