Cuyahoga County Public Library
Strongsville Branch
18700 Westwood Drive
Strongsville, OH 44136
(440) 238-5530

July 1, 2025

Mr. Tim Protiva (Host)
Children's Services Supervisor

Subject: Engineering Program at CCPL Strongsville Branch (NSPE Pilot Program for 2025)

Summer Fun, For Everyone 2025 Procedures!

Dear Students and Volunteers:

The following is our procedures for the first two exercises we will be performing on Thursday, July 3, 2025 for the CCPL Strongsville Branch celebration of **Summer Fun for Everyone!** The procedures we will be applying are from the National Society of Professional Engineers (NSPE) and the Ohio Society of Professional Engineers (OSPE) National Engineer's Week (NEW) Discover E Program.

NEW is celebrated in February around Presidents Day. This date was selected since our first president, George Washington (birthday celebrated with Abraham Lincoln on Presidents Day) was a Military Engineer.

Our plan is to help develop interest and skills in engineering for students in elementary school grades 2 through 6. The specific focus of the exercises will be detailed later in the writeup.

We are very thankful to the students, their parents, and our table volunteers for participating in this event hosted by Tim Protiva and the CCPL Strongsville Branch. We hope you will enjoy your time discovering skills in engineering. Our program will have two parts. The first part was Thursday, June 5 and the second part is Thursday, July 3rd.

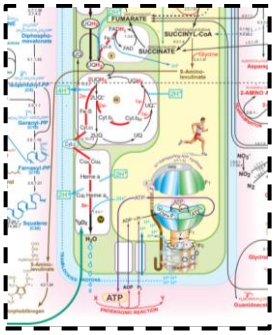
Note that the most important part of these exercises is to have FUN!

Best regards,

Joseph Yurko, PE
NSPE NEW Facilitator
yurkojoe5@gmail.com

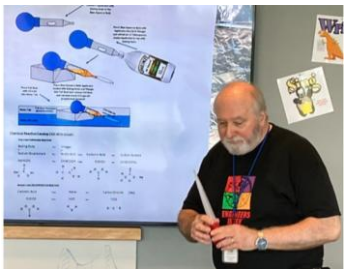
Summer Fun for Everyone Events for two hours on Thursday, July 3rd from 2 to 4 pm:

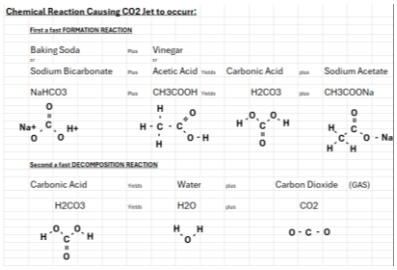
1. **Exercise # 1, Catapult Accuracy:** To test different catapult settings for range and elevation, compete between team tables for the most accurate catapult operation.
   a. Time: 60 minutes activity (hands-on)
   b. Career: Mechanical Engineering & Physics
   c. Grade: 3 to 6 grades (8 to 11 years old)
   d. Topic: Forces, Motion, Energy, Simple Machines
2. **Standard Catapult** (read before beginning the exercise):
   There are three forms of energy: They are as follows,
   a. **Internal Energy**, that is either biochemical, chemical, or nuclear.
      i. **Biochemical Energy:**



Our bodies make biochemicals in our muscle cells for energy to make our muscles move.

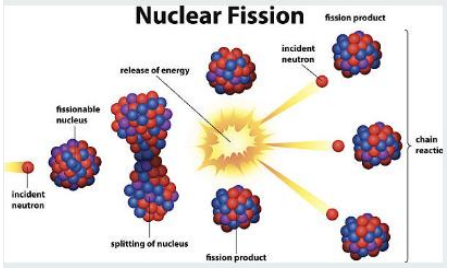
      ii. **Chemical Energy:**





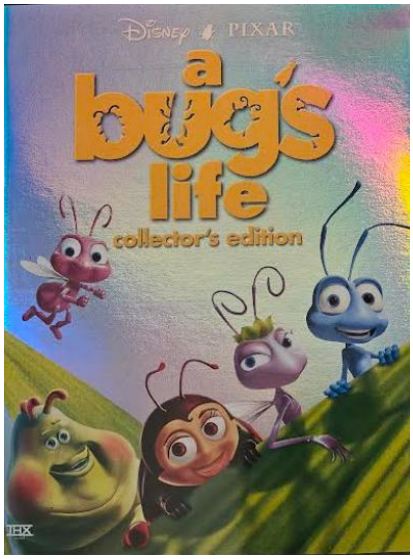
Last month we reacted vinegar and baking soda to make Carbon Dioxide for our foil boat

      iii. **Nuclear Energy:**



Enriched Uranium 238 element reacts atomically to make heat to generate electricity

   b. **Potential Energy**, this is a body of mass with an elevation above a ground level. Should that body of mass fall it will convert the potential energy into kinetic energy. We will be studying this conversion of potential energy into kinetic energy today with the catapult. A counterweight is elevated to a high potential energy level above the projectile on a lever arm. When the counterweight is released and drops, then its energy is converted into the kinetic energy of the projectile. Use book demonstration from low and high elevation drops to make a noise.
   c. **Kinetic Energy**, this is a body of mass that is in motion.

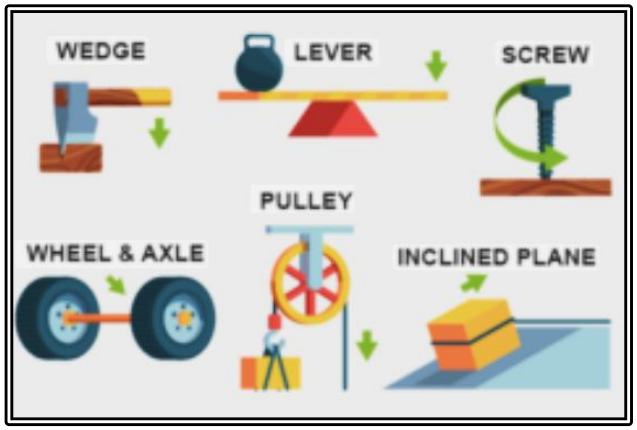


Today we will be learning how to adjust the settings for range and elevation on a miniature standard catapult for best team accuracy. Have you seen the Disney Pixar Movie "A Bug's Life?" The basic story line is that ants are industrious creatures that build for the future and store foods from the fall for the winter. On the other hand, grasshoppers are just the opposite and will move from location to location just consuming the food available with no plan for the future. When the grasshoppers demand food from the ants, the ants build a mechanical bird to scare the grasshoppers away from their food supply. Our first task for today is to learn how to operate a catapult for accuracy like the ants learned how to operate a mechanical bird to protect their food and scare off the grasshoppers! After you experiment with the catapult range and elevation settings through a trial & error process or a prediction & correction process throwing objects at targets, you will have three try's at scoring points on a target. The team with the highest score will be the winner of Exercise # 1, and the most successful ant colony at protecting their food supply for the coming winter from the invading grasshoppers.

3. Standard Catapult understandings:

    a. **Mechanical Simple Machines (6):** These devices are basic tools used to make work easier by changing the direction or the magnitude of a force. Most catapults use the Lever (the main arm of the catapult), Pulley (used to cock the catapult into position to load the projectile), Wheel & Axel (the pivot point of the catapult arm or lever), and the Inclined Plane (used to move the projectile into the catapult bucket).
    b. Some of these simple machines were developed by a Greek mathematician, physicist, engineer, and inventor known as **Archimedes** who lived in Syracuse, Italy from 287-212 BC.
        i. **Lever:** a rigid bar that pivots around a fixed point called a fulcrum (i.e., a seesaw)
        ii. **Pulley:** a wheel with a groove that a rope runs around, used to change the direction of force or reduce the force needed to lift something (i.e., a cargo ship's hoist or crane)
        iii. **Wheel & Axel:** a wheel that rotates about a rod at its center (axel) reducing friction (i.e., a bicycle wheel)
        iv. **Inclined Plane:** a rigid flat surface that is sloped like a ramp, allowing objects to be moved to different heights with less force (i.e., a wheelchair ramp)
        v. **Wedge:** a hard object that tapers to a thin edge, used to separate objects or hold them together (an ax, a knife, or a log splitter)
        vi. **Screw:** an inclined plane wrapped around a cylinder, used to hold objects together or to move them apart (i.e., a wood screw, a bolt, a jar lid, or a car jack screw)

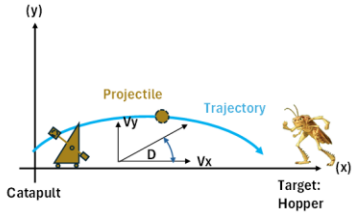
vii. Diagram of Simple Machines:



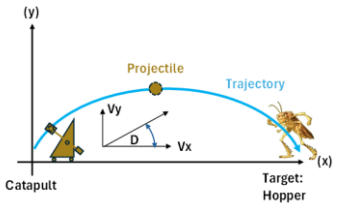
c. The Physics of a catapult's projectile and trajectory: By **Sir Isaac Newton** (1643-1727), studied physics, mathematics, and astronomy in London, England has discovered the following laws:
   i. **First Law (Inertia):** an object in motion (like a projectile) will stay in motion with the same speed and direction unless acted upon by a force like gravity. In the case of a projectile this means its horizontal velocity remains constant (disregarding air friction)
   ii. **Second Law (F = m a):** the acceleration (a) of an object is directly proportional to the net force (F) acting on it and inversely proportional to its mass (m). In projectile motion, the primary force is **gravity (g),** causing a constant downward acceleration (approximately 9.8 m/s/s or 32.2 ft/s/s).
   iii. **Third Law:** For every action there is an equal and opposite reaction. While the law is not directly used to calculate trajectory, it is important for understanding how forces interact in more complex situations.

d. Newton's equations for predicting projectile trajectory are shown below. We will do our work today using a trial & error or prediction & correction techniques:
   i. **The range X** of projectile from catapult with release velocity V and angle of elevation D.
   ii. **The time** in seconds it takes the projectile to hit the target is: **T = X / Vx**
   iii. **The vertical displacement** of the projectile when it hits the target is: **V = 2 Vy / g**
   iv. **The angle of elevation (D):** $X = V^2 \sin 2D / g$ or **$\sin 2D = gX / V^2$**
   v. Comparing Parabolic Trajectories with varying angles of elevation:

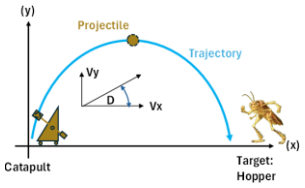
vi.



30⁰ Angle: too short



45⁰ Angle: Just Right



60⁰ Angle: too short

e. Obtain your Standard Catapult for both Ex # 1 and Ex # 2 from your table volunteer.
f. Note the different wooden peg settings for range and elevation for the object you are given. Learn how each setting will change how high the object goes and how far the object goes. This technique we will use is called Trial & Error or Prediction & Correction.

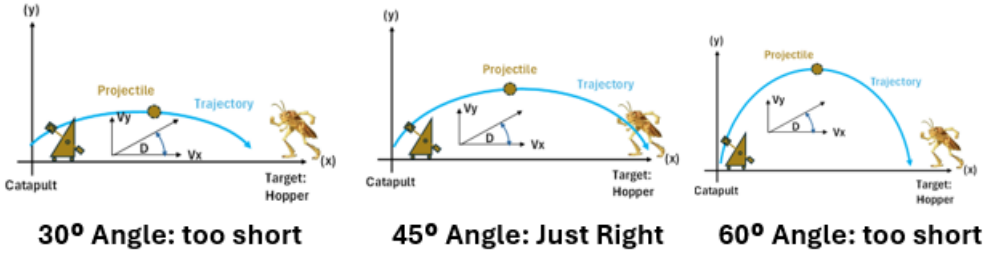


DIAGRAM of Catapult with different Peg Positions to get Accurate Range Settings

g. We will practice catapulting the projectile several times at a target (Hopper) so you can predict hitting the target with the object using the settings you have chosen. Become familiar with the parts of the catapult so you can better understand how to use it.

i. (Top) Full Stop Anchor (0^0 degrees)
ii. Trajectory Angles (30^0 degrees, 45^0 degrees, 60^0 degrees)
iii. Catapult Arm or Lever
iv. Bucket holding the Projectile (top end of the catapult arm)
v. Pivot Anchor or Fulcrum (midway of catapult arm)
vi. Counterweight (RED and at the bottom end of the catapult arm)
vii. Catapult base with two side support structures and wheels

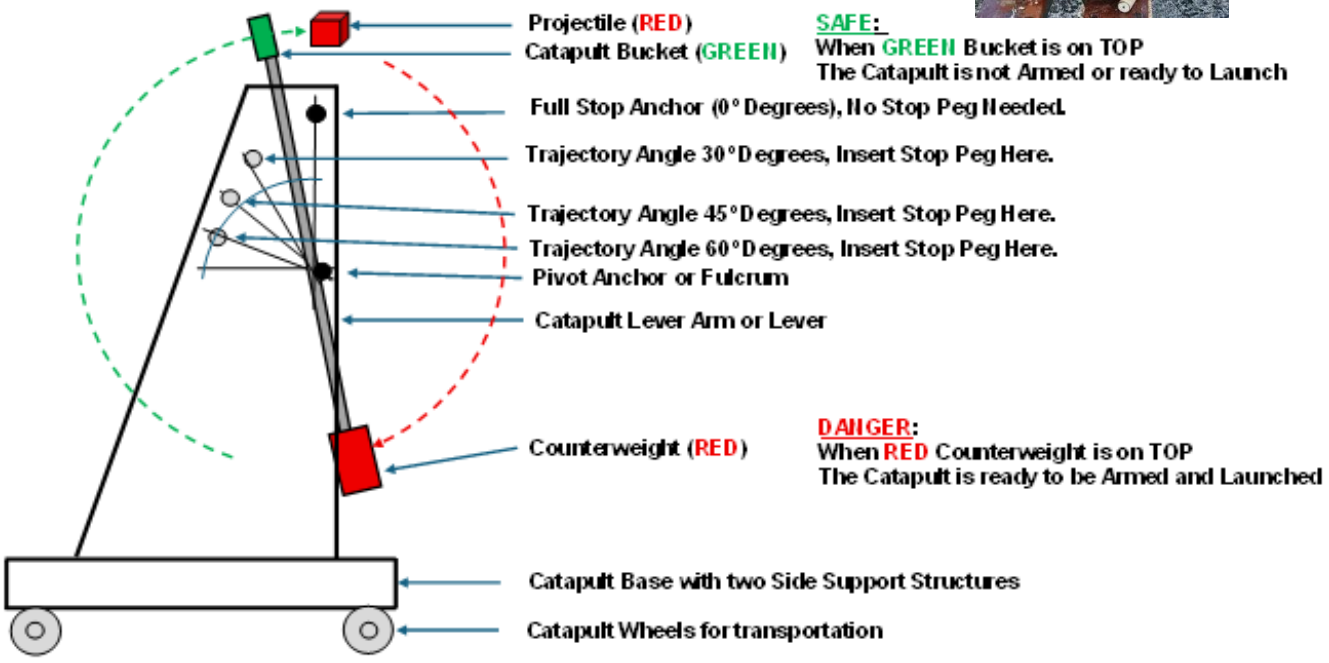


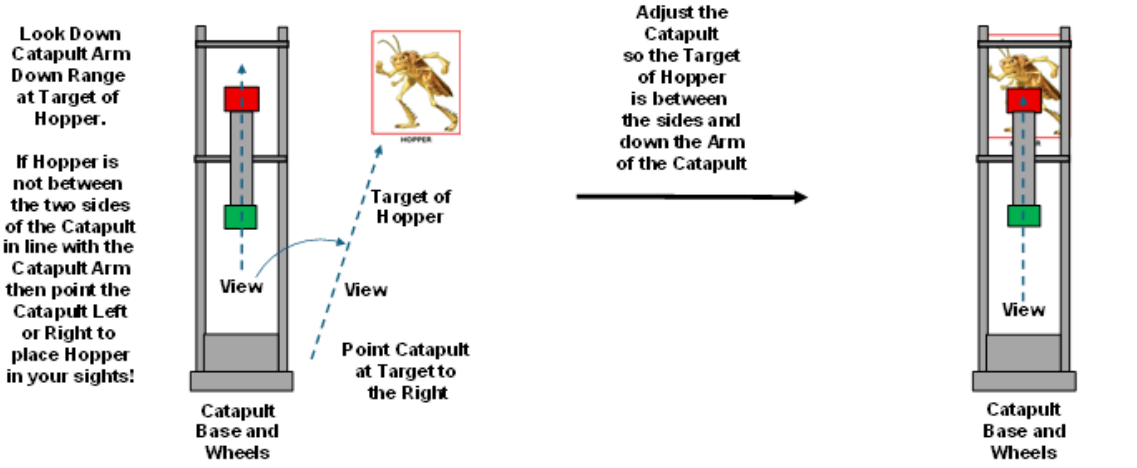
DIAGRAM of Catapult with Parts Labeled and their Safe and Danger Positions

h. Catapult Launching Safety Commands **(Red is Danger, Green is Safe)**

i. **"Safe Position"**, Catapult At Rest: **Green** Bucket up and **Red** Counterweight down
ii. **"Ready Position"**, Catapult Cocked: **Red** Counterweight up and **Green** Bucket down
iii. **"Secure Ready Position"**: Hand Hold **Red** Counterweight up to 0^0 Full Stop Anchor at the top of the Catapult
iv. **"Arm Catapult"**, Load **Red** Projectile into Catapult Bucket
v. **"All Clear Down Range"** (call before Launching)
vi. **"Launch Catapult"**, Release the Hand Hold grip on the Catapult Arm Launching the Catapult
vii. **"Safe Position",** After Launching Catapult, **Green** Bucket up and **Red** Counterweight down
viii. **"Caution Down Range"** (notify Catapult Launch Crew to remain in Safe Position)
ix. **"Retrieve Projectiles Down Range"** (collect all **Red** Projectiles Down Range for reuse
x. Repeat item commands above as needed for practice

i. How to Sight in your Target and Aim you Catapult with more accuracy and a better chance of hitting Hopper with a projectile to <u>scare him off of your ant hill!</u>

i. Push down on the empty Bucket of your Catapult so it is horizontal.
ii. Look down the Catapult Arm towards the Target of Hopper between the two sides of your Catapult, and align your target of Hopper between the two sides of the Catapult straight down the Catapult Arm. This will have your Left to Right Alignment done.
iii. Next, try different angles by setting your Stop Peg at different Trajectory settings. First start at 0^0 Degrees, 30^0 Degrees, 45^0 Degrees, and finally 60^0 Degrees.
iv. If you are not reaching the target with any of these settings notify your Table team volunteer and you may need to move closer to the target of Hopper!



<u>VIEW NOT LIKE THIS</u> **<u>VIEW LIKE THIS</u>**

<u>DIAGRAM of Catapult for Sighting In the Target of Hopper for Alignment Positions</u>

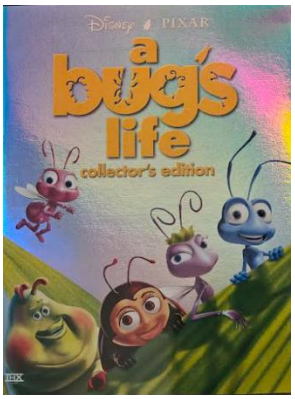
j. Please ask your Team table volunteer if you have any questions concerning this exercise. After you have tested your catapult with all the other table teams and you are comfortable with your accuracy hitting a target with a projectile using the range and elevation settings you have chosen, notify your Team table volunteer your team is ready for scoring target competition.

k. Your team will have three try's to catapult a projectile across the room at a hanging sheet with the Target of Hopper. Your best score will be to catapult your projectile and hit the Target of Hopper on the sheet. Your next best score will be the closest projectile to the Target to hit the sheet. Your least good score will be the furthest projectile hitting the sheet. Your Team table volunteer will help with your Team scoring records. Please wait for your Table team volunteer to complete the scoring before you begin another catapult launch at the Target of Hopper.

l.

4. **Intermission, Reading by Tim Protiva** to students (15 minutes) between Exercise # 1 and # 2.

5. **Exercise # 2, Trebuchet Catapult Accuracy:** To test different trebuchet settings for range and elevation, compete between team tables for the most accurate catapult operation.
   a. Time: 60 minutes activity (hands-on)
   b. Career: Mechanical Engineering & Physics
   c. Grade: 3 to 6 grades (8 to 11 years old)
   d. Topic: Forces, Motion, Energy, Simple Machines



6. **Trebuchet Catapult** (read before beginning the exercise):
   Today we will be learning how to adjust the settings for range and elevation on a miniature trebuchet catapult for best team accuracy. We are still following Disney Pixar Movie "A Bug's Life" After you experiment with the trebuchet catapult range and elevation settings launching projectiles at the Target of Hopper, you will notice the trebuchet catapult provides more range and elevation than the standard catapult. This was developed over the years of using the standard catapult and the Trebuchet discovery of improvements over the original catapult gave it improved range. You will have three try's at scoring points on a target. The team with the highest score will be the winner of Exercise # 2, and the most successful ant colony at protecting their food supply for the coming winter from the grasshoppers.

7. Trebuchet Catapult preparation:
    a. Have your Team table volunteer change out the Standard Catapult cup from Ex # 1 and exchange it with the Trebuchet Catapult cup for Ex # 2.

    b. Note the different wooden peg settings for range and elevation for the object you are given. Learn how each setting will change how high the object goes and how far the object goes.

c. Practice catapulting the object several times at a target so you can predict hitting the target with the object with the settings you have chosen.

d. After you have tested your catapult and are comfortable with your accuracy hitting a target with an object using the range and elevation settings you have chosen, notify your Team table volunteer your team is ready for scoring target competition.

e. Your team will have three try's to catapult a projectile across the room at a hanging sheet with the Target of Hopper. Your best score will be to catapult your projectile and hit the Target of Hopper on the sheet. Your next best score will be the closest projectile to hit the sheet. Your least good score will be the furthest projectile from the Target hitting the sheet. Your Team table volunteer will help with your Team scoring records. Please wait for your Table team volunteer to complete the scoring before you begin another catapult launch at the Target of Hopper.

f. Your Team table volunteer will send your Team table scores to the lead volunteer for evaluating the Team with the best scores combining Exercise # 1 and Exercise # 2.

g. Awards will be provided to all participants at this event!

h. **This will conclude the Exercise # 1 and # 2** for Thursday, July 3rd at the CCPL Strongsville Branch Summer Fun for Everyone!

8. Our first U.S. President, General George Washington, promoted Military Engineering that applied the accurate projectile and trajectory equations to cannon fire during the American Revolutionary War of 1776 and with our victory over a British king the U.S. became an independent nation with a democratic republic. So, when you are in school the first activity you do in the morning is to make your "Pledge of Allegiance" to the U.S. Flag by saying, " "I pledge allegiance to the Flag of the United States of America, and **to the Republic** for which it stands, one nation under God, indivisible, with liberty and justice for all." We have celebrated our democratic republic of government each day for the last 237 years from 1788 to 2025.

9. **Have a very Happy Fourth of July Celebration and enjoy a safe and fun Summer of 2025!**