Lesson 3: Changing the Center of Gravity Using Moment Arms
Grades 3–4

Objectives
- To discover that the center of gravity (c.g.) can be changed by adding weights to the balanced F-15 ACTIVE model.
- To calculate moment arms using weights on a yardstick.

Science Standards
Unifying Concepts and Processes in Science
Science as Inquiry
Physical Science
Positions and Motion of Objects
Science and Technology
Science in Personal and Social Perspectives
History and Nature of Science

Science Process Skills
Observing
Communicating
Measuring
Investigating
Predicting
Collecting Data
Inferring
Hypothesizing

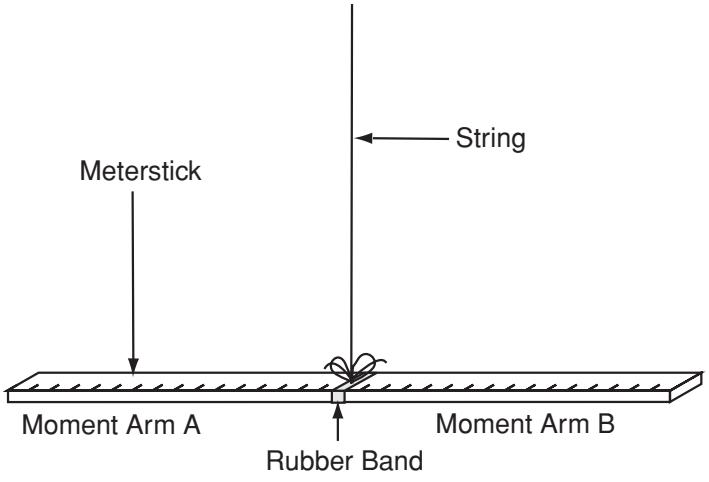
Mathematical Standards
Problem Solving
Communicating
Reasoning
Computing and Estimating
Measuring
Functions

Management
In part 1, students may work individually or in pairs. 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 can be changed by adding paper clips to the balanced F-15 ACTIVE cardboard model.

Students calculate the moment arm using a balanced yardstick, adding weights at measured differences.

Materials and Tools
For each group:
- Yardstick
- Rubber band
- String
- Cellophane tape or masking tape
- Ruler
- Weights:
  -Government Standard weight set (1, 2, 3 grams) or
  -Fishing sinkers of known weigh (1, 2, 3 ounces) or
  -Fishing sinkers all one size per group
- Copy of chart for each student



Preparation

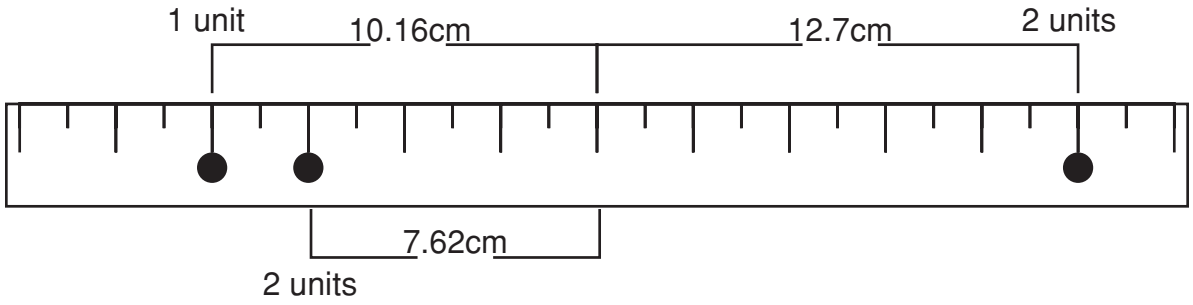
The teacher may want to arrange the hanging yardsticks before class time. Each group will use a suspended yardstick. Wrap a rubber band around each yardstick. Tie a string to the rubber band to suspend the yardstick. Move the rubber band until the yardstick is balanced. Rubber band is at the 0 point and measurements will be made in both directions, called arms, starting at this point. Explain that moment is equal to weight x moment arm (distance). Calculate moments for tests 1-4.

1. Tell students to place a 1-unit weight 2 inches (5.08 cm) from the 0 point. They should tape it to the yardstick. Suspend the yardstick. It will be unbalanced. Tell students to find out how much weight needs to be placed at 1 inch (2.54 cm) from the 0 point on the other side to make the yardstick balance. Record the answer on chart. *(2 units weight)*
   Discussion: Ask if the larger weight is closer or farther away from 0 point. Will this always be true? *(Yes, the larger weight is always closer to the 0 point*.)
2. Tell students to put 2 units of weight at 6 inches (15.24 cm) from the 0 point. Ask them to find what weight needs to be added at 4 inches (10.16 cm) from the 0 point on the other side. Record the answer. *(3 units weight)*
   Discussion: The distance the weight is from the 0 point is called the moment arm. One side is called weight A on moment arm A and the other side is weight B on moment arm B. Look at chart.
3. Tell the students to put 3 units of weight 4 inches (10.16 cm) from 0 point. (3 units weight at 4 inches or 10.16cm moment arm.) Ask where they could put a 1-unit weight to make the yardstick balance. Record the answer. (*12 units*)
4. Put 2 units of weight on one side to make the yardstick balance. It will be easier if students use even measurements. Record the answer.
   Discussion: Ask if students notice a connection between moments A and B.
   - How do you find moment?
   - What is the difference between moment and moment arm?
5. Let students experiment with weights to get other moments.
   Enrichment: Challenge students to add weights to two different spots on the same side.
   Weight A1 x Moment arm1 + Weight A2 x Moment arm2 =
   Weight B x Moment arm B
   1 x 4 + 2 x 3 = 2 x 5

Assessment

Discussion and Student Sheet

A	B
1. 1 x 2 = 2	1. 2 x 1 = 2
2. 2 x 6 = 12	2. 3 x 4 = 12
3. 3 x 4 = 12	3. 1 x 12 = 12
4. 2 x 3 = 6	4. 3 x 2 = 6 (possible answer)
5. 2 x 6 = 12	5. 3 x 4 = 12 (possible answer)
6. 2 x 9 = 18	6. 3 x 6 = 18 (possible answer)



Name: _____
Date: _____

Moment Student Work Sheet

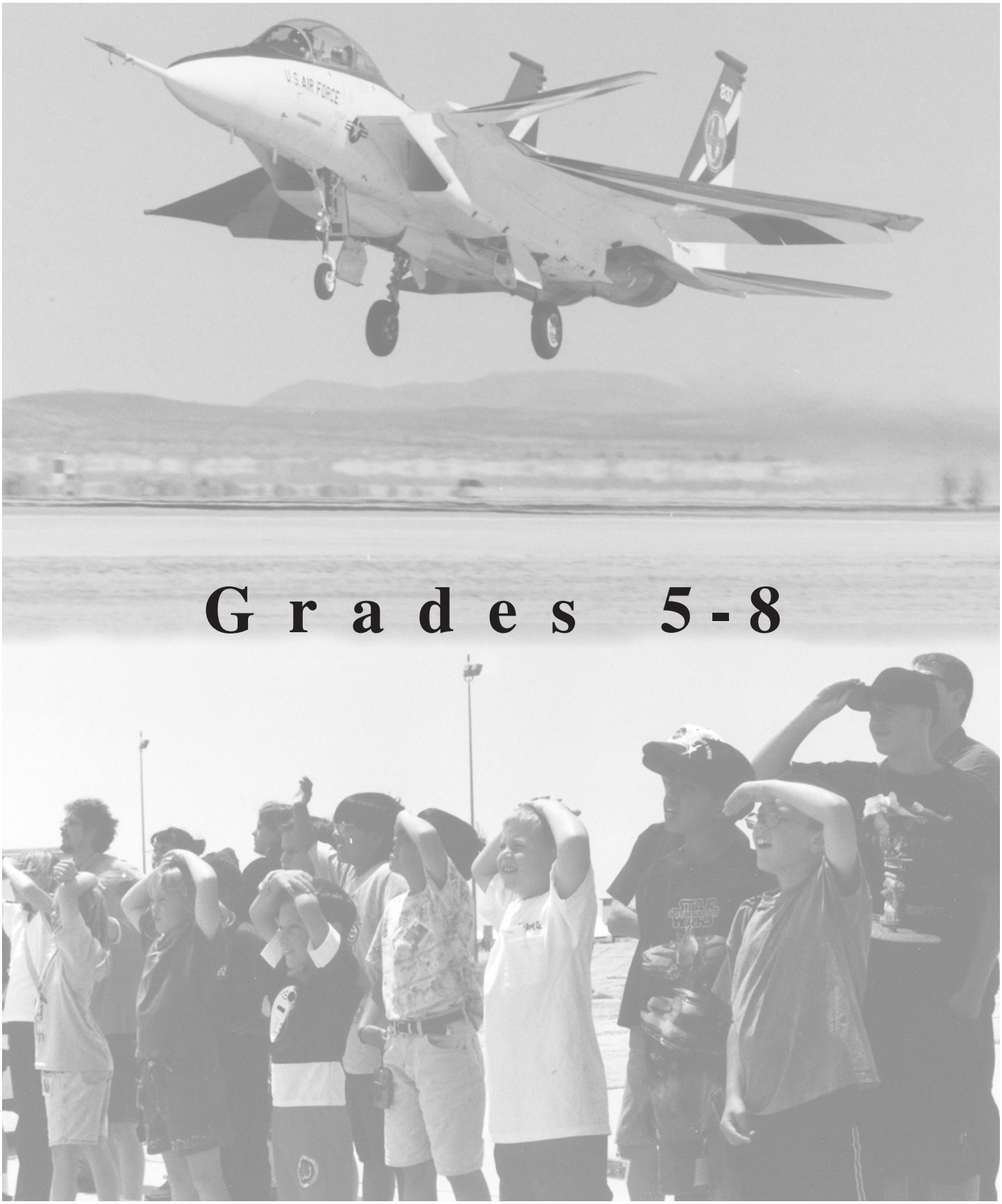
Test #	Weight A (Grams)	Distance A (Moment Arm A, Centimeter)	Moment A (Grams centimeter)	Weight B (Grams)	Distance B (Moment Arm B, centimeter)	Moment B (Grams centimeter)
#1	28.35g	5.08cm		56.7g	2.54cm	
#2	56.7g	15.24cm		85.05g	5.08cm	
#3	85.05g	10.16cm		28.35g	30.48cm	
#4	56.7g	7.62cm				
#5						
#6						
#7						

Name: _____
Date: _____

Enrichment

Calculate these moments. Use calculators if appropriate.

Item	Weight (Kilograms)	Moment Arm (Meters)	Moment Kilograms
Fuel in tank 1	4409.2 (9720 lbs.)	32.808 (1291 in.)	
Fuel in tank 2	2204.6 (4860 lbs.)	16.404 (645 in.)	
Fuel in tank 3	3306.9 (7290 lbs.)	13.1232 (516 in.)	
Fuel in tank 4	2204.6 (4860 lbs.)	26.2464 (1033 in.)	
Instruments	209.437 (461 lbs.)	9.8424 (387 in.)	
Pilot (Student Weight)		16.404 (645 in.)	



Grades 5-8