ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL TWO

INSTRUCTIONAL GUIDE

SECTION 6

EO C231.01 – OPERATE AN EXPERIMENTAL WING

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-802/PG-001, 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.

Create slides or copy handouts of Figures A-1 to A-4 for each group.

Gather cardboard boxes suitable for constructing a wind tunnel as described in TP2.

PRE-LESSON ASSIGNMENT

N/A.

APPROACH

An interactive lecture was chosen for TP1 to introduce wind tunnels and give an overview of them.

An in-class activity was chosen for TP2 to TP4 as it is an interactive way to provoke thought and stimulate an interest among cadets.

INTRODUCTION

REVIEW

The review for this lesson is from EO M231.01 (Identify the Four Forces That Act Upon an Aircraft) and will include:

- weight,
- drag,
- thrust, and
- lift.

OBJECTIVES

By the end of this lesson the cadet shall be expected to have helped to assemble a wind tunnel and to have operated an experimental wing in the wind tunnel.

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IMPORTANCE

It is important for cadets to operate an experimental wing so they can experience the change in lift that follows a change in angle of attack.

Teaching point 1 **Identify the Parts of a Wind Tunnel**

Time: 5 min Method: Interactive Lecture

PARTS OF A WIND TUNNEL

Settling Chamber. The purpose of the settling chamber is to straighten the airflow.

Contraction Cone. The contraction cone takes a large volume of low-velocity air and reduces it to a small volume of high-velocity air without creating turbulence.

Test Section. The test section is where the test article and sensors are placed.

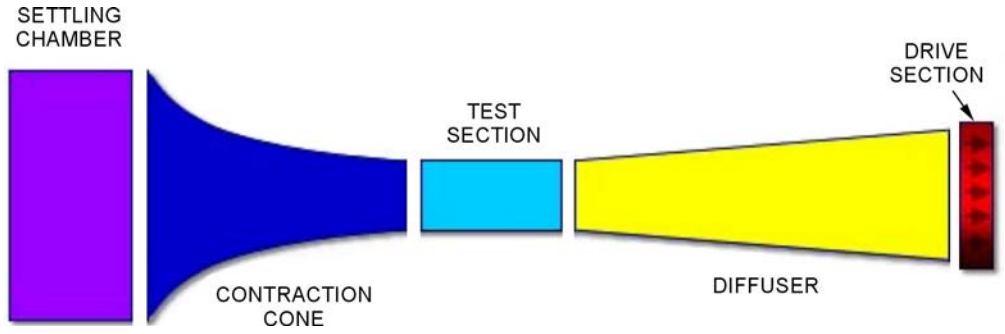
Diffuser. The diffuser slows the speed of airflow in the wind tunnel.

Drive Section. The drive section provides the force that causes the air to move through the wind tunnel.



Show the cadets a slide or handout of the five parts of a wind tunnel shown in Figure A-1.

There are two types of wind tunnels: open-loop and closed-loop. The difference is whether or not the air is re-circulated in the tunnel. The wind tunnel to be built in this lesson is an open-loop wind tunnel.



"NASA's Observatorium", The Parts of a Wind Tunnel. Retrieved 19 March 2007, from http://sln.fi.edu/flights/first/tunnelparts/index.html

Figure 1 A Simple Wind Tunnel



Not every improvised wind tunnel will have a settling chamber, contraction zone and diffuser, but these design elements can each improve the wind tunnel's performance by smoothing airflow.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS

Q1. What is the purpose of a wind tunnel settling chamber?

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Q2. What is the purpose of a wind tunnel diffuser?

Q3. What is the purpose of a wind tunnel contraction cone?

ANTICIPATED ANSWERS

A1. The purpose of the settling chamber is to straighten the airflow.

A2. The diffuser slows the speed of airflow in the wind tunnel.

A3. The contraction cone takes a large volume of low-velocity air and reduces it to a small volume of high-velocity air without creating turbulence.

Teaching point 2 **Assemble a Wind Tunnel**

Time: 15 min Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets, organized in groups but working as a coordinated team, assemble a wind tunnel for flying experimental wings.

RESOURCES

- Cardboard boxes, including two with cardboard separator inserts for packing glass bottles,
- Blank OHP slides,
- Duct tape, and
- Two multi-speed fans.

ACTIVITY LAYOUT

Place a table large enough to hold the wind tunnel and fans in an area that will provide room for groups of no more than four cadets to work comfortably, with access to power for the fans.

ACTIVITY INSTRUCTIONS

Have the cadets make a wind tunnel out of five boxes taped together with all ends open. The wind tunnel should be large enough that both hands will fit into it easily. For both the settling chamber and the drive section, use boxes that include cardboard separators for shipping glass bottles. The cardboard separators will “honeycomb” or straighten the swirling air currents from the electric fan.

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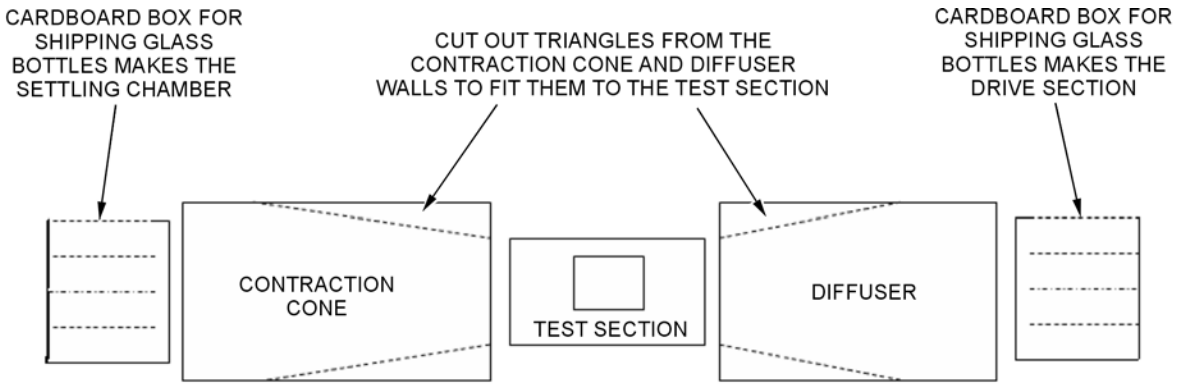

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Figure 2 Parts of a Cardboard Wind Tunnel

The parts of the wind tunnel can be divided between groups of cadets but, when completed, the wind tunnel components must fit together so that each section fits tightly inside the next section.

1. Shape the contraction zone and diffuser sections by cutting out triangles of unwanted cardboard as shown at Figure A-2. Make cuts straight and smooth so the resulting joint can be made airtight.

2. Cut “windows” in the test section and cover over with OHP slide material.

3. Tape all edges and holes airtight and ensure the inside of the wind tunnel is smooth to allow the air to pass through without turbulence. Seal all box joints with duct tape.

4. Place an electric fan so that it blows into the cardboard honeycomb of the settling chamber. The fan must be run at a speed that does not produce unreasonable turbulence, yet fast enough that it pushes a large volume of air through the glass bottle separators. Place another fan at the exit of the drive section facing away from the wind tunnel to pull air from the wind tunnel.

SAFETY

N/A.

CONFIRMATION OF TEACHING POINT 2

The cadets’ participation in the activity will serve as the confirmation of this TP.

Teaching point 3 **Form Airfoil Shapes for Testing in the Wind Tunnel**

Time: 10 min Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets create their own airfoil shapes for testing in the wind tunnel.

RESOURCES

- File folders (letter size),

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- Handout of Figures A-3 and A-4 for each group of cadets,
- Tape, and
- Locally available materials for constructing experimental wings.

ACTIVITY LAYOUT

N/A.

ACTIVITY INSTRUCTIONS

- Divide the class into groups of no more than four, giving each group a file folder and handout of Figures A-3 and .
- If file folders are used to make airfoil shapes, have the cadets bend one cover of the file folder into a curved (cambered) shape and tape it into place as shown in Figure A-3. The airfoil should be pressed into the shape shown in Figure A-4.

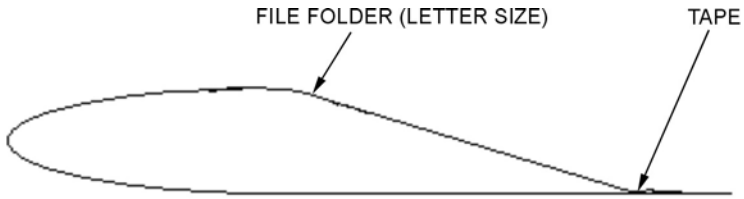

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Figure 3 File Folder Airfoil

SAFETY

If locally available materials, such as balsa wood, knives etc., are used for constructing experimental wings instead of file folder airfoils, ensure safe practices are followed. Careful supervision will prevent unsafe use of materials or unsafe actions.

CONFIRMATION OF TEACHING POINT 3

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

Teaching point 4 **Place Airfoils in the Wind Tunnel and Compare Lift and Drag**

Time: 25 min Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets suspend experimental wings in the operating wind tunnel and make changes in the wing's angle of attack, observing the change in lift.

RESOURCES

- Experimental wings created in TP3,
- String or dental floss, and

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- Stapler.

ACTIVITY LAYOUT

Place the wind tunnel created in TP2 in a location that provides room for groups of no more than four cadets to work comfortably, with access to power for operating the wind tunnel fans.

ACTIVITY INSTRUCTIONS

1. Have the cadets poke tiny holes in the roof and floor of the wind tunnel test section where the trailing edge of the experimental wing will be located.

2. Poke tiny holes in the window walls where the leading edge of the experimental wing will be located.

3. Run dental floss from window wall to window wall of the test section, passing through the interior of the experimental wing to be tested, at the wing's leading edge. This will suspend the experimental wing in the centre of the test section where it can be controlled and viewed.

4. Run dental floss from roof to floor of the test section, attaching the string to the trailing edge of the experimental wing with staples. This will allow the angle of attack to be changed by pulling on the dental floss under the test section to increase the angle of attack, or pulling on the dental floss above the test section to decrease the angle of attack.

5. With two cadets holding the ends of the horizontal string and two cadets holding the ends of the vertical string, turn on the fan.

6. Ask the cadets with the vertical string to increase the angle of attack. The cadets holding the horizontal string will detect an increase in lift.

7. Have the cadets trade positions.

8. Repeat with each group of cadets.

As a concurrent activity, while cadets are waiting for their turn on the wind tunnel, they will improve their experimental wing or develop different shapes for testing.

SAFETY

Ensure the fan has a safety guard around the blade and turn fan off when not testing a wing. Ensure that the fan is not located where a cadet might touch it accidentally during the activity.

CONFIRMATION OF TEACHING POINT 4

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

END OF LESSON CONFIRMATION

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

CONCLUSION

HOMEWORK/READING/PRACTICE

N/A.

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METHOD OF EVALUATION

N/A.

CLOSING STATEMENT

A wind tunnel provides an inexpensive opportunity to test an airfoil design and compare it to other designs, without being exposed to the dangers of a test flight.

INSTRUCTOR NOTES/REMARKS

If room permits, the wind tunnel can be preserved for future use instead of being discarded. If a glider is available from lesson C231.02 (Fly a Paper Colditz Glider) cadets can suspend that in the test chamber and perform control surface experiments with it.

REFERENCES

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C3-093 NASA. (1996). *NASA's Observatorium Teacher's Guide.* Retrieved 12 February 2007, from http://observe.arc.nasa.gov/nasa/aero/tunnel/tunnel_parts.html.

C3-116 A-CR-CCP-263/PT-001/(ISBN 0-9680390-5-7) MacDonald, A. F. & Peppler, I. L. (2000). *From the Ground Up: Millennium Edition.* Ottawa, ON: Aviation Publishers Co. Limited.

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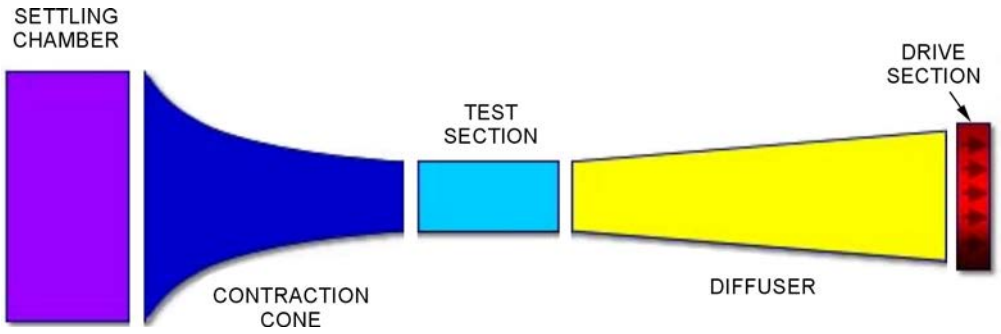
WIND TUNNEL ACTIVITY



"NASA's Observatorium" Wind Tunnel Teacher's Guide. Retrieved 12 February 2007, from http://observe.arc.nasa.gov/nasa/aero/tunnel/tunnel_parts.html

Figure A-1 Parts of a Wind Tunnel

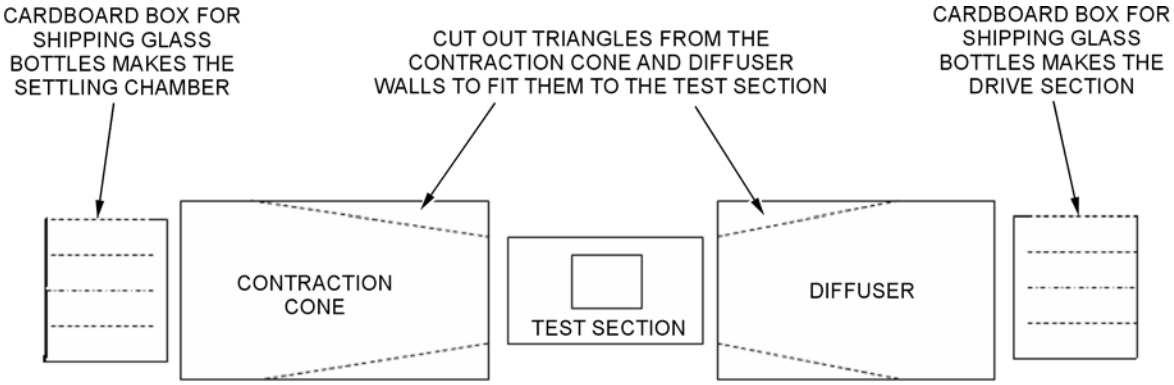


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Figure A-2 Parts of a Cardboard Box Wind Tunnel

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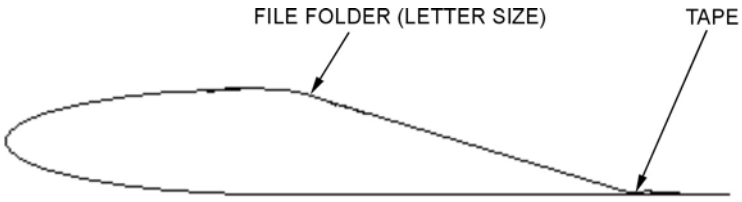

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Figure A-3 File Folder Airfoil



Cadets Canada: RCSU Pacific, 2007, Air Cadet Master Lesson Plans. Retrieved 7 March 2007, from http://www.regions.cadets.ca/pac/aircad/resources/mlp_air_e.asp

Figure A-4 Airfoil Shape

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