3D Educational Resources

Photo: Canada Aviation and Space Museum, Image Bank, CAVM 12001, 14755.

LEARN ABOUT FLIGHT

In this activity, you and your students will explore some basic concepts of flight using 3D models of planes used in the First World War.

ONTARIO CURRICULUM LINKS

Through this activity, your students will learn about the four forces of flight—lift, thrust, weight and drag—by examining 3D models of airplanes from the First World War. This activity can be connected to multiple aspects of the Ontario School Curriculum, our suggested link is:

- Grade 6 Science (Flight)

MATERIALS

1 - 3D model files of First World War planes (.obj files)
1 - Computer and a program for viewing the files*
1 - Data projector

* Note: There are many programs available for free download to view the .obj files. Some examples include Open 3D model viewer (www.open3mod.com/ for PC only) and Autodesk 123D Design (www.123dapp.com/design for PC, Mac and iPad).

Grades
5 – 9

Age Range
10 – 15 years

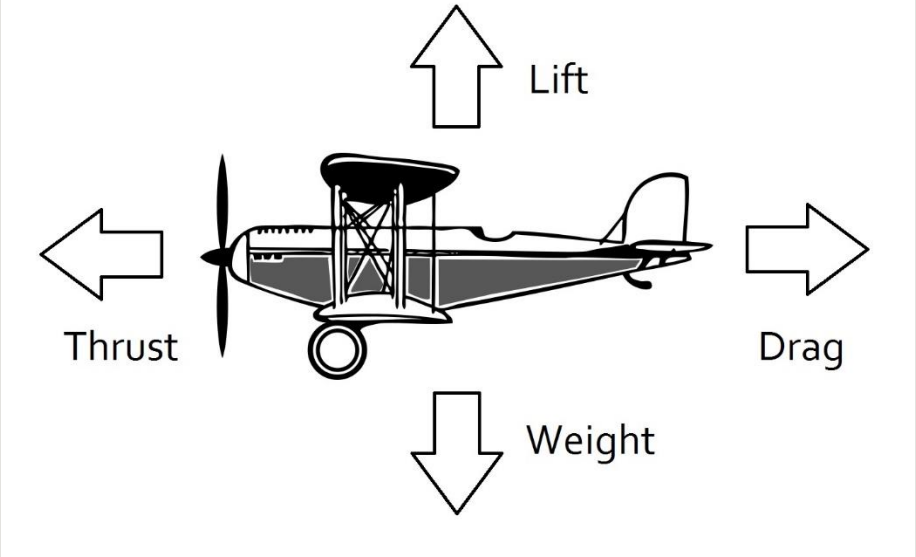
INSTRUCTIONS

In this activity, you will be showing your students the 3D models of airplanes using a computer and a data projector. This activity can also be done by having the students view the models on their own computers or tablets, or with devices such as Google Cardboard.

1. Explain the four main forces of flight—lift, thrust, weight and drag—and how they affect flight.
2. Show your students the various models of aircraft. Ask how they think the four forces act upon these planes. Background information on flight is provided in the Scientific Explanation section below, but you could begin by highlighting some of the following:
    a. Lift is mainly provided by the wings.
    b. Thrust is provided by the propeller.
    c. Weight is due to how heavy the plane is.
    d. Drag depends on the shape of the plane—specifically, how smoothly air can pass across it (i.e., how aerodynamic the plane is).
3. Ask your students to compare the various airplane models. How do they think design differences might affect the four forces? How would this affect a plane's operation? Some specific points to highlight:
    a. Most of the planes used in this activity are biplanes, meaning that they have two wings, stacked on top of one another. By contrast, the Sopwith Triplane is a triplane and has three wings stacked on top of one another. The Nieuport 12 is a sesquiplane which means that it has two wings, but one of them is smaller than the other (in this case the bottom wing is smaller).
    b. The Sopwith Triplane, with its three wings, produces more lift when compared to many biplanes. The additional wings (and support structure) also creates a small amount of additional drag.
    c. The Nieuport 12, due to its smaller bottom wing, creates less drag.
    d. The A.E.G. G.IV is the heaviest plane among the six seen in this activity. Thus, compared to the other planes, the force of weight is the greatest. To compensate for this, it has longer, wider wings.
4. Ask your students what improvements they would make to each plane and why.

SCIENTIFIC EXPLANATION

There are four main forces that act on a plane: lift, weight, drag and thrust.



Lift is the force that pushes an airplane upwards, and must be greater than the force of weight for a plane to fly. Lift is generated primarily by a plane's wings.

One way to explain this process is through the work of mathematician and physicist Daniel Bernoulli. The Bernoulli Effect is often cited as the reason airplane wings provide lift. If you look at a typical wing, you will notice that it is curved on the top. This shape causes the air passing over the top of the wing to move faster than the air on the underside. From the Bernoulli Effect we know that faster moving air has a lower pressure. The air on top of the wing thus has a lower pressure than the air on the underside, creating lift.

Another way to explain lift is through Newton's Laws of Motion. The shape of the wing causes the air passing over the top of the wing to be turned, or directed, downward. From Newton's Second Law of Motion, we know that a force is needed to cause this turning—in this case, a downward force caused by the wing on the air. From Newton's Third Law of Motion, we know that every action has an equal and opposite reaction. In this case, the "opposite reaction" to the downward force exerted by the wing on the air is an upward force by the air on the

wing. This upward force is what causes lift. The Newton and Bernoulli explanations essentially describe the same phenomenon, but in different terms.

Weight is the downward force on an airplane and is due to gravity. The heavier the plane, the greater the downward force. Weight is the force that opposes lift.

Drag is the force that works against thrust, and is caused by the interaction between an airplane and the air. A plane that has greater contact with the air (i.e., one that is less aerodynamic), will produce more drag. The difference in velocity between the plane and the surrounding air will also increase drag. In a situation where the air itself is not moving, the faster a plane moves, the more drag there is.

Thrust is the force that pushes an airplane forward, and is generated by the plane's engine and a propulsion system, such as a propeller. Each plane in this activity uses an engine to spin a propeller, providing thrust. The movement of the plane's propeller causes the air in front of the propeller to have a lower pressure than the air behind it, creating thrust and causing the plane to move forward.

When all of these forces are balanced, an airplane will not be in motion. It is only when the four forces are not in balance that a plane can move. For example, during take-off, the forces of lift and thrust are greater than the forces of weight and drag.

Ingenium – Canada's Museums of Science and Innovation has more than 110 000 artifacts in its collection, including many different First World War planes. You can explore other objects in the collection at: ingeniumcanada.org/ingenium/collection-research/collection.php.