Exciting Children About Science and Engineering: The Science of Playgrounds

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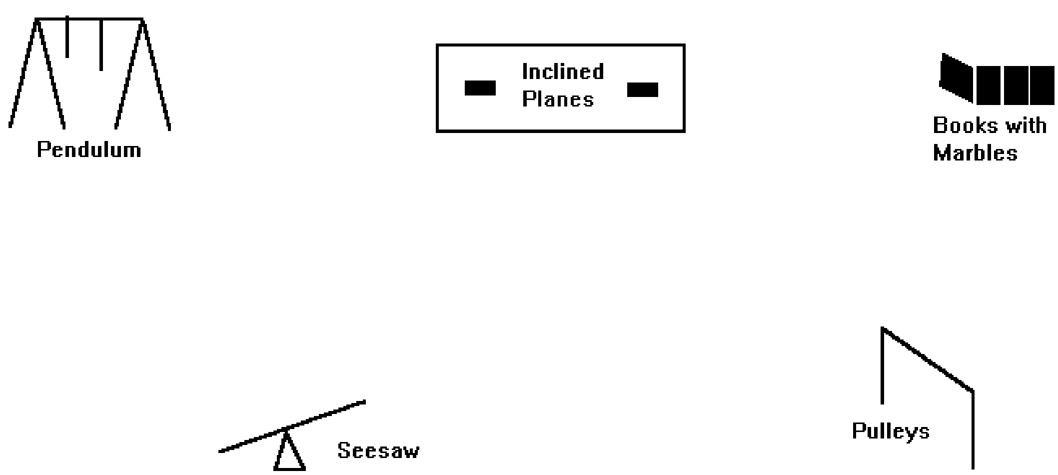
This paper describes a variety of hands-on demonstrations for use in the K-12 classroom which connect science to a venue familiar to most children: a playground. We have designed these experiments to be fun and easy to do and to have the kind of appeal for children that will make the science involved seem easy, exciting and fun. The experiments are deliberately designed to use readily available and inexpensive materials. The purpose of these demonstrations is many-fold, but primarily to excite kids about science and engineering. They illustrate various basic principles from physics and can be used to easily discuss various aspects of mechanical engineering. Many of the experiments are useful for differentiating science from engineering as well. We also find that the hands-on approach to learning increases the understanding and retention of the scientific principles under study.

The demonstrations deal with various equipment found on typical playgrounds. The demonstrations themselves have been used with children as young as three years and as old as college freshmen. Three basic centers are used: an inclined plane, a pendulum and a balance center (see picture).



The children are allowed to experiment freely at each center after a short introduction and demonstration by the teacher. We point out that science supplies the basic physical principles that allow the playground equipment to operate, while it is the responsibility of the engineer to apply those principles to make the playground fun and safe.

1.0 Preliminary Activities

Before beginning the activities, we talk to the children about Sir Isaac Newton and the three laws of motion. In order to illustrate the laws as we enumerate them, one of the instructors appears in a pair of rollerblades with kneepads and other protective gear. The instructor without rollerblades stands behind. As the first law is explained (a body at rest will remain at rest unless acted upon by an unbalanced force), the normally shod instructor pushes the rollerbladed one (usually pretending to some kind of surprise), and the moving person then coasts until she hits the wall or curb or whatever (a body in motion will remain in motion unless acted upon by an unbalanced force).

To demonstrate the second law (F=ma), ideally we use a child on rollerblades in addition to the instructor already so equipped. If this is not possible (or advisable), two round objects (or substantially different mass) could be substituted. We have the normally shod instructor push the two rollerbladers down a hill or small incline using the same amount of force. The mass difference between the two rollerbladers should result in different accelerations if the force is really kept constant.

For the third law (for every action there is an equal and opposite reaction), we have the instructor on rollerblades begin to get tired of being pushed around and go after the other instructor. The instructor in shoes must stand still and allow the rollerbladed instructor to approach and push her. They both recoil as a result of the push. The order is important as to who is standing still if you want the recoil to be strong enough to require little acting.

We then discuss forces in general, have the children identify the forces we used in the previous discussion and define what a force is. We then work our way into a discussion of gravity as a force. We talk about being so used to gravity that we do not really notice its action, and then do a demonstration of the popular myth of how Newton "discovered" gravity. One instructor puts on a bicycle helmet and sits on the ground and the other drops an apple from shoulder height onto the helmet.

(The advantage of these little playlets is that the children tend to remember the discussion long afterward. Eight months later my four-year-old remembers Sir Isaac Newton.)

2.0 Experiments

2.1 Inclined Plane (Slide)

The inclined plane experiment involves a piece of wood or cardboard used together with matchbox cars. We have found that the ramp should be at least a foot long. If the ramp is too short, the cars will not gather enough momentum to make the experiment interesting. If the ramp is too long, it will be difficult to direct the cars in such a way that they stay on the ramp until the bottom. Provided at the center are also sandpaper, a small piece of carpet, and a piece of smooth plastic. The children are then given Matchbox cars of varying weight. Races can then be conducted on the ramp with cars of differing weight, with cars of the same weight with different materials covering the ramps, etc. The children are encouraged to experiment with different combinations after an initial teacher demonstration. Supplies used include: ramp(s), matchbox cars, sandpaper, piece of carpet, and smooth plastic or aluminum foil.

2.2 Newton's First Law of Motion

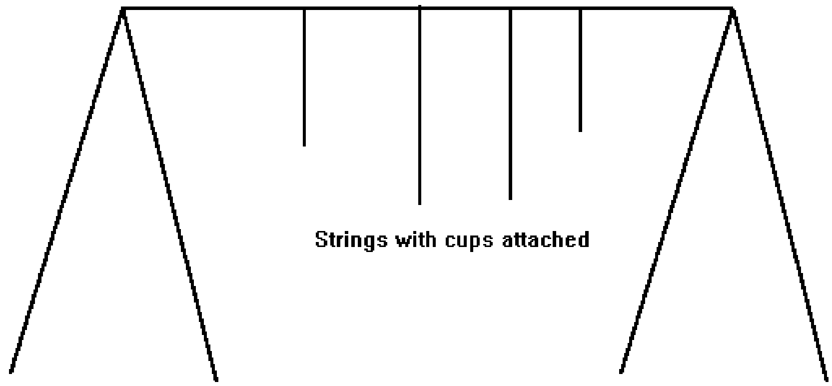
On another ramp a pencil is taped to the bottom. Clay is provided, and the children are instructed to make a small figure (about 1 inch) out of the clay. The figure can then be placed on a car which is then released at the top of the ramp. The car will be stopped at the bottom of the ramp, but the figure will fly off. This demonstrates the principle that an object in motion will remain in motion until it is stopped. It is also a powerful argument for seat belts! Supplies used include a ramp, matchbox car, clay, pencil, and tape.

2.3 Newton's Third Law of Motion

To demonstrate the Third Law of Motion, several books hard-bound of the same size (encyclopedias work well) are placed spine down on the table or floor with the flat side against a wall. One of the books is tilted and the other one or two are left flat. A channel is now evident on the upright pages of the books. (More books or rubber bands can be used to make sure the books stay tightly closed.) A number of marbles can be placed on the flat books and one marble allowed to roll down the inclined book to strike the stationary marbles. The moving marble will stop and one marble on the other side roll along the channel. Multiple marbles rolled down the ramp should cause the same number of marbles to be propelled along the channel. Students are encouraged to experiment. Supplies used include three or more encyclopedias, marbles, and rubber bands.

2.4 Pendulum (Swings)

The pendulum center is built with a simple frame of PVC pipe. Several paper cups are suspended from the frame at varying heights with string or yarn. Several experiments are suggested to the children before they are allowed to use the center. They are asked to examine the difference in behavior between pendulums of different length but the same weight and between pendulums of different weight but the same length. (Marbles are provided as weights.) Older children might be asked to see if they can use weights to cause the period of a long and a short pendulum to be the same. Supplies include the PVC frame (see picture below), paper cups, marbles, and yarn or string.



2.5 Balance (See saw)

Finally, the balance center is constructed "life size" with a ten foot length of 2”x8” board. The board is placed over two cement blocks stacked on top of each other. The children themselves are the weights used to explore the mechanics of balance. This is the only center where the children are not allowed to experiment without the aid of a teacher. (In the absence of space, the balance center could be modified to use a three foot board, short cups and marbles for weights.) Supplies include 2”x8” board-ten feet in length and two large cement blocks.

The monitoring teacher should be prepared to support one end of the board as children get on and off. Be prepared for the child who abruptly exits one side of the board leaving another child sitting on the other end!

3.0 Summary

The demonstrations are deliberately designed to use readily available and inexpensive materials. They can be easily modified to fit individual circumstances. At each center, the children are encouraged to experiment with various combinations under supervision—the balance center necessitating constant attention by one or more teachers. After the center rotations have been completed, the participants can then be offered the opportunity to use what they have learned to design their own playground. Simple materials can be provided so that they can take home a scale model, if time permits. (We have provided craft sticks, pipe cleaners, various plastic and paper cups, glue, markers, craft foam, Styrofoam shapes, etc.)

These demonstrations have proven to be quite effective in practice. They offer the opportunity to illustrate physics in a way that many adult engineers may never experience. The playground is a perfect venue to see science and engineering in action—literally!

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