CHAPTER 14

PO 140 – PARTICIPATE IN AEROSPACE ACTIVITIES

ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL ONE

INSTRUCTIONAL GUIDE

SECTION 1

EO M140.01 – LAUNCH A WATER ROCKET

Total Time:	90 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.

Photocopy and prepare Water Rocket Launch System; see instructions located at Attachment A, if required.

Prepare a Water Rocket launch site; see instructions located at Attachment B.

Practice assembling the Water Rocket launch System and launching water rockets before this lesson.

Water Rocket Safety Orders are located at Attachment C.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for TP 1 to orient the cadets to Newton's Laws of Motion.

An in-class activity was chosen for TP 2 as a fun way to have the cadets launch a water rocket in a safe and controlled environment.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet will have launched a water rocket.

IMPORTANCE

This lesson will demonstrate for the cadets Newton's Laws of Motion and they will this in action when they launch a water rocket.

Teaching Point 1	**Explain and Discuss Newton's Three Laws of Motion.**
Time: 15 min	Method: Interactive Lecture

Newton's Laws of Motion

The three laws of motion were first compiled by Sir Isaac Newton in his work *Philosophiæ Naturalis Principia Mathematica*, first published on July 5, 1687. Newton used them to explain and investigate the motion of many physical objects and systems.

Newton's laws of motion are three physical laws that form the basis for classical mechanics. They describe the relationship between the forces acting on a body and its motion due to those forces. A force can be defined as a push or a pull on an object.

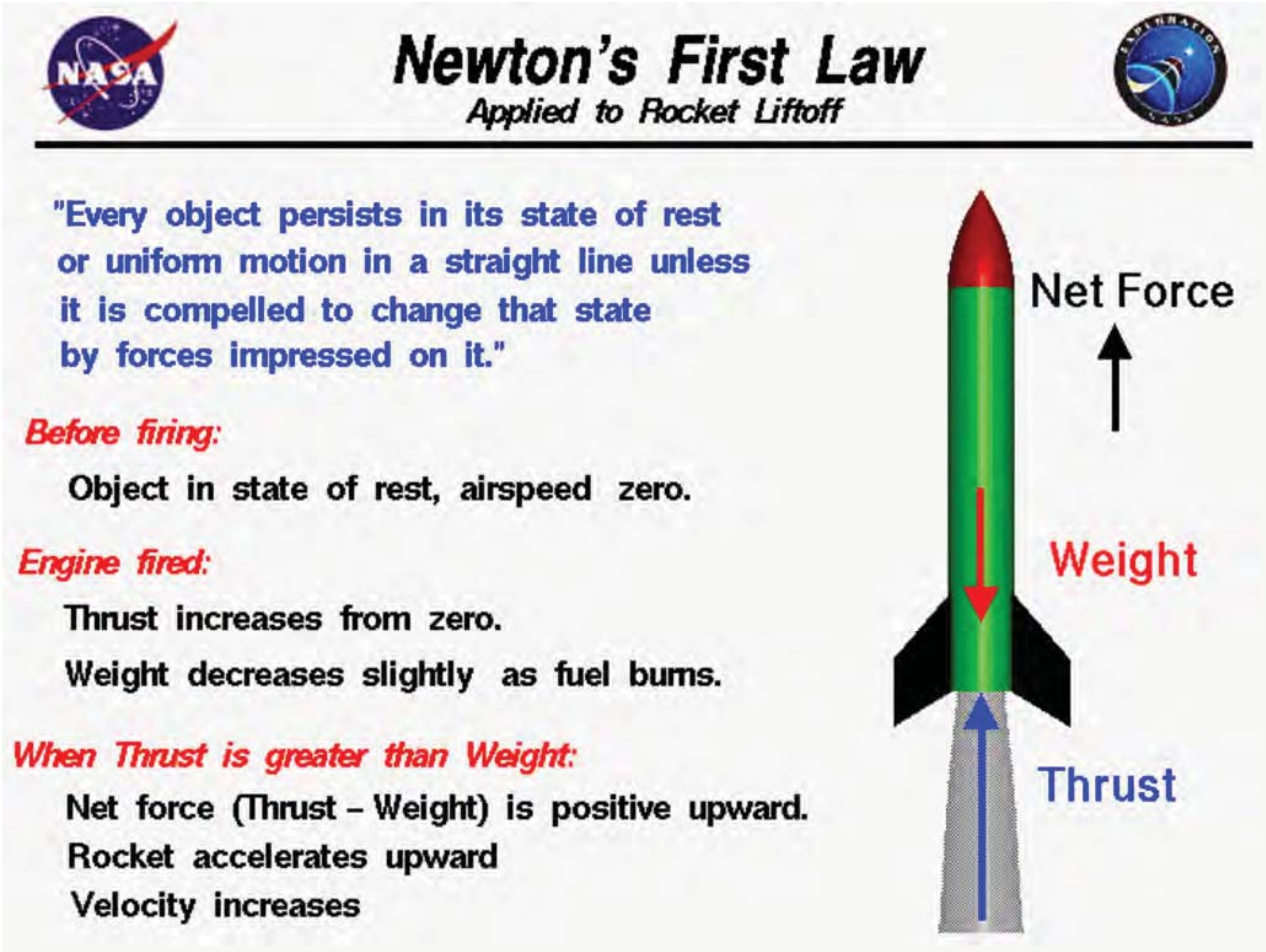
Demonstrate force by pushing and pulling an object (book, pen, etc.) in a straight line across a flat surface.

Newton's First Law of Motion, or the Law of Inertia.

Newton's first law states that every object remains at rest or in uniform motion in a straight line until an external or internal force is applied to the object. This is also the definition of inertia.

Inertia is the resistance of any physical object to a change in its state of motion or rest, or the tendency of an object to resist any change in its motion.

Point to a movable object at rest. The object is following Newton's First Law of Motion.



Note: From NASA (2011). Newton's First Law. Retrieved December 7, 2011 from http://exploration.grc.nasa.gov/education/rocket/newton1r.html

Figure 1 Newton's First law

If there is no force acting on an object then the object maintains a constant velocity. If that velocity is zero, then the object remains at rest. If an external force is applied, the velocity changes because of the external force.

Constant velocity can only happen in a vacuum like space. On Earth, air and / or gravity creates resistance or friction, slowing the object down.

This first law gives a frame of reference for the other laws of motion by establishing that an object at rest or in motion can have its state of rest or motion altered by external or internal forces.

Examples of this Law are:

- The pen placed on a flat level desk will not move as the forces of friction and gravity are acting on it.
- A satellite in outer space continues on its trajectory unless the gravity of an object it passes alters its trajectory.
- The Water Rocket on the Launch Tower will not move (other than a slight wobble due to air resistance from wind) as gravity keeps it on the launch tower until it is pressurized and launched.

Newton's Second Law of Motion

Newton's second law of motion explains how an object changes velocity if external forces are applied to it.

1. The law states that if a force is applied to an object, it accelerates or changes its velocity, and it changes its velocity in the direction of the force.

> An object accelerates in the direction that the force is applied.

2. The acceleration is directly proportional to the force applied. If an object is pushed, it causes it to accelerate. If the object is pushed three times harder, the acceleration is three times greater.

3. The acceleration is inversely proportional to the mass of the object. If two objects are pushed equally, and one of the objects has five times more mass than the other, it accelerates at one fifth the acceleration of the other.

> If the mass of an object increases, the acceleration decreases proportionately.

Some of the forces that can change an objects state are:

- gravity,
- air resistance,
- friction,
- external or internal force.

A formula to help explain this is:

$F=ma$

Where F is equal to the force, measured in Newton Metres and m is equal to the mass of the object. A is equal to the acceleration of the object.

Rockets during launch burn some of their propellant and therefore become lighter, changing their mass. As the rocket mass changes or becomes lighter, and the rocket engine continues to produce the same amount of thrust, the rocket accelerates.

Newton's Third Law of Motion

Newton's Third Law of Motion states that for every action or force in nature there is an equal and opposite reaction. This force is proportionate to the mass of the objects involved

When the trigger is pulled on a firearm, the gunpowder explodes, pushing the projectile or bullet out of the barrel. The force applied to the projectile is the same as the force applied to the firearm. The mass of the firearm is less than the mass of the projectile resulting in less force applied to the shooter.

A rocket engine forces gasses or propellant out its nozzle, pushing the rocket in the opposite direction.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. What is Newton's First Law of Motion?

Q2. What is Newton's Second Law of Motion?

Q3. What is Newton's Third Law of Motion?

ANTICIPATED ANSWERS:

A1. Newton's first law states that every object remains at rest or in uniform motion in a straight line until an external or internal force is applied to the object.

A2. Newton's second law of motion explains how an object changes velocity if it is pushed or pulled upon.

A3. Newton's Third Law of Motion states that for every action or force in nature there is an equal and opposite reaction.

Teaching Point 2	**Have the cadets launch a water rocket.**
Time: 65 min	Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to demonstrate Newton's Laws of Motion in a dynamic and interesting way.

RESOURCES

- An outdoor area 10 by 20 square metres,
- A water rocket launch system,
- A pump to supply compressed air to the launch system (a bicycle pump or tire inflator is best)
- A two litre soda bottle in good condition (no deep scratches or obvious defects). Only use carbonated drink type bottles. Water bottles are not strong enough to be used on a pressurized system,
- Safety glasses one per cadet instructors, and
- Water to launch the water rocket several times.

ACTIVITY LAYOUT

Setup the launch site using the instructions included in Attachment B.

Brief the cadets as per Attachment B Launch Site Setup.

ACTIVITY INSTRUCTIONS

> For both launches use the same air pressure, 50 to 60 Psi. For the first launch, load the 2 litre soda bottle onto the launch system without water in it to demonstrate thrust with air as the propellant mass.

1. Mount the empty two-litre soda bottle on the water rocket launch tower.
2. Explain to the cadets that the bottle is demonstrating Newton's First Law of Motion as it is stationary and the only force currently applied is gravity.
3. Pressurize the launch tower to 50 to 60 psi.
4. Have the cadets count down from five and launch the soda bottle.

> The force of the air escaping from the soda bottle pushes the bottle into the air. This demonstrates two of Newton's Laws of Motion.
>
> The First Law of Motion is demonstrated as the rocket is at rest on the tower.
>
> The Second Law of Motion is demonstrated as the rocket lifts off. The force of the air escaping pushes the bottle in a linear direction off the launch tower.
>
> The Third Law of Motion is demonstrated as the reaction of the air being pushed out of the bottle forces it away from the launch tower.

5. Recover the soda bottle and fill it one third full with water.
6. Reload the soda bottle onto the launch tower.
7. Pressurize the launch tower to the same pressure as the empty bottle launch.
8. Have the cadets count down from five and launch the water rocket.

> For the second launch, load the two litre soda bottle onto the launch system after filling it one third full with water to demonstrate thrust with water as the part of the propellant. The mass of the bottle with the water in it slows the rocket down on launch, but the mass of the water being forced out of the bottle pushes the bottle much higher. As the bottle gets lighter, it accelerates faster until the propellant and pressure diminish. Even after the water has evacuated the bottle, the air pressure left in the bottle continues to provide thrust to the bottle until it is exhausted.

9. Have the cadets discuss the difference between the two launches.

SAFETY

Water Rocket Safety Orders are located at Attachment C.

END OF LESSON CONFIRMATION

The cadets' participation in the activity will serve as the confirmation of this lesson.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Newton's Laws of Motion apply to everything around us. In rocketry, these laws govern the entire flight profile of a rocket before, during and after launch.

INSTRUCTOR NOTES / REMARKS

Cadets qualified as Advanced Aerospace may serve as assistant instructors.

The water rockets may be launched indoors in an area easy to clean up (eg, gymnasium floor) or out of doors in favourable weather.

REFERENCES

C3-266 Science Toy Maker. (2008). Making (and using) an overhead water rocket launcher. Retrieved October 1, 2008, from http://www.sciencetoymaker.org/waterRocket/buildWaterRocketLauncher.htm

C3-291 Retter, Y. (2008). *Water Rocket – Skewer Design*. Retrieved November 21, 2008, from http://www.geocities.com/yoramretter/SkewerDesign-v02.html

C3-351 National Aeronautics and Space Administration. (2008). *Adventures in Rocket Science*. Retrieved October 27, 2011, from http://www.nasa.gov/pdf/265386main_Adventures_In_Rocket_Science.pdf

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CONSTRUCTING A WATER ROCKET LAUNCH SYSTEM

Material List

Quantity	Part No.	Item	Length
1	A1	½-inch CPVC tube	7 inches
1	A2	¾ x ½ CPVC reducer	
1	A3	¾-inch CPVC tube	40 inches
1	A4	¾-inch female CPVC adapter	
1	A5	¾-inch male CPVC adapter	
1	A6	¾-inch CPVC tube	3 inches
1	B1	tire stem valve (for a ½-inch hole)	
2	B2, C1	¾-inch CPVC end cap	
2	B3,C2	¾-inch CPVC tube	24 inches
2	B4, C3	¾-inch CPVC T-joint	
1	B5	¾-inch CPVC tube	19 inches
1	B6	¾-inch CPVC ball valve	
1	C4	¾-inch CPVC tube	7 inches
1		8 x 2 inch sticky (Duct) tape	
10		6 to 7 inch long cable ties	
1		¾-inch O-ring, or soft hose washer	
2		#12 steel hose clamp	
1		1¼-inch ABS coupler	
1		braided string	
1		2-litre soda bottle	
1		CPVC Cement	
1		CPVC Solvent / Cleaner	
1		Heavy weight (eg. sand bag)	

One 10 foot length of ¾ inch CPVC schedule 40 tube will build one launch system.

7 inches of ½ inch CPVC tube is required for the bottle guide for each launch system.

Only use PET plastic soda bottles designed for carbonated drinks in good condition. Do not substitute a water PET bottle for a soda bottle. Bottles with deep scratches, hard creases, or more than 10 pressurized launches will not be used. Indicate the number of launches on the bottle with an indelible marker. Do not use sandpaper, hot melt glue, solvent based glue or any other chemical or heat that may weaken the soda bottle.

The launch system will be able to launch 500 millilitres to 2 litre carbonated soda bottles.

Tool list

Pliers,

Saw,

Scissors,

Drill,

Drill bits for ½ inch and 1/8 inch holes,

Hand file, and

Source of compressed air with a gauge (eg. bicycle pump, tire inflator or compressor).

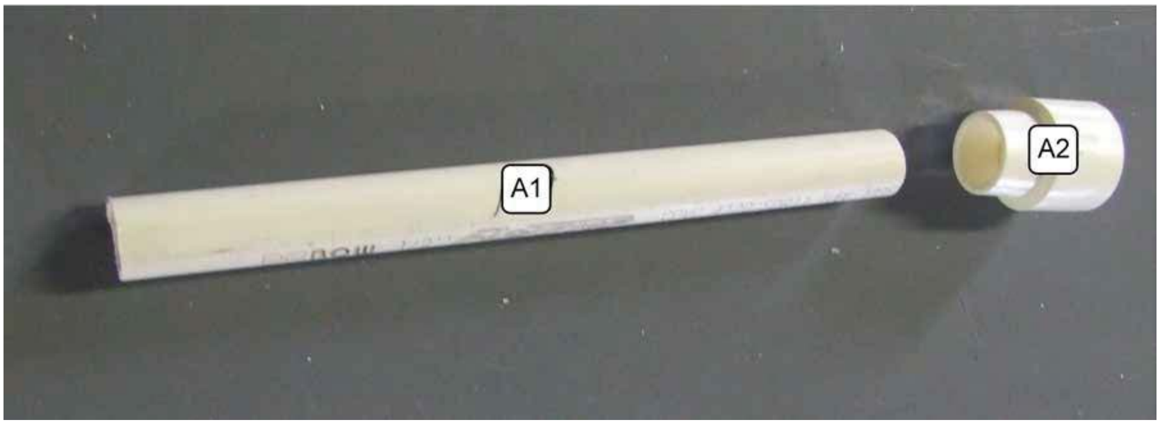
Assembling the Water Rocket Launch System

The launch system will be assembled in 3 sections of tubing, and a bottle clamp and release system

Section A

Section A consists of:

- A1 – ½-inch CPVC tube, 7 inches
- A2 – ¾ x ½ CPVC reducer



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

Figure 1-A Section A, A1 and A2

- A3 – ¾-inch CPVC tube, 40 inches
- A4 – female ¾-inch CPVC adapter
- A5 – male ¾-inch CPVC adapter
- A6 – ¾-inch CPVC tube, 3 inches

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

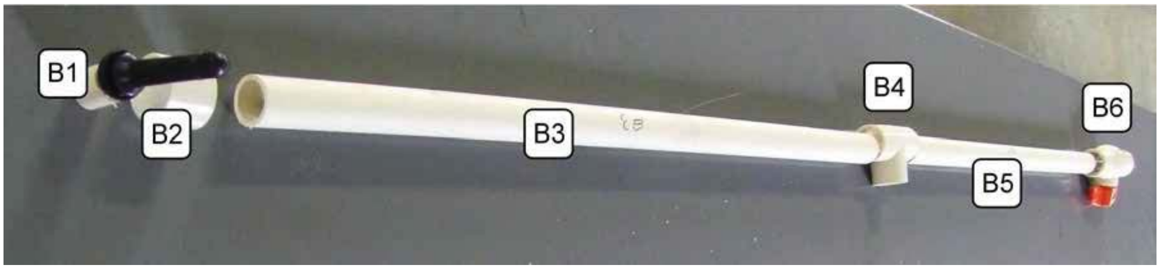
Figure 2-A Section A: A3, A4, A5 and A6

Section B

Section B consists of:

- B1 – tire valve stem
- B2 – ¾-inch CPVC end cap
- B3 – ¾-inch CPVC tube, 24 inches
- B4 – ¾-inch CPVC T-joint

- B5 – ¾-inch CPVC tube, 19 inches
- B6 – 1 ¼-inch CPVC ball valve



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

Figure 3-A Section B: B1, B2, B3, B4, B5, and B6

Section C

Section C consists of:

- C1 – ¾-inch CPVC end cap
- C2 – ¾-inch CPVC tube, 24 inches
- C3 – ¾-inch CPVC T-joint
- C4 – ¾-inch CPVC tube, 7 inches

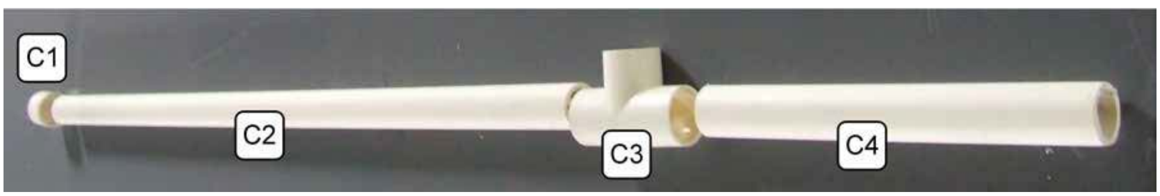


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Figure 4-A Section C: C1, C2, C3 and C4

Cut the ¾-inch CPVC pipe as close to 90 degrees as possible. This allows the most glue surface area possible, and makes a solid reliable join.

Deburr the cut edges with a file or sandpaper and when gluing the pieces together, clean all joint surfaces with CPVC Solvent / Cleaner before gluing.

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

Figure 5-A Deburring the end of the tube with a hand file.

When gluing, apply CPVC Cement to both ends to be joined, join ends and twist joint clockwise until resistance is felt. Use only enough glue to coat the two parts. Avoid excess glue as this can melt the inside of the tube or fitting, weakening it. The cement sets in less than 30 seconds so be sure to align the parts quickly and accurately.

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

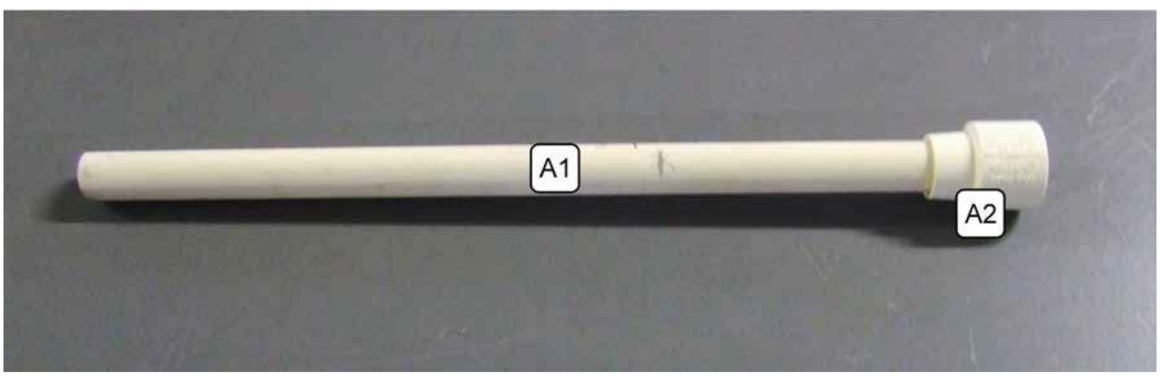
Figure 6-A Applying cleaner or glue to the joint surfaces before gluing.

Building Directions

Section A

Apply CPVC Cement and join:

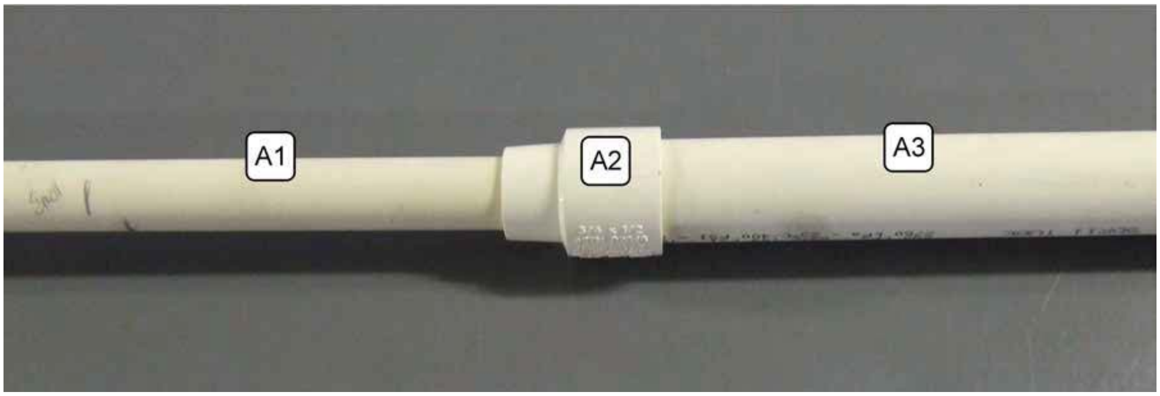
- bottom part A1 (½-inch CPVC tube, 7 inches) to A2 (½-inch end of ¾ x ½ inch CPVC reducer);



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

Figure 7-A Section A, A1 and A2

- A2 (¾-inch end of ¾ x ½ inch CPVC reducer) to A3 (¾-inch CPVC tube, 40 inches);



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

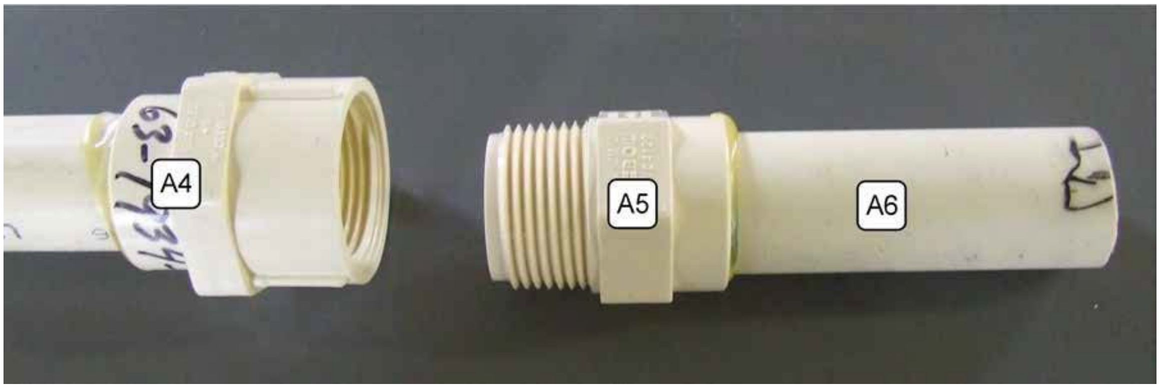
Figure 8-A Section A, A1, A2 and A3

- A3 ¾-inch CPVC tube, 40 inches) to A4 (¾-inch female CPVC adapter); and

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

Figure 9-A Section A, A3 and A4

- A6 (¾-inch CPVC tube, 3 inches) to A5 (¾-inch male CPVC adapter).



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

Figure 10-A Section A, A4, A5 and A6

Do not allow glue to touch the threaded portion or the gasket surfaces of A4 (¾-inch female CPVC adapter) and A5 (¾-inch male CPVC adapter).

Use the male / female adapter joint to disassemble the water rocket launcher for transport and storage.

Section B

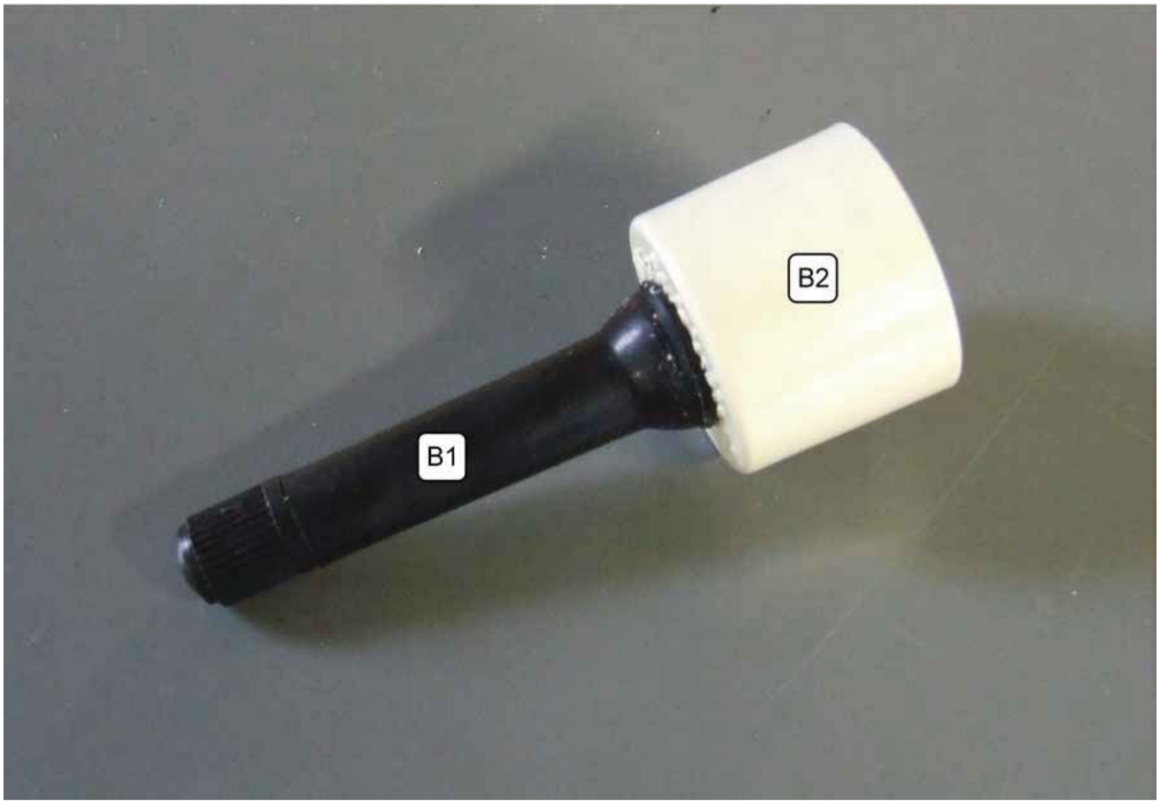
Prepare B2 (¾-inch CPVC end cap) for the tire valve stem:

- Drill a ½ inch hole in B2 (¾-inch CPVC end cap). Drill at a slow speed and hold the end cap in a vise or pair of pliers.

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

Figure 11-A Section B, Drilling the hole for the tire valve stem.

- Pull B1 (tire valve stem) through the ½ -inch hole from the inside in B2 (¾-inch CPVC end cap) until the valve stem is seated on the end cap.



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

Figure 12-A Section B, Tire Valve Pulled Through B2

Apply CPVC Cement and join:

- B2 (¾-inch CPVC end cap with tire stem valve) to B3 (¾-inch CPVC tube, 24 inches);

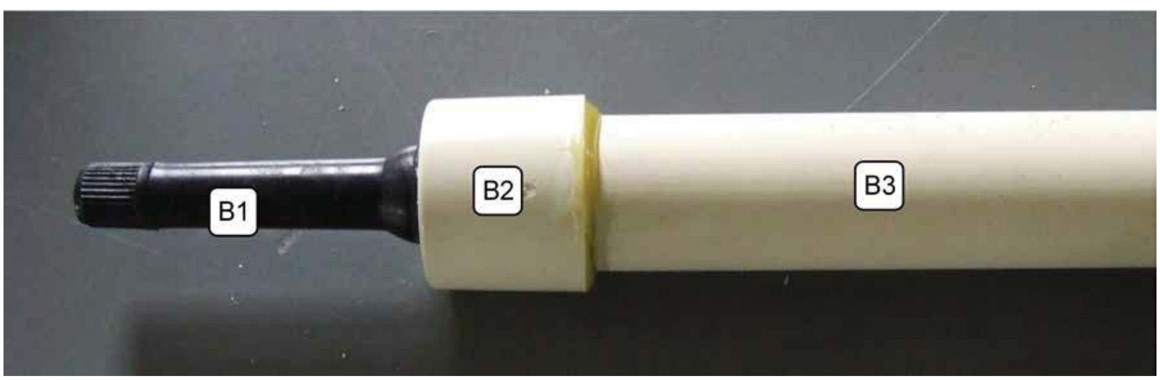


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Figure 13-A Section B, B1, B2 and B3

- B3 (¾-inch CPVC tube, 24 inches) to B4 (¾-inch CPVC T-joint);
- B4 (¾-inch CPVC T-joint) to B5 (¾-inch CPVC tube, 19 inches); and

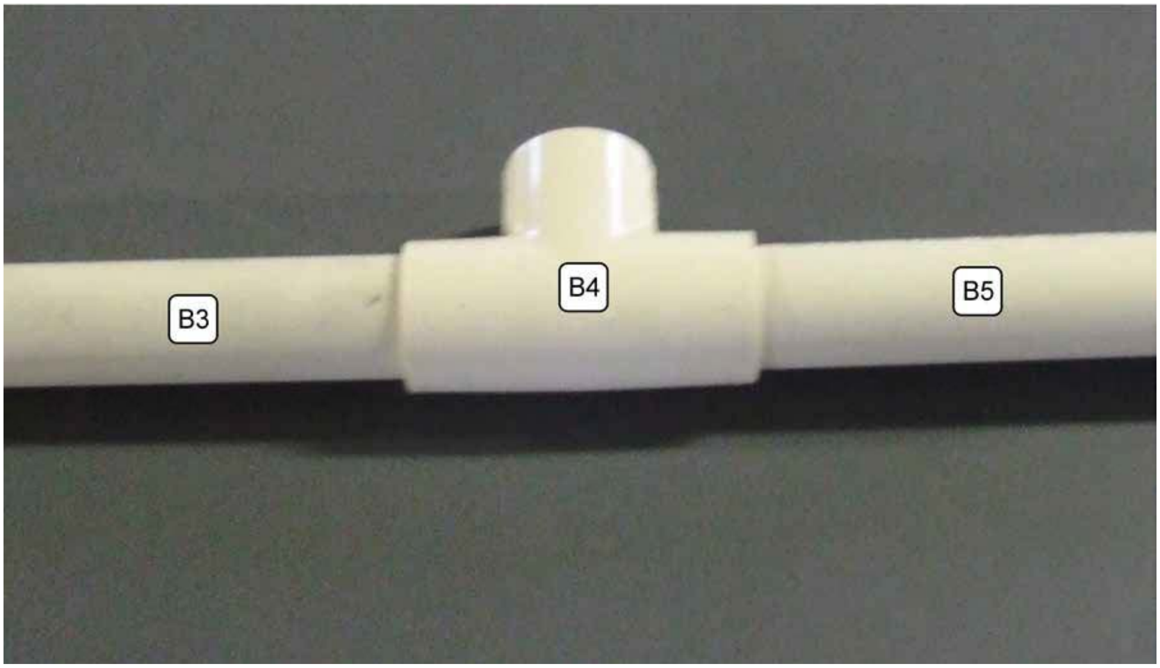

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Figure 14-A Section B, B3, B4 and B5

- B5 (¾-inch CPVC tube, 19 inches) to B6 (¾-inch CPVC valve). Ensure that the valve handle is clocked 90? to B4 (¾-inch CPVC T-joint).

Clocking is aligning the parts along their centre axis. The handle of B6 (¾-inch CPVC valve) points vertically and the open centre female connection of B4 (¾-inch CPVC T-joint) points horizontally

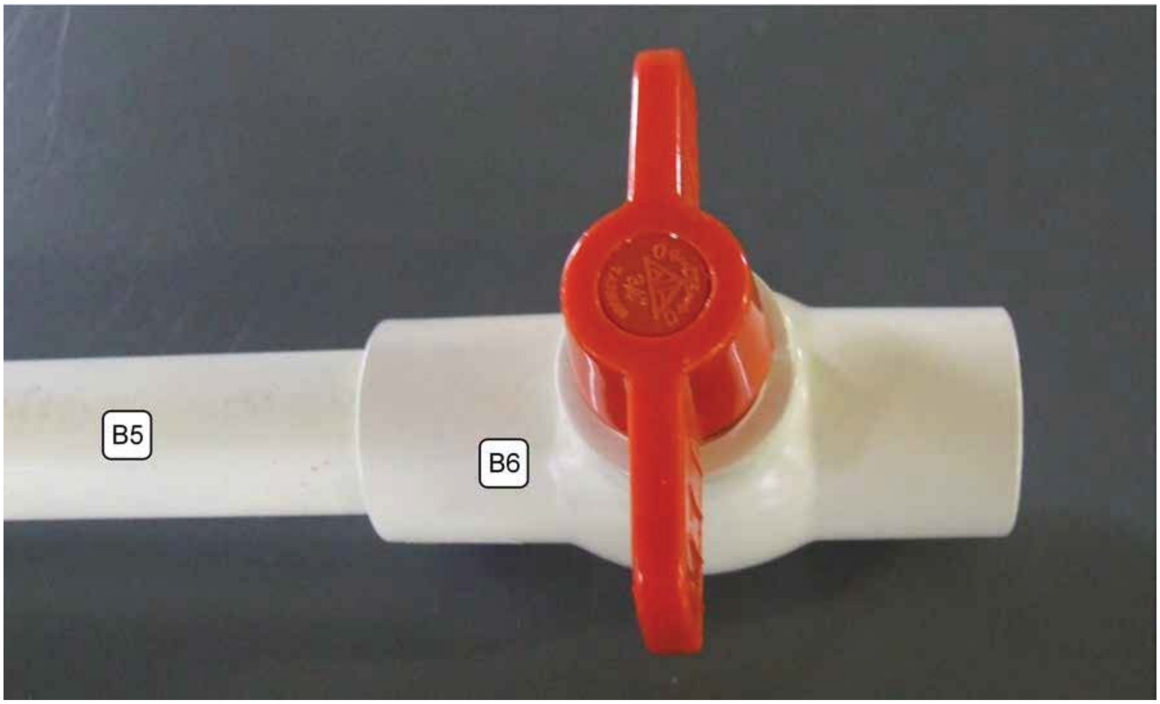

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Figure 15-A Section B, B5 and B6

The CPVC valve is a safety measure to be used to depressurize the launcher in the event of a misfire or for pressure testing the bottle clamp and release system.

Section C

Apply CPVC Cement and join:

- C1 (¾-inch CPVC end cap) to C2 (24 inches of ¾-inch CPVC tube);

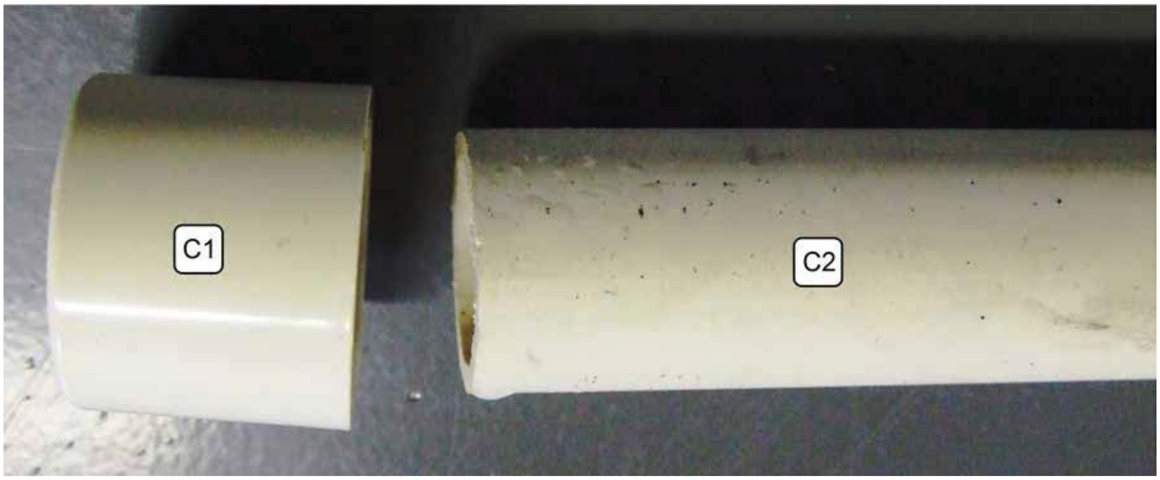

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Figure 16-A Section C, C1 and C2

- C2 (24 inches of ¾-inch CPVC tube) to C3 (¾-inch CPVC T-joint); and
- C3 (¾-inch CPVC T-joint) to C4 (7 inches of ¾-inch CPVC tube).

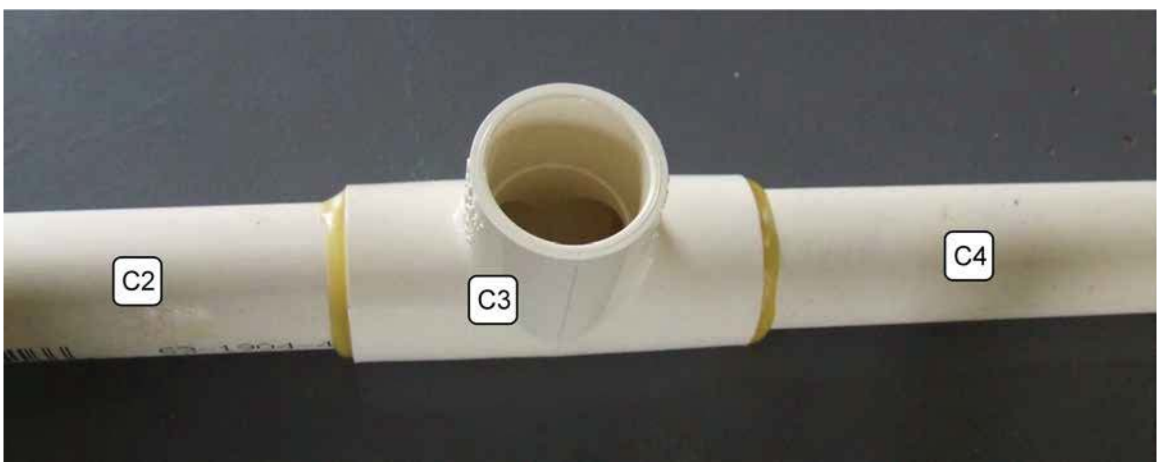

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Figure 17 Section C, C2, C3 and C4

Base Assembly

To build the base, apply CPVC Cement and join:

- A6 (3 inches of ¾-inch CPVC tube) of section A to C3 (¾-inch CPVC T-joint) of section C.
- B4 of section B to C4 of section C, make sure that section A is perpendicular to section B; and

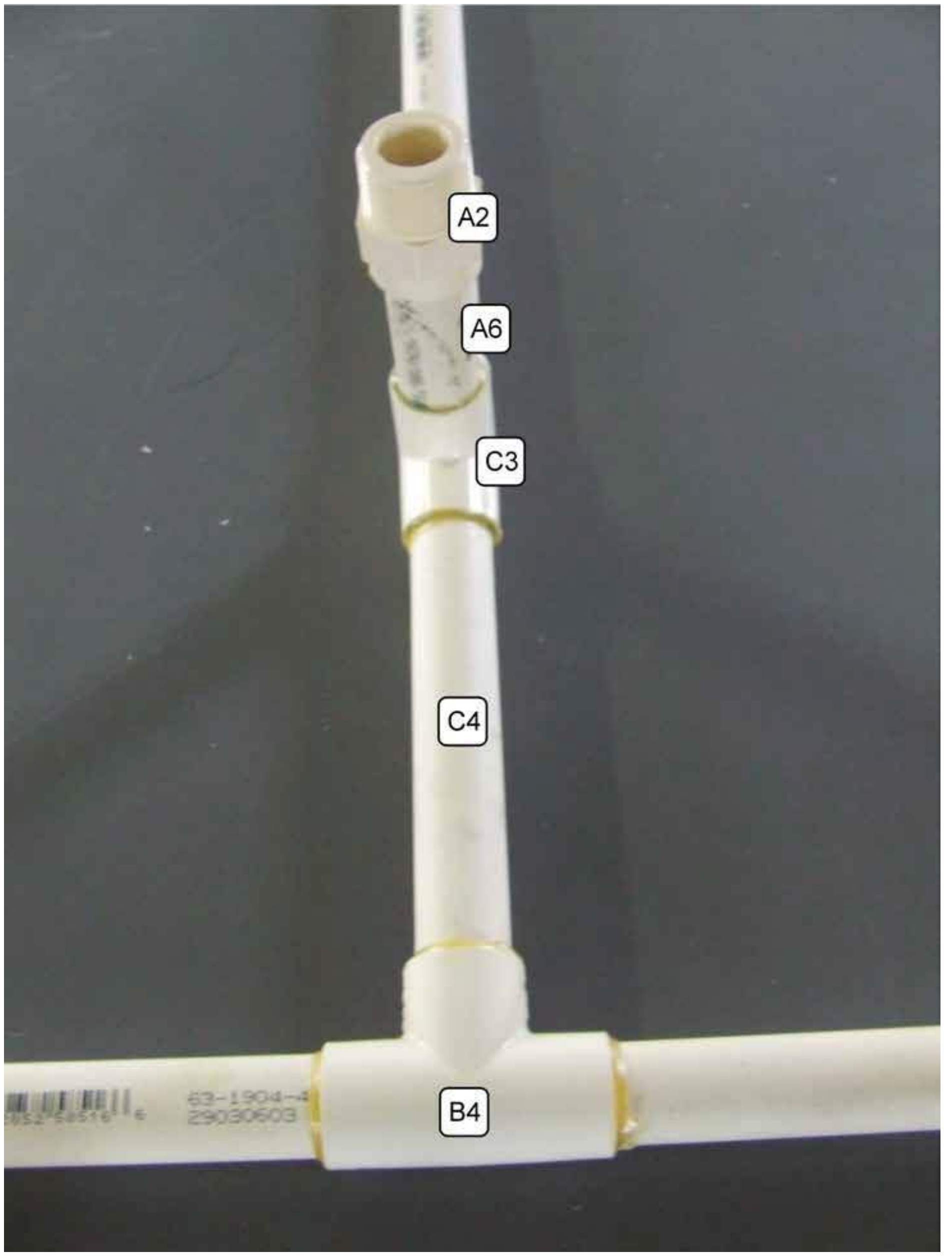

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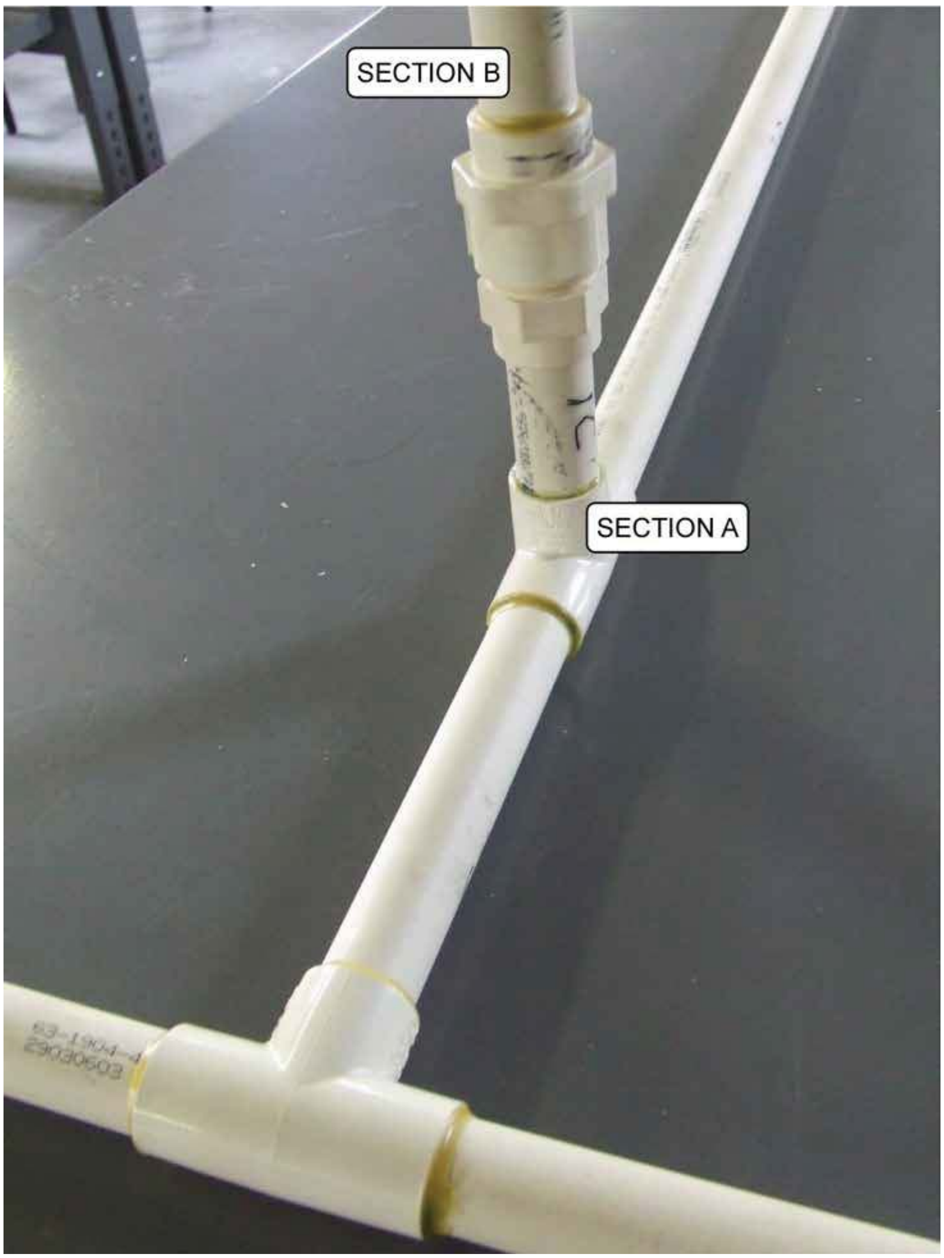
Figure 18-A Sections A, B and C Joined Together

To assemble the water rocket launcher, join section A with section B.

If during the glue process the parts fail to align properly because the glue has set too fast, cut off the misaligned part, purchase and glue a ¾ to ¾ CPVC coupler between the two parts and realign.



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

Figure 19-A Section A joined with Section B.

Bottle Clamp and Release System

To assemble the Bottle Clamp Release System

- Draw two parallel lines, six inches long on a piece of 8½" x 11" paper. Line A is one inch below the top edge of the paper and line B is three inches below line A. Use the corner of a second sheet of 8½ "x 11" paper as a square to mark a perpendicular line, line C, between lines A and B.

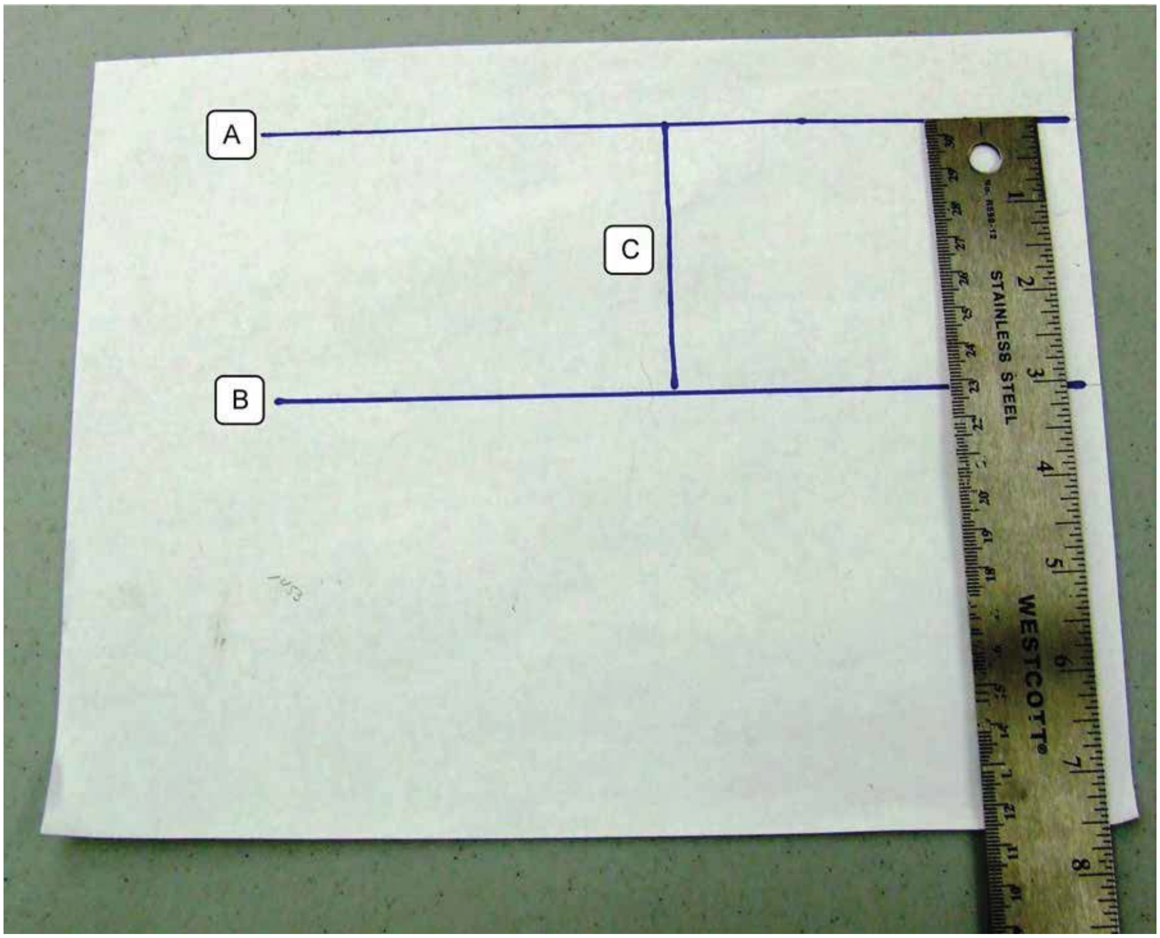


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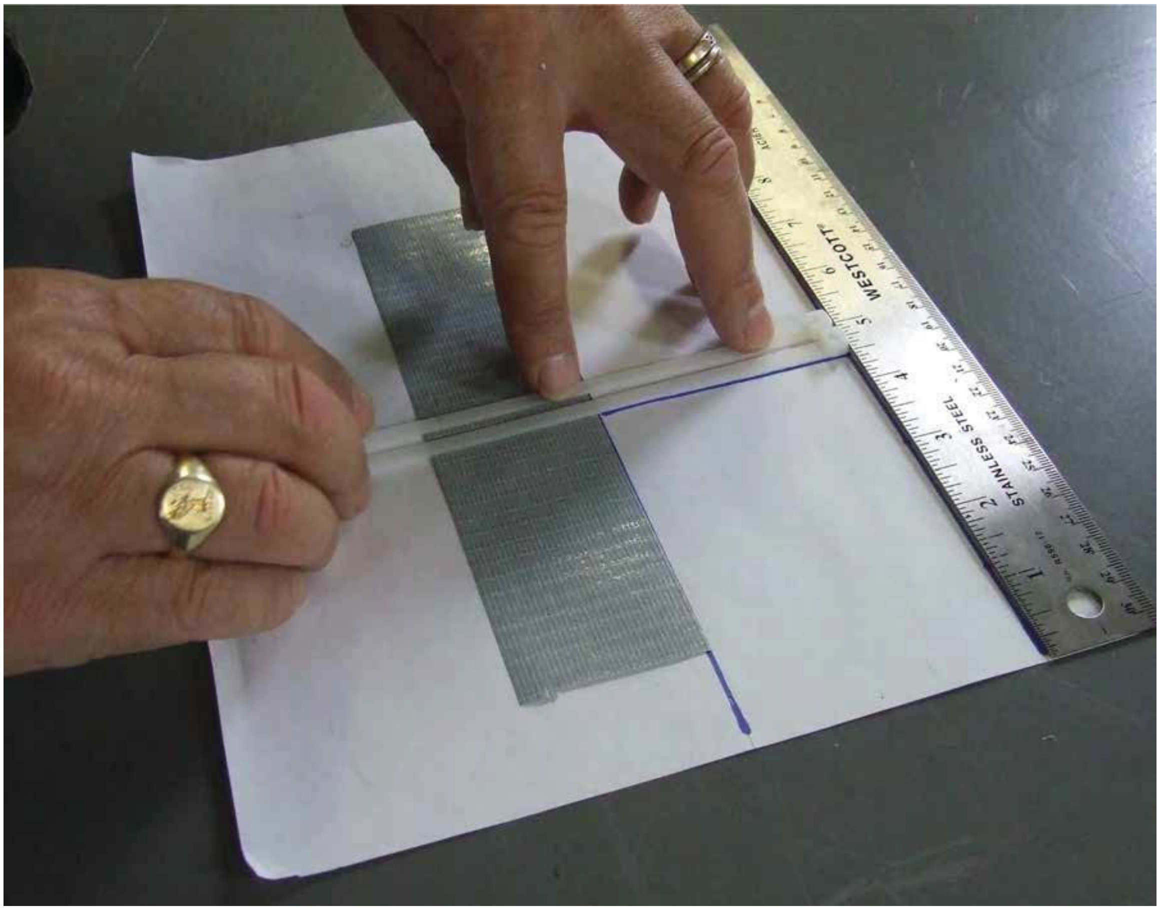
Figure 20-A Laying Out the Cable Tie Position

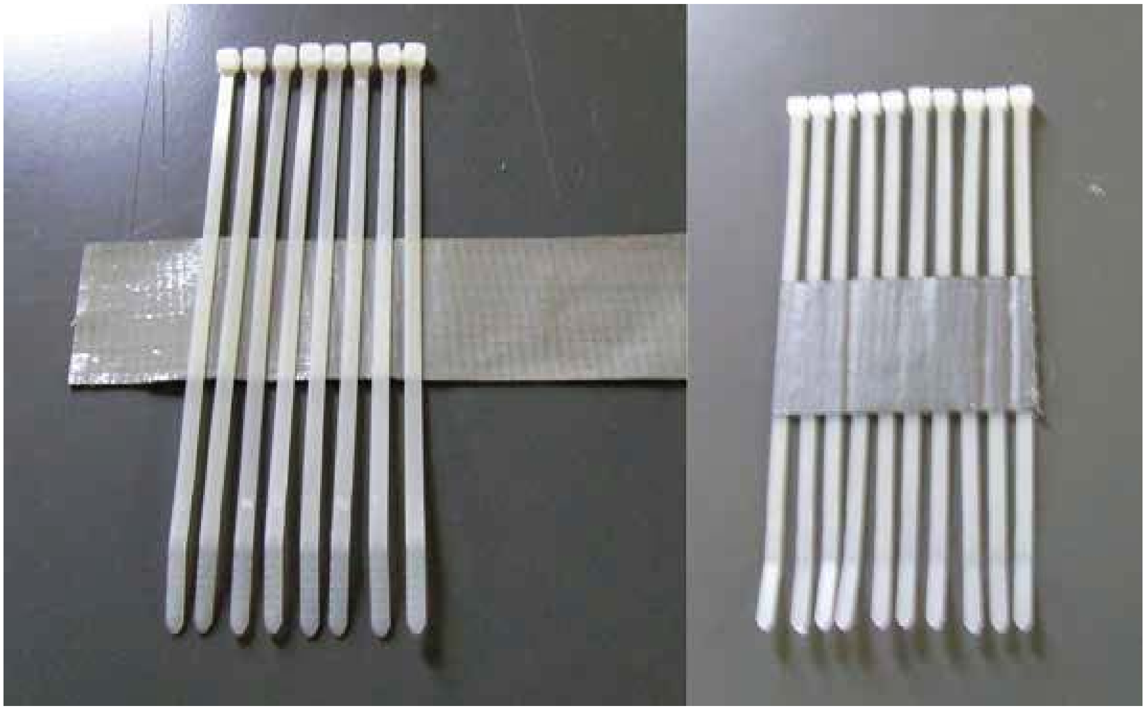
- Lay the ruler along line A and lay the tape, sticky side up along line B. Ensure the ruler will not move off of line A by using tape or a weight. Place the ties across the tape with the head touching the ruler and check that the cable ties are perpendicular to lines A and B. Start at line C laying the cable ties 2 mm between each tie.



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

Figure 21-A Placing the Cable Ties on the Duct Tape

- Fold the tape ends over the exposed portion of the ties so that no adhesive is showing.



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

Figure 22-A Cables Ties Adhered to the Duct Tape

- Place the O-ring or hose washer over the ½-inch side of A2 (¾” x ½” coupler) until it rests on the shoulder of A2. The O-ring or hose washer may have to be stretched to fit onto the shoulder of A2.

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

Figure 23-A Position of the O-Ring or Hose Washer on A2

- Place the 2 hose clamps on A (3¾-inch CPVC tube). Slide the bottle over the end of A1 (½-inch CPVC tube) and seat it against the O-ring or hose washer. Wrap the cable ties around the pipe so that the head of each cable tie faces inward and catches the lip of the bottle, holding the bottle tight to the O-ring or hose washer. Place the hose clamps over the cable ties and tape and tighten them so that the heads of the cable ties exert equal pressure around the ridge on the bottle. This makes an airtight seal between the bottle and the O-ring or hose washer.

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

Figure 24-A Cable Ties Holding the Soda Bottle

If the bottle leaks at the O-ring or hose washer, adjust the cable ties up or down on A3 (¾-inch CPVC tube) so the lip of the bottle is securely and evenly seated on the O-ring or hose washer. Lock the cable ties in this position by tightening the hose clamps around the duct tape.

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

Figure 25-A Tie Cables Clamped to A3

Bottle Release Mechanism

- Drill two 1/8-inch holes on opposite sides of the 1¼-inch ABS coupler.

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

Figure 26-A Drilling 1/8-inch Holes in the ABS Coupler

- Use scissors to cut the top and bottom off a 2-litre soda bottle. Use the centre section to make a plastic spring. Flatten the bottle section without creasing it and cut a 1¼ inch hole centered through both sides. Drill 1/8-inch holes on either side of the 1¼-inch holes through both sides.

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

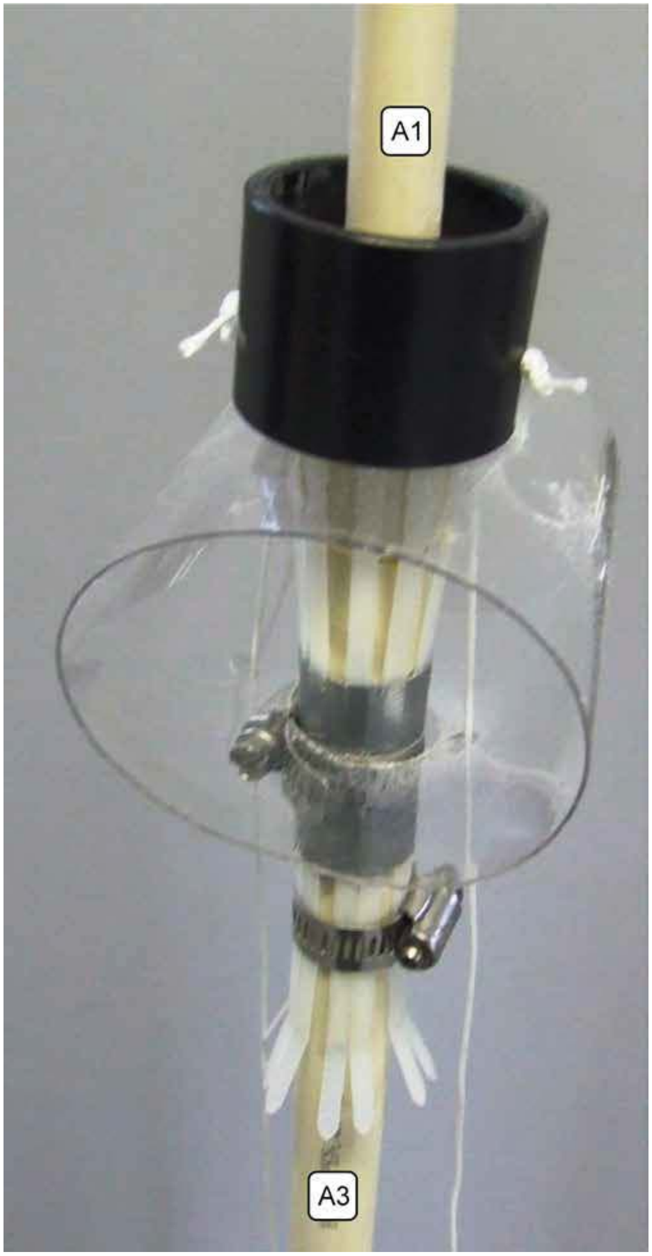
Figure 27-A Cutting the Hole in the Plastic Spring for Section A

- Slide the plastic spring over the end of pipe A1 (½-inch CPVC tube), over the cable ties and up against the hose clamps.

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

Figure 28-A Sliding the Spring over the Cable Ties

- Slide the 1¼-inch ABS coupler over A1 (½-inch CPVC tube), over the cable ties and up against the plastic spring. Thread the braided string through the holes of the plastic spring and tie the ends to the holes drilled in the 1¼-inch ABS coupler.



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

Figure 29-A Couple Installed over Cable Ties and Against the Plastic Spring

- Place a bottle in position on the launch tower. Pull the launch cords to lower the coupler and press the bottle neck onto the O-ring or hose washer. Then release the cord allowing the coupler to slide up, pressing the cable tie ends over the collar on the bottle, locking the bottle in place.

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

Figure 30-A Soda Bottle Installed on Launch System

Add a small amount of air pressure to test the bottle seal for leakage then depressurize the launcher. If air escapes around the lip of the bottle, gently rock the bottle on the tower. If the bottle continues to leak, the height of the cable ties on the upright A3 may need to be adjusted by loosening the clamps, and moving the cable ties up or down A3 to seal the bottle properly. The O-ring or hose washer should be compressed enough to seal the bottle to approximately 70 Psi.

- Test the release mechanism by pulling on the string to ensure the ABS coupler drops allowing the cable ties to open. When the string is released, the spring should push the coupler up and over the cable ties.

Launch Preparation

- Fill a bottle 1/3 full with water.

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

Figure 31-A Loading the Soda Bottle onto the Launch System

- Lay the launcher on its side and slide the bottle onto the end of the A1 (½-inch CPVC tube). Pull down on the trigger so that the bottle can seal against the O-ring or hose washer and the cable ties catch the lip of the bottle. Release the string and let the coupler slide back over the cable ties to hold the bottle in place. Sit the launcher upright and adjust the bottle to stop any leaking.

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

Figure 32-A Soda Bottle Ready for Launch

Place a weighted object (sand bag) on the launcher to hold it in an upright position.

- Run the launch cord under the tubing of the launcher so that when pulled, the cord pulls downwards on the collar of the launch tower.

- Attach the selected method for inflating air into the bottle to part B1 (tire valve stem). Method for inflating up to 70 Psi of air can include:
  - a foot air pump,
  - a bicycle air pump, or
  - a compressor.

Do not exceed 70 Psi.

When inflating air into the bottle launcher, the faster the air is added, the less amount of water leakage.

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

Figure 33-A Assembled Water Rocket Launch System

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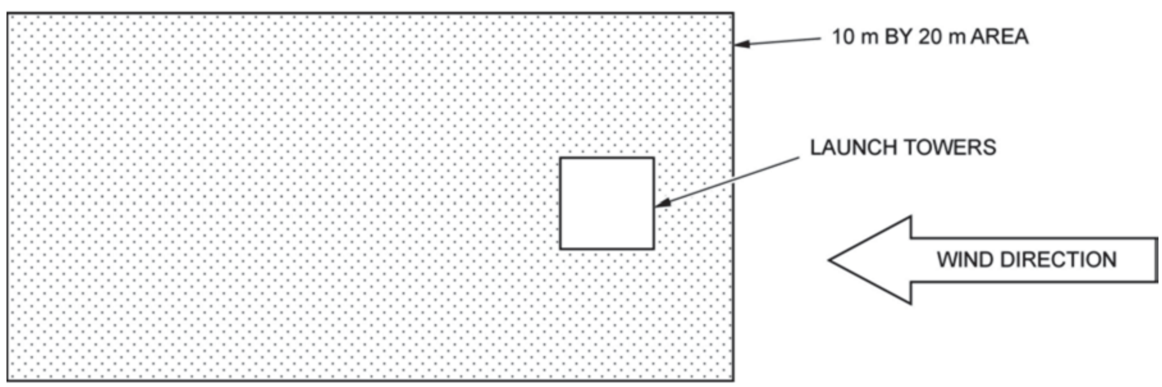
LAUNCH SITE SET-UP

1. Have the cadets participate in a safety briefing before the launch site is set up, covering the following points:

   - All launch systems will be placed in “safe” mode between each flight.
   - When a rocket is descending out of control, launch site personnel will point at the rocket and repeat the phrase “heads up” until the rocket has landed.
   - No horseplay will be tolerated.
   - A safe rendezvous point will be clearly indicated. In the event of an emergency, launch site staff will move all cadets and staff to this point.
   - The area required for launching model rockets should be at least 10 m by 20 m. The spectators should be located in an area at least 20 m from the launch tower. Bleachers at a baseball field or soccer field are suitable.
   - The rocket can reach a height of 60 m (200 feet) at apogee and can be flown safely from the suggested field size.

2. Set up rocket launch site as per Figure 5A-1. Wind direction should be accounted for by placing the tower closer to the windward side of the field.



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

Figure 1-B Layout for a Water Rocket Launch Site

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WATER ROCKET SAFETY ORDERS

1. **Definitions.** For the purposes of this safety order, a 'Water Rocket' is defined as any rocket whose thrust is generated by expansion of a compressed air. An inert fluid such as water is used for thrust augmentation. A soda bottle refers to a Polyethylene Terephthalate (PET) soda bottle between 500 ml and 2 l.

2. **Scope.** This order applies to water rockets used in cadet activities having a pressure chamber volume greater than 500 ml or a launch pressure exceeding 35 psi.

3. **Materials.** The pressure chamber of the rocket shall be a PET plastic soda bottle between 500ml and 2l. Only lightweight, non-metal parts shall be used for the nose, body, and fins.

4. **Compressed Gas Safety.** A safe distance shall be maintained at all times between persons and pressurized water rockets or launchers. The recommended safe distance is as follows:

Launch Pressure	With Eye Protection	Without Eye Protection
Up to 60 psi	10'	20'
Above 60 psi	20'	40'

5. **Pressurization System.** A small portable compressor, 12 volt tire inflator or bicycle pump is used to pressurize the launch system. The pressure shall not exceed 70 pounds per square inch.

6. **Launcher.** The launcher shall hold the rocket to within 30 degrees of vertical to ensure that it flies nearly straight up. It shall provide a stable support platform against wind and any triggering forces, and allow the rocket to be pressurized and depressurized from a safe distance. Launchers shall be constructed from materials rated for at least 3 times the intended launch pressure.

7. **Launch Safety.** A countdown prior to launch ensures that spectators are paying attention and are a safe distance away. If the rocket does not launch when triggered, all persons shall stay at a safe distance from the launch tower until it has been depressurized by launch staff.

8. **Size and Weight.** A water rocket whose mass (excluding water) exceeds 454 grams (1 lb) shall be considered a "Large Model Rocket" for the purpose of compliance with Federal Aviation Administration regulations. Rockets used in cadet activities shall exceed 454 grams (1 lb), or be longer than the length of two soda bottles.

9. **Flight Safety.** Water rockets shall not be directed at targets, into clouds, or near airplanes or other vehicles. Water rocket payloads shall not include flammable, explosive, dangerous (metal, rock, or other potentially hazardous objects) or live vertebrae.

10. **Launch Site.** Water rockets shall be launched outdoors, in an open area at least 100 feet on a side (for rockets with using a launch pressure of 60 psi or less), or 500 feet on a side (for rockets using higher pressure).

11. **Recovery System.** A recovery system such as a streamer, parachute, or tumble recovery can be used for rockets launched with over 60 psi, with the intent to return it safely to earth without damage.

12. **Recovery Safety.** Recovery shall not be attempted from power lines, tall trees, or other dangerous places.

13. **Load Fraction.** Water rockets shall be launched with a load fraction not exceeding .33. Load Fraction is the ratio of the water volume to the total volume of the motor. For example, 0.66 litres of water in a 2-liter soda bottle, one third full, the load fraction is 0.33.

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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.

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.

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). 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

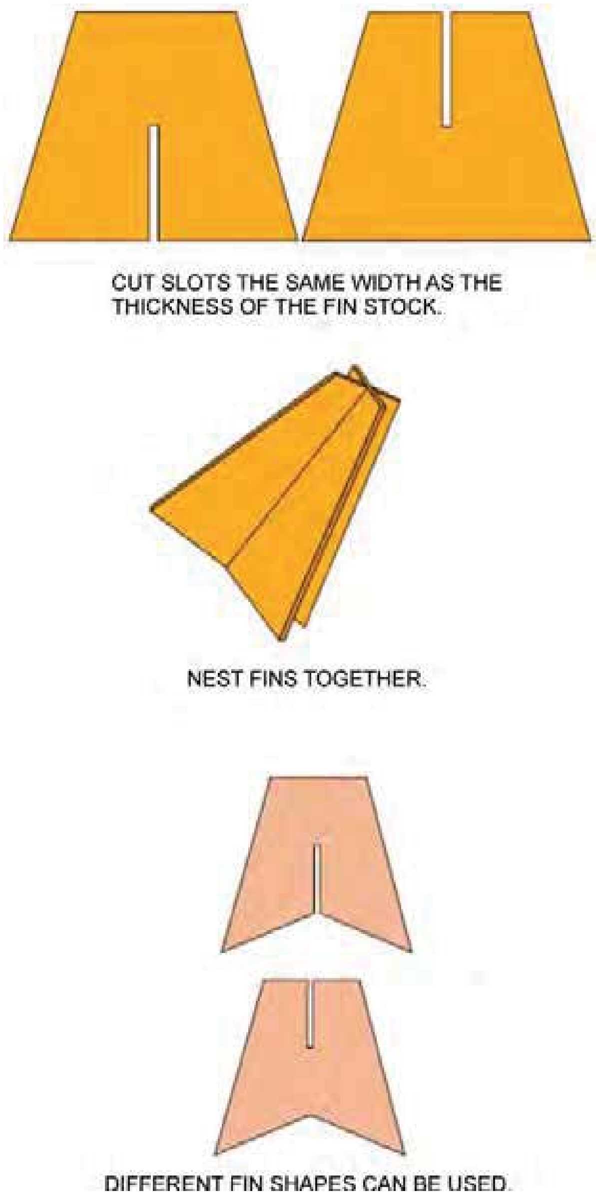
Figure 1 Exploded View of the Foam Rocket

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.



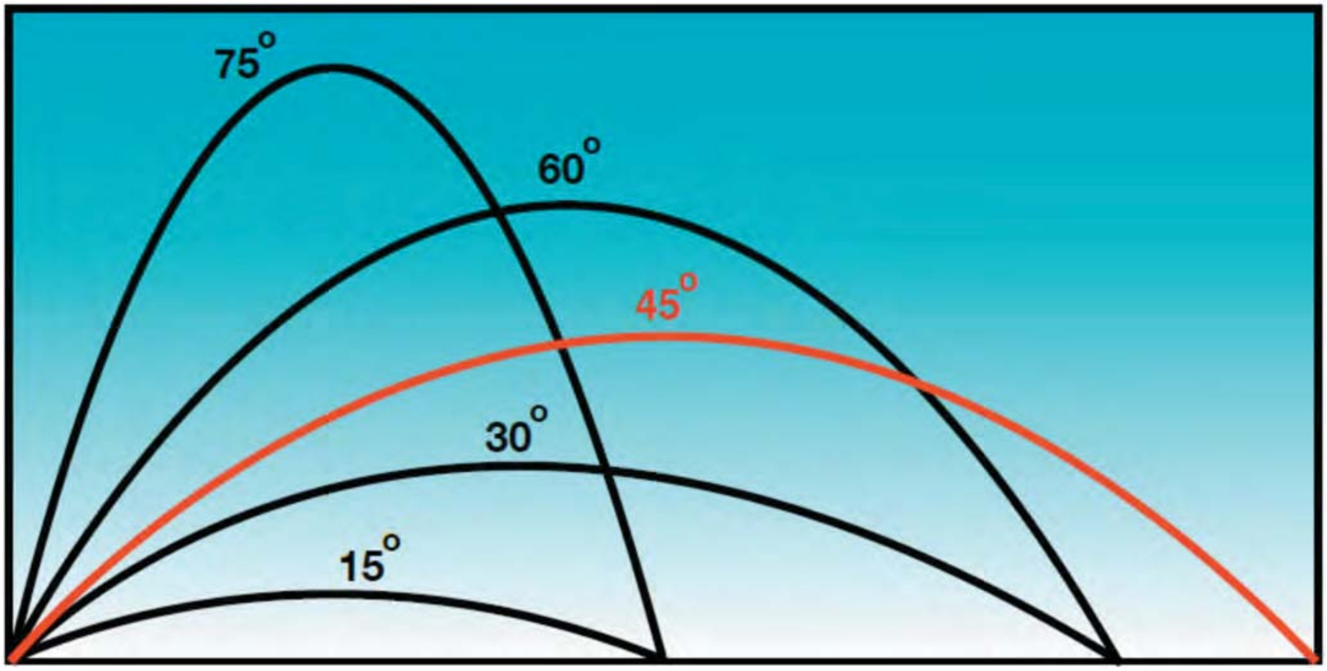
Note. From Foam Rockets Educator Guide, by NASA, 2008. Retrieved December 7, 2011, from http://www.nasa.gov/pdf/280754main_Rockets.Guide.pdf

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.



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.

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.

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.

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.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

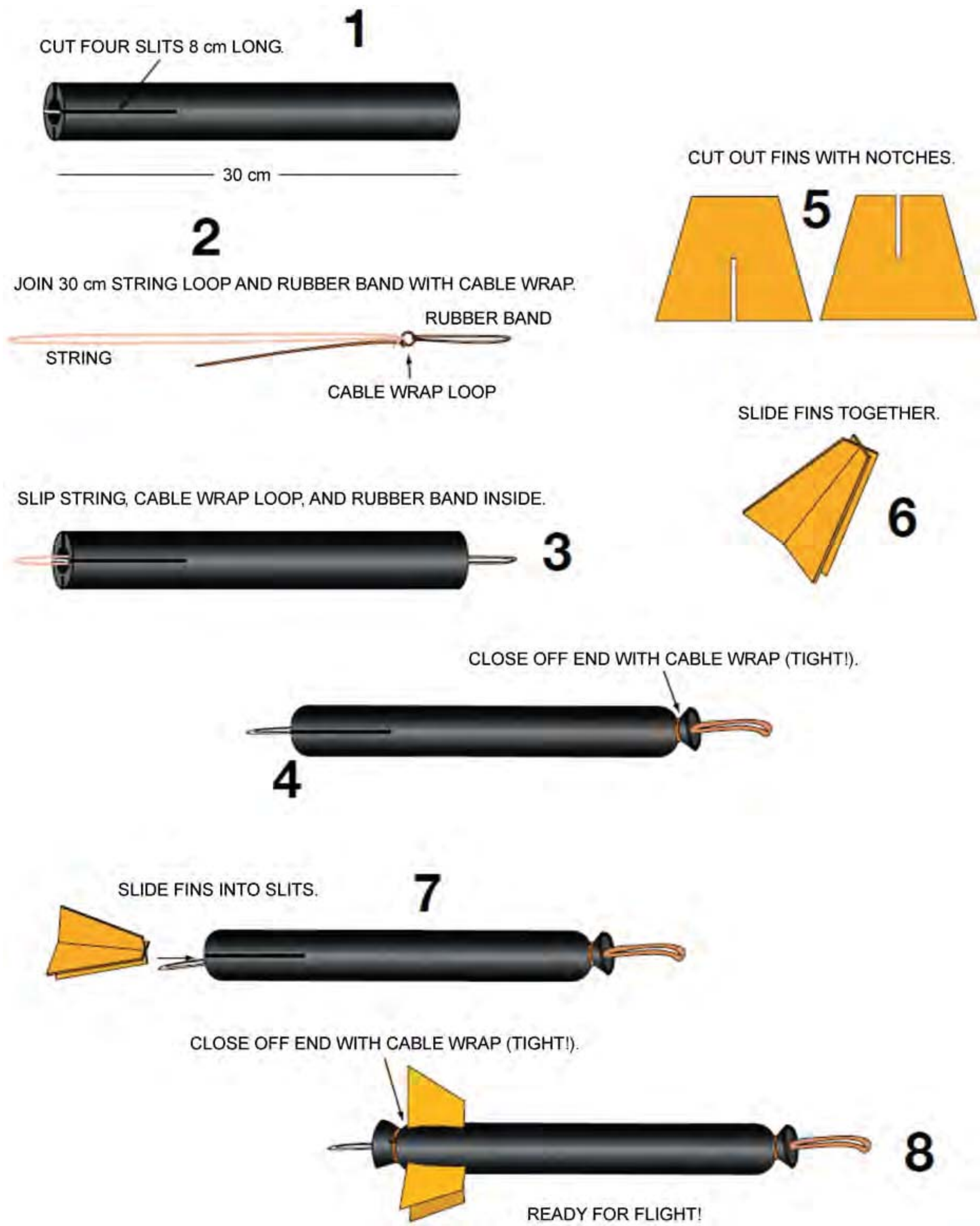
This is a dynamic way to demonstrate rocket propulsion and ballistics.

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



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

Figure A-1 Foam Rocket Instruction Sheet

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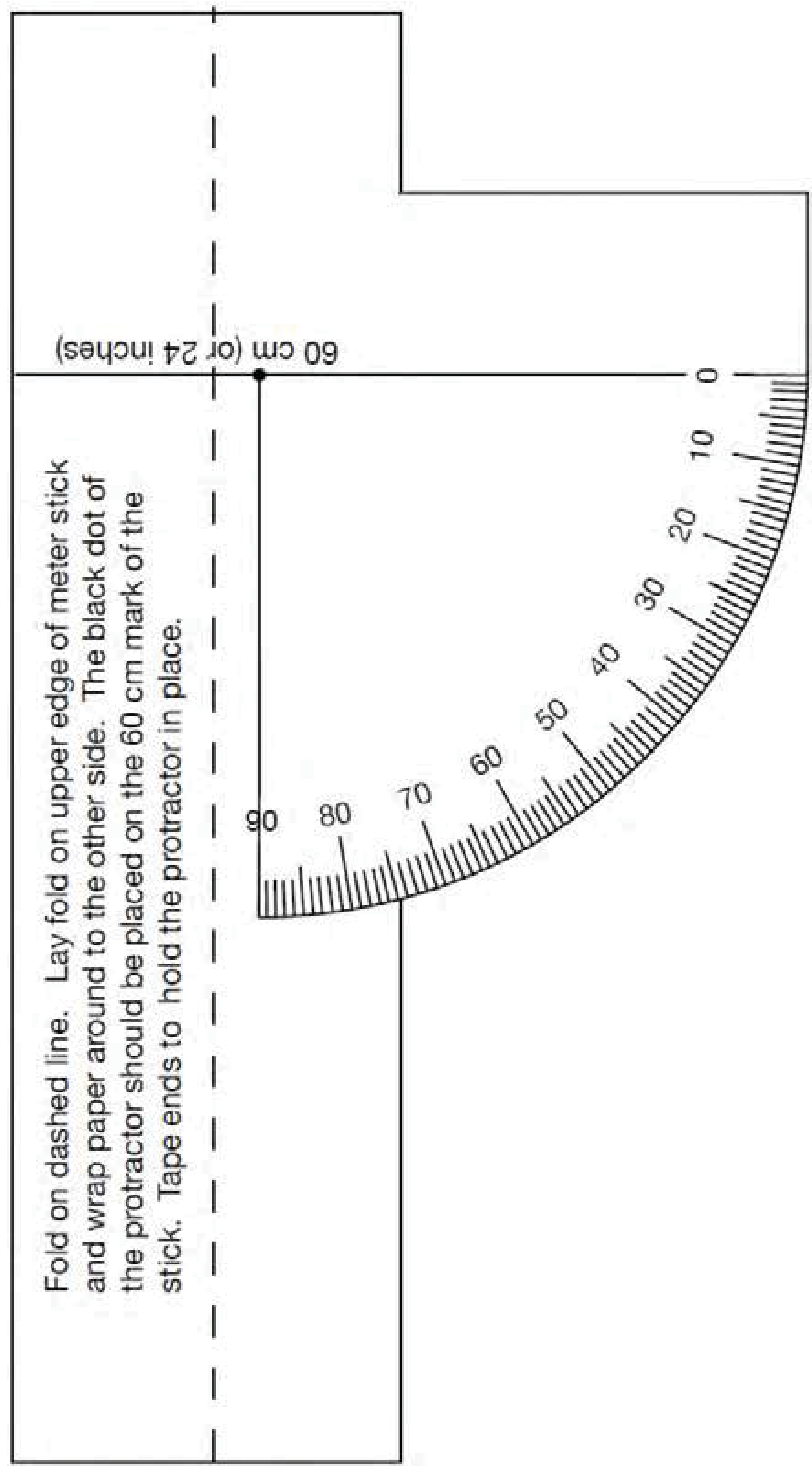
LAUNCHER QUADRANT PATTERN



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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

TEAM NAME
____
TEAM MEMBERS
____
____
____
____
____

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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ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL ONE

INSTRUCTIONAL GUIDE

SECTION 3

EO C140.02 – DISCUSS SLEEP PATTERNS IN SPACE

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.

The activities in this lesson take place over a two week period.

Photocopy the Reaction Time Sheet located at Attachment A, two copies for each cadet.

Photocopy the Multiple Rulers Sheet located at Attachment B and cut into individual rulers for each cadet.

Photocopy the Sleep Log Sheet located at Attachment C for each cadet.

Photocopy the Fraction Wheel for 24 Hours located at Attachment D for each cadet.

Photocopy the Fraction Wheel for One Complete Day located at Attachment E for each cadet (copy onto a sheet coloured differently from Attachment D).

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for TP1 to orient the cadets to the problems astronauts face sleeping in space.

An in-class activity was chosen for TPs 2 and 3 to allow the cadets to experience some of the factors facing astronauts sleeping in space.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall have discussed sleep patterns in space.

IMPORTANCE

This lesson will introduce the cadets to sleep patterns and how stressors affect astronauts sleeping in space.

Teaching Point 1	Explain sleep patterns in space.
Time: 10 min	Method: Interactive Lecture

SLEEP PATTERNS

Sleep for humans is a recurring state that is characterized by a lack of consciousness, lack of sensory activity and all voluntary muscles are inactive. It is not the same as resting, and awakening is possible, unlike hibernation or a coma. It is also a time that the body rejuvenates its immune, nervous, skeletal and muscular systems.

Sleep has a major impact on overall quality of life and affects how a person looks, feels and performs on a daily basis.

The Effects of Lack of Sleep

Lack of sleep may cause fatigue, daytime sleepiness, clumsiness, weight loss or weight gain and most importantly, deficits in attention and working memory. This can lead to errors in daily routine that can range from forgetting an ingredient while preparing a meal to falling asleep while driving.

For sleep to be effective, the length and soundness of the sleep are critical. To rejuvenate the body, a teenager needs at least 8½ hours, and on average 9¼ hours, a night of uninterrupted sleep. If sleep is interrupted, there is not enough time for the body to complete all of the phases needed for muscle repair, memory consolidation and release of hormones regulating growth and appetite. This affects concentration, decision making, and impedes the ability to participate successfully in school and social activities.

Types of Sleep

Sleep follows a pattern of alternating between REM (rapid eye movement) and NREM (non-rapid eye movement) sleep throughout a typical night in a 90-minute cycle that repeats itself.

NREM sleep takes place during three quarters of the sleep period and is the first step in falling asleep. NREM sleep is the body preparing for REM sleep and in its final stages it starts the body's restoration process. During NREM sleep, the body stabilizes and lowers blood pressure, breathing slows, temperature drops, muscles relax, and hormones are released that are essential for growth and development.

REM sleep takes place approximately 90 minutes after falling asleep and recurs every 90 minutes, getting longer later in the night. It provides energy to the brain, induces rapid eye movement and turns off voluntary muscles. It is the dream state.

Astronauts must sleep while on missions in space, but the excitement of a space mission, the inevitable motion sickness and a zero gravity environment can play havoc with an astronaut's sleep patterns. Without the effects of gravity, an astronaut can sleep in any position as long as they do not move around. Tossing and turning would send an unrestrained astronaut careening all around the cabin.

Astronauts aboard the space station use sleeping bags to restrain their movement when they need to sleep. The sleeping bags are attached to the walls of the space station. Sleep stations are spread throughout the space station.

Due to the cramped living conditions in space, the astronauts are packed into a small area where they can hear each other. Snoring has been documented on one of the missions when a medical doctor was wired to record his sleep patterns.

A circadian rhythm is a daily cycle of biological activity based on a 24-hour period and influenced by regular variations in the environment, such as the alternation of night and day. Circadian rhythms include sleeping and waking in animals, flower closing and opening in angiosperms, and tissue growth and differentiation in fungi.

We are accustomed to the circadian rhythms here on earth with the 24 hour day and night cycle. The International Space Station (ISS) orbits the Earth every 90 minutes so the sun setting cannot be used as an indicator of when to sleep. Astronauts can use a sleep blindfold, but may still be disturbed by the artificial light where they are sleeping. To overcome all of the problems of sleeping in space, astronauts may use sleeping pills to ensure they get an appropriate amount of sleep.

Note: From CSA (2011). CSA Astronaut Robert Thirsk Sleeping in the Japanese Module of the ISS. Retrieved December 7, 2011 from http://www.asc-csa.gc.ca/eng/astronauts/living_sleeping.asp

Figure 1 CSA Astronaut Robert Thirsk sleeping in the Japanese module of the ISS

The astronauts are scheduled for an 8 hour sleep period when each mission "day" comes to an end. The waking and sleeping cycle is an artificial substitute for the day night cycle on earth

Teaching Point 2 **Have the cadets participate in an activity where they measure their current state of alertness.**

Time: 15 min Method: In-Class Activity

ACTIVITY

Time: 15 min

OBJECTIVE

The objective of this activity is to have the cadets test their reaction time when well rested and after a lack of sleep and discuss their findings.

RESOURCES

- Reaction Time Sheet located at Attachment A, and
- Individual ruler located at Attachment B.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Have each cadet assess, on a scale of one to ten, how sleepy they are—with “one” being not sleepy, “five” being somewhat sleepy and “ten” being ready to fall asleep instantly.
2. Divide the cadets into pairs.
3. Distribute copy of Attachment A and a ruler from Attachment B to each cadet.
4. Within each pair, have the first cadet hold a ruler with centimetres (between the thumb and forefinger) vertically at the 30 mark with the 0 mark toward the floor.
5. Have the second cadet position their forefinger and thumb at the 0 end of the ruler without touching it, so that they will be able to grab the ruler easily by closing their finger and thumb together.
6. Have the second cadet observe the ruler carefully and then have the first cadet release the ruler.
7. Have the second cadet close their thumb onto the ruler to stop it as soon as it moves.
8. Have the cadet mark the place where the partner’s fingers were when they stopped the ruler. The cadet should discard the first result if the ruler moved less than five centimetres.
9. Have the cadets repeat the release / catch process 20 times and record and average the results the Reaction Time Sheet.
10. Have the cadets change places and repeat the test.
11. Have the cadets as a class review the average values of the reaction times. Have cadets think about what really is being measured in the activity, and how distance in centimetres reflects reaction times.
12. Have cadets calculate the average value of their reaction times and the average value of their sleepiness scores.

To calculate the average, add the values together and divide the sum by the number of values.

Example: If sleepiness score is a “3” and the average reaction time is ___, add 3 + ___ and divide the sum by ___ (number of values.) Discuss reaction time variance and alertness level.

13. Ask the cadets to identify the normal range of reaction times in their class population.

The cadets will take the ruler and data sheet home for the next two weeks and record their reaction time and calculate their average reaction times during each trial (night and morning).

14. Inform cadets that they will need to ask someone at home to help them with this activity, and suggest that the cadets perform this activity on a Friday or Saturday night so as not to disrupt their weekly routines.

15. Have cadets ask their parent(s) / guardian(s) for permission to stay up one or two hours beyond their normal bed time.

16. Instruct cadets to perform 20 trials of reaction times tests before they go to bed. Inform them that they must be feeling tired and ready to go to bed before doing this exercise. (Ask cadets to evaluate how sleepy they feel using the same scale as in the previous activity.)

17. Direct the cadets to repeat the activity after they have each had a good night’s sleep. (Again, ask them to evaluate how sleepy they feel using the same scale as in the previous activity.)

18. Have the cadets take home a copy of Attachment C Sleep Log Sheet and fill it in over the next 14 days. They will record how many hours they slept by filling in the columns for each day.

Teaching Point 3 — **Conduct an activity where the cadets discuss their sleep patterns from the proceeding two weeks.**

Time: 25 min — Method: In-Class Activity

This activity takes place 14 days after the previous TP.

ACTIVITY

Time: 25 min

OBJECTIVE

The objective of this activity is to have the cadets use the data recorded over the previous two weeks to assemble graphs and a fraction wheel to be used when discussing their sleep patterns.

RESOURCES

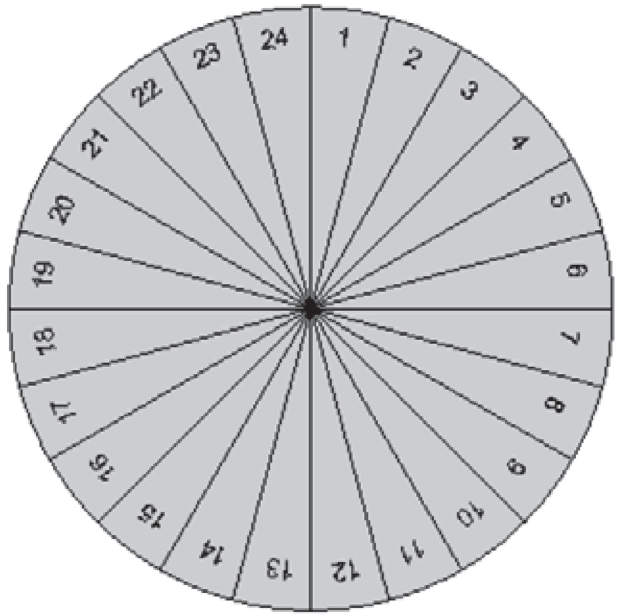
- Sleeping pattern graph,
- Sheet of white paper,
- Sheet of light coloured paper,
- Drawing compass,
- Protractor,
- Different coloured felt tip markers,
- Pair of scissors, and
- Pencil.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Have the cadets discuss their sleep patterns they have recorded on the Reaction Time Sheet located at Attachment A.
2. Have the cadets, cut out the 16 cm diameter circle located at Attachment D out of a piece of white paper. Have them cut one radius line from the edge to the centre.
3. Have the cadets, using felt tip markers, indicate the 24 hours in a day by writing each hour in each segment.

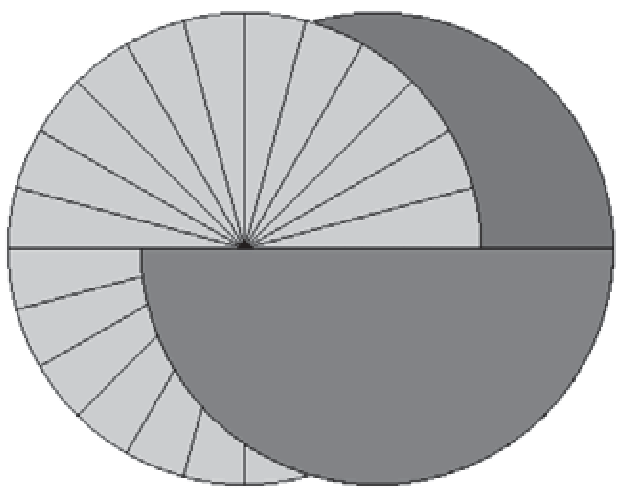


Note. Created by Director Cadets 3, 2011, Ottawa, ON: Department of National Defence.

Figure 2 Hours Indicated on Fraction Wheel

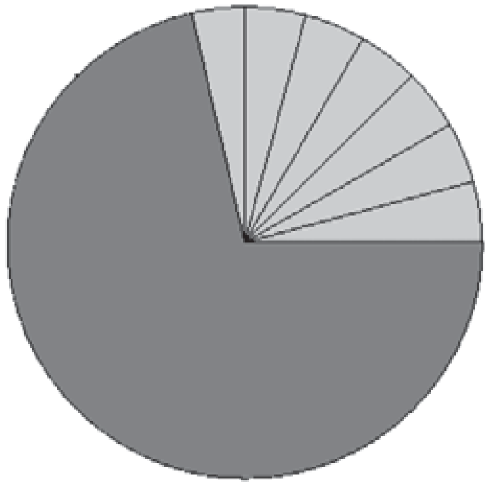
4. Have the cadets cut out the circle located at Attachment E out of a piece different coloured paper. Have them cut the 24 / 1 radius line from the edge to the centre.

5. Have the cadets slide the radius cuts of Attachment D and E together, with the lower numbers on Attachment D visible, so the two pieces make one circle.



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

Figure 3 Fraction Wheel Assembly



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

Figure 4 Fraction Wheel Assembled

6. The Fraction Wheel is used to indicate the fraction of hours slept in a 24 hour period. Rotating circle E will show different amounts of circle D. If circle E represents one, as in the whole of one, then any parts of C showing will be a fraction of E. The circles are based on a 24 hour period, with D representing the 24 hours in one day and E demonstrating one day. Any part of D showing will be the indicated number of hours as a fraction of one day.

7. Ask the cadets to set their Fraction Wheel to the average number of hours of daylight within Earths light dark cycle (12 hours). Write the number as a fraction, 12/24. Have the cadets move their fraction wheels to the average number of hours they slept over the last 14 days.

8. Have the cadets calculate the fraction of the day that they slept on average, on the least amount of sleep day and on the most amount of sleep day.

9. Ask the cadets to compare their fractions and see how many cadets are getting enough sleep.

10. Have the cadets discuss the findings of the experiment.

Use the following questions to stimulate discussion.

Q1. What are some of the environmental constraints that can prevent sleep?

Q2. What can an astronaut do in space to ensure adequate sleep?

Q3. What can lack of sleep cause?

Q4. Where do astronauts sleep on the space station?

SAFETY

Nil.

END OF LESSON CONFIRMATION

The cadets' participation in the activity will serve as the confirmation of this lesson.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Sleep is an important factor in maintaining a healthy and efficient lifestyle. Lack of sleep causes many accidents and slows our day to day efficiency. Astronauts need to adjust to the challenges of sleeping while in space.

INSTRUCTOR NOTES / REMARKS

Nil.

REFERENCES

C3-350 The science of Sleep and Daily Rhythms. (2009). *Sleep Patterns*. Retrieved December 13, 2011, from http://www.nsbri.org/default/Documents/EducationAndTraining/MiddleSchool/Sleep/TSO_Sleep.pdf

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REACTION TIME SHEET

NAME		DATE	

CENTIMETRES WHEN CAUGHT																				
25																				
24																				
23																				
22																				
21																				
20																				
19																				
18																				
17																				
16																				
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6																				
5																				
4																				
3																				
2																				
1																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	ATTEMPTS AT CATCHING THE RULER																			

TIREDNESS	1	2	3	4	5	6	7	8	9	10

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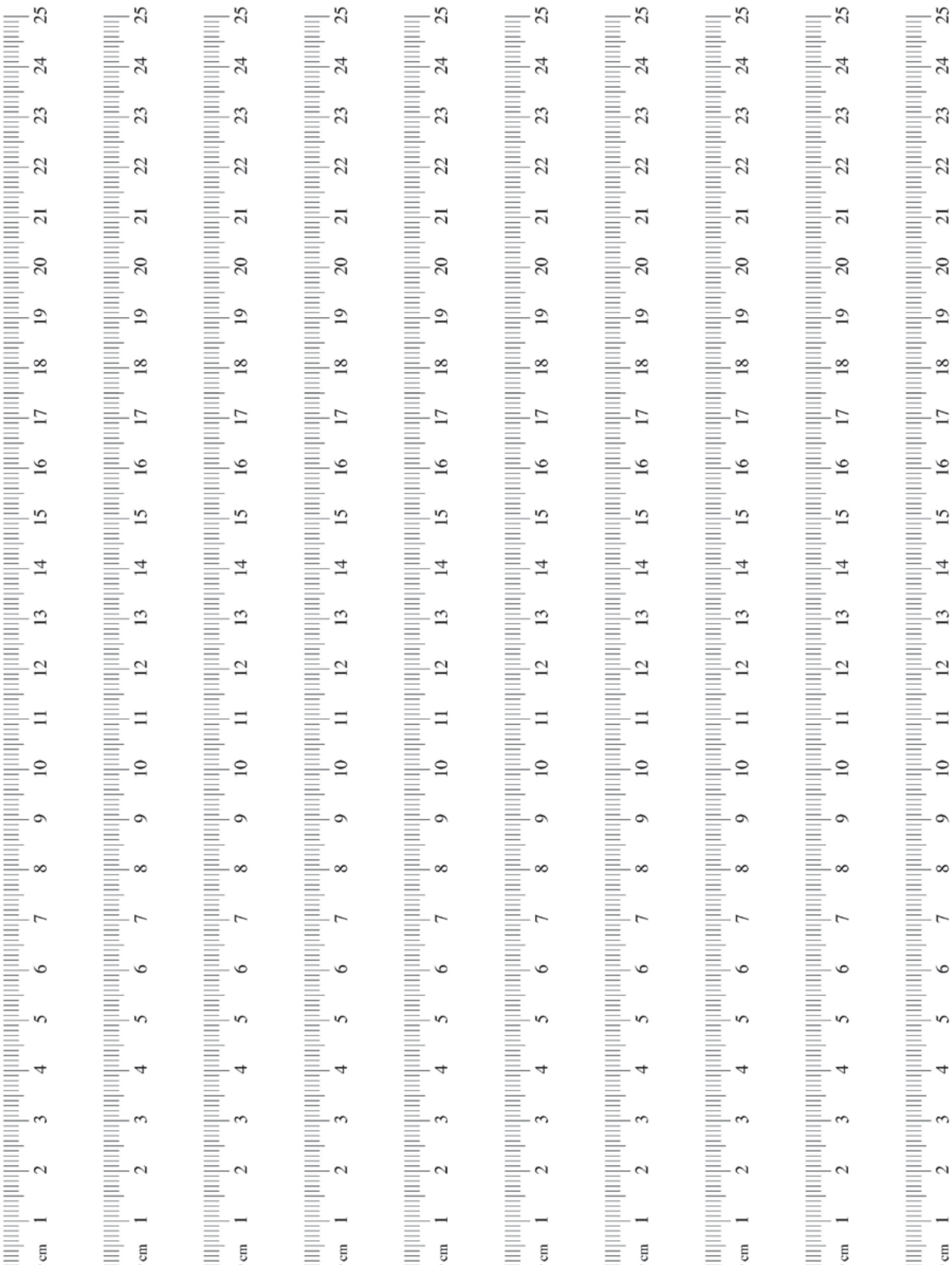
0 cm
1
2
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11
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25

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SLEEP LOG SHEET

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DATE →														
1200A														
0100														
0200														
0300														
0400														
0500														
0600														
0700														
0800														
0900														
1000														
1100														
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1600														
1700														
1800														
1900														
2000														
2100														
2200														
2300														
TOTAL →														

Using the Sleep Log

Colour in the square representing the time you went to sleep and the time you woke up. Only count the hours.

With another colour, fill in the squares between the time you went to sleep and the time you awoke. Fill in any squares where you took a nap. Record the number of hours you slept for each 24 hour period in the TOTAL line.

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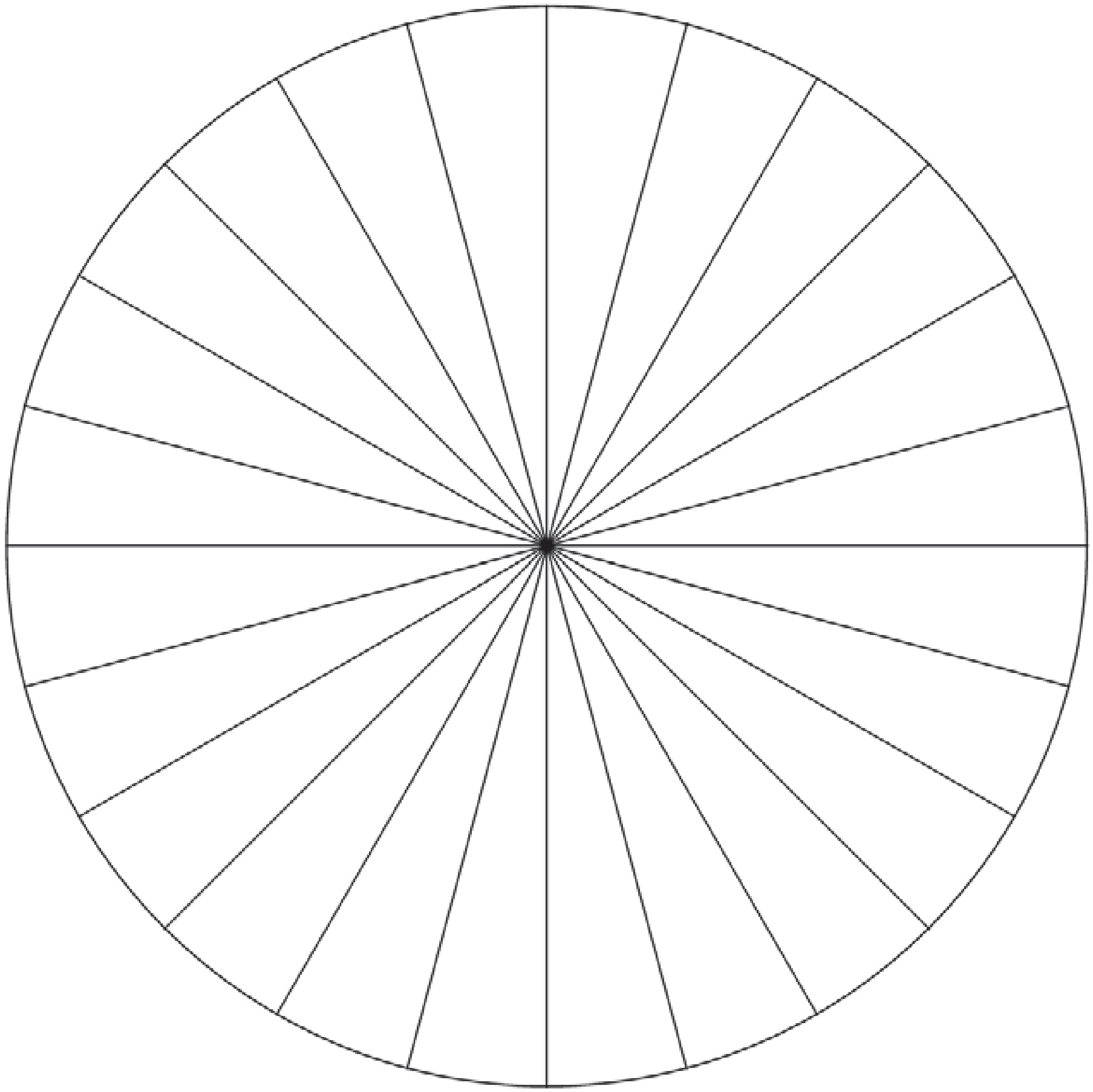
FRACTION WHEEL FOR 24 HOURS



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FRACTION WHEEL FOR ONE COMPLETE DAY