ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL ONE

INSTRUCTIONAL GUIDE

SECTION 2

EO C140.01 – LAUNCH A FOAM ROCKET

Total Time: 60 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-801/PG-001, *Proficiency Level One Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Make photocopies of the handouts located at Attachments A and B for each group of four cadets.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

A practical activity was chosen for TPs 1 and 2 as it is an interactive way to demonstrate rocket propulsion to cadets. This activity contributes to the understanding of rocketry in a fun and challenging setting.

A group discussion was chosen for TP 3 as it allows the cadets to interact with their peers and share their knowledge, opinions, and feelings about their experiences launching foam rockets.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall have constructed and launched a foam rocket.

IMPORTANCE

It is important for cadets to build and launch foam rockets to understand rocket propulsion, and learn rocket construction techniques in a group setting.

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Teaching point 1 **Have the cadets, in groups of four, construct a foam rocket.**

Time: 25 min Method: In-Class Activity

Ballistics is the study of the flight of projectiles after the power phase has terminated, moving under their own momentum and the external forces of gravity and air resistance. The effects of gravity and air resistance cause the projectile to move in an arc, as gravity pulls it towards the centre of the Earth and air resistance slows the projectiles velocity. To obtain orbit, the projectile must balance its speed to counteract the effects of gravity.

The foam rocket flies ballistically and receives its entire thrust from the force produced by the elastic rubber band. When the rubber band is stretched and released, the rubber band quickly returns to its original length, launching the foam rocket in the process.

Once in flight, the foam rocket coasts. The mass of the foam rocket does not change in flight. Rockets used in space exploration consume propellants and their total mass diminishes.

Gravity and drag or friction, affect the projectiles' motion and course within the atmosphere.

The launch of a foam rocket is a good demonstration of Newton's Third Law of motion.

The contraction of the rubber band produces an action force that propels the rocket forward while exerting an opposite and equal force on the launcher.

For this activity, the launcher is a meter stick.



Be sure the range-measuring cadet measures where the rocket touches down and not where the rocket ends up after sliding or bouncing along the floor / ground.

During flight, the fins stabilize the foam rocket. The fins, like feathers on an arrow, keep the rocket pointed in the desired direction.

If launched straight up, the foam rocket points upward until it reaches the top of its flight. Both gravity and air drag act as brakes. At the very top of the flight, the rocket momentarily becomes unstable. The momentum slows and gravity overcomes the velocity of the rocket. At apogee, the rocket begins its downward phase returning to Earth, and stabilizes as its velocity increases and air flows over the fins.

When launched at an angle of less than 90 degrees, the foam rocket is remains stable through the entire flight. Its path is an arc whose shape is determined by the launch angle. For high launch angles, the arc is steep, and for low angles, it is broad.

A launch angle of less than 90 degrees will cause the rocket to land a distance from the launch site. Gravity, launch angle, initial velocity, and atmospheric drag affect how far the rocket will land from the launch site.

Gravity causes the foam rocket to decelerate as it climbs upward and then causes it to accelerate as it falls back to the ground. The launch angle works with gravity to shape the flight path. Initial velocity and drag affects the flight time.



After launching, cadets are to compare the launch angle to the range or distance the foam rocket lands from the launch site. Launch angle is the independent variable. Gravity can be ignored because the acceleration of gravity remains the same for all flight tests.

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ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets construct a foam rocket.

RESOURCES

Each team will construct one foam rocket and one launcher

- 30-cm long piece of polyethylene foam pipe insulation (for ½ inch pipe),
- Rubber band size 64,
- Bristol board,
- 3-7 to 8 inch cable ties,
- 75-cm string,
- 25-cm string,
- Scissors,
- Meter stick,
- Metal washer, nut or other small weight that can be attached to a string,
- Quadrant plan,
- Masking tape,
- Rocket construction instructions located at Attachment A,
- Launcher Quadrant Pattern located at Attachment B, and
- Launch record sheet located at Attachment C.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

Construct the Rocket

1. Using scissors cut one 30-cm piece of foam tubing for each team.

2. Have the cadets cut four equally spaced slits at on end of the foam tubing. Ensure the slits are perpendicular to the centre of the foam tube and longitudinally straight along the foam tube. The slits should be 8 to 10-cm long. The fins will be mounted through these slits.

3. Have the cadets tie the 75-cm string into a 30-cm long loop.

4. Have the cadets using the cable tie, attach the rubber band to the string by passing it through the centre of the rubber band and string. Pull the cable tie until the loop holding the string and rubber band is approximately one to two-cm.

5. Have the cadets pass the rubber band, cable tie and string assembly through the foam tube so the string is at the end with the slits (tail of the rocket) and the rubber band is at the other end (the nose of the rocket).

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The cable tie that attaches the rubber band to the string should be approximately 3-cm from the end of the foam tube.



Note. From Foam Rockets Educator Guide, by NASA, 2008. Retrieved December 7, 2011, from http://www.nasa.gov/pdf/280754main_Rockets.Guide.pdf

Figure 1 Exploded View of the Foam Rocket

6. Have the cadets place a cable tie around the nose of the rocket and cinch it tight. It should be over the cable tie that attaches the string to the rubber band. This cable tie should prevent the string rubber band and cable tie that is in the rocket from being pulled out. Trim the outer cable tie excess.



Remind the cadets to NOT pull on the string or the rubber band unless the rocket is on the launch system. If the string or rubber band is pulled out of the foam rocket, remove the cable ties at the nose and tail of the rocket, reinsert the string, cable tie and rubber band, and place new cable ties at the nose and tail of the rocket.

7. Cut out fins from a sheet of Bristol board according to the pattern located at Attachment A. Allow some leeway in design but constrain the fins to 10-cm long and 12-cm wide total. Notch both fins as indicated on the Foam Rocket Instruction Sheet, so one fin can slide over the other fin. Slide the assembled fins into the slits cut into the tail of the foam rocket. Make sure the string hangs out the end of the rocket after the fins are in place.

8. Place a cable tie around the foam tube after the fins and cinch it tight, holding the fins in place. Trim the cable tie flush.

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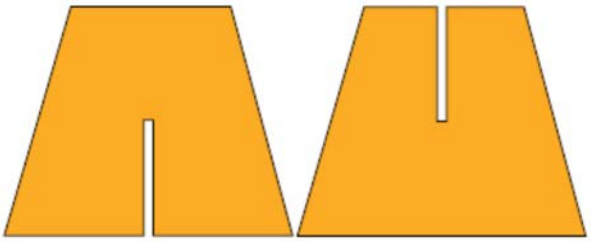
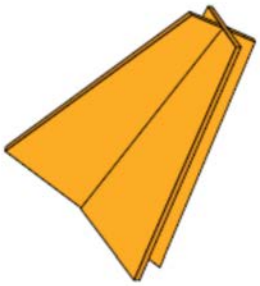
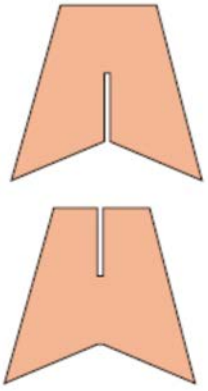


CUT SLOTS THE SAME WIDTH AS THE THICKNESS OF THE FIN STOCK.



NESTS FINS TOGETHER.



DIFFERENT FIN SHAPES CAN BE USED.

Note. From Foam Rockets Educator Guide, by NASA, 2008. Retrieved December 7, 2011, from http://www.nasa.gov/pdf/280754main_Rockets.Guide.pdf

Figure 2 Fin Construction Details

Construct the Launcher

1. Have the cadets cut out the quadrant pattern and fold along the dashed line.

2. Have the cadets tape the quadrant pattern to the metre stick so the black dot is 60-cm from the end of the stick. Have the cadets tape the 25cm string to the quadrant pattern so the string hangs freely from the black dot. Have the cadets attach a small weight (wash, nut or other small weight) to the free end of the 25-cm string.

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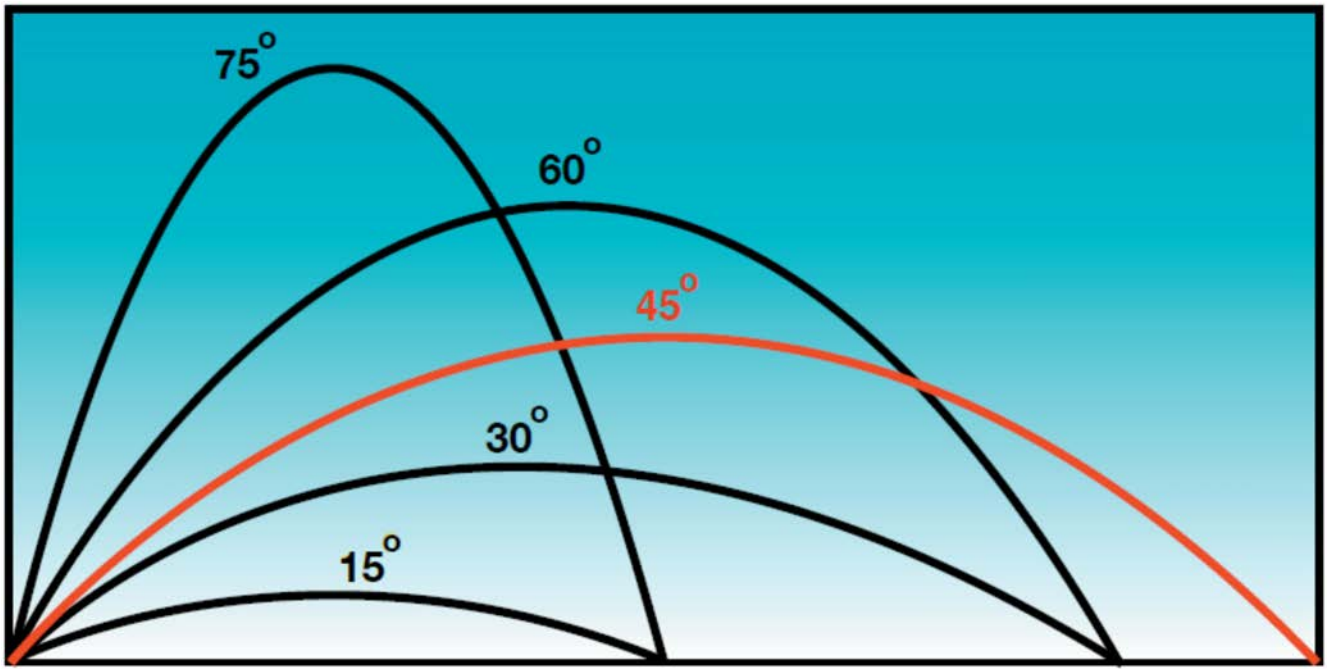

Note. From Foam Rockets Educator Guide, by NASA, 2008. Retrieved December 7, 2011, from http://www.nasa.gov/pdf/280754main_Rockets.Guide.pdf

Figure 3 Rocket Trajectories

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. What is ballistics?

Q2. What stabilizes the foam rocket during flight?

Q3. What are the four forces that affect a foam rocket during flight?

ANTICIPATED ANSWERS:

A1. Ballistics is the study of the flight of projectiles after the power phase has terminated, moving under their own momentum and the external forces of gravity and air resistance.

A2. During flight, the fins stabilize the foam rocket. The fins, like feathers on an arrow, keep the rocket pointed in the desired direction.

A3. Gravity, launch angle, initial velocity, and atmospheric drag affect how far the rocket will land from the launch site.

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Teaching point 2 **Have the cadets, in groups of 4, launch the foam rockets and record the launch data.**

Time: 25 min Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets launch foam rockets and record the launch data.

RESOURCES

- Foam rocket launcher, one per group,
- Experiment data sheet located at Attachment B, one per group,
- Launch record sheet located at Attachment C, one per group, and
- Foam rocket. one per team,

ACTIVITY LAYOUT

Select a large room with a high ceiling for the launch range, such as a cafeteria or gymnasium or set up the activity out of doors.

Place masking tape markers on the floor / ground at 1 meter intervals starting at 5 meters and going to 20 meters.

If it is a calm day, the investigation can be conducted outside. Although the rockets can be launched outside on windy days, the wind becomes an uncontrollable variable that will invalidate the results.

ACTIVITY INSTRUCTIONS



In this activity, control will be how much the rubber band is stretched when launching the rockets. The rocket must be launched with exactly the same amount of force each launch in order to acquire accurate data.

The experimental variable will be the angle of launch. Cadets will compare the launch angle with the distance the rocket travels.

The cadets will each be given a title and responsibility for the experiment. The experiment will be conducted in four series of four launches.

1. Launch Officer – will attach the rocket to the launcher by placing the rubber band over the end of the launcher and pull the string back until the tail of the rocket reaches the 60-cm mark on the launcher. Tilt the launcher until it is pointing upwards at an angle of between 10 and 80 degrees. The launch officer will stand at the start mark and release the rocket when the launch command is given.

2. Launch Director – Record the angle on a copy of Attachment B. Give the launch command. Record the distance the rocket travels.

3. Range Officer – Measure the distance from the launcher to where the rocket hit the floor (not where it slid or bounced to). Report the distance to the launch director.

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4. Recovery Officer – Return the rocket to the launcher for the next launch.

5. Repeat the launch procedure three more times changing the angle for each launch and record the distance for each launch.

6. Conduct the activity three more times switching the team members' jobs for each launch.



Assuming cadet groups are careful in their control of launch angles and in the stretching of the launch band, they will observe that their farthest flights will come from launches with an angle of 45 degrees. They will also observe that launches of 30 degrees, for example, will produce the same range as launches of 60 degrees. Twenty degrees will produce the same result as 70 degrees, etc. (Note: Range distances will not be exact because of slight differences in launching even when teams are very careful to be consistent. However, repeated launches can be averaged so that the ranges more closely agree with the illustration.)



The countdown is a warning that a rocket is about to be launched. When counting down, do so in a loud voice so everyone can hear.

SAFETY



Each step during a pre-launch and launch sequence is important. Personnel at a launch must always be aware of what is happening.

Teaching point 3 **Conduct an activity debriefing.**

Time: 5 min Method: Group Discussion

BACKGROUND KNOWLEDGE



The point of the group discussion is to draw the following information from the group using the tips for answering / facilitating discussion and the suggested questions provided.

The foam rocket experiment has demonstrated the effects of gravity and air resistance on flight. The launch angle determines the distance the rocket will travel from the launch tower. With an increase in power, a rocket can be launched and accelerated with enough force to continuously fall toward Earth. This is a basic orbit. If the rocket is outside the atmosphere, air resistance is removed from the equation and gravity will continue to pull the rocket towards the Earth. Force must be applied periodically to ensure the speed is maintained allowing the rocket to remain in orbit.

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GROUP DISCUSSION



TIPS FOR ANSWERING / FACILITATING DISCUSSION:

- Establish ground rules for discussion, eg, everyone should listen respectfully; don't interrupt; only one person speaks at a time; no one's ideas should be made fun of; you can disagree with ideas but not with the person; try to understand others as much as you hope they understand you; etc.
- Sit the group in a circle, making sure all cadets can be seen by everyone else.
- Ask questions that will provoke thought; in other words avoid questions with yes or no answers.
- Manage time by ensuring the cadets stay on topic.
- Listen and respond in a way that indicates you have heard and understood the cadet. This can be done by paraphrasing their ideas.
- Give the cadets time to respond to your questions.
- Ensure every cadet has an opportunity to participate. One option is to go around the group and have each cadet answer the question with a short answer. Cadets must also have the option to pass if they wish.
- Additional questions should be prepared ahead of time.

SUGGESTED QUESTIONS:

Q1. What launch angle gave the longest distance?

Q2. Why is it important to use the same amount of force for each launch?

Q3. What would happen if the amount of launch force is increased?

Q4. How can ballistics be used to achieve orbit?



Other questions and answers will develop throughout the group discussion. The group discussion should not be limited to only those suggested.



Reinforce those answers given and comments made during the group discussion, ensuring the teaching point has been covered.

END OF LESSON CONFIRMATION

The cadets' launch of a foam rocket will serve as the confirmation of this lesson.

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CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

This is a dynamic way to demonstrate rocket propulsion and ballistics.

INSTRUCTOR NOTES / REMARKS

Nil.

REFERENCES

C3-349 *Rocket Activity, Foam Rocket*. Retrieved October 1, 2008, from http://www.nasa.gov/pdf/295787main_Rockets_Foam_Rocket.pdf

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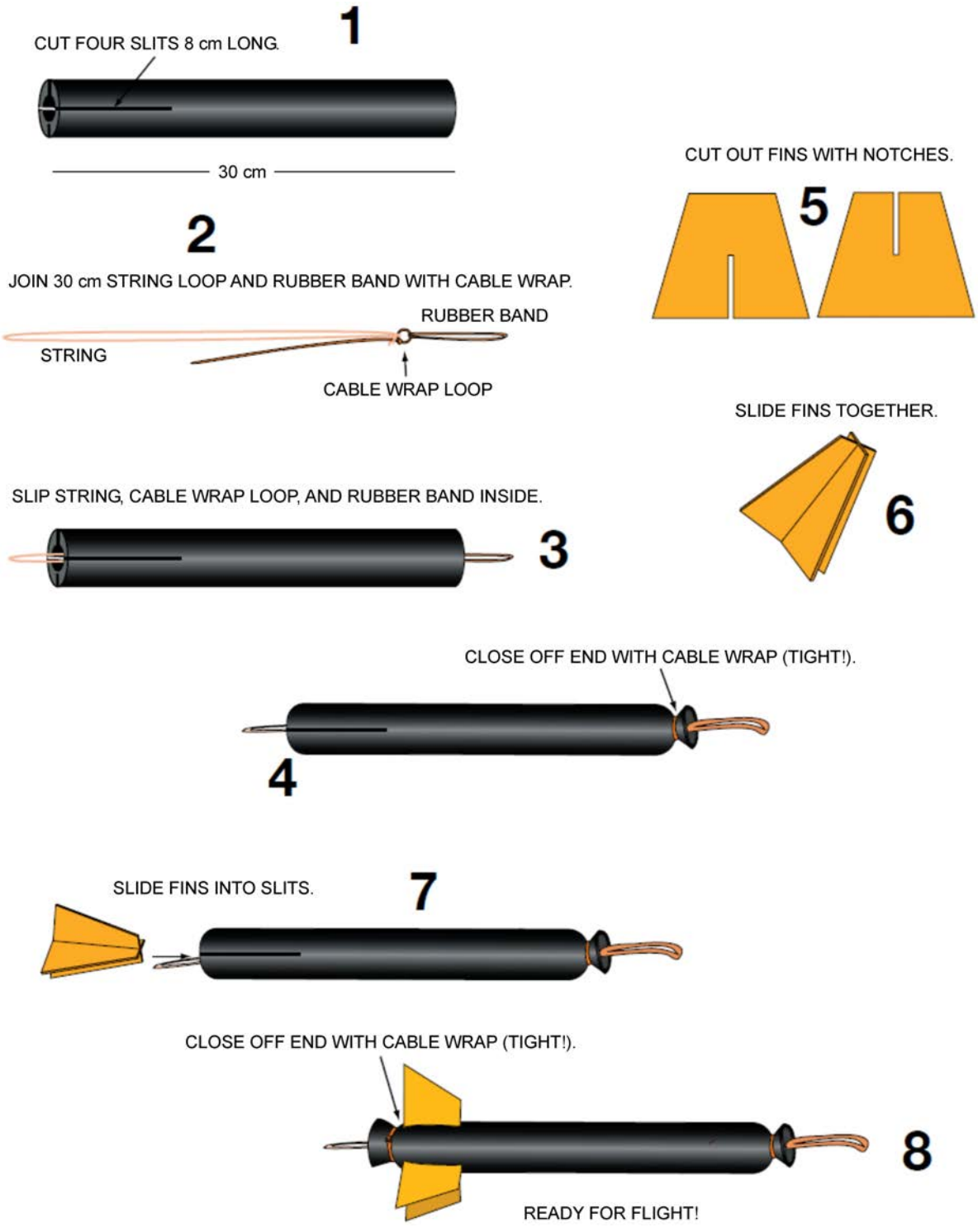

Note. Created by Director Cadets 3, 2011, Ottawa, ON: Department of National Defence.

Figure A-1 Foam Rocket Instruction Sheet

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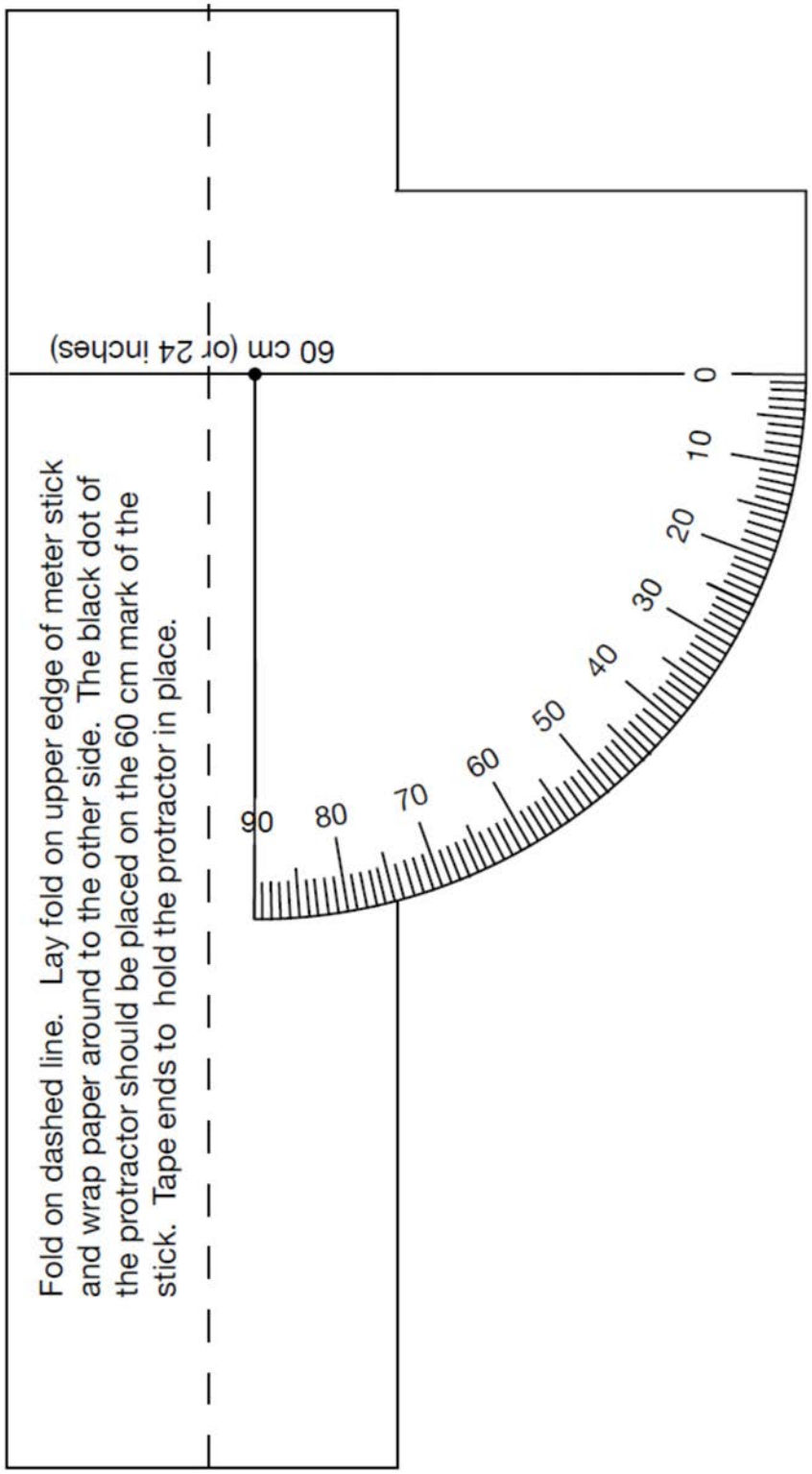
LAUNCHER QUADRANT PATTERN



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Rocket Range Experiment

Assign duties to team members. You will need the following positions (team members switch positions after each series of launches):

Launch Director

Launch Officer

Range Officer

Recovery Officer

First Launch:

Launch Officer – attach the rocket to the launcher by placing the rubber band over the end of the launcher and pull the string back until the tail of the rocket reaches the 60-cm mark on the launcher. Tilt the launcher until it is pointing upwards at an angle of between 10 and 80 degrees. Release the rocket when the launch command is given.

Launch Director – Record the angle on the data table. Give the launch command. Record the distance the rocket travels.

Range Officer – Measure the distance from the launcher to where the rocket hit the floor (not where it slid or bounced to). Report the distance to the launch director.

Recovery Officer – Return the rocket to the launcher for the next launch.

Repeat the launch procedure three more times changing the angle for each launch.

Conduct the activity three more times switching the team members' jobs for each launch.

Compare the data for the four experiments.

LAUNCH EXPERIMENT 1	
LAUNCH ANGLE	DISTANCE

LAUNCH EXPERIMENT 2	
LAUNCH ANGLE	DISTANCE

LAUNCH EXPERIMENT 3	
LAUNCH ANGLE	DISTANCE

LAUNCH EXPERIMENT 4	
LAUNCH ANGLE	DISTANCE

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