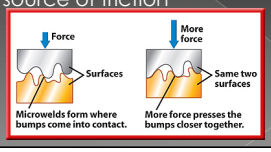
Chapter 3

Force

Friction

- Friction
  - force that opposes motion between two surfaces that are touching each other
- microwelds
  - areas where surface bumps stick together, are the source of friction



Types of Friction

- static friction
  - friction between two surfaces that are not moving past each other
- sliding friction
  - force that opposes the motion of two surfaces sliding past each other
- rolling friction
  - friction between a rolling object and the surface it rolls on

Air Resistance

- air resistance
  - opposes the motion of objects that move through the air
- When an object falls toward Earth, it is pulled downward by the force of gravity (weight).
- Air resistance depends on an object's
  - shape
  - size
  - speed

Terminal Velocity

- terminal velocity
  - forces on a falling object are balanced (gravity and air resistance) and the object falls with constant speed
- As an object falls, the downward force of gravity (weight) causes the object to accelerate.
- As an object falls faster, the upward force of air resistance increases.
- This causes the net force on a sky diver to decrease as the sky diver falls.

Terminal Velocity

- When the upward air resistance force becomes large enough to balance the downward force of gravity the net force equals zero
- The forces are balanced.
- If the net force equals zero, the acceleration equals zero.
- If acceleration is zero the object falls with a constant velocity called the terminal velocity.

Terminal Velocity

- The terminal velocity is the highest speed a falling object will reach without an additional external force.
- The terminal velocity like air resistance is depends on the size, shape, and mass of a falling object.

Section 3.2: Gravity

- gravity
  - an attractive force between any two objects that depends on the masses of the objects and the distance between them

The Law of Universal Gravitation

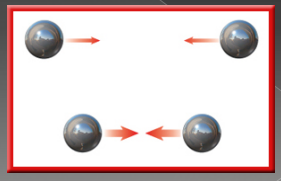
- enables the force of gravity to be calculated between any two objects if their masses and the distance between them is known

$$F = G\frac{m_1 m_2}{d^2}$$

- G
  - a constant called the universal gravitational constant
  - 6.67×10^{-11} N x m^2/kg^2
- d
  - distance between the two masses
- m_1 and m_2
  - the masses of the objects

The Range of Gravity

- the gravitational force between two masses decreases rapidly as the distance between the masses increases.



The Range of Gravity

- the gravitational force between them never completely goes to zero
  - gravity is called a long-range force

Earth's Gravitational Acceleration

- free fall
  - when all forces except gravity acting on a falling object can be ignored
- known as acceleration of gravity (g)
  - 9.8 m/s^2

Weight

- **weight**
  - the gravitational force exerted on an object
- the weight of an object on Earth is equal to the force of Earth's gravity on the object (Newton's 2nd Law)
- so,

$$F_W = mg$$

  - F_W = weight (N)
  - m = mass (kg)
  - g = acceleration due to gravity (9.8 m/s^2)

Weight and Mass

- weight
  - a force
  - can change depending on the gravitational force on the object
- mass
  - a measure of the amount of matter an object contains
- weight increases as mass increases

Projectile Motion

- Earth's gravity causes projectiles to follow a curved path
- **projectile**
  - anything that is thrown or shot through the air
- One forces act on a ball in the air
  - Gravity
    - This explains the vertical motion of the object
  - Horizontal motion is explained by Inertia which is not a force.

Centripetal Force

- centripetal acceleration
  - acceleration toward the center of a curved or circular path
- when a ball has centripetal acceleration, the direction of the net force on the ball also must be toward the center of the curved path (Newton's 2nd Law)
- centripetal force
  - the net force exerted toward the center of a curved path

Centripetal Force

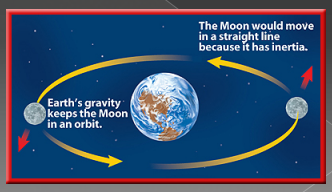
- Centripetal Force increases with:
  - an increase in velocity
  - an increase in the mass of the object
  - a decrease in the radius of the object

Centripetal Force and Traction

- a car rounding a curve on a highway has centripetal force acting on the car to keep it moving in a curved path
  - the centripetal force is the frictional force, or the traction, between the tires and the road surface

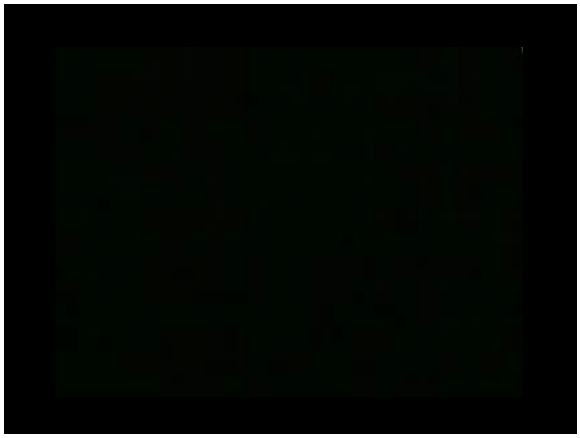
Gravity Can be a Centripetal Force

- Earth's gravity exerts a centripetal force on the Moon that keeps it moving in a nearly circular orbit



Section 3.3: The Third Law of Motion

- Newton's third law of motion
  - when one object exerts a force on a second object, the second one exerts a force on the first that is equal in strength and opposite in direction



Action and Reaction

- when you jump on a trampoline, you exert a downward force on the trampoline
- the trampoline exerts an equal force upward, sending you high into the air

Action and Reaction forces don't cancel

- action and reaction forces act on different objects
- even though the forces are equal, they are not balanced because they act on different objects

Rocket Propulsion

- burning fuel in a rocket produces hot gases.
- the rocket engine exerts a force on these gases and causes them to escape out the back of the rocket
- the gases exert a force on the rocket and push it forward

Momentum

- momentum
  - property of a moving object that equals its mass times its velocity
- So,

$$p = mv$$

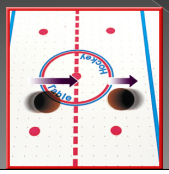
- p = momentum (kg · m/s)
- m = mass (kg)
- v = velocity (m/s)

Law of Conservation of Momentum

- Momentum can be transferred from one object to another.
  - momentum of an object doesn't change unless its mass, velocity, or both change.
- The law of conservation of momentum states that if a group of objects exerts forces only on each other, their total momentum doesn't change.

When Objects Collide

- The results of a collision depend on the momentum of each object.
- When the first puck hits the second puck from behind, it gives the second puck momentum in the same direction.



When Objects Collide

- If the pucks are speeding toward each other with the same speed, the total momentum is zero.