Chapters 11.3 & 12

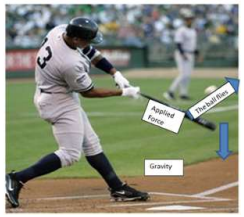
FORCES

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
- Force = F

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



Ex: Floor exerts forces on your feet

Forces

Changing Motion

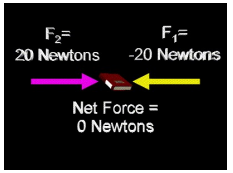
- Can cause a change in motion
- Can cause a change in velocity
- Can cause acceleration
- There can be no acceleration without a force

Describe things a soccer player could do to change the velocity of a soccer ball?

What causes the ball to stop?

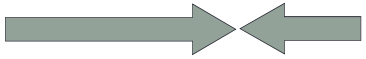
Net Forces

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



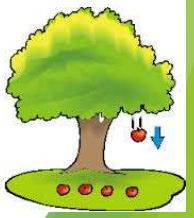
- *Balanced Forces*:
  - Opposing forces are equal & completely cancel each other; Net force of zero (Ex. constant speed, no motion)

- *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)



Force of Gravity

- Gravity: the force that exists between any two objects that have a mass.
- What does this mean?
  - Gravity pulls us (a small mass) towards the Earth (a very LARGE mass)
- Written as: F_g

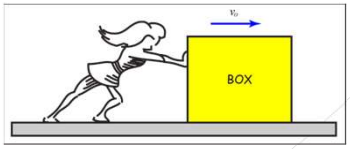


Normal Force

- Normal: the component perpendicular to the surface of contact
- Written as F_N

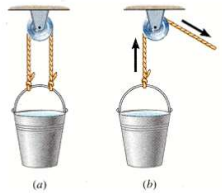
Applied Force

- Applied: a force that is applied to an object by a person or another object.
- Written as F_{app}



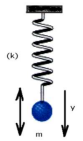
Tension Force

- Tension: the force in a rope, string, cable, or wire when it is pulled tight by forces acting on opposite ends.
- Written as F_T



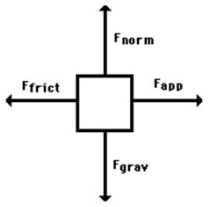
Spring Force

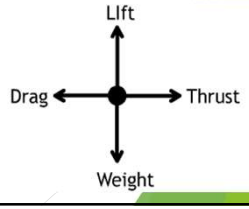
- Spring (also called compression): force exerted by a compressed or stretched spring on any object that is attached to it.
- Written as F_{spring}



Determining Net Force

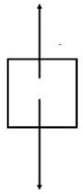
- In order to determine net force, we look at a free body diagram.
- If the vectors on the diagram are pointing in opposite directions, we subtract the forces.
- If the vectors are going in the same direction, we add the forces.





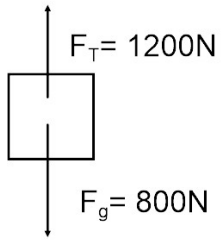
Free Body Diagram

1. Draw a box to represent your object
2. Draw arrows pointing in the direction that a force is pulling or pushing the object
3. Add the amount of force to your arrows to demonstrate the amount of force.



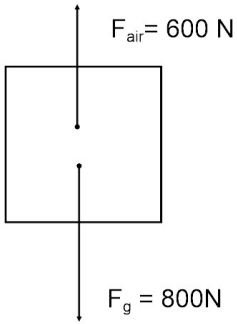
A box is being pulled up by a rope.

- Do we add or subtract?
- Subtract! The arrows are going in opposite directions.
- What is the net force acting on this object?
  - 400N up!
- Are these forces balanced?
- No.



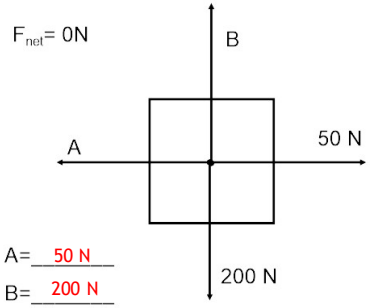
Forces Problems

Problems #1



- Net Force?
- 200 N down
- Are these forces balanced?
- No!

Problem #2: What would be the unknown forces acting on this object given the net force?



A= 50 N

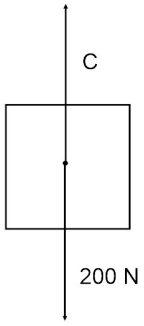
B= 200 N

Problem #3

F_{net}= 900 N, up

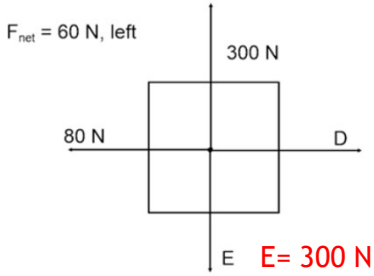
What is C?

F= 1100 N



Problem #4

Solve for D & E



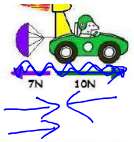
D= 20 N

E= 300 N

1. Look at the picture to the right. What is the net force on the car?

Net force = 3n right

Is this force balanced or unbalanced? unbalanced



2. Look at the picture to the left. The dog is pulling with a force of 30N to the right and the boy is pulling backwards with a force of 18N. What is the net force on them?

Net force = 12n, Right

Is this force balanced or unbalanced? unbalanced

18N 30N

3. Look at the picture to the right. Both men are pushing on the refrigerator with a force of 100N. What is the Net force of on the refrigerator?

Net force = 0n

Is this force balanced or unbalanced? balanced

60N 55N

4. Look at the picture to the left. **Both** of the people on the left are pulling with a force of 30N to the left. On the right side of the rope, one person is pulling with 35 N to the right, and the other person is pulling with 20N to the right. What is the net force on the rope?

30N 30N 35N 20N

Net force = 25N → Right

5N left

Is this force balanced or unbalanced? unbalanced

5. Look at the picture to the right. The Jet is traveling with a force of 1000N. The friction of the air causes a force of about 50N on the Jet. What is the net force of the Jet?

Net force = 950n right

Is this force balanced or unbalanced? Unbalanced

Word Problems (try drawing a picture if you need help)

6. Frankie and Caitlin are trying to move a small four-wheeler out of their garage. Frankie pushes with a force of 40N towards the outside. Caitlin pulls with a force of 20 N towards the outside. What is the net force on the four-wheeler?

Net force = 60N right

Is this force balanced or unbalanced? balanced

40N → □ → 20N

7. Jennifer just went out and bought a new television to replace her old broken down one. She pushes the new television across her living room floor. She pushes with 18N of force. What is the net force on the television?

Net force = 18n right

Is this force balanced or unbalanced? Unbalanced

□ → 18N

8. Kathryn decides to take her dog for a walk one day. Her dog tries pulling on her with a force of 15N. Kathryn pulls back with a force of 20N.

Who is pulling who? Kathryn pulls

Net force = 5N, Right

Is this force balanced or unbalanced? unbalanced

15N ← □ → 20N

9. Look at the picture below. The arrow shows the direction of movement of the two bighorn sheep.

Which sheep is pushing with more force?

The one on the left

Is this force balanced or unbalanced?

Unbalanced

The Force of Friction

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

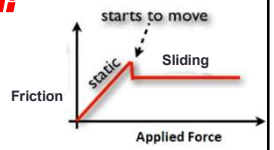
Depends upon:

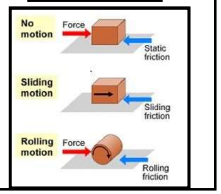
1. Kind of surface
2. Force pressing two surfaces together

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

Types of friction:

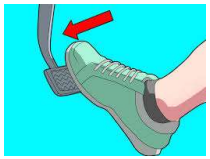
1. Static friction- between surfaces that are stationary (at rest). Initial friction when moving an object
2. Sliding friction- opposes the motion of two surfaces sliding past each other. Ex. Ice skating
3. Rolling friction- the force resisting the motion when a body (such as a ball, tire, or wheel)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





Why would friction cause brakes pads to ware down in cars?

- Friction between brake pads and the rotors causes the materials that makes up the pad to rub off.



Old New

Friction and Motion

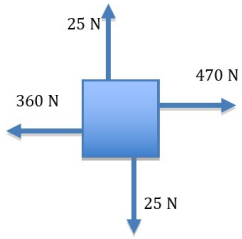
- Friction is necessary for many everyday tasks to work correctly.
  - Ex: walking, holding cellphone
- Reducing friction: add lubricants or other low-friction materials.
  - Ex: motor oil, wax and grease

- Increasing friction: make surface rougher
  - Ex: sand on icy roads, textured batting gloves

Curling Video

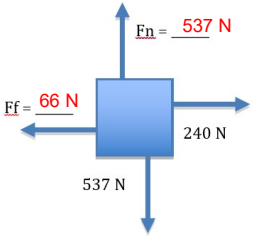
Calculate the missing forces on the objects below:

A



Fnet = 110 N to the right

B



Fnet = 174 N right

Ch. 12.1 Newton's Laws

Sir Isaac Newton (1642-1727)

- Described motion and force in 3 laws
  - **Newton's First Law-** inertia
  - **Newton's Second Law-** (Force= m x a)
  - **Newton's Third Law-** action and reaction

Velocity vs Time Graph

Describe the force used by the object during the first 3 seconds.

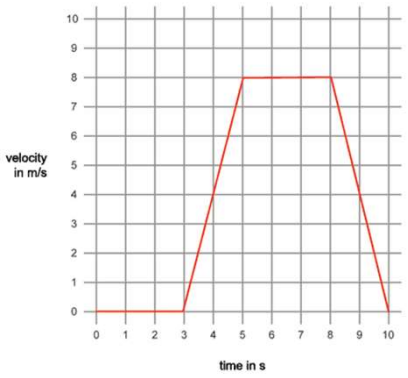
0 N so it is Balance

Describe the force used by the object from 3s to 5s.

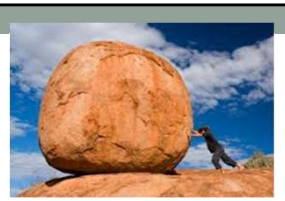
Net force is great then 0, so forces are unbalanced

Describe the force used by the object from 5s to 8s?

Constant force is it is Balance

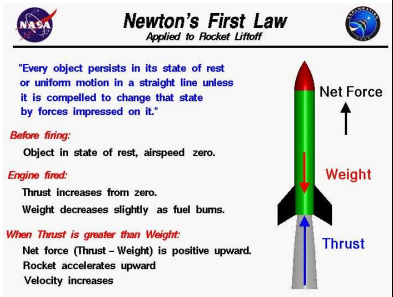


Newton's First Law

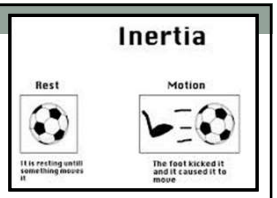


What does Newton's First Law of Motion state?

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



Newton's First Law



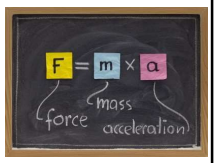
Inertia

- 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.

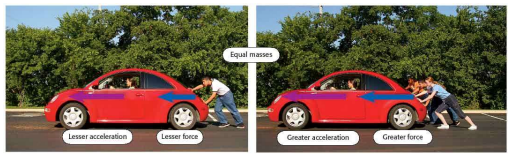
Inertia Depends on Mass

- The more mass an object has, the harder it is to get it to move *or to stop*!
- This is why seatbelts save people – they prevent you from maintaining a speed of 60-70 miles an hour when the car suddenly stops!

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



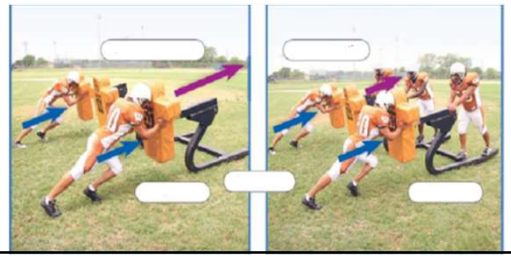
Newton's Second law Examples

1.

How does Newton's second law apply to each example?

2.

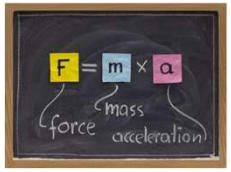
3.



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

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



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

Calculating Newton's Second Law:

What's the formula when looking for force?

What's the formula when looking for acceleration?

What's the formula when looking for mass?

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

$F = ma$

Setup the equation by inserting the known value

F = 175 kg × 0.657 m/s^2

F = 115 kg × m/s^2

Solve

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 2nd Law Practice Problems F=ma

Directions: Be sure to show your work, circle your final answers. For each question, you must provide you answer in both extended form and scientific notation.

1. The gravitational force that the Earth exerts on the moon equals 2.03 x 10^{20}N. The moon's masse equals 7.35 x 10^{23} kg. What is the acceleration of the moon due to Earth's gravitational pull?

G U E S S

2. Assume that a catcher in a professional baseball game exert a force of -65.0 N to stop the ball. If the baseball has a mass of 0.145 kg, what is the acceleration as it is being caught?

G U E S S

3. A type of elevator called a cage is used to raise and lower miners in a mine shaft. Suppose the cage carries a group of miners down the shaft. If the unbalanced force on the cage is 60.0 N, and the mass of the loaded cage is 1.50 x 10^2 kg, what is the acceleration on the cage?

G U E S S

Newton's 2nd Law Practice Problems

4. The tallest man-made structure at present is the Warszawa Radio mast in Warsaw, Poland. This radio mast rises 646 m above the ground, nearly 200 m more than the Sears Tower in Chicago. Suppose a worker at the top of the Warszawa Radio mast accidentally knocks a tool off the tower. If the force acting on it is 3.6 N, and its acceleration is 9.8 m/s^2, what is the tool's mass?

G U E S S

5. The whale shark is the largest of all fish and can have the mass of three adult elephants. Suppose that a crane is lifting a whale shark into a tank for delivery to an aquarium. The crane must exert an unbalanced force of 2.5 x 10^4 N to life the shark from rest. If the shark's acceleration equals 1.25 m/s^2, what is the shark's mass?

G U E S S

Newton's 2nd Law Practice Problems

6. A freight train slows down as it approaches a train yard. If a force of -3.8 x 10^6 N is required to provide an acceleration of -0.33 m/s^2, what is the train's mass?

G U E S S

7. In drag racing, acceleration is more important than speed, and therefore drag racers are designed to provide high accelerations. Suppose a drag racer has a mass of 1250 kg and accelerates at a constant rate of 16.5 m/s^2. How large is the unbalanced force acting on the racer?

G U E S S

8. A 5.22 x 10^7 kg luxury cruise ship is moving at its top speed as it comes into port. The ship then undergoes an acceleration equal to -0.357 m/s^2 until it comes to rest at its anchorage. How large must the unbalanced force acting on the ship be in order to bring the ship to rest at the proper location?

G U E S S

Newton's 2nd Law Practice Problems

9. The giant sequoia redwood trees of the Sierra Nevada mountains in California are said never to die from old age. Instead, an old tree dies when its shallow roots become loosened and the tree fails over. Removing a dead mature redwood from a forest is no easy feat, as the tree can have a mass of nearly 2.0×10^6 kg. Suppose a redwood with this mass is lifted with an overall upward acceleration of 0.85 m/s^2. How large is the unbalanced force lifting the tree?

G U E S S

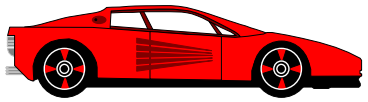
10. A house is lifted from its foundation onto a truck for relocation. The unbalanced force lifting the house is 2850 N. This force causes the house to move from rest to an upward speed of 0.15 m/s in 5.0 s. What is the mass of the house? *(Hint: 2 problems)*

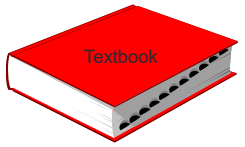
G U E S S

- Which needs a greater force to obtain the same acceleration?

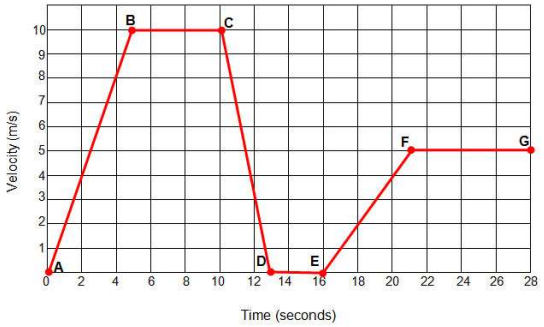
Why?

Car



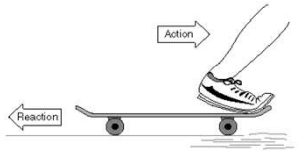


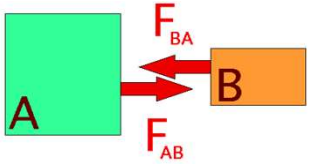
Explain the force use throughout the motion of the object represented by the red line.



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

- **Problem:**
  - How can a horse pull a cart if the cart is pulling back on the horse with an equal but opposite force?

  - Aren't these "balanced forces" resulting in no acceleration?

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

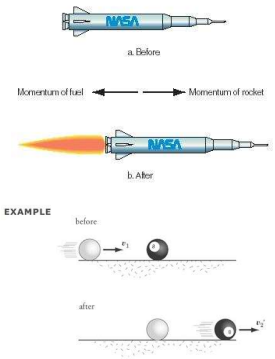
Where are the forces that are acting on the horse occurring?

Action and Reaction

- When a force is applied in nature, a reaction force occurs at the same time.
- When you jump on a trampoline, for example, you exert a downward force on the trampoline.
- Simultaneously, the trampoline exerts an equal force upward, sending you high into the air.

Momentum

- A moving object has a property called momentum that is related to how much force is needed to change its motion.
- The momentum of an object is the product of its mass and velocity



- A truck is harder to stop than a car
- Mass affects motion

GET READY FOR YOUR QUIZ

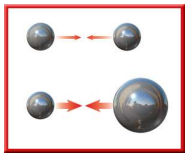
Force of Gravity

Why do objects fall to the ground when dropped?

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

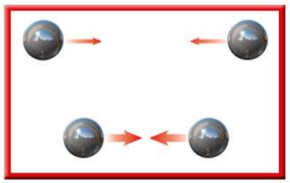
Law of Universal Gravitation

Mass



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

Distance

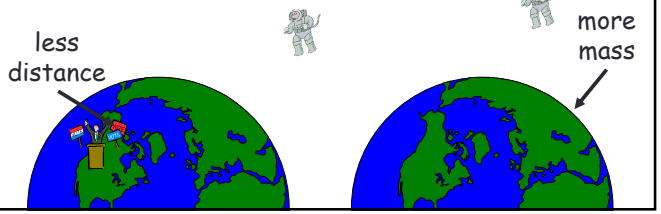


If the objects are closer together, the gravitational force between them increases

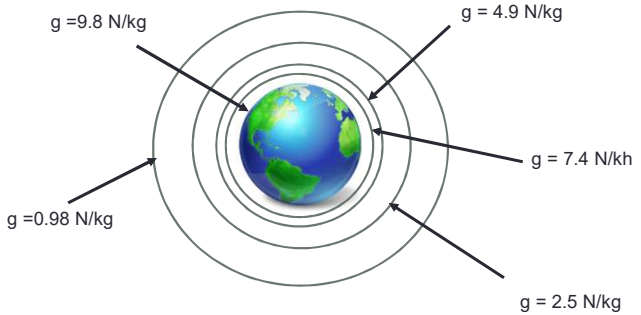
Gravity

- 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.



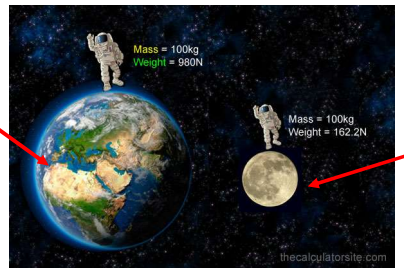
Gravitational Field of Earth



Weight

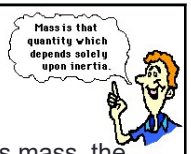
- The gravitational force exerted on an object is called the object's weight
- Larger mass, larger weight
- Different planets different values of gravity (g)
  - so you would weigh different amounts

9.8 m/s2 gravity on Earth



1/6 of gravity of Earth

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.


My WEIGHT on Earth is around 560N


My WEIGHT on the moon is around 90N


My MASS is always 56kg!!

MASS
always the same (kg)

WEIGHT
depends on gravity (N)

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

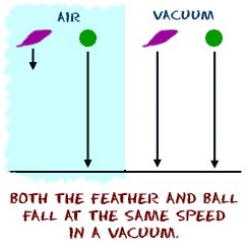
Free fall

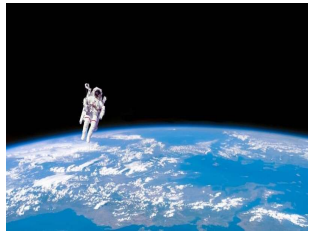
Must be in a vacuum

- 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.

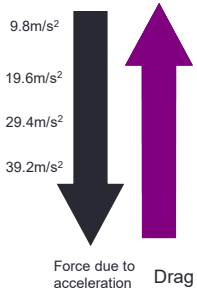




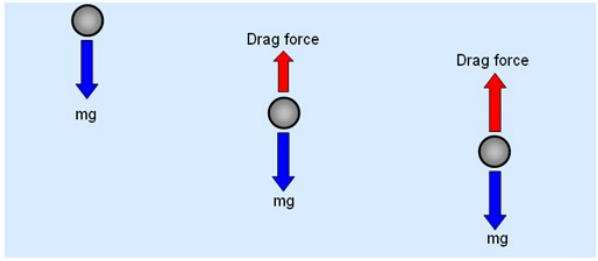
Free Fall Video

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**



Terminal Velocity



Calculating Weight

W=m x g

- **Weight = mass x free-fall acceleration**
- **W = m x g**
- **g = 9.8 m/s²**
- **Unit of weight is (N) Newtons**

For the EOC: g = 10 m/s²

W: weight **(N)**
m : mass **(kg)**
g : acceleration due to gravity **(m/s²)**

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

W=m x g

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/s²

W = m x g

W = 37.5 kg x 9.8 m/s²

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/s²

W= m x g

W= 72 kg x 9.8 m/s²

W= 705.6 N

Practice Problem: Weight

W=m x g

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

W = 400 N
m = ?
g = 9.8 m/s²

m=W/g

m=400 N/ 9.8 m/s²

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

Check for understanding

- The Moon has 1/6 the gravity on Earth, which is approximately 10 m/s². If something has a mass of 60 kg, what will be its approximate weight on the moon?
  a. 0.03 kg
  b. 100 kg
  c. 37.5 N
  d. 100 N

W=m x g

1. What is the difference between mass and weight?

2. How are weight and mass related?

Solve the following weight and mass problems. Use the GUESS steps to show all of your work where appropriate.

3. Amber, a volley ball player, has a mass of 60 kg.

   a. What is Amber's weight on Earth, where the acceleration due to gravity (g) is ~ 10 m/s^2?

   b. What is Amber's mass on Jupiter, where the acceleration due to gravity (g) is 25.0 m/s^2?

   c. What is Amber's weight, in Newton's, on Jupiter?

4. Juan weighs 850 N on Earth.
   a. What is Juan's mass?

   b. He travels to the planet Mercury where he weighs 338 N. What is the acceleration due to gravity on Mercury?

The acceleration due to gravity on different places in the Solar System is given in the table below.

Mercury	Venus	Moon	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
								
3.8	8.8	1.6	3.7	23.1	9.0	8.7	11.0	0.6

5. The mass of a 10 kg suitcase is greatest on because

6. Show calculations to determine if a 25 kg Martian or a 45 kg Venetian has more inertia. (Hint: Inertia depends on _____)

7. If you were in a sitting position, on which location would it be most difficult to stand up? Why?

The acceleration due to gravity on different places in the Solar System is given in the table below.

Mercury	Venus	Moon	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
								
3.8	8.8	1.6	3.7	23.1	9.0	8.7	11.0	0.6

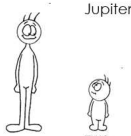
8. The Curiosity rover on Mars has a weight of 3330N. What is its weight on earth?

$W = mg$ $\quad m = \frac{3330N}{3.7 m/s^2}$ $\quad W = (900kg)(10 m/s^2)$

$W = 3330N$ $\quad m = 900kg$ $\quad W = 9000N$

$g = 3.7$

9. Both of these creatures have a mass of 80 kg. Which is more likely to originate from Jupiter? Which is more likely to originate from Pluto? Explain your thinking.



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.

Review

TRUE or FALSE:

An astronaut on the Space Shuttle is 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 but she is not without weight. There is a very small amount of gravity in space.

Newton's 3 Laws Activity

Match the situation to the appropriate Newton's Law. Explain how you identified which Law it was. If there is a calculation to be done then complete this in the box provided.

Situation	Newton's Law & explanation
If you use the same amount of force to push a car and a truck then the car will move with more acceleration than the truck.	2nd

Math Review

$F = m \times a$ $a = \frac{V_f - V_i}{t}$

1. A car is lifted from the ground onto a semi-truck for delivery to it's new owner. The mass of the car is 770 kg. The car is lifted from rest to an upward speed of 1.2 m/s in less than 4.0 s. What forces was used to lift the car?

G
$m = 770\,kg$
$V_f = 1.2\,m/s$
$t = 4.0\,s$
$V_i = 0\,m/s$

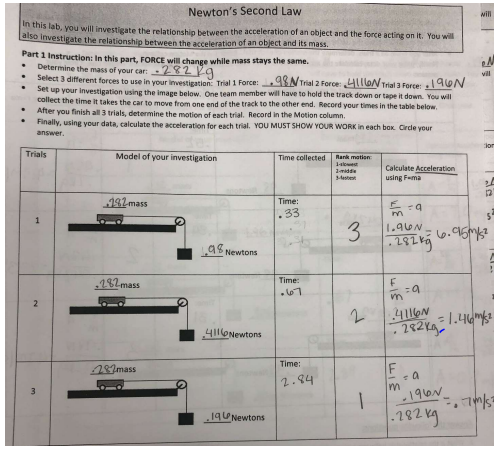
U
$F = ?$
$a = ?$

E
$F = m \times a$
$a = \frac{V_f - V_i}{t}$
$a = \frac{1.2\,m/s - 0\,m/s}{4.0\,s}$
$a = 0.3\,m/s^2$

S
$F = 770\,kg \times 0.3\,m/s^2$
$F = 231\,N$

What is the relationship between acceleration of the cart and the force? Explain how your data and observations support your answer.

F = ↓
m = constant
a = ↓



Newton's Second Law

In this lab, you will investigate the relationship between the acceleration of an object and the force acting on it. You will also investigate the relationship between the acceleration of an object and its mass.

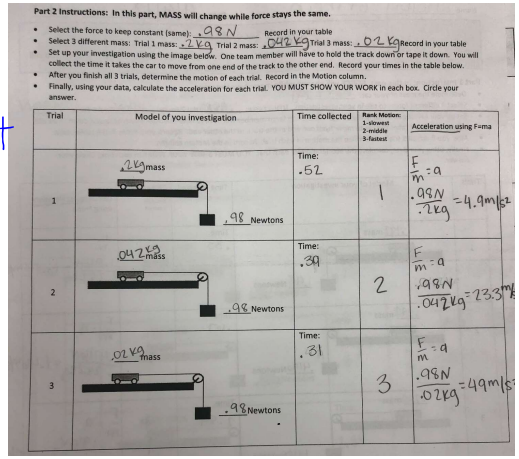
Part 1 Instruction: In this part, FORCE will change while mass stays the same.

- Determine the mass of your car: .282 kg
- Select 3 different forces to use in your investigation: Trial 1 Force: .98N Trial 2 Force: .4116N Trial 3 Force: .196N
- Set up your investigation using the image below. One team member will have to hold the track down or tape it down. You will collect the time it takes the car to move from one end of the track to the other end. Record your times in the table below.
- After you finish all 3 trials, determine the motion of each trial. Record in the Motion column.
- Finally, using your data, calculate the acceleration for each trial. YOU MUST SHOW YOUR WORK in each box. Circle your answer.

Trials	Model of your investigation	Time collected	Rank motion: 1-slowest 2-middle 3-fastest	Calculate Acceleration using F=ma
1	.282 mass; .98 Newtons	Time: .33	3	$\frac{F}{m}=a$ $\frac{1.96N}{.282kg}=6.95m/s^2$
2	.282 mass; .4116 Newtons	Time: .67	2	$\frac{F}{m}=a$ $\frac{.4116N}{.282kg}=1.46m/s^2$
3	.282 mass; .196 Newtons	Time: 2.84	1	$\frac{F}{m}=a$ $\frac{.196N}{.282kg}=.7m/s^2$

What is the relationship between acceleration of the cart and the force? Explain how your data and observations support your answer.

m = ↓
F = constant
a = ↑



Part 2 Instructions: In this part, MASS will change while force stays the same.

- Select the force to keep constant (same): .98 N Record in your table
- Select 3 different mass: Trial 1 mass: .2kg Trial 2 mass: .042 kg Trial 3 mass: .02 kg Record in your table
- Set up your investigation using the image below. One team member will have to hold the track down or tape it down. You will collect the time it takes the car to move from one end of the track to the other end. Record your times in the table below.
- After you finish all 3 trials, determine the motion of each trial. Record in the Motion column.
- Finally, using your data, calculate the acceleration for each trial. YOU MUST SHOW YOUR WORK in each box. Circle your answer.

Trial	Model of your investigation	Time collected	Rank Motion: 1-slowest 2-middle 3-fastest	Acceleration using F=ma
1	.2kg mass; .98 Newtons	Time: .52	1	$\frac{F}{m}=a$ $\frac{.98N}{.2kg}=4.9m/s^2$
2	.042kg mass; .98 Newtons	Time: .39	2	$\frac{F}{m}=a$ $\frac{.98N}{.042kg}=23.3m/s^2$
3	.02kg mass; .98 Newtons	Time: .31	3	$\frac{F}{m}=a$ $\frac{.98N}{.02kg}=49m/s^2$

$m=\frac{F}{a}$

Fill in the missing Data

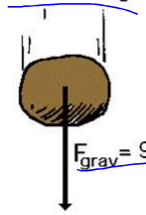
Net Force N	Mass Kilograms	Acceleration m/s/s
10	2	5 m/s/s
20	2	10 m/s/s
20	?4	5 m/s/s
10	5	2 ? m/s/s
10	1	10 m/s/s

If mass remains constant, doubling the acceleration, doubles the force. If force remains constant, doubling the mass, halves the acceleration.

Solve for the following objects:

$F = m \times a$
$W = m \times g$

Problem 1
m = 10 kg



F_{grav} = 98 N

Problem 2
m = 1 kg

F_{grav} = 9.8N

$a = \frac{F}{m}$ or $\frac{W}{m}$

$\frac{98N}{10kg}$

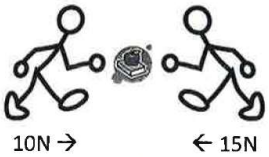
$a = 9.8 m/s^2$

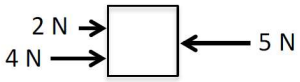
Newton's 3 Laws Activity

Match the situation to the appropriate Newton's Law. Explain how you identified which Law it was. If there is a calculation to be done then complete this in the box provided.

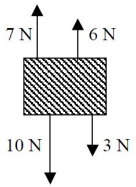
Situation	Newton's Law & explanation
Sliding a hockey puck on ice will eventually stop due to friction or if it is hit by a hockey stick.	1st

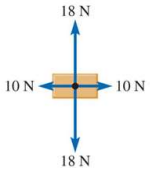
Math Review: Determine the Net Force





Math Review: Determine the Net Force





Mr. Smith and his wife were trying to move their new chair. Mr. Smith pulls with a force of 30 N while Mrs. Smith pushes with a force of 25 N in the same direction. What is the net force?