Resistance Is Futile!

INTRODUCTION

The science behind how things move when forces are applied (physics) is of great importance to engineers. **Statics** is the science of equilibrium forces, where there is no motion and all the forces are balanced. **Dynamics** is the science of objects in motion.

Interestingly enough, it takes a larger force to set an object in motion than it does to keep the object moving.

GRADE LEVEL

This activity is appropriate for any age group, depending on the depth of the technical explanations and discussions. The audience here is grade 7-10.

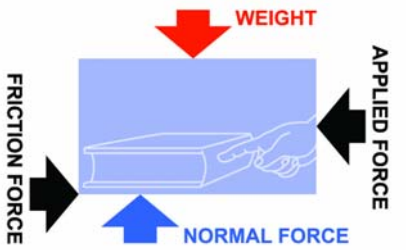
OBJECT OF ACTIVITY

Students experimenting with marbles and coins on various surfaces are introduced to basic statics and dynamics in engineering.

DISCUSSION:
Is it easier to push a heavy box across a thick carpet or a slick patch of ice? (over ice) Why? There is less **friction** between the ice and the box than there is between the thick carpet and the box. Friction can make objects hard to push.

The **coefficient of friction** is a measurement used to calculate the effect a surface has on motion. A very smooth surface like ice has a very small coefficient of friction, so the friction force is also very small. As a surface gets rougher, the coefficient of friction increases and so does the friction force. The coefficients of friction are determined from experiments and can be found in engineering reference books for a wide range of surfaces.

To help calculate the friction force, engineers and scientists use a drawing called a **free body diagram** to picture the forces on an object.



The fact that forces have directions is important. For example, if you push straight down on a book on a table, no matter how hard you push down, the book will not move to the side. The force downward is balanced by an equal and opposite force up from the table. The book is in **static equilibrium**. If you push hard on the side of the book parallel to the table, however, it will move across the table. It is no longer in equilibrium.

Friction works against the applied force and the possibility of motion. If the applied force is larger than the friction force, the object will move across the table.

MATERIALS *(for each group)*

- 3 marbles
- A smooth surface
- Piece of very rough sand paper *(6" x 6" or larger)*
- 3 coins
- A wooden surface (cutting board or desk top)
- A carpeted surface or a piece of carpeting
- A cookie sheet, coated with ice
- Piece of plywood or very sturdy cardboard

ACTIVITY

Before the class period, pour water on the cookie sheet and let it freeze. Prepare the other surfaces. Before letting the students experiment with the materials, ask them to make predictions and record them.

Step 1: Drop a few marbles a short distance above the smooth surface. What did you observe? Is there much friction between the marbles and the smooth surface?

Step 2: What do you think will happen when the marbles are dropped on the piece of rough sandpaper? Try to drop the marbles onto the sandpaper from the same height as in Step 1. What happened?

Step 3: Flick the coins across each surface. Which will have the most friction? The least friction? Try to use the same amount of force each time. What happens if you use more force to flick the coin across the surfaces?

After the students have experimented with the marbles and coins on all surfaces, call on them to summarize their findings. Which surfaces have the smallest coefficient of friction? The largest? Ask the students WHY it is important for engineers to know this. Help the students develop an understanding of the attributes of design in the invention process.

CONNECT TO ENGINEERING

Engineers must consider friction forces when designing things. For example, the friction of a tennis shoe on a clay court is very different from its friction on asphalt or on an indoor court. Engineers design cleats on sport shoes to improve traction on various surfaces. They design bobsleds with lightweight materials to travel faster in the Olympics. Surfaces that could be slippery when wet need larger coefficients of friction than dry areas (wet sidewalks/dry floors; bathtub bottoms/ tile walls).

This activity provided by the Society of Women Engineers. www.swe.org.