

3rd Grade – Forces & Engineering

Objective:

Students will learn about the forces imposed on a building structure as well as potential and kinetic energy stored in a catapult.



5-PS2 Motion and Stability: Forces and Interactions

5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down **PS2.B: Types of Interactions**

☞ The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1)

3-5-ETS1 Engineering Design

ETS1.A: Defining and Delimiting Engineering Problems

☞ Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

ETS1.B: Developing Possible Solutions

- ☞ Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
- ☞ At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
- ☞ Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)

ETS1.C: Optimizing the Design Solution

☞ Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

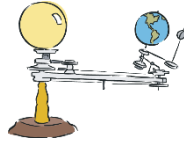
Docent Lab Guidelines:

1. Docent(s) should plan to arrive early to set up before the class arrives.
2. Reserve the science room on the Science Lab Master Schedule. This can be found on the Rock Creek Elementary school website. Click the left-hand side tab labeled "Science Docent Website". Please make sure you add 30-40 minutes of set up time and about 30 minutes of clean up time to the overall class time.
3. This lab works best if there is at least 3 docents. If possible allow 1-1/2 hours for this session.
4. Safety glasses are required when launching the catapults. Aprons are not required.

5. Have the teacher assign groups before arriving to save time.
 6. There is only one experiment with three parts to it.
 7. If it is a sunny day docents can have the students launch their catapults outside.
 8. The last 5-10 minutes of class review the student's observations and ask if they would like to share their hypothesis and conclusions.
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Forces & Motion Facts from *Science Trek*

(For Docent's Reference Only)



Motion makes the world go 'round. Motion makes the moon go 'round too. In fact, motion makes lots of things go. When we think of motion we often think of cars, bicycles, kids running, basketballs bouncing and airplanes flying. But motion is so much more. Motion is important to our lives and impacts so many things that we do. Motion is the changing of position or location. But motion requires a force to cause that change. Let's learn about force and motion and the effects of these physical laws in our world.

What is Force?

Force is just a fancy word for pushing or pulling. If I push on something or pull on it, then I am applying a force to it. Force makes things move or, more accurately, makes things change their motion. Two natural forces that we have experienced are the force of gravity and magnetic forces.

These two forces act at a distance and do not require direct contact between the objects to function. Gravity produces a force that pulls objects towards each other, like a person towards the ground. It is the force that keeps the Earth revolving around the sun and it's what pulls you toward the ground when you trip.

Types of Contact Forces

There are 6 kinds of forces which act on objects when they come into contact with one another. Remember, a force is either a push or pull. The 6 are:

- normal force
- applied force
- frictional force
- tension force
- spring force
- resisting force

Normal Force

A book resting on a table has the force of gravity pulling it toward the Earth. But the book is not moving or accelerating, so there must be opposing forces acting on the book. This force is caused by the table and is known as the normal force.

Applied Force

Applied force refers to a force that is applied to an object such as when a person moves a piece of furniture across the room or pushes a button on the remote control. A force is applied.

Frictional Force

Frictional force is the force caused by two surfaces that come into contact with each other. Friction can be helpful as in the friction that allows a person to walk across the ground without sliding or it can be destructive such as the friction of moving parts in a motor that rub together over long periods of time.

Tension Force

Tension force is the force applied to a cable or wire that is anchored on opposite ends to opposing walls or other objects. This causes a force that pulls equally in both directions.

Spring Force

The spring force is the force created by a compressed or stretched spring. Depending upon how the spring is attached, it can pull or push in order to create a force.

Resisting Forces

Resisting force, like air resistance or friction, change motion. Whether the forces actually stop or slow something depends upon your point of view. Air friction makes a leaf travel along in the wind. When you pick up a pencil, it's friction with your fingers that gets the pencil in motion. In each case, the friction makes the two things (like the air and the leaf) move together.

Experiment: Angry Birds – a lesson in potential and kinetic energy and the forces

Estimated hands-on time: 45-55 minutes, working in groups.

Shared Class Materials:

- Pre-assembled catapult (see separate instructions on how to assembly), groups may need to share if there are not enough
- Assorted Plastic launching Angry Birds
- Scissors
- Rulers (if needed – see instructions below)
- Pencils
- Scotch Tape
- Markers

The following materials are to be handed out to each group

- Cardboard base
- 30 craft sticks
- 7 straws
- 1 piece of construction paper or card stock (any color)
- 10 paper clips
- 3 arm lengths of making tape (about 6 feet)
- 1 set of Angry Birds Paper Model templates
- Set of Instructions

The following materials are for the testing station

- Table fan
- Weights
- Electrical extension cable if needed
- Assorted plastic launching Angry birds

Preparation:

1. Set scissors, scotch tape, pencils and rulers at each table.
2. Set out the materials listed above for **each** group.
3. Place a set of instructions per group at the tables.
4. Do not handout out the plastic “launching” Angry Birds and catapults until the groups have completed the Parts 1 & Part 2 below.
5. Designate and set up a Testing Station area. This is where the students will bring their structures to be tested. This station should have a table, table fan with an adjacent electrical outlet and weights. Docents can also have the plastic “launching” Angry Birds and catapults at this station to hand out to the students when they have completed their testing.

Docent Instructions:

- 1.** Before starting the experiment explain what is a force? Explain that forces effect the stability of all structures (buildings and bridges). Structural engineers design all structures with forces in mind. If they didn't the very building you are in may fall down. Structural engineers keep people safe. Structural engineers must have an understanding of different materials and the different types of forces applied on those materials. The structural engineer uses math calculations to determine how strong each material is when a maximum force is applied. Some of the forces on a structure are gravity (for example the weight of the building materials, the stuff inside it or snow on top of a roof), wind loads (forces caused my strong wind like hurricanes), and seismic loads (the forces caused by earthquakes. A good video to show the students is: <https://www.youtube.com/watch?v=ogpp8L4J4ek> .

Tell the students they will be structural engineers today. Their job is to build a structure for their Angry Birds that will hold up to the forces of gravity, hurricanes and earthquakes.

- 2.** Explain the instructions to the students. They will also have printed instructions at the tables to refer back to, if needed. There are 3 parts.
 - a.** Part 1: **Create:** Groups are to build a structure for the Angry Birds using the materials provided. The structure will need to withstand the forces of gravity, hurricane and an earthquake. (Note: Give a time limit for this part.)
 - b.** Part 2: **Test One:** Groups are to take their completed structure to the testing station to test their structures against gravity, hurricane and earthquake forces.
 - c.** Part 3: **Playtime with kinetic and potential energy:** Students then test out their structures against the forces of gravity as well as experiment with potential and kinetic energy by launching plastic Angry Birds at their structure, with the provided catapult.
- 3.** Each group will cut, color (coloring optional) and assemble their Angry Bird Paper Models. These models will be placed inside and on top of the structure they will make. **If time is limited the docent can preassemble these paper angry birds for the class.**
4. Next, each group will use the provided materials: craft sticks, straws, masking tape, construction paper and paper clips, to make a structure.
5. If the docent or teacher would like to bring some measurement practice into this lesson then ask each group to make their structure at least 12 inches tall (30 cm) and have a 4 inch x 4 inch (10 cm x 10cm) platform at the top of their structure using only the provided materials. In lieu of exact measurements, ask the students to create a multi-story structure with a platform on the top story.
6. Once a group has completed their structures they can take it over to the "testing station".
7. Create a testing station either in the classroom or outside. There should be at least one docent at this station. The docent will test each structure to see if it can withstand the forces of gravity, tension and compression (gravity, hurricane and earthquake).
8. For the gravity testing the docent will load the platform with brass weights.
9. For the hurricane testing the docent will use a table fan to create a wind force.
10. Last, for the seismic test (earthquake) the docent will shake or pound on the table with their fists to recreate an earthquake.
11. After the group has completed their testing they will collect a catapult and some launching Angry Birds and test out the potential and kinetic energy and trajectory of a catapult and see if they can knock over their paper angry birds.
12. Docents can do this part outside.



13.

Example

Assembly Video for the Catapult (written instructions on a separate file):

<https://www.youtube.com/watch?v=neyF9AegvXA&feature=youtu.be>