Motion, Forces & Energy

Study Guide

Motion, Forces & Energy

KEY TERMS

- **Acceleration-** the time it takes an object to increase or decrease its speed or direction.
- **Balanced forces-** equal forces acting on an object.
- **Distance-** The total length moved by an object.
- **Force-** a push or pull on an object causing it to change its motion.
- **Friction-** a force that slows down motion whenever the surfaces of two objects rub against each other.
- **Gravity**- the force of attraction between objects.
- **Kinetic energy-** the energy of a moving object.
- **Mass**- The amount of matter an object contains.
- **Potential energy-** the energy that is stored in an object.
- **Reference point-** a place or object used to determine if something is in motion.
- **Speed-** the distance traveled by a moving object in a specific amount of time.
- **Unbalanced Force-** a force or group of forces that push more on one side of an object than the other and causes a change in its motion.

THE BIG Idea

Invisible forces cause every object in the known universe to be in constant motion.

GOALS

#1: I will be able to determine when an object is moving by comparing it to its background or to another object.

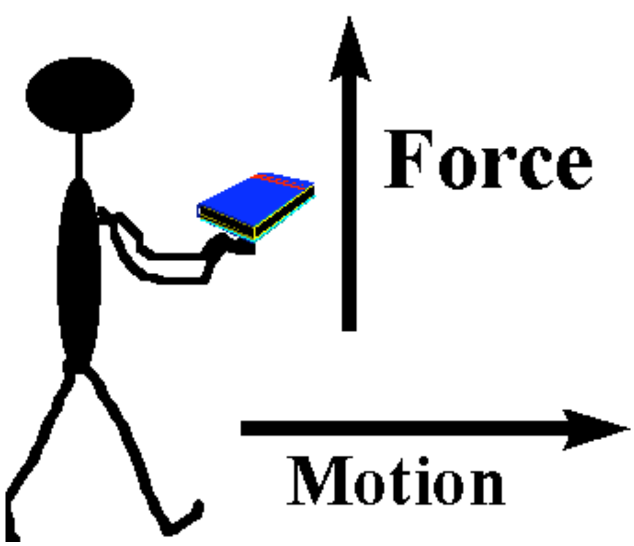
#2: I will be able to describe an object's motion and change in position over time.

#3: I will be able to determine an object's speed by dividing the distance traveled by the time taken to travel that distance.

#4: I will be able to make and interpret distance time graphs.

#5: I will be able to identify situations where potential energy is turned into kinetic energy.

#6: I will be able to describe how forces like gravity affect the motion of all objects in the universe.



Performance Task:

At the end of this unit you will build a model roller coaster and be expected to describe how each of the following forces are involved in moving a marble down its track; *inertia, friction*, *acceleration, gravity, potential energy* and *kinetic energy.*
(Oh yeah, the marble has to stay on the track!)

Wicked Important Stuff to Know…*Newton's Laws of Motion!*

Newton's 1st Law of Motion → ***"Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it."***

Hugh?

Translation: **<u>All objects like to keep on doing what they are already doing and will resist any change until a force causes them to.</u>**

Kick your sister in the shins. Go on, do it now. You will see that she reacts. Let's just think about what happened there. If you hadn't kicked her, she would have stayed where she was, probably sitting in front of the TV. eating Oreos proving the first law. Since you did kick her, she'll keep moving (trying to kick you back) until your mother stops her. When you kick your sister in the shin, you are using **force.** If she's been eating lots of Oreos she has lots of **mass** and she will not be able to chase you. She has **inertia.** Every time you kick her, molecules in the form of waves pass from your foot to her shin. That's **energy** and that's the law!

==

Newton's 2nd Law of Motion → ***"Change of motion is proportional to the impressed force and takes place in the direction of the straight line in which that force is impressed."***

Hugh?

Translation: <u>The more MASSive an object is, the more force you'll need to move it.</u>

I swing a bat at a tennis ball and I swing a bat at a bowling ball. -- The same strength of swing will cause greater acceleration in the tennis ball. Very little force is needed. Why? The answer is the **mass.** The mass of the bowling ball is much more than the mass of the tennis ball. So it is much harder to move the more massive bowling ball; it takes more force. Now, where's my sister?

==

Newton's 3rd Law of Motion → ***" All forces occur in pairs, and these two forces are equal in magnitude and opposite in direction."***

Hugh?

Translation: <u>For every action there is an equal and opposite reaction.</u>

If you weigh 120 pounds that means that Earth's gravity is pulling down on you with a force of 120 pounds. If you are standing on a solid floor, (or you little sister) you do not accelerate downward because the floor (along with your sister) is holding you up. The floor exerts an upward force of 120 pounds on you. These forces are equal and opposite, so you remain at rest on the floor and on your sister. Newton's Third Law states that she will absorb all the impact (get flattened) and you will survive.

Motion
All objects in the universe are in constant motion. Even when you are sitting still in a chair, your body is moving thousands of kilometers per second. The earth is spinning on its axis, carrying you with it. Our planet orbits the sun, which is a star orbiting the center of the Milky Way Galaxy. Normal, everyday motion such as a rolling ball or a moving vehicle can be explained by the science of physics. **Motion is defined as the change in position of any object**. In order to see motion, you need to have a reference point. In a race, this could be referred to as the starting line. The distance that an object travels is described throughout the world by using only the metric system's units of length.
==

Speed
You are probably familiar with the concept of speed when traveling in automobiles. The speed limit is posted at 70 mph on the interstate. This means that a car can legally travel 70 miles in distance over one hour of time. **Speed is the distance an object travels per unit of time**. Speed is also the rate at which the distance is traveled or the rate of change in position. Speed relates two variables (distance and time) and can be worked out mathematically using a formula. The formula for speed is s = d/t. This formula shows the relationship between each of these terms defined so far: s = speed, d = distance, and t = time. So if you traveled for a half hour and went a distance of 30 km, divide 30 km by 30 minutes to obtain a measurement of your speed, which would be 1 km per minute. Units of speed can be measured in meters per second, kilometers per hour, or a variety of other measures of distance and time.
==

Velocity
Velocity includes the speed of an object and the direction of its motion. For example, an elevator may move at a speed of 5 km/sec, but the speed does not tell in which direction it is moving. Velocity would include a description of its up or down motion. The velocity of an airplane could be described as moving 200 km/h in a northeasterly direction. A car on a highway could be moving with a velocity of 100 km/h to the west. An object that changes its direction only is also changing its velocity. **Don't think of speed and velocity as the same thing; they are not.**
==

Acceleration
When the velocity of an object changes, the object is accelerating. Notice that I did not say the velocity is getting faster. **Acceleration refers to changes in speed or direction**, so **when an object slows down it is also accelerating.** When an object changes direction, this is called acceleration as well. Acceleration can be positive or negative. What is commonly referred to as slowing down or deceleration physicists call negative acceleration. As you stand on the planet Earth, you are moving at about 1,000 km/h. That speed is constant, but your direction is always turning, following the circular shape of the earth so you are accelerating all the time. Your body can feel acceleration, especially as a passenger in a car. When the car speeds up or has positive acceleration, you are thrown back into the seat. This also happens when the car accelerates negatively and you are thrown forward. As the car turns, your body leans in the opposite direction, so you can feel acceleration happening as changes of speed or direction.
==

Forces
No object can move unless there is a force causing it to move. Objects such as cars, rocks, and planets have forces that will cause them to move; otherwise they would sit still forever. Living things move because energy from food is transformed into chemical energy, which can change into forces or motion. Physicists define a **force as a push or pull** that one body exerts on another. For example, when two balls collide on a pool table, the motion from the first ball transfers as a force into the second ball, causing it to move. Forces are all around us, and they are the cause of all motion in the universe.

Objects move in the direction of the force applied to them. Whenever an object changes its direction (also called its velocity), a force has acted on the object to cause this change. Forces can be balanced or unbalanced, causing an object to behave differently. When two equal forces are pushing on an object in opposite directions, then the object will not move. The combined or net force is equal or balanced. When you are standing up, the force of gravity is pulling your entire body toward the surface of the earth, but the force of your muscle power is equal to this gravitational pull, and so you are able to remain upright. When you jump into the air, your muscles are momentarily able to exert a greater force than gravity, and so you leave the ground. This is called an unbalanced force. **Unbalanced forces occur when one force is greater than the other**. **When forces are unbalanced, objects move.**

==

Inertia and Mass

Inertia is the tendency of an object to resist any change in its motion. If an object is moving, it will keep moving unless an unbalanced force causes it to stop or change direction. If an object is at rest, it will stay at rest until a force causes it to move. This idea is also known as **Newton's first law of motion**. Sir Isaac Newton stated this law of the universe in the 1600s, and millions of experiments and observations since then have found it to be true. It is also known as the law of inertia, which is simply stated as: objects like to keep on doing what they are already doing and will resist any change. An object has inertia because it has mass. **The larger the mass, the greater the inertia**. This is why it is harder to move more massive objects.

Passengers inside cars also have mass, therefore inertia. When you are traveling at 70 mph in a car, your body has a large amount of momentum. It wants to keep on doing what it is doing, which is traveling at a high speed. If the car is involved in a collision, the mass of the car can be stopped by the mass of the object it hits. Your body will continue to travel at this high speed into the dash, windshield, or out onto the street. Newton's first law explains why seatbelts and airbags are so important.

==

Friction

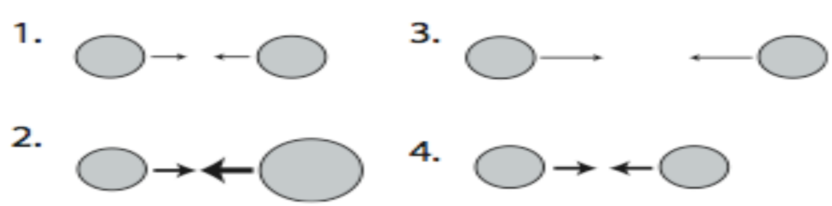
If an object tends to keep on doing what it is doing, why does a ball rolling down a hill finally come to a stop? Newton's first law states that a marble rolling across the floor will only stop if an outside force stops it. So what is the force that stops the ball or marble from rolling? Why don't most objects here on the planet Earth continue to travel in a straight line forever? Most of the time the answer is friction. **Friction is the force that opposes motion between two surfaces that are touching each other.** The ball is touching the hillside; the marble is touching the floor. A baseball thrown by a pitcher is touching the air through which it travels. Friction slows down and then stops these objects.

Friction between surfaces depends on two factors: the roughness of the surfaces and the force pressing the surfaces together. Using a microscope, you would be able to see that even very smooth and polished metal is actually pitted with groves and cracks. Most other objects are not nearly so smooth, and it is these bumps on the surface, which rub between two objects, that cause frictional forces to slow down motion.

==

The Law of Gravity

Isaac Newton also studied the force of gravity. He developed the law of universal gravitation. This law states that because **all objects have mass, they are all attracted to each other by the force of gravity.** This includes all massive bodies, from planets and stars and WWWF wrestlers to atoms and molecules. Your body has a gravitational attraction to all the other objects you encounter. The strength of this attractive force depends on the mass of the two objects and the distance between them. The distance between the two objects also affects gravitational attraction. **Gravity increases the closer two objects are to one another and decreases the farther away they are.**



1. Two objects of the same size have the same attraction between them.
2. The larger object has more force.
3. Objects farther apart have weaker force.
4. Two objects close together have stronger force.

Study /Possible Test Questions

1. What's the First Law of Motion? Give an example.
2. What's the Second Law of Motion? Give an example.
3. What's the Third Law of Motion? Give an example.
4. Which two Laws of Motion are in effect when the space shuttle takes off? Discuss.
5. What is a force?
6. Which Law of Motion is in effect for each of the following:
   a. the Space Shuttle speeding past Mars.
   b. a wrecking ball hitting a building.
   c. a person pulling on a boat oar.
   d. a car going around a banked turn.
7. Why does a snow plow work better when it's full of sand?
8. If you're driving with your mom and she hits the breaks suddenly will you be thrown forward or pushed backward into your seat? If you were holding a helium balloon at the time which direction would the balloon go? Why? Now go get a balloon and try it (tell her it's for science).
9. Which would drive a nail deeper into a piece of wood, a heavy hammer or a light hammer?
10. Cindy is standing in a canoe at the end of the dock but she has forgotten to tie the canoe up. Cindy starts to walk in the canoe. What will happen to the canoe? Which Law does this demonstrate?
11. You start pushing your shopping cart toward the cookies, your mom pushes from the other end of the shopping cart with an equal force but she is pushing the cart toward the vegetables in the opposite direction. Where will the cart go? Why?
12. Your little red wagon is full of rocks, your sister's little red wagon is full of feathers, you tie them together with a bungee cord, pull them apart and let go. What will happen to the wagons?
13. Who's wagon will go faster? How mad will your mom be when she sees what you've done to your and your sister's wagon?
14. Which has more inertia, your Father in front of the TV during the Super bowl or you in your bed on Monday morning?
15. Describe how the following forces are each involved in a roller coaster: Inertia, Friction, Air resistance, Acceleration, Gravity, Gravitational Potential Energy and Kinetic Energy. You might want to draw a picture.

Possible Answers

1. **1st Law of Motion**: An object at rest will stay at rest and an object in motion will stay in motion (until an outside force acts upon it). INERTIA. An example would be the rolling bowling ball on the stage, it stops when it hits Dr. Quark or the wall otherwise it would stay in motion. The ball at rest would stay at rest until someone pushes it acting as an outside force to put it in motion.
2. **2nd Law of Motion**: If a force acts on an object, the object will accelerate in the direction of the force. How much depends on the size of the force. F= ma (Force = mass x acceleration). An example would be if you were to put a trashcan at the end of your drive way and roll a bowling ball at it. Then using the same speed try rolling a basketball at the trashcan. The bowling ball will push the trash can more than the basketball because even though they rolled at the same speed the mass of the bowling ball was greater than the mass of the basketball, therefore the force generated by the bowling ball was greater than the force generated by the basketball. Now imagine that you are driving your mom's car. You push the gas peddle down 1/4 of the way and you will feel pushed back into your seat. Then you try it again but this time you push the peddle down 3/4 of the way, you still have the same amount of mass but because the car has more acceleration the force pushing you back into your seat is greater.
3. **3rd Law of Motion**: For every action there is an equal action in the opposite direction. Action & Reaction. An example of this would be watching a hunter fire his rifle. When the bullet is discharged out of the barrel of the gun, the gun will 'kick' or push backward into the hunters shoulder. The reason the gun doesn't go mass than the mass of the bullet.
4. The answer is primarily the 2nd & 3rd although all 3 laws are always in effect. The gas is being discharge

making as action for which the reaction is the space shuttle going up into space (3rd). At the same time the expulsion of gas generates a great force, which accelerates the mass of the rocket into space (2nd).

5. FORCE is a push or a pull.
6. a. Law #1, INERTIA, there is very little friction in space so an object in motion will stay in motion.
   b. Law #2, F= ma, there is a big force (wrecking ball) hitting a building which sends the building in the direction of the force.
   c. Law #3 Action & Reaction, you pull one way and the boat goes the other direction.
   d. Law # 1, INERTIA, the car wants to keep going straight, the banked turn helps the car get around the corner.
7. Because of the 2nd Law of Motion, the truck exerts more force on the snow and moves it more easily because it has more mass.
8. You would be pushed forward against your seat belt. The helium balloon would go backward while you went forward because while you had more mass than the air in the car the helium balloon has less mass than the air in the car.
9. Fat Albert would be harder to push than Skinny Scotty because of Law # 1, INERTIA. Fat Albert has more mass and therefore more INERTIA to stay at rest than Skinny Scotty.
10. The heavy hammer would drive the nail further than the light hammer because of Law # 2, F = ma. The heavy hammer has more mass and therefore more force against the nail than the light hammer.
11. As Cindy walks toward the dock the canoe will be pushed back away from the dock. The effect being that Cindy will remain the same distance from the dock. This demonstrates Law # 3 11. Action & Reaction. The action is Cindy walking forward; the reaction is the canoe going backward.
12. The shopping cart will stay in the same spot because of Law # 3. Your action is being countered by an equal reaction of your mothers and the cart goes nowhere. You don't get the cookies but look at the bright side, your mom doesn't make it to the broccoli either.
13. The wagons will be pulled back together by the bungee cord. The wagon of feathers will be pulled faster than the wagon of rocks because it has less INERTIA to stay where it was.
14. Whichever has more mass has more INERTIA to remain at rest. If your father weighs more than you do he has more INERTIA in front of the TV, if you weigh more than your father than you have more INERTIA in bed on Monday.
15. Describe how the following forces are each involved in a roller coaster: Inertia, Friction, Acceleration, Gravity, Gravitational Potential Energy and Kinetic Energy. You might want to draw a picture.

If a roller coaster, is standing still, it won't want to move unless some force pushes or pulls it. This resistance of the roller coaster to move is called <u>inertia</u>. The more mass a body has the more <u>inertia</u> it has. A motorized pulley drags the roller coaster up the initial hill. Once the roller coaster is moving, it will want to keep moving, along the direction of motion, unless something causes it to speed up or slow down. This resistance of the moving roller coaster to changing its velocity is another example of its <u>inertia</u>. Again, the greater the mass of the body, the more <u>inertia</u> it has.

When you ride a roller coaster a motor does the work to get you up the first hill. As the coaster is being pulled up the hill by the motor it is storing more and more <u>potential energy</u>. That potential energy is turned into <u>kinetic energy</u> as <u>gravity</u> pulls you down the first hill. The farther you go down the hill, the more potential energy is changed into kinetic energy, which you feel as speed. The ride goes fastest at the bottom of the hill because more and more of the <u>potential energy</u> has been changed to <u>kinetic energy.</u>

On a downhill slope or a sharp curve, a ride will probably increase in velocity or <u>accelerate</u>. While moving uphill or in a straight line, it may decrease in <u>velocity</u> or <u>decelerate</u>. The force of <u>gravity</u> pulling a roller coaster down hill causes the roller coaster to go faster and faster, it is accelerating. The force of gravity causes a roller coaster to go slower and slower when it climbs a hill, the roller coaster is decelerating or going slower. The acceleration of a roller coaster depends on its mass and how strong is the force that is pushing or pulling it.

Coaster designers know that <u>friction</u> and <u>air resistance</u> play a part in the ride. Therefore, they make each successive hill LOWER so that the coaster will be able to make it over each peak. Coaster designers also take advantage of <u>friction</u> to slow the coaster and bring it to a safe stop when breaks are applied at the end of the ride.

Great Games & Quizzes
http://www.reviewgamezone.com/game.php?id=782
http://quizlet.com/502982/motion-forces-and-energy-21-flash-cards/
http://quizlet.com/467441/force-and-motion-flash-cards/

Motion Quiz
http://www.glencoe.com/qe/science.php?qi=420

Laws of Motion Quiz
http://glencoe.mcgraw-hill.com/sites/0078778360/student_view0/chapter2/chapter_review_quizzes-eng_.html

Sir Isaac Newton
http://www.tretherras.cornwall.sch.uk/Library%20Web/Library_Services/Help_sheets/Isaac%20Newton.htm

Newton's Physics Notebook
http://www.can-do.com/uci/ssi2001/newtonsphysicsnb.html