

# Lesson 1: Finding the Center of Gravity Using Rulers

## Grades K–4

### Objectives

- To discover the center of gravity (c.g.) by balancing a cardstock shape (two-dimensional model) of an F-15 ACTIVE on a ruler both longitudinally and laterally.
- To demonstrate balance (state of equilibrium) by suspending a cardboard shape of an F-15 ACTIVE from a string at the center of gravity (c.g.).

### Science Standards

Scientific Enterprise  
Science and Technology  
Science as Inquiry  
Physical Science  
    Position and Motion of Objects  
    Change, Constancy, and Measurement  
    Evidence, Models, and Explanation

### Science Process Skills

Observing  
Communicating  
Measuring  
Collecting Data  
Inferring  
Predicting  
Hypothesizing  
Investigating

### Mathematical Standards

Problem Solving  
Communication  
Reasoning  
Measuring

### Management

This lesson may be a whole class lesson. For kindergarten and first grade students, the teacher may demonstrate using one cardstock model of an F-15 ACTIVE. Students in grades 2-4 may each have their own cardstock model or work in small groups of two to four sharing a cardstock model.

This lesson is divided into two parts. In part 1, students draw longitudinal and lateral axes to find the center of gravity. In part 2, students may need help to suspend models. The models are needed for lesson 3, and part 2 may be postponed until lesson 3 is scheduled. Allow approximately 30 to 45 minutes to complete.

The center of gravity is the average location of the weight of the aircraft. The mass and weight are distributed throughout the airplane.

### Part 1

#### Materials and Tools

- Cardstock F-15 ACTIVEs (see page 21) for each student or group
- Ruler for each group
- Crayon
- Masking tape
- Scissors

#### Preparation

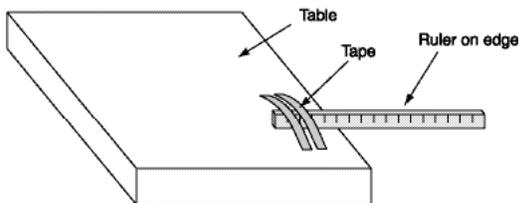
Teacher uses the pattern to trace and cut out F-15 ACTIVE models from light cardstock (see page 21). If students are capable, they can cut out their own models.

#### Procedure

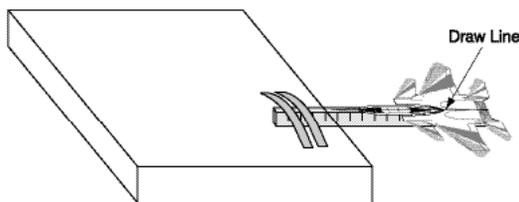
1. Ask students what they know about the F-15. (It is a highly maneuverable fighter capable of achieving Mach 2 and high altitudes. Explain that the F-15 ACTIVE was a special one-of-a-kind airplane flown by NASA and U.S. Air Force research pilots for research purposes.)
2. Bring out a cardstock F-15 ACTIVE model. Balance it flat on your finger or fist. Ask the students if they think they could balance it too. If using one model to demonstrate, give several students a chance to balance it, or distribute the cardstock F-15 ACTIVEs. Allow time for experimentation.



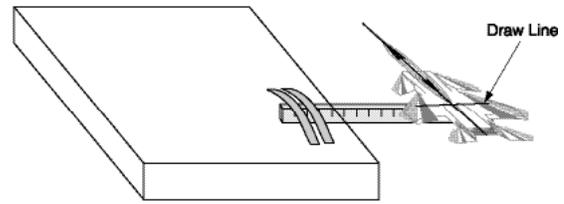
3. Tell students that NASA engineers need to know the exact place to balance the real airplane, just as they balanced their model airplanes. This place is called the center of gravity (c.g.). Balance an F-15 ACTIVE model on your finger. Tell students this is a stable position—it wobbles back and forth, but doesn't fall. It will come back to a stable, balanced position. Tell them NASA engineers use science and mathematics to find the center of gravity (c.g.), and they can do it too.
4. Tell students they will balance the F-15 ACTIVE models on the edge of a ruler instead of on their fingers. Demonstrate how to position the ruler on the edge of a table and tape it in place with masking tape.
5. Most of the ruler's length should extend past the edge of the table.
6. Demonstrate how to balance the cardstock F-15 ACTIVE on the ruler in a longitudinal direction. Draw a line down the middle of the F-15 ACTIVE with a crayon.



7. Demonstrate how to balance the F-15 ACTIVE on the ruler in a lateral direction. Draw a line.



8. The point of intersection of the two lines is the center of gravity (c.g.).

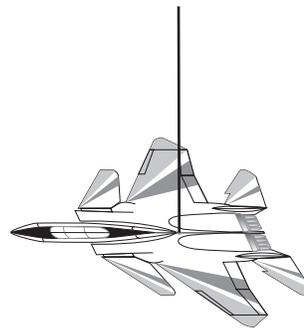


9. Distribute tape and rulers to each group. Students will tape the ruler to a desk and take turns helping each other balance and hold the F-15 ACTIVE steady so lines may be drawn. This could be a learning center with an adult helper. Save F-15 ACTIVE for part 2.

## Part 2

### Materials and Tools

- Cardstock F-15 ACTIVE from part 1
- Crayons
- Needle and string for teacher
- Paper clips
- Ceiling hooks
- Meter sticks or rulers



## Procedures

1. Allow students to color their F-15 ACTIVEs using the colors of red, white and blue. Use the Exploring the Extreme poster as a color guide or look on-line at [www.spacelink.nasa.gov](http://www.spacelink.nasa.gov). Teacher punches a small hole in each F-15 ACTIVE at the center of gravity with the needle and thread.
2. Tie a large knot on the bottom of the string. The knot must be larger than the hole.
3. Hang from ceiling using paper-clip hooks or suspend from meter stick/ruler, which will be held by the teacher or partner. Save F-15s for lesson 3.

## Assessment

1. Conduct a class discussion where students demonstrate their understanding of:
  - Balance
  - Stability
  - Center of gravity
2. Ask students to predict what they think might happen if the teacher pushes the F-15 ACTIVE in:
  - A forward direction
  - A sideways direction
3. Push the F-15 ACTIVE and allow it to swing back to a resting position. Discuss the action in terms of balance and stability. Compare the push to a pilot flying (controlling) the airplane and the airplane being designed to return to a stable position. The F-15 ACTIVE uses computers to integrate the control surfaces and the vectored thrust so that the plane is stable.

## Management

In part 1, students may work individually or in pairs using their F-15 ACTIVE models from lesson 1 or lesson 2. Using just one suspended cardstock F-15 ACTIVE model, the teacher may demonstrate part 1.

In part 2, students working in pairs or groups of three will be able to help each other. Allow 20–30 minutes for part 1, and 45 minutes for part 2.

## Description

Students discover the center of gravity of a cardstock shape of an F-15 ACTIVE using plumb lines and suspend the F-15 ACTIVE from a string.

## Materials and Tools

- Cardboard F-15 ACTIVEs
- String for each group, 18 inches (45.72 centimeters)
- Hole punch for each group
- 2 pushpins
- Paper clip for each group
- Ruler for each group



**Drawing of F-15 ACTIVE**  
(Teachers, copy this page on to cardstock.)

