Effervescent Launchers

Pre lesson setup and notes

The effervescent launcher lesson is best conducted outside with a minimal amount of wind. If there is a high, sustained wind speed or the ambient temperature is too cold, the lesson may be conducted inside. If conducted inside, the launchers will need about 25 feet of space for the flight path and must be conducted on a tiled (non-carpeted) floor surface. Also at the 60º angle the lid may hit low ceilings when launched.

The Alka Seltzer tablets need to be broken in half for use. The best method to achieve a clean break is to gently score the tablet with the plastic knife on the halfway line, then use your hands to break the tablet in half. This can be done before the lesson begins to facilitate a lack of wait time during the lesson while the tablets are broken. Small individual plastic bags are provided to place broken tablets into before the lesson for distribution to each group.

SCP Notes

- The Alka-Seltzer tablets are included, but they have not been broken up. It’s probably a good idea to do these the night before (or even before each class period if you have the time) and place them in the baggies.
- For the demonstration, just use a 10 cc syringe.
- The markers (poker chips) are only in five different colors. Just spread out the groups with the same color.
- Paper towels, waste containers, etc. are not in the kit.
- Make enough copies of the worksheet for your classes.
- Rather than water bottles, there are cups for storing the water. You can also take a gallon jug if you need a way to bring water outside.
- Consider dry ice instead of alka-seltzer.

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
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Effervescent Launcher

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8th grade

Goal: To explain the concepts of angle of trajectory vs. distance and the horizontal/vertical components of projectile motion. To apply basic graphing and data interpretation skills to the physics of projectile motion. Secondly to understand the type of gas produced during the chemical reaction and a basic understanding of pressure. These objectives will be accomplished through the use of an 'effervescent launcher' that is fueled by Alka-Seltzer and water to produce $CO_{2(g)}$.

Lesson Outline

I. Introduction

Discuss the general concepts behind projectile motion: angle vs. distance and horizontal/vertical components of force.

II. Setup and Demonstration

Explain the reaction and type of gas produced along with a brief discussion of gas pressure. Demonstrate how the launcher should be setup and used to determine the angle for maximum distance.

III. Identifying the Best Angle for Maximum Distance of the Projectile

Students will use the 'effervescent launcher' to conduct a series of trials to determine the angle that yields maximum distance.

IV. Discussion of Student's Results

Students will plot their data on a graph and then be asked to interpret this information. Briefly discuss some problems encountered during testing that may have lead to the incorrect angle being identified.

Materials (for 32 students in 8 groups of 4 students)

- 8 Effervescent launchers
- 8 6oz bottles for clean room temperature water
- 8 #1 bags
  - 1 10cc syringe
  - 1 film canister
  - 6 disc markers (single color per bag)
- 8 small bags with 8 ½ size tablets of Alka-seltzer
- 2 10 meter flexible measuring tapes
- 2 rinse pans (filled half full with water)
- 2 waste containers
- 1 #2 bag
  - 1 20cc syringe
  - 1 film canister
  - 1 small bag with 1 ¼ size Alka-seltzer tablet
- 32 Student Handouts
- 32 Student Observation/Graph sheets
- 32 Safety goggles
- 1 Paper towel roll
- 1 trash bag
- 1 bag with 2 extra film canisters and extra disc markers
- 1 box with extra Alka-seltzer tablets
- 1 plastic knife

Pre-lesson Setup

Split the students into eight groups (each group should have 4 students) for the hands-on-activity, later in the lesson.

The VSVS volunteers can accomplish the following items, while one volunteer gives the introduction portion of the lesson.

a. Identify the best location to conduct the testing. Outside or a large tiled cafeteria floor works best. The launchers will need approximately 25 feet of flight path. Begin to setup the launchers and all needed material at this location. Fill the two rinse pans half full of water and set them behind the launchers with the two waste containers. Reserve one launcher and clean water bottle near the volunteer instructor for use in demonstration of the procedure.

b. Make sure that all needed effervescent launchers are assembled and set to 60º. The top hole is 60º, next down the upright is 45º, 30º, and last 20º.

I. Introduction

This lesson is designed to help the students gain an understanding of projectile motion and the concept that the angle of trajectory can vary the distance traveled by the projectile.

Projectile motion is defined as the curved path an object follows when propelled by an external force. Examples of projectile motion include throwing a football, hitting a golf ball with a golf club, or launching a model rocket. The object is initially propelled forward by a force with a certain angle between the path of the object and the ground. This angle is called the launch angle. Together, the launch angle and launch force define the trajectory that an object will follow. The object then travels upward in a downward-shaped arc until it reaches a high point. After the maximum height, the object continues to travel downward in a downward-shaped arc until it reaches the ground.

This path (downward-shaped arc) is composed of two independent components. One portion of the curved path is the horizontal component or the part that is parallel to the ground. The force that causes the horizontal component leads to the distance that the object will travel and is only affected by drag (air resistance). The other portion of the curved path is the vertical component or the part that is perpendicular to the ground. Gravity affects the vertically component by causing the object to decelerate on its upward path until it reaches maximum height. After this point is reached, gravity causes the object to accelerate downwards until it hits the ground. Both the horizontal and vertical components of force act to form the curved trajectory of the object.

II. Setup and Demonstration

Explain to the students that Alka-seltzer and water will be used as the fuel to launch the rocket. When mixed with water, the $NaHCO_3$ in the Alka-seltzer tablet will produce CO_2 gas. The gas provides the launch force. This production of gas causes a change in pressure inside the film canister. As the pressure inside the canister increases, a point is reached where the gas pressure inside the canister is sufficiently greater than the outside atmospheric pressure to shoot the rocket (canister lid) off of the launch vehicle (film canister tube).

Effervescent Launcher Demo

Materials

1 #2 bag
- 1 20cc syringe
- 1 film canister
- 1 small bag with 1 ¼ size Alka-seltzer tablet

1 6oz bottle of water (use one from the student's group)

1 effervescent launcher (use one from the student's group)

Do not do this demo directly underneath a fluorescent light. There is a good chance that the lids will hit the ceiling.

Tell the students that you will now demonstrate this reaction that produces CO_2 gas. Show the students the bag with the ¼ size Alka-seltzer tablet. Note that this tablet is only ¼ size while the students will use ½ size tablets. Tell the students that the difference will be in the amount of time taken to launch the rocket. The ½ size will work faster and allow the students to spend less time on each trial. Place the film canister on a level surface (desk) well in front of the first row of students. Empty the Alka-seltzer bag into the film canister. Measure 10mL into a syringe. Warn the students that the launch makes a very loud popping noise. Add the water and quickly place the lid on the canister. Step back away from the canister and wait (may take up to two minutes). Have a paper towel ready to wipe up the water because the force of the launch will tip the canister over.

The point of this demo is to show how to use the film canister rocket. Next display the launcher; show the students how to vary the angle by removing the bolt and adjusting both uprights; explain that the fours holes represent angles of 60º, 45º, 30º, and 20º; and insert the film canister into the pocket and tell the students that the procedure to load the launcher is exactly the same a used in the demo. The thumb screw on the launcher does not need to be tightly against the film canister. The thumb screw should only be **loosely** tightened against the canister to hold it in place.

III. Identifying the Best Angle for Maximum Distance of the Projectile

Materials

- 8 Effervescent launchers
- 8 6oz bottles for clean room temperature water
- 8 #1 bags
  - 1 10cc syringe
  - 1 film canister
- 8 small bags with 8 ½ size tablets of Alka-seltzer
- 2 10 meter flexible measuring tapes
- 2 rinse pans (filled half full with water)
- 2 waste containers
- 32 Student Handouts
- 32 Student Observation/Graph sheets
- 32 Safety goggles
- 1 Paper towel roll

Keep the groups in their seats until you have explained all of the produce and instructions.

Pass out the Student Handouts, Student Observation/Graph sheets, and make sure that all students know that they will need to have a pencil with them to record their results.

Tell the students that now they will identify the best angle of launch to achieve the farthest distance from the launch point using angles of 60º, 45º, and 30º.

Ask the students to listen to the following instructions and tell them that a volunteer will be available to help each group through the testing procedure.

Tell each group that the separate trials will be conducted one at a time. No student should be in front of the launch or enter the 'flying zone' to mark the landing location of their rocket until all the groups have conducted the first test. The lids all have a different number so the students can find their group's lid. One student from each group may then walk in front of the launcher to mark the landing spot and retrieve the lid. Then, together, the groups repeat the procedure for the second trial. Measurements can be made in-between different angles while a member of the group changes the launch angle of the launcher. Only two measuring tapes are included in the kit. The students do not need to roll up the measuring tape after each measurement, but can walk both ends of the tape to the next group for their use.

The procedure: (Students need to wear goggles during testing, but may remove them with permission of the instructor during the measuring parts of the test)

- Set the launcher to the correct angle (60º first).
- Place the canister with the lid removed in the pocket. Do not tighten the thumb screw. It should only loosely hold the canister in place.
- Set the launcher firmly on the ground in the correct direction.
- Put a ½ piece of Alka-Seltzer tablet into the canister.
- Measure 10mL into the syringe from the clean water bottle.
- Only two group members should now be near the launcher. The rest should be behind the launcher.
- Together, one member should add the water to the canister while the other member quickly places the lid tightly on the canister.
- Both should then move behind the launcher. One member will hold the launcher at the base from behind to prevent recoil or tipping of the launcher.
- After all launchers have fired, one group member should place a marker at the landing spot and retrieve the lid. Another group member should take the canister and pour the liquid into the waste container. Then the canister should be rinsed in the rinse pan and **completely dried**. Replace the canister into the launcher. The lids do not need to be rinsed between trials.
- Repeat the procedure, but all group members should perform a different task.
- After the second trial, two group members can measure and record on the data sheet both distances, while the remaining members change the launch angle and rinse the canister.
- Conduct two trials for each angle and record all the distances.
- Take an average of the two trial distances as the distance for that angle.

Tell each student to use the group's average distance values to graph their data. They may need some help accomplishing this task. The average distance is on the y-axis and the angle is on the x-axis. After plotting the data, ask the students to draw a curve through their data points. This curve will look like a hill with a gently slope on both sides. Pages 8 and 9, respectively, provide example curves for tests conducted indoors or with no wind and tests conducted outside with a crosswind. (If done outside, the curve may be a straight line with a negative slope.)

If a group's launcher does not fire, make sure that they are tightly placing the lid on the canister. If this still fails, there are extra film canisters and lids in the kit. Use one of the extras to replace the group's defective canister. The seals on the lid can become damaged during testing and will no longer function correctly. There are a few packets of extra Alka-seltzer tablets in a box. If needed, use the plastic knife to score the tablet then break in half.

IV. Discussion of Student's Results

Ask each group what launch angle provided the maximum distance and how far the rocket flew on average from that launch angle?

Discuss any variations between the groups' results.

Angle:
Most groups should have found that 45º provided the best angle to achieve the farthest distance. An angle of 30º will produce a very close second maximum distance. This is the reason for multiple trials, however due to variations in the lid and seal, 30º may still produce the best angle. If conducted outside, the wind may also allow for the best angle to be 30º due to the increase drag on the lid at higher launch angles. An angle of 60º would indicate that part of the procedure was not conducted correctly.

Distance:
Ask the students if they can come up with any reasons why the distance varied between trials?

Accept any reasonable answer. Some variables include:

- Inability to measure exactly the same amount of water for each trial. A solution would be a more accurate measuring device.
- Slight differences in the amount of Alka-seltzer in each tablet. This variable was beyond their control since the tablets were provided in a pre-broken state. A solution would be to weigh each tablet to get the same weight in each trial.
- Variations and slight imperfections in the seal on the lid of the canister. This is beyond control with no easy solution.
- Over-tightening the thumb screw would deform the canister and affect the seal.

If a suggestion is made about the time between adding the water and placing the lid on the canister, tell the students that this will be discussed latter in the lesson.

Summary Questions (these may be difficult for the students to answer)

Did the amount of time between adding the water and placing the rocket lid on the canister affect how far the rocket traveled?

Their initial thought will probable be that the time elapsed did make a difference. However, as long as the lid is put on the canister in a reasonable amount of time (≤ 7 seconds), this makes no difference. The amount of water and Alka-seltzer *used is sufficient to launch the rocket two times. These amounts have been chosen to produce faster results that allow for the students to achieve all two trials in the time allotted. The reality is that the rocket lid is only capable of maintaining a set pressure difference before popping off of the canister tube.*

Why did 45º produce the maximum distance?

> *An angle of 45º leads to neither a maximum vertical or horizontal component, but reaches a compromise between the two components to achieve the maximum distance. Only a set amount of force is available to launch the rocket. This force must be split in the best possible way between achieving distance through the horizontal component and allowing the rocket enough 'hang time' (vertical component) to use all the available force behind the horizontal component before hitting the ground.*

Based upon the graph and data, ask the students to predict the distance that the rocket will travel if launched from an angle of 20º.

> *Their predictions should be shorter than the distance for the 30º angle, unless the wind is a factor when done outside.*

Optional Activities (if time permits)

Allow the students to test their prediction about how far the rocket will travel with a launch angle of 20º. The setup for the launcher is the same except that it needs to be reset to an angle of 20º. **STUDENTS MUST WEAR GOGGLES IF THIS ACTIVITY IS CONDUCTED.** Adding 10mL of water to the canister at this angle will be difficult. Students will need to add the Alka-seltzer tablet and then tilt the entire launcher upwards so that the film canister is in a more vertical position. Add the water and then very quickly place the lid tightly on the canister and return the entire launcher to the firing position flat on the floor. Tell the students to add the new data to their graph and compare their prediction to the experimental results.

Clean up instructions

Empty the waste container, clean water bottles, and rinse water down the sink. Replace all the lids. Place used syringes and film canisters with lids into the provided wet bag. Ask students to break the launchers down by removing the nut/bolt assemble and replacing it back into only one of the launcher legs. The launchers can then be flattened for transport. Return the kit and all the materials to the VSVS lab (SC 5416).

Reference: Carlson, Kenneth. *The Effervescent Launcher*. Science Kit & Boreal Laboratories.

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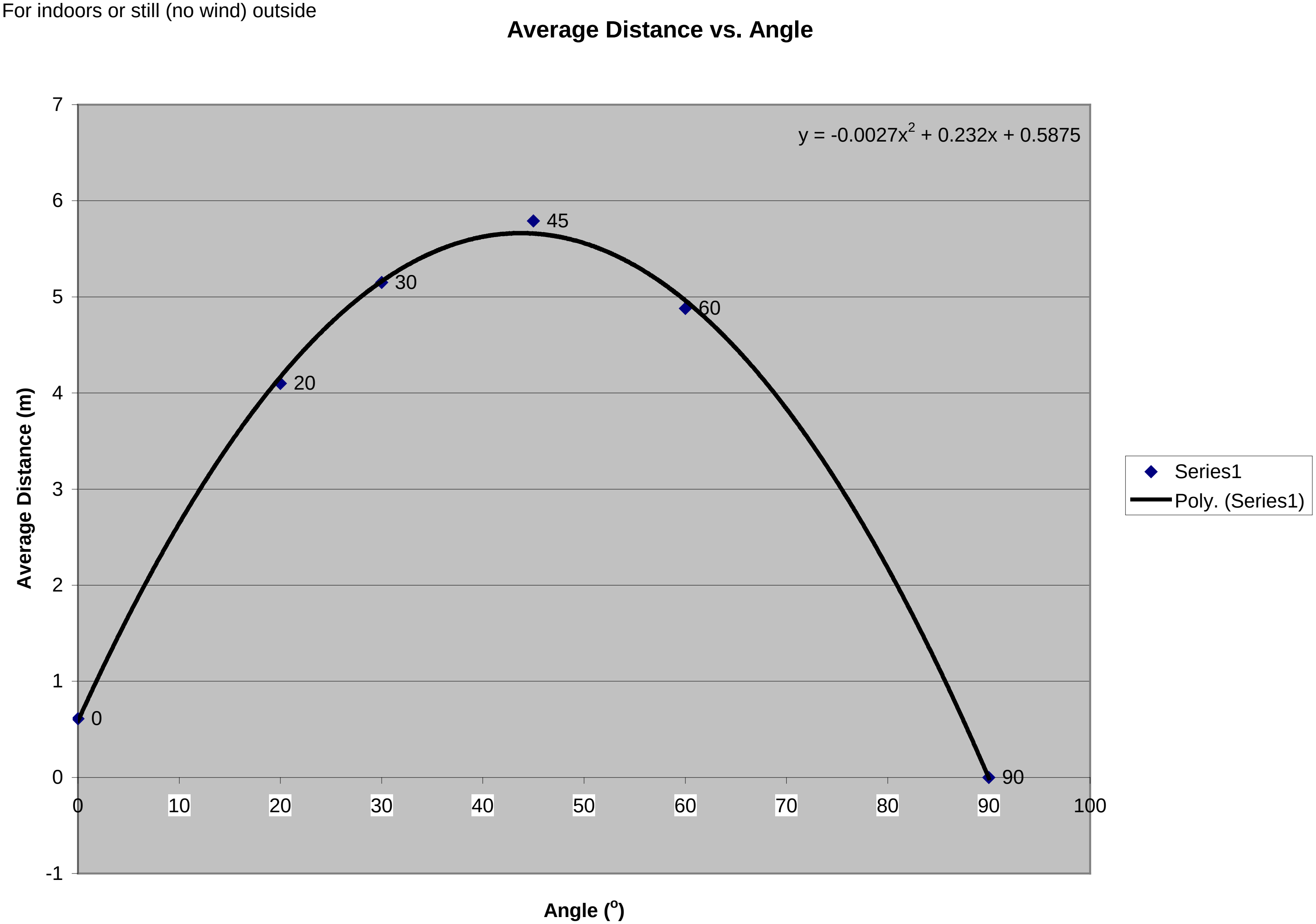
For indoors or still (no wind) outside



For outside with a crosswind

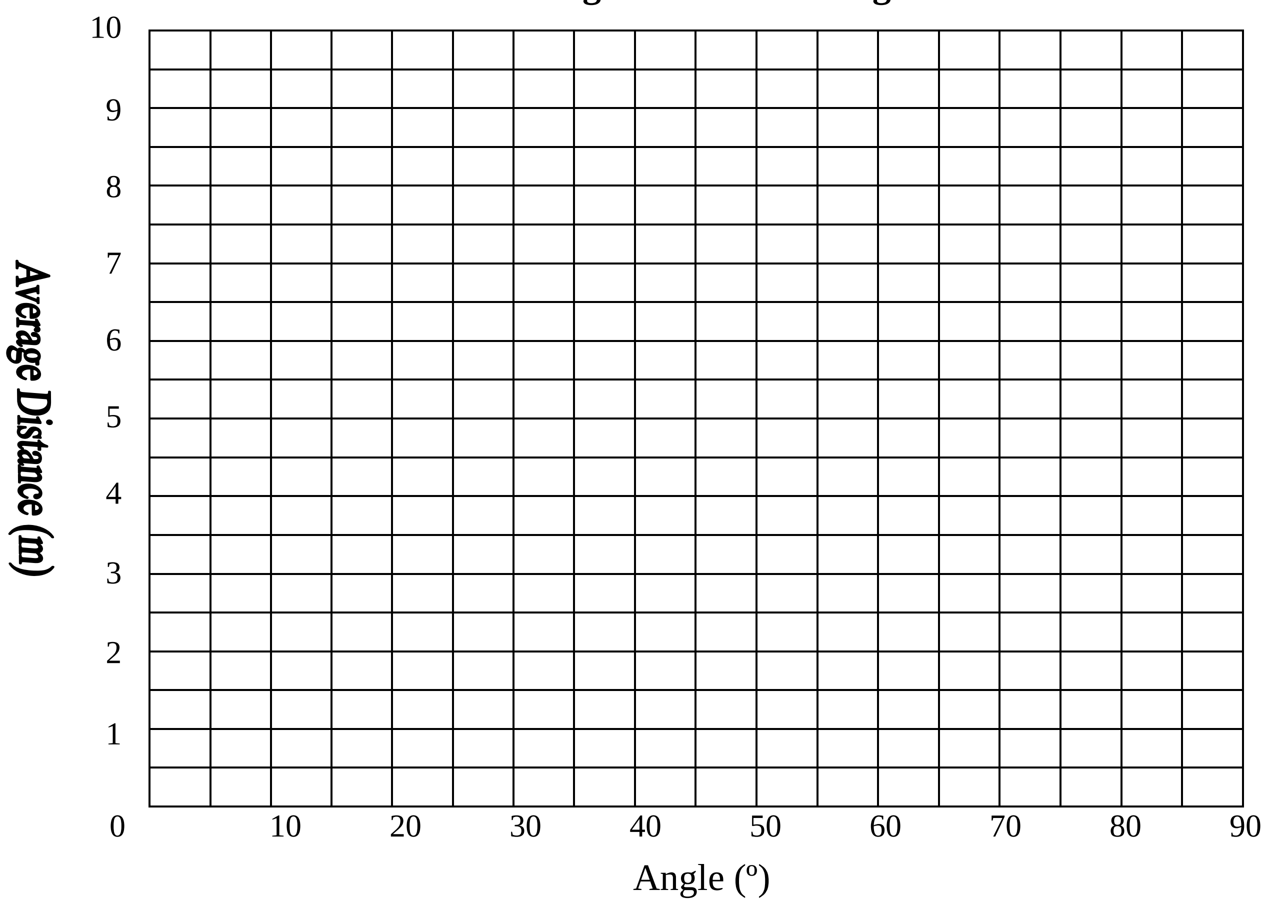
Student Observation/Graph Sheet

Angle (º)	Water (mL)	Alka-seltzer tablet size	Trial 1 Distance (m)	Trial 2 Distance (m)	Average Distance (m)
60	10	½			
45	10	½			
30	10	½			
Only use the 20º angle if time permits and instructed to do so by the lesson leader.					
Predicted distance of rocket travel at a launch angle of 20º _____________					
20	10	½			

What angle provided the maximum distance? _________________

Graph the data recorded above using the average value for the distance (y-axis) versus the angle (x-axis).

Average Distance vs. Angle



Student Handout

The procedure for conducting the trials using the effervescent launcher is listed below. Trial angles should be 60º, 45º, and 30º. A trial with an angle of 20º will only be conducted if time permits and with permission of the instructor.

The top hole on the launcher upright corresponds to an angle of 60º.
The 2nd hole from the top is 45º.
The 3rd hole from the top is 30º.
The bottom hole is 20º.

The procedure: (Students need to wear goggles during testing, but may remove them with permission of the instructor during the measuring parts of the test)

- Set the launcher to the correct angle (60º first).
- Place the canister with the lid removed in the pocket. Do not tighten the thumb screw.
- Set the launcher firmly on the ground in the correct direction.
- Put a ½ piece of Alka-Seltzer tablet into the canister.
- Measure 10mL into the syringe from the clean water bottle.
- Only two group members should now be near the launcher. The rest should be behind the launcher.
- Together, one member should add the water to the canister while the other member quickly places the lid tightly on the canister.
- Both should then move behind the launcher. One member will hold the launcher at the base from behind to prevent recoil or tipping of the launcher.
- After all launchers have fired, one group member should place a marker at the landing spot and retrieve the lid. Another group member should take the canister and pour the liquid into the waste container. Then the canister should be rinsed in the rinse pan and completely dried. Replace the canister into the launcher. The lids do not need to be rinsed between trials.
- Repeat the procedure, but all group members should perform a different task.
- After the second trial, two group members can measure and record on the data sheet both distances, while the remaining members change the launch angle and rinse the canister.
- Conduct two trials for each angle and record all the distances.
- Take an average of the two trial distances as the distance for that angle.