ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL TWO

INSTRUCTIONAL GUIDE

SECTION 2

EO M231.02 – DESCRIBE THE PRODUCTION OF LIFT BY AN AIRCRAFT 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 presentation slides or handouts of Figures A-1, A-2, B-1 and C-1.

PRE-LESSON ASSIGNMENT

N/A.

APPROACH

An interactive lecture was chosen for TP1, TP2 and TP4 to introduce the production of lift and give an overview of it.

An in-class activity was chosen for TP3 and TP5 as it is an interactive way to provoke thought and stimulate interest among cadets.

INTRODUCTION

REVIEW

Review for this lesson is from EO M231.01 (The Four Forces That Act Upon an Aircraft). Review the four forces that act upon an aircraft and the condition of equilibrium.

OBJECTIVES

By the end of this lesson the cadet shall be expected to describe the production of lift by an aircraft wing.

IMPORTANCE

It is important for cadets to learn about the production of lift by an aircraft wing so that they can develop an understanding of subsequent and related principles of flight.

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

Teaching point 1 **Explain That Air Acts Like a Fluid Insofar As It Has Inertia, Speed, and Pressure**

Time: 5 min Method: Interactive Lecture

Air follows Newton's laws of motion:

- Newton's first law predicts that air, being a gaseous fluid, tends to remain in motion when it is moving.
- Newton's second law of motion requires that a force must be applied to change the air's motion.
- Newton's third law of motion allows the aircraft wing, by applying a force that changes the motion of air, to develop lift through an opposite and equal reaction.



The fact that air has mass is very important in aviation. Even though air's mass is less than the mass of most solids, its mass is still great enough to allow an aircraft to fly and to allow the aircraft to control its own flight.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS

Q1. How does air follow Newton's first law of motion?

Q2. How does air follow Newton's second law of motion?

Q3. How does air follow Newton's third law of motion?

ANTICIPATED ANSWERS

A1. When in motion, air tends to remain in motion.

A2. When in motion, a force must be applied to change air's motion.

A3. When air's motion is changed, an equal and opposite reaction results.

Teaching point 2 **Introduce Bernoulli's Principle, Which States That a Liquid's Pressure Drops When Its Speed Increases (Venturi Effect)**

Time: 10 min Method: Interactive Lecture

To develop the equal and opposite reaction described by Newton's third law of motion, the wing is given a shape that takes advantage of Bernoulli's Principle to make the air change direction. Air behaves like a fluid since it has pressure and speed. As airspeed increases, its pressure drops. A wing uses Bernoulli's Principle to deflect air, which causes an equal and opposite reaction.



Show the cadets a slide or handout of definitions of Bernoulli's principle shown in Figure A-1.

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.



One part of Bernoulli's Principle that is very useful to remember is that if air speed increases, pressure decreases and if speed decreases, pressure increases. This is an inverse relationship between airspeed and air pressure. This part of Bernoulli's Principle is often referred to as the venturi principle. The shape of the wing is carefully calculated to decrease pressure above while increasing pressure below.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS

Q1. What relationship exists between air speed and air pressure?

Q2. What is the wing's connection between Newton's third law and Bernoulli's Principle?

Q3. What is a wing's shape calculated to do?

ANTICIPATED ANSWERS

A1. An inverse relationship: as speed increases, pressure drops and as speed drops, pressure increases.

A2. A wing uses Bernoulli's Principle to deflect air, which causes an equal and opposite reaction.

A3. A wing's shape is calculated to decrease pressure above while increasing pressure below.

Teaching point 3 **Have the Cadets Explore Bernoulli's Principle**

Time: 10 min Method: In-Class Activity

The pressure of moving air can be examined by blowing gently over a small piece of curved paper. The air does not push the paper down as might be intuitively assumed. Instead, the paper behind the curve rises toward the moving air. This happens because the air pressure drops over the paper due to the air's increased speed – this would seem to match the description of speed/pressure relationship. The curvature in the paper enhances the effect of the lowered air pressure.

A similar effect can be observed when air moves past any object that is light enough to be affected by the drop in air pressure associated with movement. A balloon is light enough to show this effect clearly.



Show the cadets a slide or handout of Figure A-2. Have one half of the class duplicate this paper airfoil activity at their desks while the other half of the class performs the following activity with balloons.

Then, have the groups switch and repeat.

ACTIVITY

Time: 5 min

OBJECTIVE

The objective of this activity is to have the cadets reduce the air pressure over a sheet of paper and observe the results.

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

RESOURCES

- Paper 8 1/2 x 11, and
- Pencil.

ACTIVITY LAYOUT

N/A.

ACTIVITY INSTRUCTIONS

1. Tear a sheet of paper 8 1/2 x 11 vertically, into two pieces.
2. Curve one end of the sheet gently over a pencil as shown in Figure A-2.
3. Blow gently over the paper as shown in Figure A-2.
4. Observe that the paper rises into the moving air.

SAFETY

N/A.

ACTIVITY

Time: 5 min

OBJECTIVE

The objective of this activity is to have the cadets see the action of air pressure.

RESOURCES

- Balloons, and
- String.

ACTIVITY LAYOUT

Hang two long well-inflated balloons at the front of the classroom so they are at shoulder height, hanging 15 centimetres apart. This must be in a draft-free area. The balloons must hang very still so that the effect is clearly visible.

Alternatively, for more visual effect, this can also be done with helium-filled balloons with strings weighted to the floor, floating a metre high.

ACTIVITY INSTRUCTIONS

Have each cadet approach the balloons slowly, one at a time, and blow gently between them. The cadet will observe that the balloons move toward each other, not apart.

If a single balloon is used, the cadet can simply blow beside the balloon and the balloon will move toward the moving air.

SAFETY

N/A.

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

CONFIRMATION OF TEACHING POINT 3

QUESTIONS

Q1. Why does the paper airfoil rise when a cadet blows over it?

Q2. Why do balloons move toward moving air?

Q3. Why was the paper deliberately curved before blowing over it?

ANTICIPATED ANSWERS

A1. Air pressure over the paper drops as the air moves, so the still air below the paper pushes it up.

A2. Moving air pressure is lower, so still air pushes the balloon into the moving air.

A3. The curvature in the paper enhances the effect of the lowered air pressure.

Teaching point 4 **Introduce Angle of Attack**

Time: 5 min Method: Interactive Lecture

An aircraft wing is an airfoil because of its cross-sectional shape. The top surface is curved outward (convex curvature). Therefore, the air flowing over the top has further to go, over the curve, and so it must move faster which, as we know, will result in lower pressure. This happens above the wing.

Below the wing, the air is deliberately slowed to increase its pressure. This is done by curving the surface slightly inward (concave curvature) and by sloping the wing so that it is slightly higher at the front (leading edge) than it is at the back (trailing edge). This angle of the wing's under-surface, which encounters the moving air, is called the wing's angle of attack.



Use a model aircraft to demonstrate to the cadets that the wing's angle of attack increases when the aircraft's nose is raised during flight.



The greater the wing's angle of attack, the more air the under-surface of the wing will encounter, thereby generating more lift. This is a direct relationship between angle of attack and lift.

Increasing the wing's speed will also cause it to encounter more air, thereby generating more lift. This is also a direct relationship between speed and lift.

There is a limit to the amount of lift that can be produced by merely increasing the angle of attack. Long before the wing becomes vertical, it stops generating lift above and this often happens abruptly. The wing "stalls" and stops generating lift when this happens.

CONFIRMATION OF TEACHING POINT 4

QUESTIONS

Q1. Which surface of an aircraft wing is curved outward (convex)?

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

Q2. What shape is often given to the underside of an aircraft wing?

Q3. What happens to air pressure under a wing as angle of attack increases?

ANTICIPATED ANSWERS

A1. The top surface of a wing is curved outward.

A2. A slight inward, or concave, curve is often given to an aircraft wing.

A3. The pressure increases as angle of attack increases.

Teaching point 5 **Have Each Cadet Create and Fly an Airfoil**

Time: 25 min Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets see an airfoil lift itself in a stream of moving air.

RESOURCES

- Index cards,
- Tape,
- Hole punch or sharp pencil,
- Scissors,
- Plastic drinking straw,
- Bamboo skewers or large straightened paper clips,
- Base that the skewers can stick into (Styrofoam or corrugated cardboard), and
- Hairdryer or fan.

ACTIVITY LAYOUT

This activity may take place at the cadets' desks/tables.

ACTIVITY INSTRUCTIONS

Give each cadet an index card to fold into an airfoil shape with mounting holes for the launching skewers. The cadets will:

1. Fold the card in half. Tape the top of the card down to the bottom half of the card so that about 6 mm (1/4 inch) of the bottom shows, leaving the top in a curve and the bottom flat. This will produce a cross-section airfoil shape.

2. Use the hole punch (or a sharp pencil) to put two sets of holes in the thickest part of the airfoil.

3. Cut the straw so you get two pieces 5 cm (2 inches) long. Fit these mini-straws through the holes in the airfoil.

4. Set the airfoil on the base and slip a skewer or unbent paper clip through each of the mini-straws and into the base.

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

5. Use the hairdryer or fan to move air over the airfoil to create lift. Try it both ways—with the flat side of the airfoil on the bottom and with the flat side on the top. Note which position the airfoil is in when it climbs best.

SAFETY

N/A.

CONFIRMATION OF TEACHING POINT 5

The cadet's participation in creating and flying an airfoil will serve as the confirmation of TP5.

END OF LESSON CONFIRMATION

QUESTIONS

Q1. How does the top surface of a wing generate lift?

Q2. How does the under-surface of a wing generate lift?

Q3. What determines how much lift is produced by a wing at a given speed?

ANTICIPATED ANSWERS

A1. The top surface of a wing generates lift by lowering air pressure over the wing.

A2. The under-surface of a wing generates lift by raising air pressure under the wing.

A3. The angle of attack will determine how much lift is produced at a given speed.

CONCLUSION

HOMEWORK/READING/PRACTICE

N/A.

METHOD OF EVALUATION

N/A.

CLOSING STATEMENT

There are other methods of producing lift, such as rocketry, but airfoils are by far the most common, not just because of their elegance, but because they are best suited to prolonged horizontal flight.

INSTRUCTOR NOTES/REMARKS

N/A.

REFERENCES

C3-017 (ISBN 1-895569-23-0) Schmidt, N. (1998). *Fabulous Paper Gliders.* New York, NY: Sterling Publishing.

C3-058 (ISBN 1-4027-3034-9) Schmidt, N. (2005). *Paper Creations Paper Airplanes.* New York, NY: Sterling Publishing.

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

C3-091 (ISBN 1-55652-477-3) Carson, M. K. (2003). *The Wright Brothers for Kids: How They Invented the Airplane.* Chicago, IL: Chicago Review Press.

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

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

PAPER AIRFOIL ACTIVITY

- BERNOULLI'S PRINCIPLE STATES THAT THE TOTAL ENERGY IN A SYSTEM REMAINS CONSTANT.

- A FLUID SYSTEM HAS ENERGY IN THE FORM OF SPEED AND PRESSURE.

- IF SPEED INCREASES, PRESSURE DECREASES AND IF SPEED DECREASES, PRESSURE INCREASES.

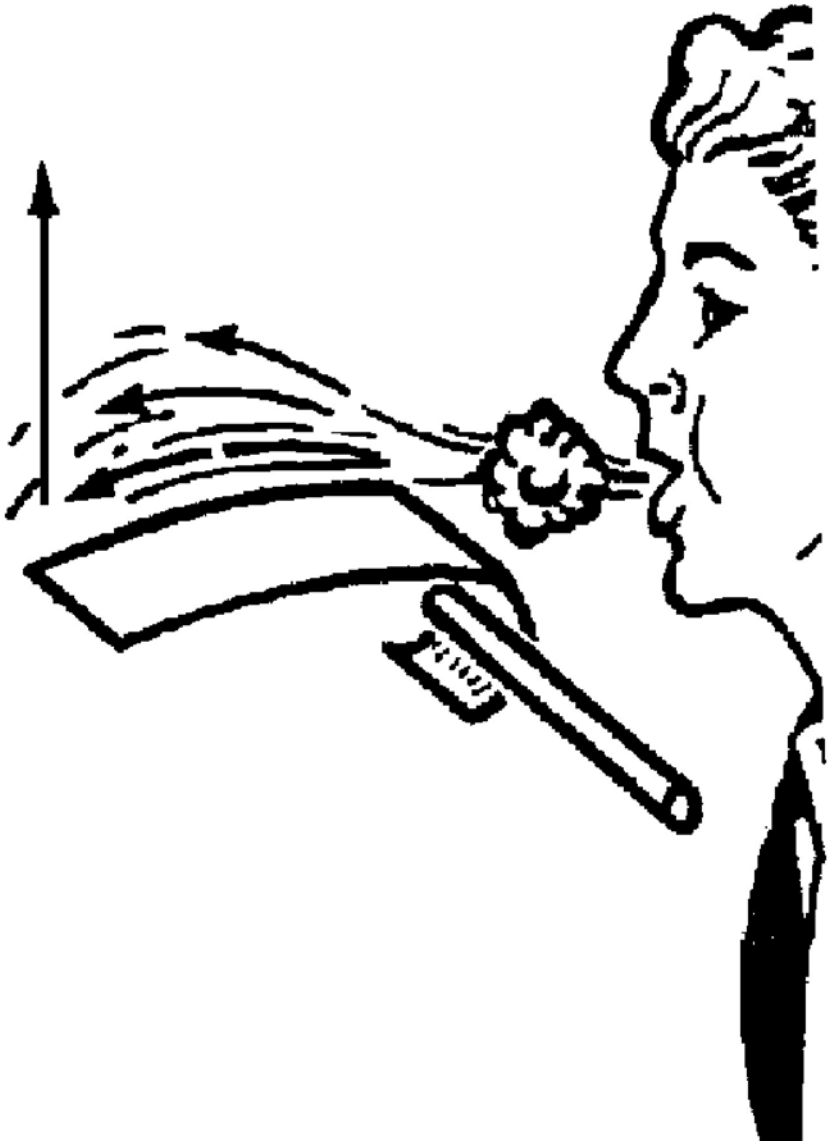


Cadets Canada: RCSU Pacific, 2007, Air Cadet Master Lesson Plans. Retrieved 7 March 2007, from http://www.regions.cadets.ca/pac/aircad/resources/mlp_air_e.asp

Figure A-1 Bernoulli's Principle

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

CREATING LIFT



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-2 Lift

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

AN AIRFOIL SECTION



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 B-1 An Airfoil Section

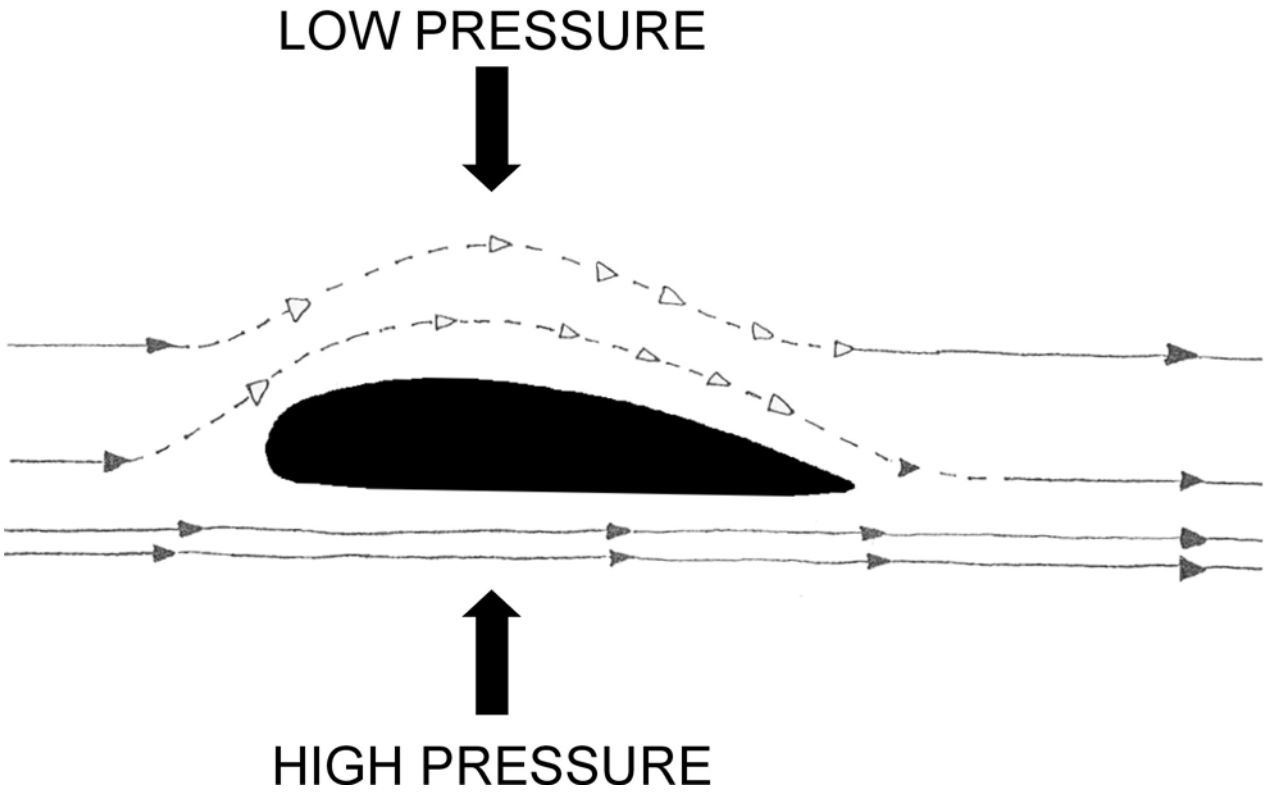
Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

THIS PAGE INTENTIONALLY LEFT BLANK

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

LIFT FROM AN AIRFOIL

LIFT PRODUCTION



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 C-1 Lift from an Airfoil

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.

THIS PAGE INTENTIONALLY LEFT BLANK

Unofficial convenience copy of A-CR-CCP-802/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-802-PF-001/A-CR-CCP-802-PF-001.pdf.
Verify against the official publication.