Chapters 11.3 & 12

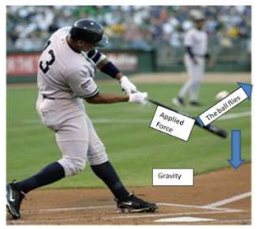
FORCES

11.3 Force

What is a force?

- Push or pull that one body exerts on another
- It is cause of acceleration or change in object's velocity

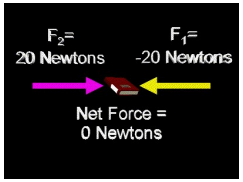
Ex: Catching a basketball and hitting a baseball with a bat.



Ex: Floor exerts forces on your feet

Net Forces

- *Net Force:*
  - The sum of all of the forces acting on an object.



- *Balanced Forces*:
  - Opposing forces are equal & completely cancel each other; Net force of zero (Ex. constant speed, no motion)

- *Unbalanced Forces*:
  - Forces acting on object, changing its motion due to acceleration: Net force is not zero (Ex. object moves in direction of greater force)

The Force of Friction

- **FRICTION**- A force that opposes motion between 2 surfaces in contact with one another
  - Causes a negative acceleration

Depends upon:

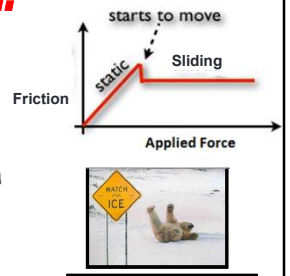
1. Kind of surface
2. Force pressing two surfaces together

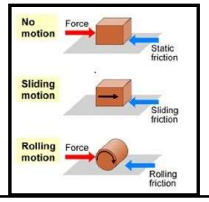
What is this unbalanced force that acts on an object in motion? **Friction!**

Types of friction:

1. Static friction- between surfaces that are stationary (at rest). Initial friction when moving an object
2. Sliding friction- opposes the motion of two surfaces sliding past each other. Ex. Ice skating
3. Rolling friction- the force resisting the motion when a body (such as a ball, tire, or wheel) rolls on a surface. Causes resistance. Ex. Bowling

- Less than sliding

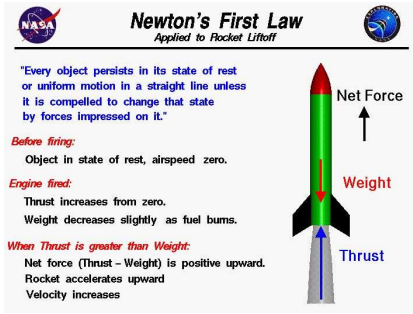




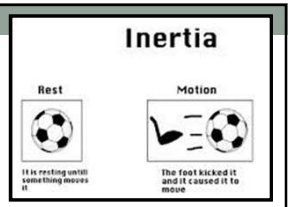
Newton's First Law

What does Newton's First Law of Motion state?

Object at rest remains at rest unless an unbalanced force acts on it; *also called the law of inertia.*

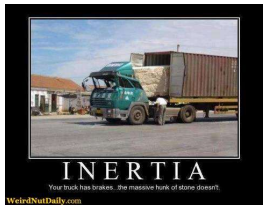


Newton's First Law

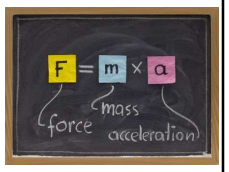


Inertia

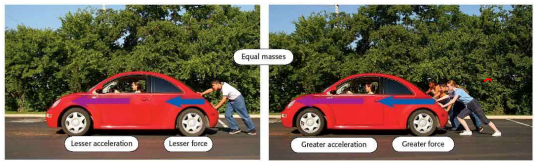
- The tendency of an object to remain at rest or in motion until acted upon by an external force.
- If object is moving, it keeps moving at same speed & in same direction unless unbalanced force acts on it
- So, an object at rest will stay at rest, and an object in motion will remain in motion unless acted by an outside force.



Newton's Second Law



- Newton's Second Law: net force acting on object causes object to accelerate in direction of force
- Larger mass requires greater force smaller mass to achieve the same acceleration
- Acceleration depends on the mass of the object and the unbalanced force applied
  - more mass, harder to accelerate
  - more force, faster acceleration

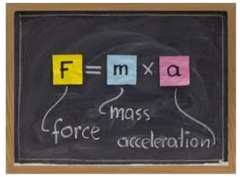


Calculating Newton's Second Law:

- **Formula: F = m x a**
- **Unit for Force: Newton (N)**
  - Equal the force needed to change the velocity of a 1 kg mass by 1 m/s^2

1 N = 1kg x 1 m/s^2

F = Force (N)
m =mass (kg)
a = acceleration (m/s^2)



What's the formula when looking for acceleration?

What's the formula when looking for force?

Problem: Newton's Second Law

1. Zookeepers lift a stretcher that holds a sedated lion. The total mass of the lion and stretcher is 175 kg, and the upward acceleration of the lion and stretcher is 0.657 m/s^2. What force is needed to produce this acceleration of the lion and the stretcher?

List the given and unknown values.

m = 175 kg
a = 0.657 m/s^2
F= ?,

Write the equation for Newton's second law.

force = mass × acceleration

$F = ma$

Insert the known values into the equation, and solve.

F = 175 kg × 0.657 m/s^2

F = 115 kg × m/s^2

F = 115 N

Practice Problem:

2. What net force is needed to accelerate a 1.6 x 10^3 kg automobile forward at 2.0 m/s^2?

m = 1.6 x 10^3 kg
a = 2.0 m/s^2
F=?

F= ma

F=(1.6x 10^3 kg)(2.0 m/s^2)

F= 3.2 x10^3 N

3. A baseball accelerates downward at 9.8 m/s^2. If the gravitational force is the only force acting on the baseball and is 14 N, what is the baseball's mass?

m = ?
a = 9.8 m/s2
F= 14 N

m= F/a

M= (14 N/9.8 m/s^2)

m = 1.4 kg

Practice Problem:

4. A sailboat and its crew have a combined mass of 655 kg. If a net force of 895 N is pushing the sailboat forward, what is the sailboat's acceleration?

m = 655 kg
a = ?
F= 895 N

a = F/m

a = 895 N/655 kg

A =1.37 m/s^2 in the direction of the force

5. The net forward force on the propeller of a 3.2 kg model airplane is 7.0 N. What is the acceleration of the airplane?

m =3.2 kg
a = ?
F= 7.0 N

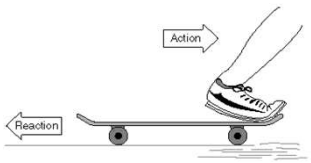
a = F/m

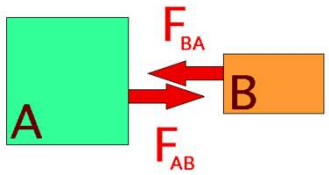
a = 7.0 N forward/3.2 kg

a = 2.2 m/s^2 forward

Newton's Third Law (Action-Reaction)

- When one object exerts a force on a second object, the second object exerts an equal but opposite force on the first.
- For every force, there is an equal and opposite force
- For every **action** there is an equal and opposite **reaction**.





Newton's Third Law

- **Explanation:**
  - forces are equal and opposite but act on different objects
  - they are not "balanced forces"
  - the movement of the horse depends on the forces acting on the horse

Where are the forces that are acting on the horse occurring?

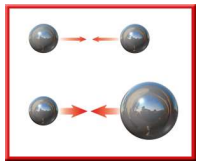
Why do objects fall to the ground when dropped?

All objects in the universe attract each other through the force of gravity.

- Gravity: force of attraction between any two objects in the universe
- Acts on all objects with mass
  - The strength of the force depends on the mass of the objects and the distance
    - increases as...
      - mass increases
      - distance decreases

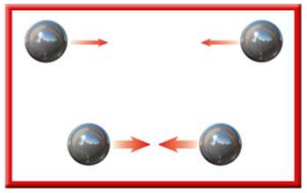
Law of Universal Gravitation

Mass



If the mass of either of the objects increases, the gravitational force between them increases

Distance

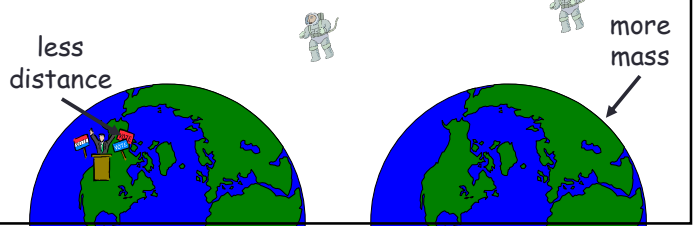


If the objects are closer together, the gravitational force between them increases

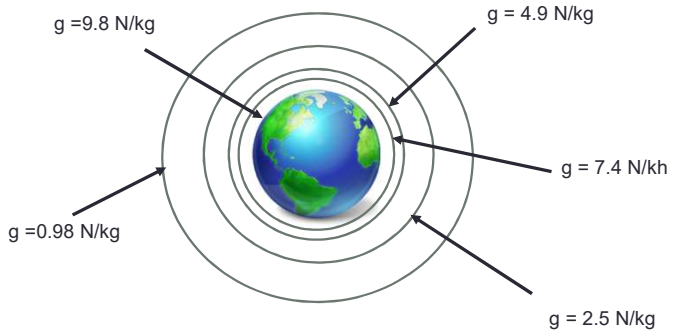
Gravity

- Who experiences more gravity - the astronaut or the politician?
  - Politician, WHY?
  - Which exerts more gravity - the Earth or the moon?
    Earth, WHY?

The further from earth you travel the less gravitational force is on you.

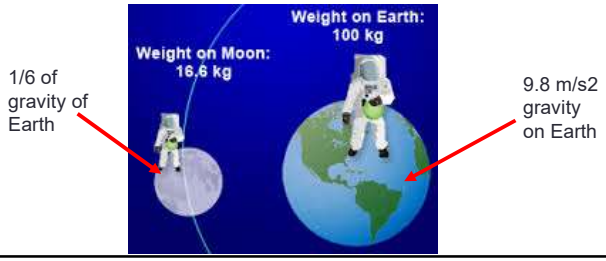


Gravitational Field of Earth



Weight

- The gravitational force exerted on an object is called the object's weight
- Larger mass, larger weight
- Different planets different values of gravity (g)
  - so you would weigh different amounts



Mass vs Weight

- Mass is the amount of matter in an object
- Since an object's force of gravity depends on its mass, the more mass an object has, the stronger the force of gravity it exerts.

MASS
always the same (kg)

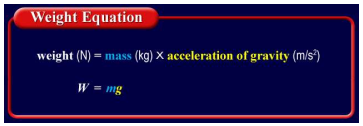
WEIGHT
depends on gravity (N)

Check for understanding

- The Moon has 1/6 the gravity on Earth, which is approximately 9.8 m/s^2. If something has a mass of 120 g, what will be its approximate weight on the moon?
  a. 0.2g
  b. 120 g
  c. 120 N
  d. 0.20N

Remember: 1 N = 1kg x 1 m / s^2

1 g= 0.001 kg



Calculating Weight

W=mxg

- **Weight = mass x free-fall acceleration**
- **W = m x g**
- **g = 9.8 m/s^2**
- **SI unit of weight is Newtons (N)**

***W*: weight (N)**
***m*: mass (kg)**
***g*: acceleration due to gravity (m/s^2)**

What does the formula look like when solving for mass?

m=W/g

What does the formula look like when solving for gravity?

g=W/m

Practice Problem: Weight

1. Jimmy has a mass of 37.5 kilograms here on earth. What is his **weight**?

W = ?
m = 37.5 kg
g = 9.8 m/s^2

W = m x g

W = 37.5 kg x 9.8 m/s^2

W = 367.5 N

W = 368 N

2. What is the weight of a person with a mass of 72 kg on Earth?

W= ?
m= 72 kg
g = 9.8 m/s^2

W= m x g

W= 72 kg x 9.8 m/s^2

W= 705.6 N

Practice Problem: Weight

3. A boy weighs 400 N. What is his mass?

W = 400 N
m = ?
g = 9.8 m/s^2

m=W/g

m=400 N/ 9.8 m/s^2

m = 41 kg

4. An astronaut has a mass of 100 kg and has a weight of 370 N on Mars. What is the gravitational strength on Mars?

W = 370 N
m = 100 kg
g = ?

g=W/m

g = 370 N/ 100 kg

g = 3.7 N/kg

Air Resistance

- Type of friction
- Force air exerts on moving object
- Acts in opposite direction to object's motion
- Air resistance pushes up as gravity pulls down.
- Depends on size, speed, shape, & density of an object
- Large surface area = Large amount of air resistance

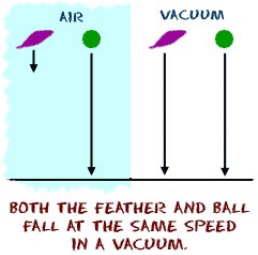
Lift Jump Video

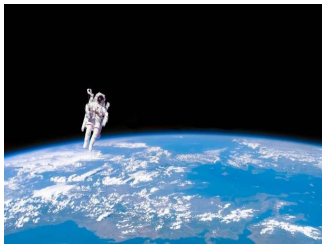
Free fall

- When the force of gravity is the only force acting on an object
- If there was no air resistance, all objects would fall at the same speed

Why do astronauts in orbit seem weightless?

They are in free fall. Objects in the shuttle seem to be floating because they are all falling with the same acceleration. Acceleration is much slower than on earth.





Free Fall Video

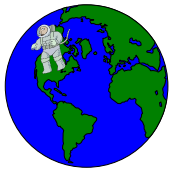
Terminal velocity

- **terminal velocity - highest speed reached by a falling object.**
- **Force of gravity is constant**
- **Eventually gravity will balance with air resistance**
  - **air resistance increases as you speed up until the force is equal**
  - **Equal forces, no acceleration**
  - **constant velocity terminal velocity**

Section 2: Review

- Is the following statement true or false?
  - An astronaut has less mass on the moon since the moon exerts a weaker gravitational force.

- False! Mass does not depend on gravity, weight does. The astronaut has less weight on the moon.



Section 2: Review

TRUE or FALSE:

An astronaut on the Space Shuttle feels weightless because there is no gravity in space.

FALSE!

There is gravity which is causing the Shuttle to free-fall towards the Earth. She feels weightless because she's free-falling at the same rate.