DISCREPANT EVENTS GALORE

...AND MORE

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STRING MAZE

Purpose: To challenge students' observation skills.
Materials: A one and one-half meter long piece of string or yarn.
Procedure: Tie the string into a loop. While holding the loop in front of you with one hand, pass the other hand through the loop from the front. Then you...... and then...., you really have to experience this first hand.
Principle involved: Students have to observe very carefully to detect the motion that produces the desired results.

HOVERING HALO

Purpose: To demonstrate the repulsion by objects with like charges.
Materials: A Styrofoam block, an aluminum pie pan, a Styrofoam or plastic cup, a wool cloth, thin aluminum Christmas tree tinsel, glue (preferably a glue gun and glue stick).
Procedure: 1) Glue the cup to the inside bottom of the pie pan.

2) Make a circle with the tinsel and glue the ends together. The ends can be tied if no glue is available.
3) Charge the Styrofoam block with the wool. The first time the Styrofoam is charged may requires several minutes of rubbing.
4) Place the pie pan assembly on the Styrofoam and touch the pan with your finger. You should receive a slight electrostatic shock
5) Pick the plate up by the cup and drop the halo onto the plate from a distance.
6) The halo should then be repelled from the plate. Some practice may be required to balance the halo above the plate.
7) If the halo approaches anything neutral, it will be attracted to it.

Principle involved: Rubbing the Styrofoam imparts a negative charge to it by rubbing electrons onto it from the wool. When the pie pan is placed on the Styrofoam, the electrons in the aluminum are repelled to the outer edge of the plate. Some of these electrons will jump to your finger when you touch the plate. The plate now has a positive charge. When the tinsel hits the plate, it picks up the same charge as the plate (positive). Like charges repel.

INERTIA RINGS

Purpose: To show that objects at rest tend to stay at rest.
Materials: A ring cut from a four or six inch PVC pipe (the ring should be approximately 1/2 in wide), a bean or small dense object, a glass soda bottle.
Procedure: Balance the ring upright on the top of the bottle. Place a small object (bean) on top of the ring directly over the mouth of the bottle. Snatch the ring from under the bean. The bean should fall into the bottle. The key is to have the ring parallel to your body and catch the ring on the inside and on the side opposite to the hand you are using.
Principle involved: If the ring is struck firmly in the center, it will be jerked from under the bean without imparting any energy to it. The bean should then fall straight down into the bottle.

A 3-D MAGNETIC FIELD

Purpose: To show that a magnetic field is three-dimensional.
Materials: A strong bar magnet (a one piece cow magnet), iron filings, a plastic test tube in which the magnet will fit (a plastic syringe with the end sealed will work), a 12 to 16 oz. plastic bottle, tape, a stopper to fit the tube, and a hot glue gun.
Procedure: The magnet must fit inside the plastic tube and the tube must fit inside the bottle. You may have to cut away part of the bottle top to get the tube to fit. Wrap enough tape around the top of the tube to provide a snug fit in the bottle. Before seating the tube, add two to three teaspoons of iron filings to the bottle. Twist the tube into the bottle firmly. Place the magnet inside the tube and shake gently. If you get the desired effect, glue the tube into the bottle with the hot glue gun. Fill the rest of the tube with cotton or aluminum foil and stopper it tightly. Shake the apparatus to distribute the filings around the magnet. The magnet may be removed to be used in other activities.
Principle involved: The lines of force of the magnet extend outward from the poles of the magnet in all directions.

BALANCE BALLS

Purpose: To demonstrate a center of gravity device and to show the principle of inertia.
Materials: A wire clothes hanger, two tennis balls or rubber balls, and a wire pliers.
Procedure involved: Open up the hanger and bend into the shape of a "M" with a twist in the center to keep the two parts from separating. The ends should be much lower than the center. Stick tennis balls or other similar objects on each end. To final appearance should be as diagrammed below.
The center of the hanger can now be balanced on your finger. Better yet, it can be balanced on your head. You now can demonstrate inertia by spinning the balls while you remain still or by pirouetting while the balls remain still.
Principle involved: The mass of the balls on the end is lower than the balance point and as the balls spin and turn the center of mass stays lower than the balance point.

MYSTERY PAPER

Purpose: To demonstrate the pressure that can be exerted by a lever (scissors).
Materials: Strips of newspaper, rubber cement, talcum powder, and scissors.
Procedure: Coat one side of the paper with a thin coat of rubber cement. Allow to dry and put on another coat. When dry, sprinkle talcum powder on the rubber cement and blow off excess. Fold the paper and cut with the scissors. The cut will re-seal.
Principle involved: The pressure of the scissors (a lever) will break through the powder coating and bring the glued portions in contact.

LASER ACTIVITIES

Purpose: To demonstrate a variety of properties of light.
Materials: A laser (an inexpensive laser pointer works well), color filters (colored report covers do a good job. Make sure one is green), Polaroid lens (use old lens from Polaroid sun glasses), Chalk dust, and candle.
Procedures:

1. In a darkened room, place the laser where the light from it can not be seen. Clap two chalk board erasers together near the beam. The reflected beam can then be seen.
2. Aim the laser at a white surface. Put a Polaroid lens in the beam and observe the results. Put a second lens in the beam and turn observing the results.
3. Aim the laser at a white surface. Pass the beam through red, blue, and yellow filters. Observe the results. Put a green filter in the beam and observe.
4. Aim the beam at a white surface. Hold the flame of a lit candle directly under the beam near the laser and move it back and forth under the beam. Observe the results.

Principle involved:

1. A beam of light cannot be seen unless it inters the eyes directly or reflects off something. The beam will not reflect off the molecules in the air but will off the dust particles.
2. The beam will pass through the parallel lines of the Polaroid lens. When a second lens is placed in the beam, the light will still pass through both if the parallel lines of both lens run in the same direction. If the lenses are placed so that the lines are 90 degrees with respect to one another, the light will be blocked.
3. The red light of the laser passes through all colors except the complimentary color of red which is green. The green filter will block more light than the others.
4. The heat changes the density of the air in the beam. Light rays passing through gases with different densities is bent. The effect is to make the beam appear to flicker. This is why the light from stars and planets appear to flicker as it passes through the atmosphere.

Safety Precautions: All of these activities can be carried out with low power pointer lasers. However, make sure that the laser beam is never directed into anyone's eye.

BERNOULLI'S PRINCIPLE #1

Purpose: Bernoulli's principle is a way to reduce air pressure by rapid air flow over a surface. This shows how to suspend a ball in mid air by applying air flow to the surface.
Materials: A hair dryer, Styrofoam ball or ping pong ball, a flexible straw.

Procedure: Turn the hair dryer on to full speed and place a compressed Styrofoam ball or ping pong ball into the air flow. When the ball suspends, you can tip the hair dryer to the side and the ball will remain suspended in the air flow. Blowing in a flexible straw bent in an "L" shape should suspend the ping pong ball also.
Principle involved: The air stream moving around the ball reduces the pressure immediately above the ball. The greater pressure underneath will keep it suspended.

PING PONG POP-UP

Purpose: To provide a hands-on example of Bernoulli's Principle.
Materials: A small plastic medicine cup, a flexible drinking straw, a ping pong ball, a Philips screwdriver
Procedure:

1. Heat the tip of the screwdriver and melt a hole in the bottom of the plastic cup.
2. Insert the short end of the straw into the hole until it is just below the top rim of the cup.
3. Place the ping pong ball in the cup and blow your breath strongly through the straw. The ball should rise. By using breath control, the ball can then be lowered gently back into the cup.
4. If the straw is not inserted far enough into the cup, it will be impossible to blow the ball out of the cup which is another aspect of the demonstration. With the straw in the lower position, and the system inverted, it is possible to keep the ball in the cup (inverted) while blowing hard.

Principle involved: As the air flows over a curved surface, it sweeps more air away from that side and creates a partial vacuum. A ball will stay in the air flow since as the ball moves to one side, the greater airflow on the other side will reduce the pressure causing the ball to be pushed back into the stream.

DIME IN A PLATE

Purpose: To show the force that can be exerted upon an object by reducing the air pressure on one side of it.
Materials: One dime and a plate
Procedure: Place the plate on a table with the edge of the plate about 12 cm from the edge of the table. Put the dime about 4 cm from the table edge, position your mouth to blow OVER the dime and toward the plate. Do not blow down on the dime. Use a quick hard puff and the dime should end up in the plate.
Principle involved: By blowing over the dime, the air pressure on top of the dime is reduced. The dime will then be pushed up into the stream of air by the pressure underneath it. The stream of air from your breath should blow the dime into the plate. Practice!!

PENETRATING POLYMERS

Purpose: To show that the greater the depth of water, the greater the water pressure.
Materials: A zip lock bag, three sharpened pencils, and water.
Procedure: Fill the bag with water and close tightly. Holding the gab by the top, thrust a pencil into the bag through one side about 1/4 of the way from one end and near the top. Do the same with the second pencil about midway from each end and the top. The third pencil should be inserted a little closer to the bottom. Turn the bag 90 degrees so that the zip lock portion is vertical. Hold the bag by the upper edge and above a bucket to catch the water. Remove the pencils. The water will flow out the holes with different forces. The pencils can be replaced in the holes.
Principle involved: The fact that the bag does not leak illustrates the elasticity of the plastic. The differences in the stream shows that the deeper the water, the greater the pressure.

ARM STRETCH

Purpose: To demonstrate the interaction of muscle groups and to encourage students to propose experimental tests.
Materials: Five or six small objects (coins, marbles, paper clips), and a small plastic bag.
Procedure: Place the objects in the bag. Have one of your stronger students wad the bad up in a hand and hold their arm straight out to one side. Place your hand on their wrist and instruct the student to resist the downward pressure you are going to exert. Push down firmly for a few seconds. Remove the objects from the bag and have the student hold them in the same hand in the same way. Now push down with the same force on the wrist. You should be able to push the arm down MUCH easier. Allow other students to try. Entertain questions about changes in position, sequence, and number of objects, etc. and allow the students to test the safe ones. Point out that they have designed experiments.

Principle involved: The best explanation that we have received is that it requires more fine muscle interaction to hold the loose objects which detract from using the larger muscles required to hold the arm outstretched.
Safety Precautions: The pressure exerted should be between the wrist and elbow and should be a firm steady pressure. Do not allow students to try to snap other students arms down suddenly as this could result in shoulder injury.

SPEED AND ACCELERATION

While the concepts of velocity and acceleration are fundamental to a good understanding of physics, to beginning students, especially those students with a weak science background, these concepts are often nothing more than memorized algorithms memorized to solve problems in the back of the chapter. The best way to understand these concepts is to also get an intuitive feel for what is actually happening.

Fortunately there are some very simple pieces of apparatus that can help with students with an intuitive feeling for these concepts. In fact, most students have played with some of this apparatus when they were very young. Many preschool toys make sounds as they are pulled or pushed across the ground because the wheels are connected to a noise maker of some kind. Since the turning of the wheels produces the sound, the frequency of the sound produced is directly related to the toy's speed.

Thus, a slow speed might sound like:

pop......................pop......................pop......................pop......................pop

while a faster speed might sound like:

pop..........pop..........pop..........pop..........pop..........pop..........pop..........pop

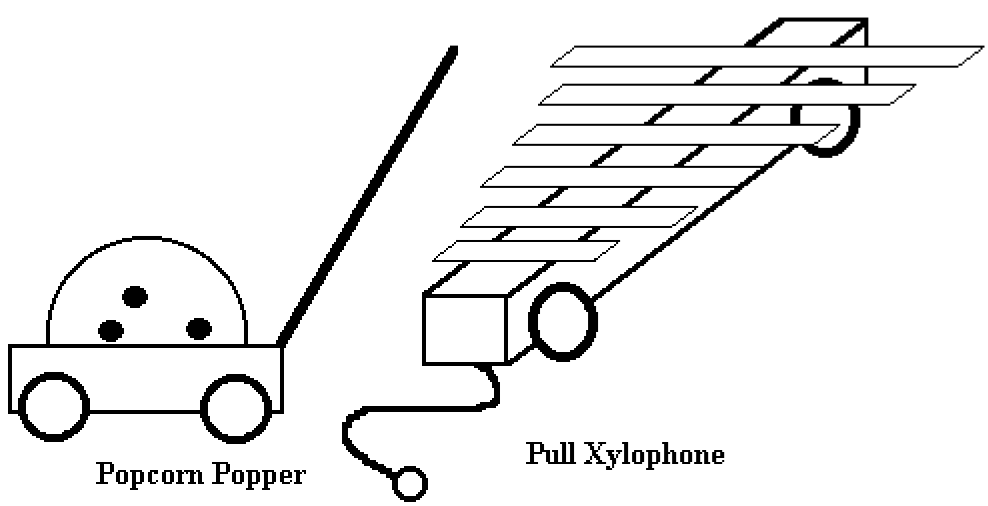
A positive acceleration might sound like:

pop.....pop..........pop...............pop....................pop.........................pop

while a negative acceleration might sound like:

pop.........................pop....................pop...............pop..........pop.....pop

Asking students to close their eyes while you demonstrate some of these and then have then quickly describe what they think was happening can help them with some of the more complicated concepts later on such as why the distance an accelerating object travels is proportional to the square to the time and NOT to time itself.

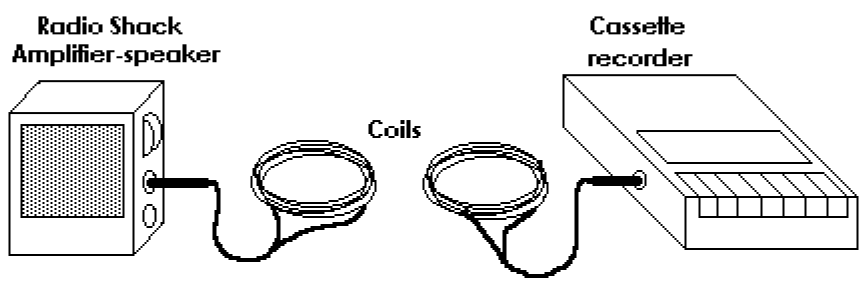


ELECTROMAGNETIC INDUCTION

(©1987, Courtney Willis, Physics Department, University of Northern Colorado, Greeley, CO 80639)

Students often have difficulty understanding the concept of electromagnetic induction. One problem is that induction is often demonstrated using apparatus that is foreign to students' everyday life. The common demonstrations also usually lack excitement since they only involve watching a meter attached to a coil of wire as electrical current is varied in another coil near by. The following demonstration of electromagnetic induction is simple in concept but very effective in the classroom. It also has the added benefits of using familiar equipment and involving more than just the sense of sight.

Students in high school usually have had a lot of experience using cassette recorders. They realize that the recorder uses electricity to reproduce the sound (that's why they have to replace batteries from time to time). Since the sound is constantly changing, the electric current must also be constantly changing. This changing electric current can be brought outside the recorder by plugging headphones into the jack on the side of the recorder. A coil of wire can be attached to this jack rather than a headphone. Usable coils of wire can be made by winding about 50 turns of #26 magnet wire in a circle 5 cm. in diameter or if available an old PSSC solenoids will work well. The changing electric current will then produce a changing magnetic field around the coil. This changing magnetic field can be detected by placing a second coil near by. If this second coil is attached to the input of a small amplifier-speaker, the music being played on the recorder can be heard on the amplifier-speaker some distance away. An ideal amplifier-speaker for this experiment can be purchased at Radio Shack (#277-1008B) for about twelve dollars. The loudness of the music will vary as the second coil is moved around. The polarized nature of the magnetic fields can also be demonstrated by turning the second coil at right angles to the first and observing that the music stops playing all together.



CENTER OF MASS

One of the most commonly encountered concepts in elementary physics is that of center of mass. Center of mass is commonly taken to be that point where the entire mass of an object can be considered to be concentrated. Center of mass is encountered in stability problems, gravitational problems, and motion problems.

There is a common method for finding the center of mass of an irregularly shaped object. If an object in hung from several points and a plumb line in dropped from each of the supporting points, the plumb lines will all cross at the center of mass. If the object is displaced to one side or the other it will always reposition itself so that the center of mass is in a vertical line with respect to the point of support,

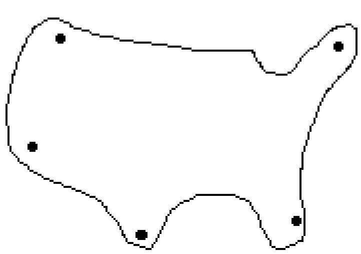
The most important property of the center of mass in the one most commonly overlooked. Using the concept of center of mass simplifies the motion of complex objects. The center of mass will move with the most simple motion while the motion of the other parts of the object might be very complex. This can be strikingly shown using a very simple apparatus.

Finding the Center of Mass

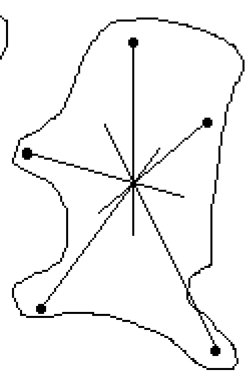
An irregularly shaped board is cut out of thin plywood (mine is a cut-out map of the United States on 1/8 inch plywood). A number of holes are randomly drilled near the perimeter. The board and a plumb bob are hung by a nail through one of the holes in the board. The line of the plumb bob is drawn on the board. The board and a plumb bob are then hung by a nail through a different hole and another line drawn. The lines of the plumb bob will all cross at the same point, the center of mass.

Motion of the Center of Mass

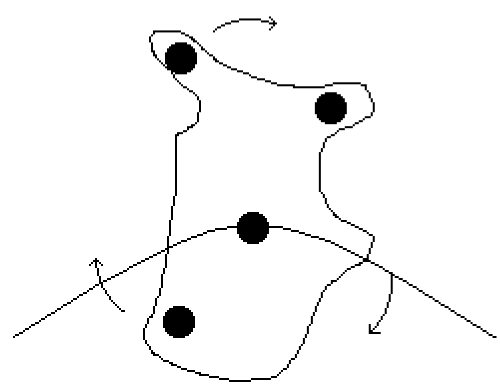
On the reverse side of the board I have stuck a colored circle at the center of mass and several other randomly locations. As the board is spun while throwing, it is easy to keep your eye on the circle at the center of mass but the other circles all blur.



Shape with random holes



Shape with plumlines from holes



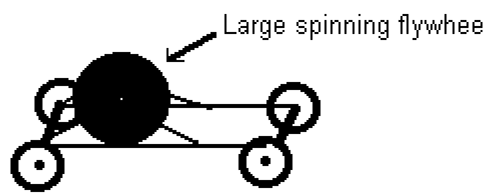
smooth parabolic path of the center of mass

STORED KINETIC ENERGY

One of the worst misconceptions that is commonly taught is the idea the stored energy is Potential Energy. This is commonly taught in early grades and is very difficult to overcome. It is fairly easy to teach the concept of Kinetic Energy as the energy an object has by virtue of its motion. Therefore if students do not see something moving they assume it must have potential energy somewhere. In actuality, Potential Energy is energy an object has by virtue of its position. A ball held above the floor has Potential Energy, as it falls its Potential Energy is gradually transformed into Kinetic Energy. Just before hitting the floor, all the Potential Energy has been changed into Kinetic Energy. After hitting the floor and eventually coming to rest the ball has neither Potential Energy nor Kinetic Energy. The energy has been transformed mostly into heat and a little bit of sound.

A number of "friction" type toys store energy in the form of a spinning flywheel. In this case the toy has "stored energy" that most students will agree is really Kinetic Energy and a better definition of Potential Energy is required.

"Friction" Powered Car



A number of physicists insist that all energy is either Kinetic Energy or Potential Energy. According to this concept thermal energy is really a form of Kinetic Energy while the energy held in a stick of dynamite is really Potential Energy of the atoms in the dynamite. While this argument might be true at the microscopic level, I think that it is a disservice to students to try and teach this concept when they are just learning about energy in the first place. I prefer to talk about macroscopic forms of energy. These are the forms of energy we see around us every day.

Mechanical Energy (of which can be either Kinetic Energy of Potential Energy.)
Chemical Energy
Thermal Energy
Light Energy
Electromagnetic Energy
Sound Energy
Nuclear Energy

In this way we can talk about how different devices transform energy from one form into another. For example a battery transforms chemical energy into electromagnetic energy or a light bulb transforms electromagnetic energy into thermal energy and light. Or people transform chemical energy into thermal energy and a bit of motion. In this way students can trace most of the energy we use on the Earth back to the Light Energy from the Sun.

THE LEVER AND THE DOUBLE PAN BALANCE

Most students learn (often on their own and not in school) a little about levers. The heavy thing has to be close to the pivot to balance a light thing a long ways from the pivot. A balance looks very similar to a lever but does not work in the same way. An object on one side can be balanced by the same mass no matter where that mass is placed on the balance. This can bee easily demonstrated by constructing a simple model of a double pan balance similar to the one below.

Materials:

3 strips of 1/8 inch plywood about

2 - should have 3 holed drilled (center and each end)

1 should have 2 holes drilled (center and end)

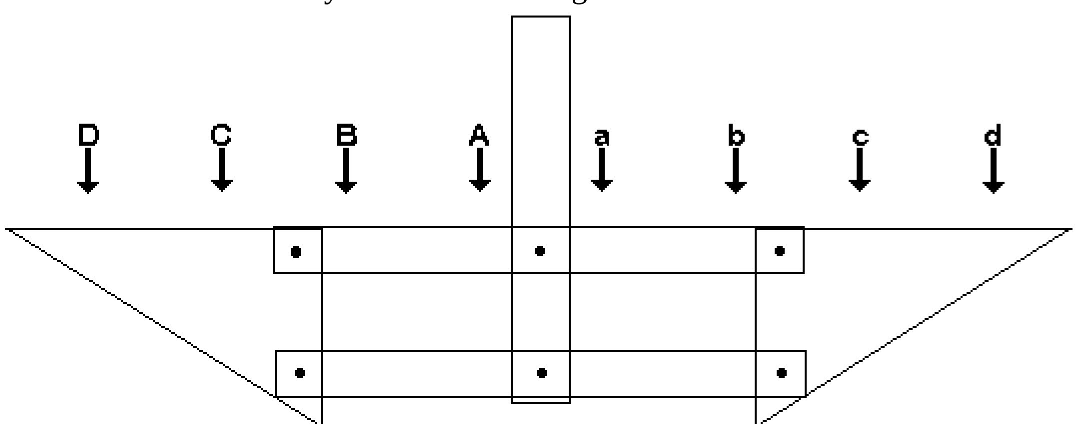
2 triangles of 1/8 inch plywood about

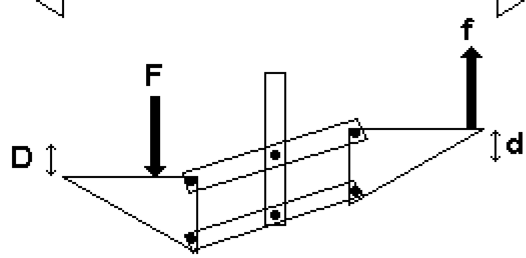
Both should have holes drilled as shown in the diagram

(actual size of the above pieces is not particularly important)

6 small bolts with nuts which fit easily through the holes

If the balance worked as a lever, then a mass placed at points **A**, **B**, **C**, or **D** could only be balanced by an equal mass at the corresponding point on the opposite side. The balance above will work the same way at points **A** or **B**, however a mass placed at **C** or **D** will be balanced by an equal mass at either **c** or **d** or anywhere on the triangle.





The operation of the balance can be explained most simply by invoking the conservation of work and energy as shown in the small diagram. A force **F** pushes down a distance **D** on the long side of the triangle on one side. Since the long sides of the triangles always remain horizontal, the long side of the triangle on the other side will move up a distance **d** equal to the distance **D** on the first side. Since work is equal to force times distance and the two horizontal sides move the same distance, the two forces (placed anywhere on the horizontal sides) will also be equal. In other words, **F** x **D** must equal **f** x **d** by the law of conservation of work and energy. Since **D** equals **d** anywhere along the horizontal sides, **F** equals **f** anywhere along the parallel sides.

COLLIDING SPHERES
CONSERVATION OF ENERGY

In this demonstration you will look at the conservation of mechanical energy. While the conversion of mechanical kinetic energy to mechanical potential energy and back again is relatively easy to demonstrate it is often much harder to demonstrate the transfer of mechanical energy into other forms. This is an especially important concept to demonstrate and discuss, especially since it took so long to understand historically.

If a small rubber ball is dropped, it is easy to discuss the transfer of potential at the top into kinetic at the bottom. However, after a few bounces the ball will come to rest on the floor. It no longer is moving so it has no kinetic energy and it does not have a special position so it no longer has potential energy. Where has the energy gone has it disappeared? The answer of course is that it has been converted into thermal energy. The ball and the floor are a bit warmer at the end of the demonstration than they were at the beginning. While this is true, it is often hard to convince students of this since they cannot feel the increase in temperature.

This can be demonstrated by using two large steel ball bearings (4 to 6 cm. in diameter)* and some paper.
If thermal paper of the type used in FAX machines is available, the two balls can be smashed together with moderate amounts of energy and the thermal paper will leave behind a discolored mark where the two spheres collided showing the thermal energy was created in the collision. (The students will also be able to hear the collision showing that a bit of sound energy was also created) The demonstration can also be performed by forcefully smashing the two spheres together with a piece of normal paper between them. In this case, small holes will be made in the paper. On close examination these holes will often have brown scorched marks around the edges and a definite odor of burning paper can be detected.

* Two such spheres can be purchased from Education Innovations, 151 River Road, Cos Cob, CT 06807, (203) 629-2739.