FORCES WORKBOOK

Name:__________________________________

You must bring this workbook to class every day between March 26th and April 6th. If you do not have this packet in class, you will earn a homework detention.

Vocabulary Words:

- Force
- Net Force
- Acceleration
- Normal Force
- Friction
- Thrust

Work & Simple Machines

Name___________________

Forces

When you ride a bike, your foot **pushes** against the pedal. The push makes the wheels of the bike move.

When you drop something, it is **pulled** to the ground by gravity.

A **PUSH** or a **PULL** is a **FORCE**. So, a good definition for ***force*** *is a push or pull in a particular direction.*

Forces affect how objects move. They may cause motion; they may also slow, stop, or change the direction of motion of an object that is already moving.

Give an example of a pushing force AND a pulling force at school:

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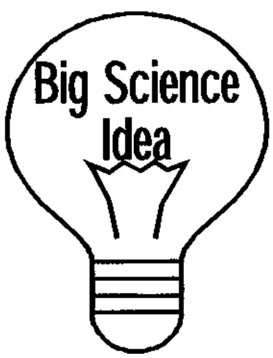

Forces can affect motion in several ways:

→ They can make objects start moving
→ They can make objects move faster
→ They can make objects move slower
→ They can make objects stop moving
→ They can make objects change direction
→ They can make objects change shape

Since force cause changes in the **speed** or **direction** of an object, we can say that forces cause changes in **velocity**, so....
Forces cause acceleration!

List 3 examples of acceleration:

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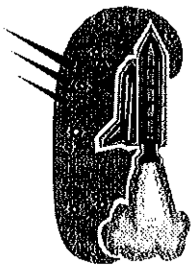
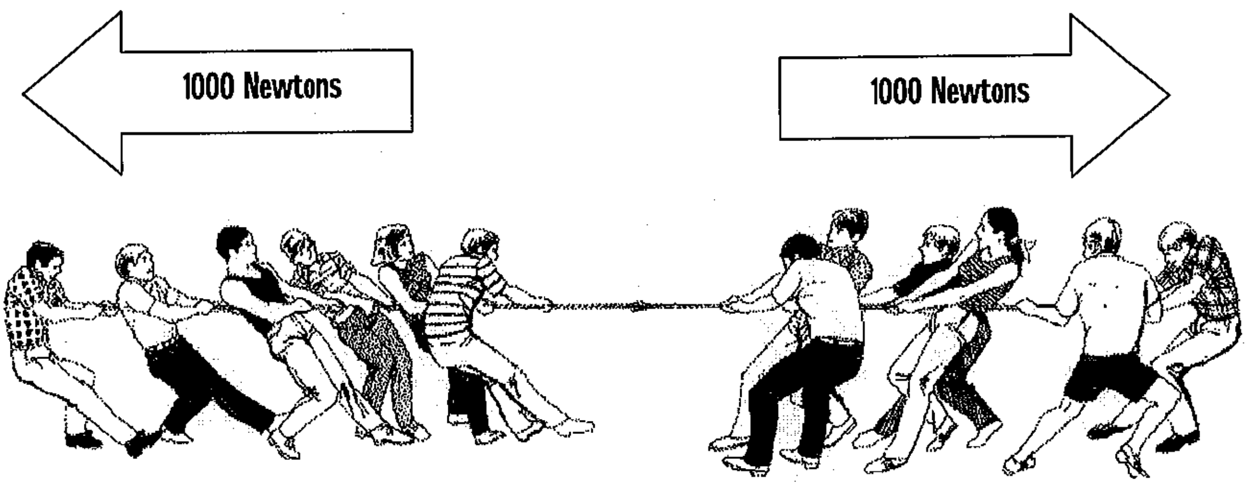
FORCE FACTS:

→ Forces are measured in Newtons (N)
→ Forces usually act in pairs
→ Forces act in a particular direction
→ Forces usually cannot be seen, but their effects can

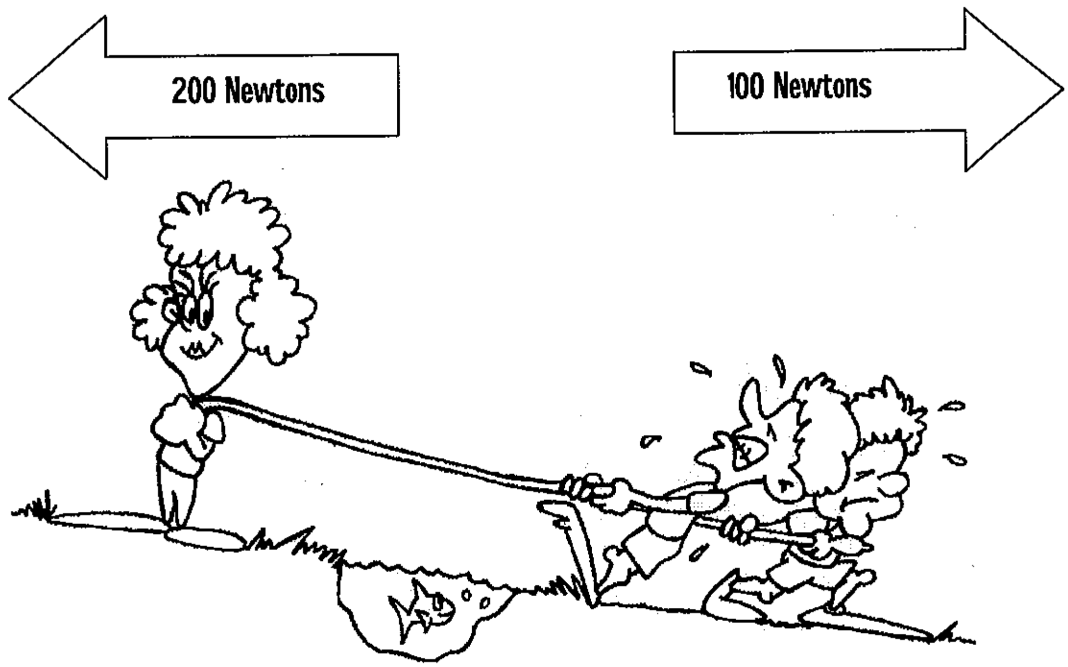
Label the force in each picture as a push or pull. Then describe whether the force is causing a change in speed or direction or both.

Circle the best answer:



1. The forces shown above are PUSHING / PULLING forces.
2. The forces shown above are WORKING TOGETHER / OPPOSITE FORCES.
3. The forces are EQUAL / NOT EQUAL.
4. The forces DO / DO NOT balance each other.
5. The resultant force is 1000 N TO THE RIGHT / 1000 N TO THE LEFT / ZERO.
6. There IS / IS NO motion.



7. The forces shown above are PUSHING / PULLING forces.

8. The forces shown above are WORKING TOGETHER / OPPOSITE FORCES.

9. The forces are EQUAL / NOT EQUAL.

10. The forces DO / DO NOT balance each other.

11. The stronger force is pulling to the RIGHT / LEFT.

12. The weaker force is pulling to the RIGHT / LEFT.

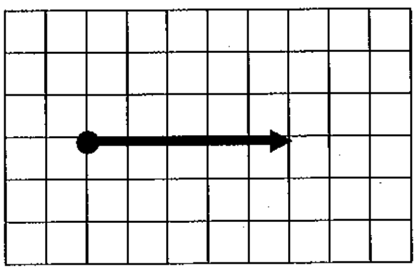
13. Motion is to the RIGHT / LEFT.

SHOWING FORCES:

A force can be shown with a **vector**. A vector is a line with an arrow. It begins with a dot.

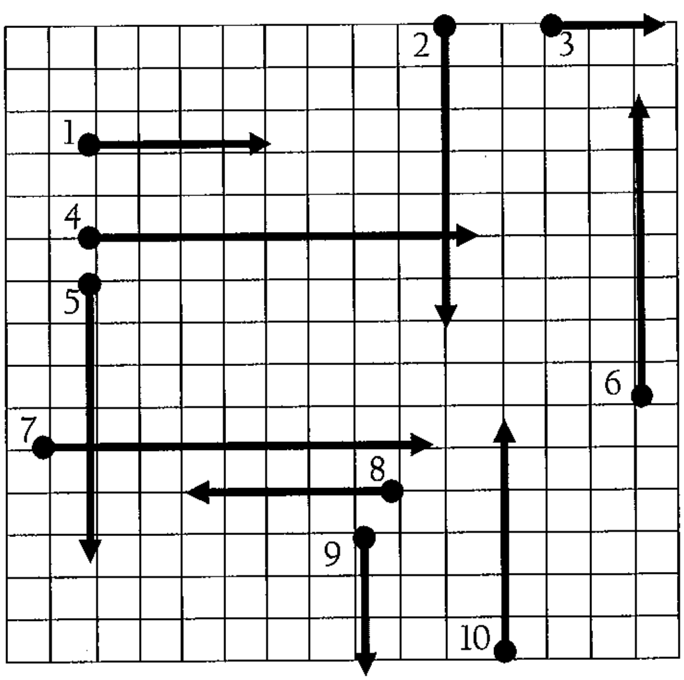
- → The dot shows where the force begins
- → The length of the arrow shows the amount of force
- → The arrows shows the direction of the force

Example:



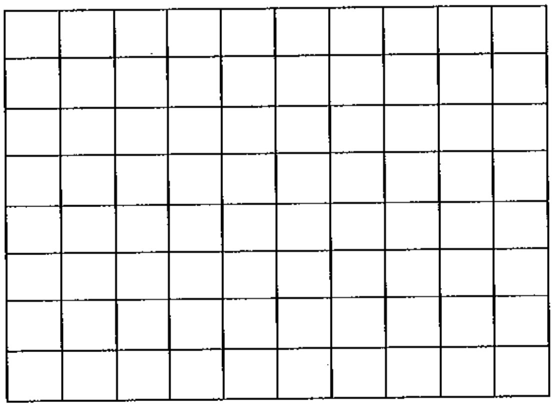
Each square represents force of ONE NEWTON. This vector shows a 5 n force to the right.

Fill in the chart on the right with the information found in the figure on the left. Each square represents 1 N of force.

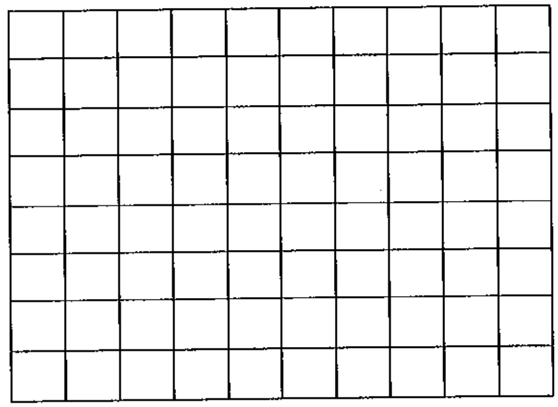


	Force (N)	Direction (right, left, up, down)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

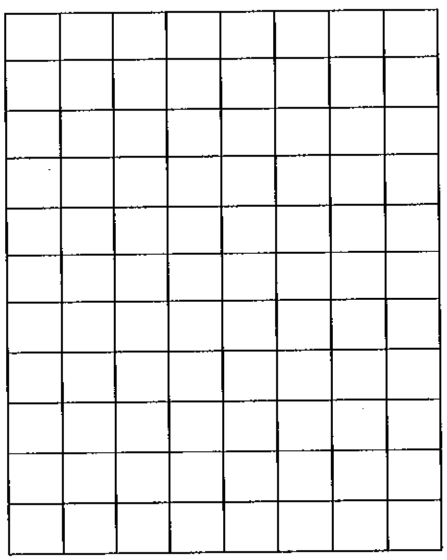
Draw each vector on the chart below. Start at the dot. Each square represents one n of force.



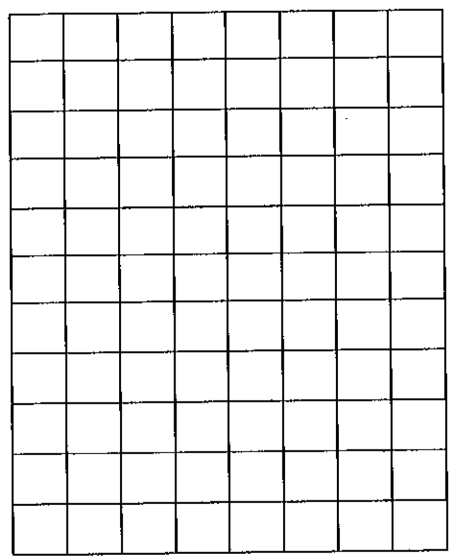
7 n force to the right



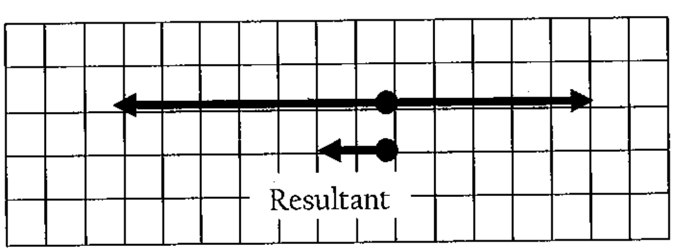
5 n force to the left



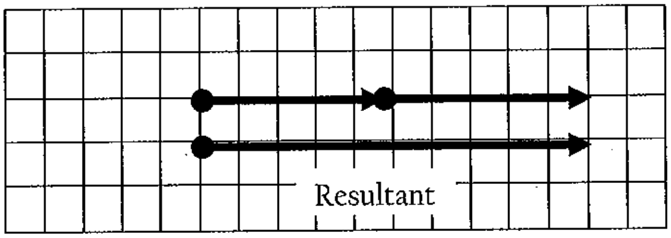
10 n upward force



3 n downward force

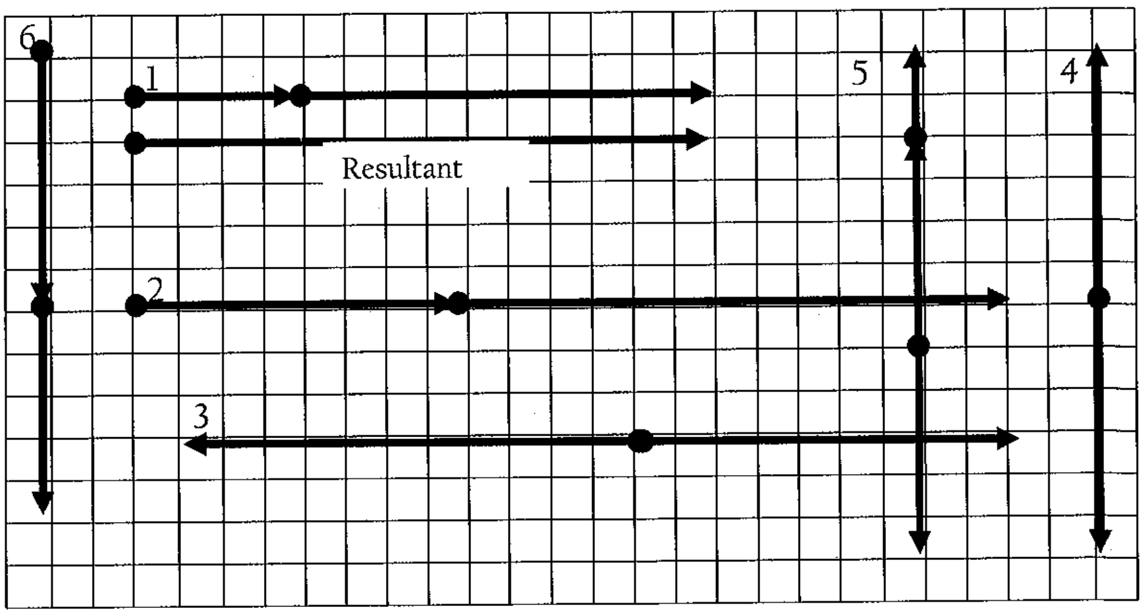


The figure to the left shows two opposite forces.
There is a 5 kg force to the right and a 7 n force to the left. Subtract 5 from 7.
The resultant is a 2 n force to the left.
The resultant vector is shown



This figure shows two forces in the same direction.
They are both 5 n forces.
Add 5 and 5.
The resultant is a 10 n force to the right.

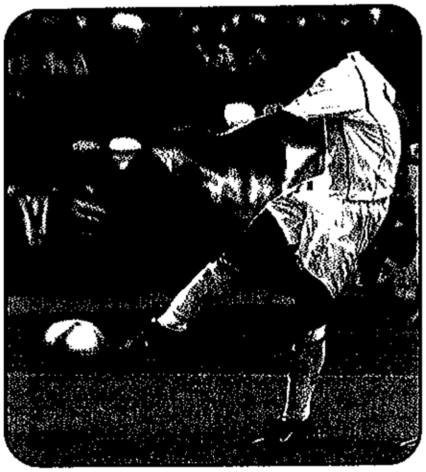
Six sets of vectors are shown below. Draw the resultant vector next to each set. Start at the dot. One has been for you.



Use the above information to fill the chart:

	Total number of forces	Amount of force (n)	Direction (right, left, up, down)	Resultant	Movement? (yes, no)
1					
2					
3					
4					
5					
6					

Forces and Motion



▲ **Figure 3** The force of a kicker's foot causes a soccer ball to start moving, change speed, or change direction.

READ TO UNDERSTAND

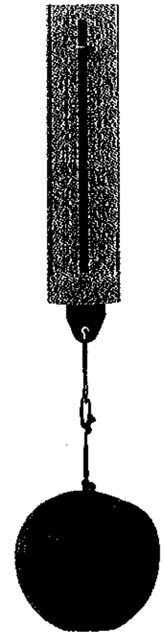
- How are force and motion related?
- How do friction and gravity affect objects?
- What is momentum, and how can it be conserved?

VOCABULARY

force	air resistance
gravity	mass
newton	weight
net force	terminal velocity
balanced forces	momentum
unbalanced forces	law of conservation of momentum
acceleration	
friction	

What Are Forces?

A **force** is a push or pull. Forces can cause objects to move, change speed, or change direction. Some forces act between objects that are touching one another. For example, a soccer player's foot touches a ball as he kicks it along the ground. A student's hand touches a book as she lifts it out of a backpack. Other forces can act on objects over long distances. For example, **gravity** is a force that pulls all objects toward one another. Gravity between the Sun and the planets keeps the planets in their orbits. Magnetism is another force that can act at a distance. A magnet can attract a magnetic object without touching it.



▲ **Figure 4** The spring scale shows that the force needed to lift the apple is 1 newton.

The amount of force acting on an object can be measured using a spring scale, as shown in Figure 4. Force is measured in units called **newtons.** The force needed to lift a large apple is approximately 1 newton (N).

How Do Forces Affect Objects?

An object can be acted upon by more than one force at a time. The forces can act together or against each other. The force that results from all the combined forces acting on an object is called the **net force.**

A stationary object has at least two forces acting on it. Hold an apple in your hand. The force of gravity pulls the apple down against your hand. At the same time, your hand pushes up on the apple with an equal force. Without the upward force supplied by your hand, gravity would cause the apple to fall to the floor.

Every force has both size and direction. In the case of the apple in your hand, the forces acting on it are equal in size but opposite in direction. The forces balance, or cancel, each other and the apple stays in the same position. Forces that cancel each other completely are called **balanced forces.** The net force is zero.

Sometimes the forces acting on an object do not cancel each other. These forces are called **unbalanced forces.** The net force is not zero. In the game called tug-of-war, two teams pull on a rope in opposite directions. If one team pulls harder on the rope, the forces are unbalanced. The amount of force in one direction cancels only part of the force in the opposite direction, leaving a net force that is not zero. The rope moves in the direction of the greater force.

A net force that is not zero causes changes in velocity. That means the object changes speed or direction or both. **Acceleration** is the rate at which an object's velocity changes. You may have heard people use the word *accelerate* for "speed up." Acceleration actually refers to speeding up, slowing down, or changing direction. Acceleration is calculated by dividing the change in velocity by the time it takes for the change to occur.

Velocity is measured in meters per second, and time is measured in seconds. So acceleration involves two units of time. This is why the unit of acceleration is meters per second per second, or meters per second squared (m/s^2).

Suppose you want to know the acceleration of a ski racer. You know the racer's velocity increased from 0 m/s to 20 m/s in 5 seconds. Substitute the amounts into the formula for acceleration:

$$\textbf{acceleration} = \frac{\textbf{final velocity} - \textbf{initial velocity}}{\textbf{time}}$$

$$= \frac{20\ m/s - 0\ m/s}{5\ s}$$

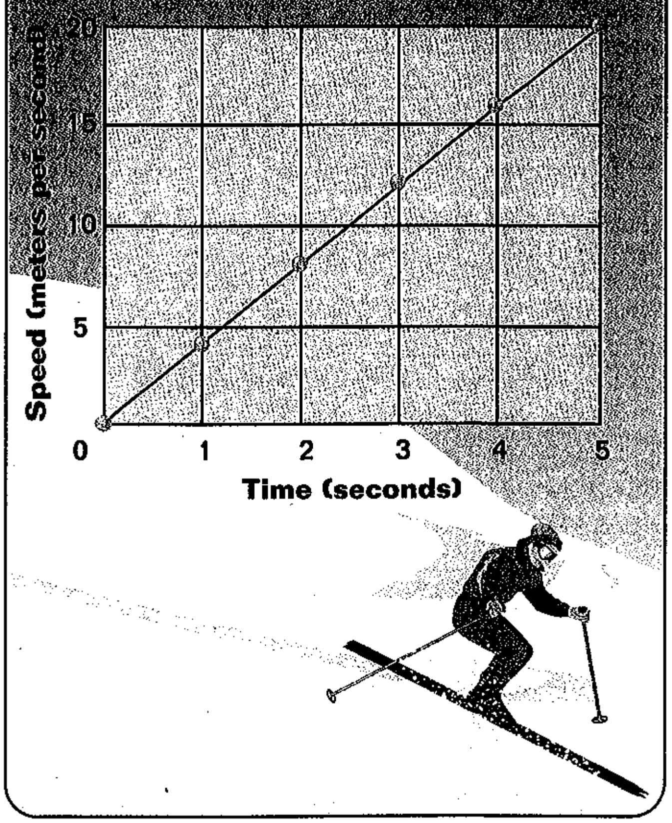
$$= \frac{20\ m/s}{5\ s}$$

$$= 4\ m/s^2$$

So the skier's acceleration was $4\ m/s^2$. In other words, the skier's speed increased by 4 meters per second each second during the first 5 seconds of the race. The changes in the skier's speed and distance over time are shown in Figure 5.

Changes in Speed and Distance Over Time

Time (s)	Speed (m/s)	Distance (m)
0	0	0
1	4	2
2	8	8
3	12	18
4	16	32
5	20	50



▲ **Figure 5** Notice how the line on the speed-time graph slopes upward and to the right. This shows that the skier's speed increased at a constant rate. We say the skier's acceleration was positive. Look at the last column of the data table, which shows the total distance traveled. What do you notice about the distance the skier traveled each second?

Now suppose the skier was slowing down at a constant rate. The skier's acceleration would be negative. How would that change the slope of the line on the graph?

12

Name:________________________
Hour:_________________

FORCE WORKSHEET

1. What is net force?

Show your work on #'s 2-4

2. A boy pulls a wagon with a force of 6 N east as another boy pushes it with a force of 4 N east. What is the net force?

3. Mr. Smith and his wife (Mrs. Smith) 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?

4. The Colts team is playing tug of war. Mrs. Larson's homeroom pulls with a force of 50 N. Ms. Mitko's homeroom pulls with a force of 45 N in the opposite direction. What is the net force? And who won?

5. What is a balanced force?

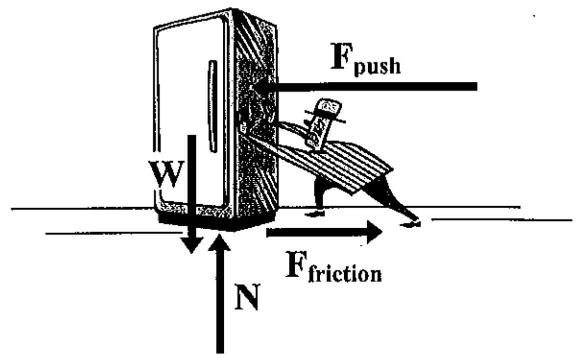
6. What is an unbalanced force?

7. Draw a picture below that shows an example of a balanced force (examples: a bird's nest in a tree, a hat on a person's head, or a light hanging from a ceiling). Show the forces acting on the object. In a separate picture show what would happen to the object if the forces became unbalanced.

Name ________________________________

Balanced and Unbalanced Forces Worksheet

Examine the forces acting on the freezer in the diagram and answer questions 1 – 3.



1. Are any of the forces acting on the freezer balanced?

   If so, which ones?

2. Are any of the forces acting on the freezer unbalanced?

   If so, which ones?

3. Describe the motion of the freezer.

4. Two men of equal strength have a tug-of-war. Draw the forces that are acting onto the picture.

Which man will win the tug-of-war? **Left** or **Right**

5. Another man joins each end of the rope. Does this affect the result of the tug-of-war? If not, why not? ________________________________

____

6. Another man joins the team on the left. Which team will win the tug-of-war now? Why?

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____

In the picture for Question 6 above, each man pulls with a force of 10 Newtons.

7. How much force do the team on the left pull with? ________ Newtons
8. How much force do the team on the right pull with? ________ Newtons

9. Explain the result of the tug-of-war using the values for the forces in each team.

SCIENCE 8 – BALANCED & UNBALANCED FORCES WORKSHEET

NAME: ______________________________

1) A driver and a passenger get out of their car that has run out of gas on a city street. They cannot agree on which gas station is closer, so they begin pushing with equal force on opposite ends of the car.

   (a) Make a sketch of this car-pushing situation using arrows to represent the forces on the car.

   (b) Use your sketch to explain whether the forces on the car are balanced or unbalanced.

   ____

   ____

   ____

   (c) Re-draw the sketch with force arrows illustrating a more effective way for the driver and passenger to get the car to the gas station.

   (d) Does this new sketch illustrate balanced or unbalanced forces? Explain.

   ____

   ____

   ____

2) A floatplane lands on a harbour. When the floats touch the water, the plane slows down.

   (a) Are the forces on the plane balanced or unbalanced? Explain.

   ____

   ____

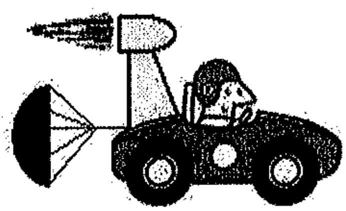
   (b) What type of force does the water exert on the plane's floats, which causes the motion of the plane to slow?

   (c) Sketch the floatplane at the moment of landing on the water using arrows to represent the forces on the plane.

3)

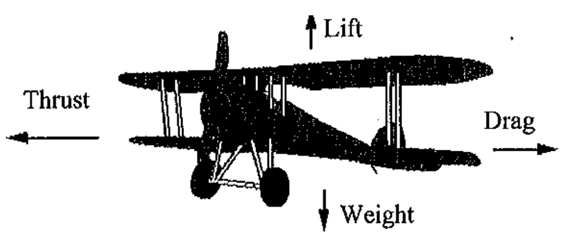
Assume that the wheels of the car apply 10 N of force forward. Add a force arrow to the picture showing this situation. What is the combined force (net force) if friction and drag are negligible?

Now assume that a parachute opens that applies 7 N of force in the other direction opposite to the 10 N of force still being applied by the wheels. Add force arrows to the picture showing this situation. What is the new combined force (net force) and direction?



A rocket applies an additional force of 10 Newtons to the 10 Newtons that are applied by the wheels. Add force arrows to the picture assuming that the parachute continues to apply 7 N of force in the opposite direction. What is the new combined force (net force) and direction?

4)



Flight condition	**Effect**
Lift > Weight	Plane Rises
Weight > Lift	Plane Falls
Drag > Thrust	Plane Slows
Thrust > Drag	Plane Accelerates

An airplane has a weight of 100,000 N and a lift force of 75,000N.

(a) What is the combined force (net force) on the airplane? __________________

(b) Are the forces balanced or unbalanced? __________________

(c) What will happen to the plane? __________________

An airplane has a thrusting force of 200,000 N and a drag force of 23,000 N.

(d) What is the combined force (net force) on the airplane? __________________

(e) Are the forces balanced or unbalanced? __________________

(f) What will happen to the plane? __________________

What Is Friction?

Friction is a force that occurs when two surfaces rub against each other. Every surface has tiny high and low spots. On a smooth surface, such as glass or polished steel, the high and low spots may be so tiny that you can see them only with a microscope (Figure 6). However, on a rough surface such as sandpaper, you can easily see or feel these uneven places. When two surfaces are touching, the high spots of one surface can get stuck in the low spots of the other. This causes friction. The force of friction always acts opposite to the direction of an object's motion. Friction can slow the motion of an object or keep an object from moving at all.

Without friction, our world would be a very different place. Every surface would be more slippery than the smoothest sheet of ice. Walking would be impossible. You would not even be able to hold a pencil or write on paper. The four main types of friction are static friction, sliding friction, rolling friction, and fluid friction.

▲ **Figure 6** This magnification of a piece of metal shows that even a very smooth surface has tiny high and low areas that cause friction.

Static Friction Static friction occurs between stationary objects. It is the force that keeps a book from sliding off a desktop, even if the desktop is slightly tilted. Static friction also keeps a pencil from slipping through your fingers when you hold it to write. You experience static friction every time you walk. As you push off with each step, static friction between the ground and your shoe keeps your shoe from sliding. Static friction also keeps a box of books in place on a carpet. To begin to slide the box along the floor, you have to first overcome the force of static friction between the box and the carpet.

▲ **Figure 7** Without static friction, a climber's hands and feet could not grip a steep rock.

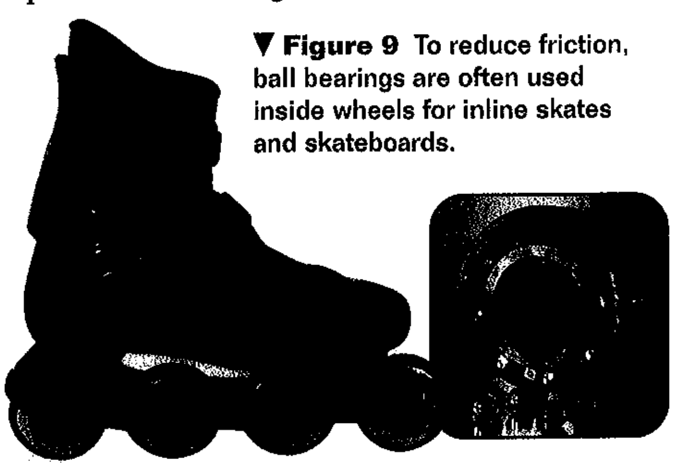
Sliding Friction Sliding friction occurs when one object slides over another object. If you push hard enough on a box of books, the box may slide across the carpet. Sliding friction is now acting between the box and the carpet. Sliding friction is weaker than static friction. So it takes less force to keep the box sliding than it did to get it moving in the first place. Sliding friction also causes surfaces in contact to heat up. When we rub our hands together, sliding friction produces heat that warms our skin.

▲ **Figure 8** Friction between a racer's tires and the surface of the road may slow the athlete down, but it also allows for control.

Rolling Friction Rolling friction occurs when one surface rolls across another. When a wheel or other round object rolls over another surface, the high spots on one surface are lifted up and over the other surface's high spots. Rolling friction is not as strong as sliding friction. It also produces less heat than sliding friction does.

Putting a box of books on a wheeled cart makes the box easier to move. It is easier because the rolling friction between the carpet and the cart's wheels is weaker than the sliding friction between the box and the carpet. Movers often use wheeled dollies to make it easier to move heavy objects such as refrigerators.

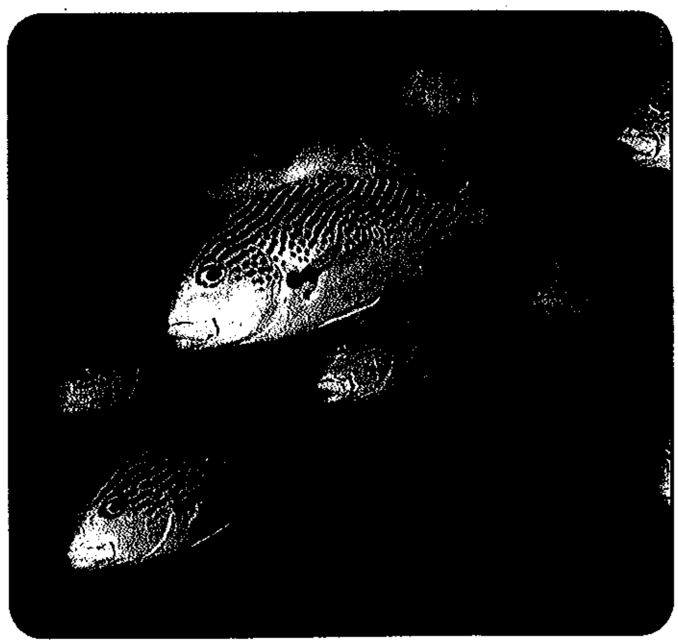
Many machines contain ball bearings, such as those inside the skate wheel in Figure 9, to reduce friction. A ball bearing is a set of round balls placed between two smooth surfaces. The balls roll as the surfaces move past each other. This rolling friction helps keep the machine parts from wearing out.



▼ **Figure 9** To reduce friction, ball bearings are often used inside wheels for inline skates and skateboards.

Fluid Friction Liquids, such as water, and gases, such as air, are both called fluids. When an object moves through a fluid, the object experiences fluid friction. An aquatic animal experiences fluid friction when it moves through the water (Figure 10). The surface of its body rubs against the water particles. An airplane experiences **air resistance,** which is a kind of fluid friction, as it flies through the air.

The amount of fluid friction acting on an object depends on the object's size and shape and the kind of fluid it is moving through. Objects with more surface area experience greater fluid friction and move more slowly through air or water. A flat sheet of paper falls slowly through the air. If you crumple the paper into a ball, you reduce its surface area, and the paper will fall much faster.



▲ **Figure 10** Fluid friction acts on a fish as it moves through the water. Fluid friction is sometimes called drag. Competitive swimmers often wear special caps or swimsuits. These items are designed to reduce the drag between a swimmer's body and the water.

Net forces worksheet Name: ____________________

1. Josh is on the right of a table and Ethan is on the left. Josh **pushes** with 39 N and Ethan **pulls** with 34 N. Draw and label the free body diagram for the table. What is the net force? Which way will the table accelerate?

2. Josh is on the right of a table and Ethan is on the left. Josh **pushes** with 39 N and Ethan **pushes** with 34 N. Draw and label the free body diagram for the table. What is the net force? Which way will the table accelerate?

3. Josh is on the right of a table and Ethan is on the left. Josh **pulls** with 39 N and Ethan **pulls** with 34 N. Draw and label the free body diagram for the table. What is the net force? Which way will the table accelerate?

4. Nancy joins Josh on the right of a table and Ethan is joined by Jessica on the left. Josh pushes with 39 N and Ethan pushes with 34 N. Draw and label the free body diagram for the table. What is the net force? Which way will the table accelerate?

5. An alphabetical group of friends are planning a tug of war. If Annabel can pull with 27N, Bonnie can pull with 30N, Caleb can pull with 33N, Daria can pull with 29N, Edwin can pull with 35N, Frank can pull with 20N, Garrett can pull with 30N, and Heidi can pull with 36N.

    a. Draw the forces acting on the rope (yes draw the rope as a box so you can attach all the forces to it) if it is a matchup between boys and girls.

    b. Who would win if it was girls vs. boys? By how much would they win?

    c. If you could switch one person to change the outcome who would it be and why?

    d. Is there a configuration of people that would result in a tie? How would you find one?

6. Draw the free body diagram for a book sitting on a table

7. Draw the free body diagram for a cart rolling at a constant speed to the right

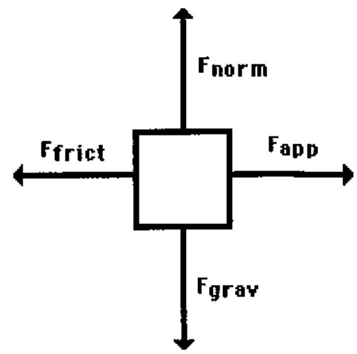
Worksheet #1 Free Body or Force diagrams...

Drawing Free-Body Diagrams

Free-body diagrams are diagrams used to show the relative magnitude and direction of all forces acting upon an object in a given situation. A free-body diagram is a special example of the vector diagrams; these diagrams will be used throughout your study of physics.

The size of the arrow in a free-body diagram is reflective of the magnitude of the force. The direction of the arrow reveals the direction in which the force acts. Each force arrow in the diagram is labeled to indicate the type of force.

It is customary in a free-body diagram to represent the object by a box or a small circle and to draw the force arrow from the center of the box or circle outward in the direction in which the force is acting. One example of a free-body diagram is shown to the right.



The free-body diagram above depicts four forces acting upon the object. Objects do not always have four forces acting upon them. There will be cases in which the number of forces depicted by a free-body diagram will be one, two, or three. There is no hard and fast rule about the number of forces which must be drawn in a free-body diagram. The only rule for drawing free-body diagrams is to depict all the forces which exist for that object in the given situation.

Thus, to construct free-body diagrams, it is extremely important to know the types of forces. If given a description of a physical situation, begin by using your understanding of the force types to identify which forces are present. Then determine the direction in which each force is acting. Finally, draw a box and add arrows for each existing force in the appropriate direction; label each force arrow according to its type.

Apply the method described in the reading to construct free-body diagrams for the situations described below. Use the symbols we discussed in class. Draw force vectors on the circle and label them.

1. A book is at rest on a table top. Diagram the forces acting on the book.

2. A girl is suspended motionless from the ceiling by a rope. Diagram the forces acting on the girl as she holds onto the rope.

3. An egg is free-falling from a nest in a tree. Neglect air resistance. Diagram the forces acting on the egg as it falls.

4. An egg is falling (not freely, do not neglect air resistance) from a nest in a tree. Diagram the forces acting on the egg as it falls.

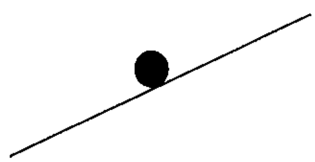
5. A rightward force is applied to a book in order to move it across a desk with a rightward acceleration. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.

6. A rightward force is applied to a book in order to move it across a desk at constant velocity. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.

7. A car is stopped at a stop light.

8. A skydiver is descending with a constant velocity. Consider air resistance. Diagram the forces acting upon the skydiver.

9. A car is parked on a sloped street.



10. A hot air balloon is accelerating upward.

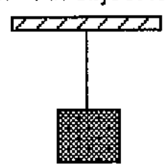
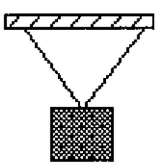
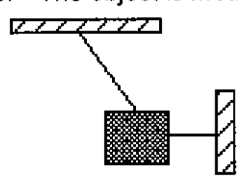
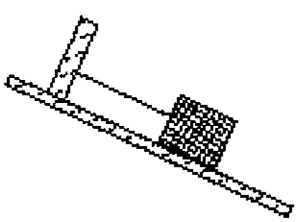
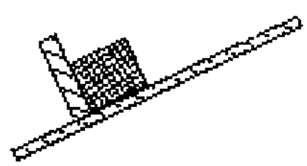
11. A car is coasting to the right and slowing down. Diagram the forces acting upon the car.

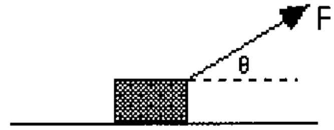
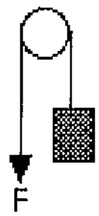
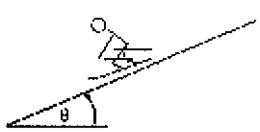
Name________________________________

Date __________ Pd____

Worksheet 2, Drawing Force Diagrams

In each of the following situations, represent the object with a dot. Draw and label all the forces using standard force symbols as learned in class.

1. Object lies motionless on a surface. 	2. Object slides at constant speed along a Smooth (frictionless) surface. 
3. Object slows due to friction (rough surface). 	4. Object slides on a smooth incline. 
5. Friction on an incline prevents sliding. 	6. An object is suspended from the ceiling. 
7. An object is suspended from the ceiling. 	8. The object is motionless. 
9. The object is motionless. 	10. The object is motionless. 

11. The object is pulled by a force parallel to the surface. The surface is rough or has friction. 	12. The object is pulled by a force at an angle to the surface. The surface is rough. 
13. The object is pulled upward at constant speed. 	13. A hot air balloon is held down to keep it From accelerating upward. 
15. The object is falling (no air resistance). 	16. The object is falling at constant (terminal) velocity. 
17. The ball is rising in a parabolic trajectory. Do not neglect air resistance 	18. A rocket is accelerating straight upward. 
19. A skier is accelerating down a slope. There is friction and air resistance. 	20.A big block of mass M is attached via a string to a smaller block of mass m. A student attaches a string to block M and pulls everything to the right along the rough surface. Both blocks travel at constant velocity. Do force diagrams for each block separately. 

CALCULATING FORCE WORKSHEET

Calculate the force in the following problems by using the equation:

Force = mass x acceleration **F = m x a**

Be sure to(1) ALWAYS write the equation, (2)plug in the numbers and units, and (3) give the answer with the correct units.

1. A man hits a golf ball (0.2 kg) which accelerates at a rate of 20 m/s^2. What amount of force acted on the ball?

2. You give a shopping cart a shove down the isle. The cart is full of groceries and has a mass of 18 kg. The cart accelerates at a rate of 3 m/s^2. How much force did you exert on the cart?

3. The wind pushes a paper cup along the sand at a beach. The cup has a mass of 25 grams (= ? kg) and accelerates at a rate of 5 m/s^2. How much force (in Newtons) is the wind exerting on the cup?

4. You push a friend sitting on a swing. She has a mass of 50 kg and accelerates at a rate of 4 m/s^2. Find the force you exerted.

5. How much force would it take to push another, larger friend who has a mass of 70 kg to accelerate at the same rate of 4 m/s^2?

6. A worker drops his hammer off the roof of a house. The hammer has a mass of 9 kg, and gravity accelerates it at the usual 9.8 m/s^2. How much force does the earth apply to the hammer?

7. A car whose mass is 1000 kg is traveling at a <u>constant</u> speed of 10 m/s. Neglecting any friction, how much force will the engine have to supply to keep going the same speed? (tricky question) (think INERTIA) (look at the units)