Experiment

Intermediate

Rise and Fall by Invisible Force

sead : stem

Subjects

Physics | Engineering | Engineering Design Process

Topics

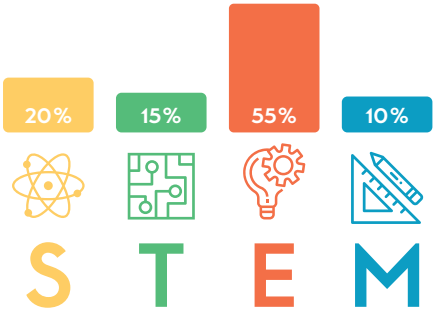
Physics | Engineering | Simple Machines | Energy

Key Words

Catapult | Launch Angle | Work | Force | Kinetic Energy | Projectile Motion | Simple Machines | Gravitational Potential Energy | Range | Inclined Plane

Connection to SDG

STEM Chart



Time for Activity

2–3 hours or 4 Classes

Introduction

Have you ever played volleyball, a game where you try to hit a ball back and forth over a net without letting it touch the ground? Can you imagine building a machine—actually, two machines, one on each side of the net—to do that instead? That is what we will do in this engineering design project, but we will not use a full-sized volleyball. Instead, we will try to launch a ping pong ball back and forth over a much smaller "net" (a folded piece of paper).

This project allows us to explore some interesting topics in physics and engineering. It's a great opportunity to learn about simple machines such as the lever or the inclined plane. Here we can also investigate more complex machines like catapults and slingshots, which are used to launch projectiles. Just think about how you could incorporate different aspects of these machines into your design.

The ball needs kinetic energy, the energy of motion, in order to fly through the air. Where will that energy come from? It could come from elastic potential energy, the energy stored in stretched material, like a rubber band. it could come from gravitational potential energy. The energy stored in an object that is raised off the ground could come from work that you do with your hand by exerting a force.

Finally, we can use this project to demonstrate the engineering design process. It is unlikely that you will think of an idea for a machine, sit down and build it, and have it work perfectly on the first try. Just encourage students to come up their own designs, test the designs and modify the designs to improve them.

Professional engineers rarely get things right on the first try!

Key Objectives

1. Building a machine that can launch and return a ping pong ball back and forth over a net.
2. Understanding the relation between forces, motion and energy and projectile motion.
3. Understanding that kinetic energy depends on mass of an object.

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Materials

1. Cardboard (max size 12" * 12" or 30x30 cm)
2. Plastic cups (holding 500 ml)
3. Wooden craft sticks (11.5 cm)
4. Paper (A4 size)
5. Wooden pencils
6. Rubber bands
7. Clear tape

Safety

1. Be careful while using scissors for cutting cardboards and papers.

Guiding Questions

1. How could you build a machine to launch a ball by using these materials?
2. Where will the energy to launch the ball come from?
3. Which device could you build to catch the ball without dropping it?
4. How can you get the ball back over the net?
5. How could your machine convert one form of energy into another?
6. Which trajectory (path the ball takes through the air) will make it easier to catch the ball or get it over the net: a high, steep trajectory or a low, shallow trajectory?

Procedure

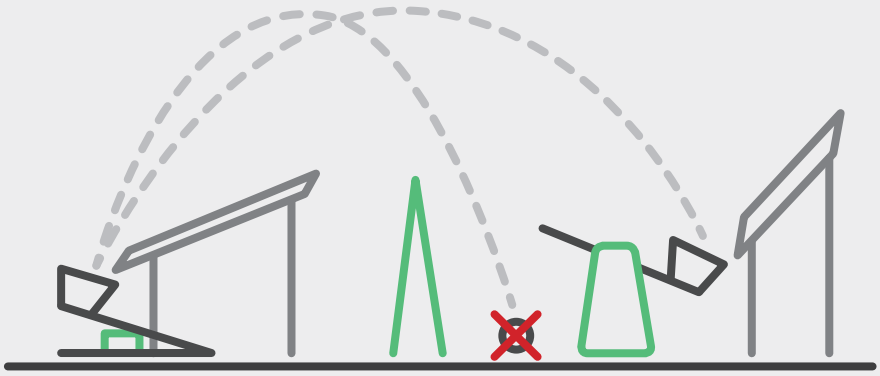
(Experimental Procedure or how it works and how to design)

The objective of this project is to build two devices that could launch a ping pong ball back and forth over a net without letting the ball touch the ground.

Engage (5 minutes)

Introduce the challenge to students. Explain that the main goal is to build two machines that can launch a ball back and forth over a net, like in a game of volleyball.

5 min



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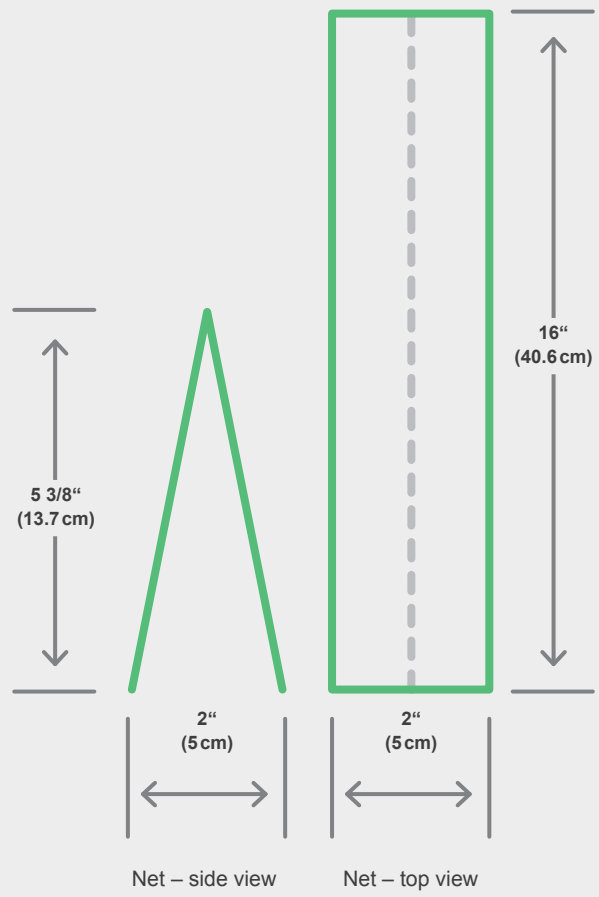
The more times your ball goes over the net, the higher your score will be. The “net” will be made from two pieces of 8.5”x11” paper, taped together side-to-side (along the 11” edge), and folded in half to form an upside-down “V” shape, as shown in Figure 1.

Fig 1



Design

Before you start building anything, it is a good idea to brainstorm different designs. Try sketching your designs on paper. Which designs will work best given the rules and materials you are allowed to use? Which design do you think will be the most reliable? Think about these questions and select two designs to move forward with. Remember that you need two devices, one for each side of the net and they do not need to be identical.

Build

Once you have decided on designs, it is time to start building them. You might find out that your designs “on paper” do not work as planned when you try to build them in the real world. That is OK! You do not have to stick to your original plan. You can make modifications to your design, or even start over with something completely new.

Rules for Building a Machine

1. Only use items listed in the Materials section.
2. Build two machines (one for each side of the net). The machines can be different from each other.
3. Either machine can be „active“ (meaning it launches the ball) or „passive“ (meaning it lets the ball roll back over the net, powered by gravity).
4. Both machines must be freestanding. They cannot be taped to the ground or supported by a person.
5. Your machines cannot touch each other or the net. The two machines have to be separated by the width of the net.

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Test

Once you have built two devices, put one on each side of the net and try them out. This is your opportunity to identify weak spots in your designs and things that can be improved. Try launching the ball back and forth, and make sure you follow the rules about operating the devices and touching the ball. Here are some things to consider:

Rules for Testing a Machine

1. One person at a time can use both hands to operate a machine to launch the ball (two people in total, one for each machine).
2. After the ball is launched, nobody can touch either machine until the ball has stopped moving completely.
3. The ball is allowed to touch the net.
4. After the ball has come to a complete stop, you cannot touch or move the ball, even if you do not touch it directly. You can use both hands to operate the machine to launch the ball back across the net.
5. The ball cannot touch the ground. It is allowed to touch another material (like a piece of paper or cardboard) that is sitting on the ground.
6. You continue launching the ball back and forth over the net until one of three things happens:
   1. The ball touches the ground.
   2. The ball gets "stuck" and you cannot relaunch it without touching or moving it first.
   3. Five minutes pass.
7. If you need to make repairs, you must start over counting the number of launches at zero.

Assessment

1. How reliably can you launch the ball over the net? Does your device have trouble launching the ball far enough to go over the net? Do you ever launch the ball too far?
2. How accurately can you launch the ball? Does the ball ever go off to the side or miss the catching device? If so, you could make your catching device bigger so it is easier to catch the ball—but that means you will need to use more materials.
3. How easily does your device catch the ball? Even if the ball lands in your device initially, does it bounce or roll out? How could you stop that from happening?
4. How sturdy is your device? Does it stand up to repeated use without breaking? Remember that if you need to stop for repairs, you have to start over again counting at zero!
5. What is a force that opposes motion between two surfaces?
6. What is the difference between mass and weight?
7. What slows down the motion of an object or keeps it starting?
8. What does force allow a ball player to do?