2004 Transportation Education Academy Activity:

Title: Calculations and Transportation Support Systems for a Cargo Jet

Education Level: This transportation activity is designed for high school, grades 10-12.

Time to Complete: Estimated completion for the labs and the construction of a model will be 8 hours.

Standards Being Met: At the completion of this course, the student will meet the following Standards for Technological Literacy:

1. Number 9, Engineering Design
2. Number 10, The Role of Troubleshooting, Research and Development, Invention, Innovation, and Experimentation in Problem Solving
3. Number 11, Apply Design Processes
4. Number 18, Transportation Technologies

Brief Description: This activity is designed to give students an understanding of how weight affects flight, and what transportation systems are required to complement the air transport system.

Objectives: At the completion of this activity, the student will be able to:

1. Calculate torque and understand the effects of weight on flight.
2. Design and construct a model airplane.
3. Develop and understand an intermodal system.

Group Size: This activity will be completed in groups of five students.

Background Information:

The instructor should provide an explanation for the formula on torque and how to derive the balance point of an airplane. Students will use a fulcrum to visually see the effects of weight.

The instructor should also provide information on the different types of material handling and transportation systems. Visuals will be provided for the students:




Supplies, Tools, Materials Needed: The following materials will be need for this activity:

1. A hand held calculator
2. Pencil and paper for making calculations
3. A wooden pendulum
4. Two different weights for each group
5. Balsa model airplane for each group
6. Visuals of transportation modes

Safety Precautions: The following are a list of safety procedures:

1. Make sure to cut away from hands when cutting with utility knives.
2. No disruptive behavior.
3. Students will be required to be respectful of other students when using tools and materials.
4. Instructor will review all SRDS sheets for hazards.
5. No inappropriate use of materials.

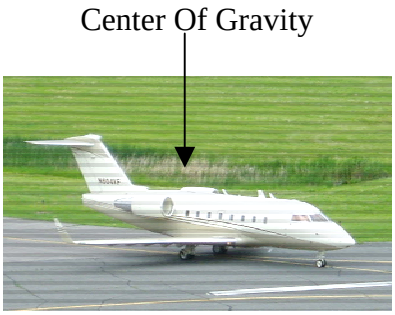
Procedure:

1. Students will break into groups of five. Students will assist each other in deriving the answers. Instructor will provide clarification to groups as needed.
2. Groups will determine torque and the fulcrum point, from the following explanation:

"Gravity always acts downward on every object on earth. Gravity multiplied by the object's mass, produces a force called weight. Although the force of an object's weight acts downward on every particle of the object, it is usually considered to act as a single force through its balance point, or center of gravity. If the object has its weight distributed equally throughout, its balance point is located at its geometric center. If the object has unequal weight distribution, its balance point or its center of gravity may not be at its geometric center.

The force that opposes the force of weight of an aircraft is called lift. The lift force must be greater than the weight force in order for an airplane to fly.

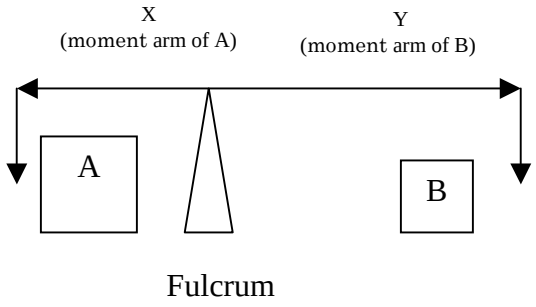
For aircraft, it is important that the location of the center of gravity fall within the limits specified by the design of the aircraft. If it falls outside these limits, it will have adverse effects on how the airplane will fly.



Force acting on a body some distance from the center of gravity or fulcrum causes a torque from the center of gravity. Its formula is:

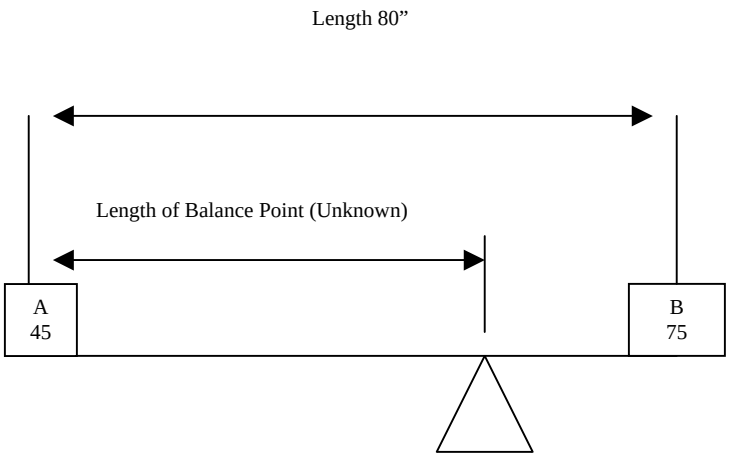
Torque = force x distance from fulcrum (moment arm)

The force is always acting perpendicular to the moment arm. In the diagram below, the force (item **A**) is at a distance or moment arm (**X**) from the fulcrum or pivot point, while the force (item **B**) is at distance **Y** from the fulcrum. If the system shown is balanced, then the product of **A** and **X** must equal the product of **B** and **Y**:



The product of force **A** and its distance from the pivot point (**X**) produces a counterclockwise torque when it is greater than the product of force **B** and its moment arm **Y**. When the products are equal, the force is balanced along the plane. Any downward torque in front of the plane's center of gravity is considered a negative value, having a negative force, while downward torque behind the plane's center of gravity is considered to be a positive value with a positive moment arm.

Finding the balance point: Students are given the following setup, where the length of weightless beam is 80 inches long. To find the balance point (or fulcrum) of this system, we first must set up an arbitrary zero reference point. This can be located anywhere on the line of the beam. For this example, we will choose the zero reference point to be at A.



Item	Weight	Arm Length	Moment
A	45	0	0
B	75	80	6000
Total	120		
Balance Point		50	

Figure 1

Constructing the chart in Figure 1: Item A has a weight of 45 pounds. Since the zero reference point was selected at A, its arm length is 0. Zero times 45 is 0, so A's torque or moment is zero. B weighs 75 pounds and its arm length is 80 inches. Since 80 times 75 equals 6000 inches-pounds, B has a torque of 6000 inches-pounds. The total weight is 120 pounds and the total moment 6000 inches-pounds. The balance point is found by dividing the total moment by the total weight. This value is 50 inches located to the right of point A or since 80 - 50 = 30, it is also 30 inches to the left of B.

The moment arm of A would be negative; therefore
A's torque = force x distance = 45 pounds x -50 inches = -2250 inches-pounds

B's torque = force x distance = 75 pounds x 30 inches = 2250 inches -pounds

Since the counterclockwise torque (-2250) and the clockwise torque (2250) sum to zero, the beam will balance at the point located 50 inches to the right of point A.”

After each student is able to calculate the balance point, the teams will construct a balsa model airplane provided by the instructor. They will then determine the balance point when cargo is added and/or taken away from the airplane.

3. Each student will complete an essay paper on an intermodal support system required for 10 cargo planes. The product being delivered will

be picked by the students with approval from the instructor. This system will include unloading the product and delivering it from Minneapolis down to New Orleans.

4. This part of the project will require the product to be delivered in a Just-In-Time Process. The instructor will designate the transit time.
5. Each student will be required to select two major modes of transportation to get the product to its destination point. This can include trucking, train, barge, or ships. The student is also required to identify at least three types of minor forms of transporting goods, such as conveyors, forklifts, pallet jacks, etc.
6. A final requirement is to list at least 30 careers that support the distribution system.




Evaluation and Assessment:

1. Multiple Choice Questions:
   1. Torque is equal to what?
      a. force x distance
      b. force x weight
      c. weight x distance

   2. Any downward torque in front of the plane's center of gravity is considered_____.
      a. positive value, having a positive force
      b. positive value, having a negative force
      c. negative value, having a negative force
   3. When the products are equal, the force is balanced along the _____.
      a. fulcrum
      b. plane
      c. front of the plane's center of gravity

2. Essay Questions:
   a. How does weight affect flight?
   b. Calculate torque given a distance of 60" and a force of 50 lbs. Explain what you did.
   c. What effects does Just-In-Time play in transportation?

3. Student Learning
   a. What were the two most important things that you learned in this activity?