

## Lesson 2: Finding the Center of Gravity Using Plumb Lines

### Grades 3–4

#### Objectives

- To discover the center of gravity (c.g.) of a cardstock shape (two-dimensional model) of an F-15 ACTIVE using plumb line.
- To demonstrate balance (state of equilibrium) by suspending a cardstock shape of an F-15 ACTIVE from a string at the center of gravity.

#### 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  
Investigating  
Predicting  
Controlling Variables

#### Mathematical Standards

Problem Solving  
Communicating  
Reasoning  
Measuring  
Functions and Patterns



## Preparation

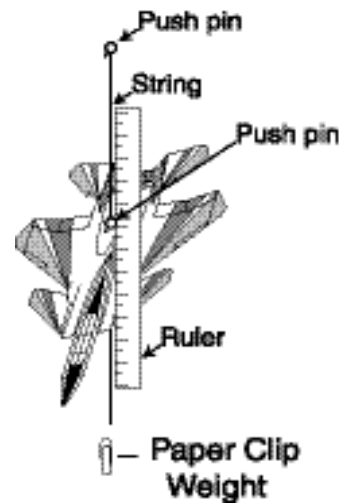
Use the pattern of the F-15 ACTIVE to trace and cut out cardboard shapes. Older students can do the cutting.

### Part 1

1. Introduce the F-15 ACTIVE
  - Ask students what they know about the F-15 ACTIVE. (A highly maneuverable fighter capable of achieving over Mach 2 and altitudes of 60,000 feet.) Bring out one of the cardstock F-15 ACTIVEs. Explain this as an F-15 ACTIVE, a special one-of-a-kind airplane flown by NASA test pilots for research purposes.
  - Balance it flat on your finger. Ask the students if they think they could do the same if they had an F-15 ACTIVE. Challenge students.
  - Distribute cardboard F-15 ACTIVEs or distribute materials so students can cut out the F-15 ACTIVEs.
  - Allow time for exploration as students will want to fly their airplanes.
  - Tell students that NASA engineers need to know the exact place to balance the F-15 ACTIVE just as the students did when they balanced the models on their fingers.
  - Tell them NASA engineers use mathematics to find the center of gravity, and they can, too.
  - Students will do each step in small groups, or teacher may demonstrate.

## Procedure

1. Attach the paper clip weight to one end of a string.



2. Attach the string and paper clip weight to a wall with a pushpin. This is the plumb line.
3. Punch one hole anywhere on the F-15 ACTIVE.
4. Put the other pushpin through the hole, and let the F-15 ACTIVE dangle from the pin until it settles in a stable position.
5. Put the pushpin (and hanging F-15 ACTIVE) right on the plumb line.
6. Use a ruler to draw a line on the F-15 ACTIVE, following path of the plumb line.
7. Repeat steps 3, 4, 5, and 6 once or twice. Take turns.
8. Where the lines intersect is the center of gravity.



## Part 2

Have the students color their F-15 ACTIVEs and punch a small hole in each F-15 ACTIVE at the marked center of gravity with a needle and thread. Tie a large knot at the bottom. Hang from the ceiling using paperclips or hooks. Hang the F-15 ACTIVEs low enough so that students can use them to complete 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.

### Extensions

Use other shapes to find center of gravity. For example: initials, outlines of states, birds.

