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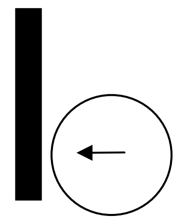
Homework Assignment: Class 3 – Theory

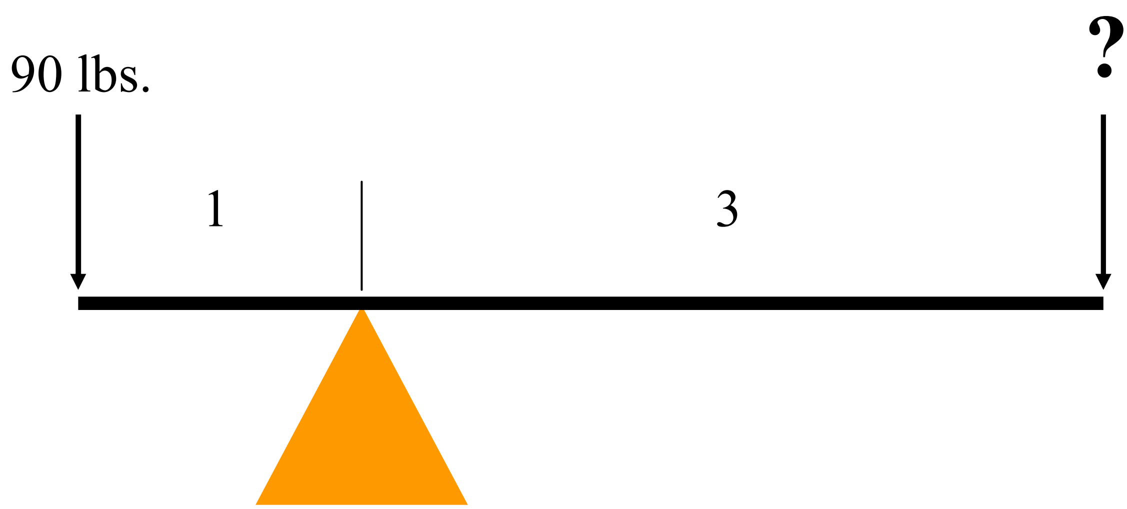
1. Find a round glass. Holding the glass on one end near a running faucet, move it till the side of the glass just touches the stream of water. Describe what happens. If we could measure the force of the water on the glass, which way is the water pushing the glass in the horizontal direction (Remember Newton's Third Law, every action causes an equal and opposite reaction)?



You can learn more about lift caused by a solid body disturbing the flow of a fluid by visiting:
http://www.grc.nasa.gov/WWW/K-12/airplane/lift1.html

2. As we learned in class, the weight and balance of an aircraft is very important in terms of being able to safely fly and control an airplane. Before each flight, the pilot must check that the weight and balance of an aircraft are within limits. To do this, he or she calculates the "moment arm" of the airplane and each of the payload items it will carry in the flight.

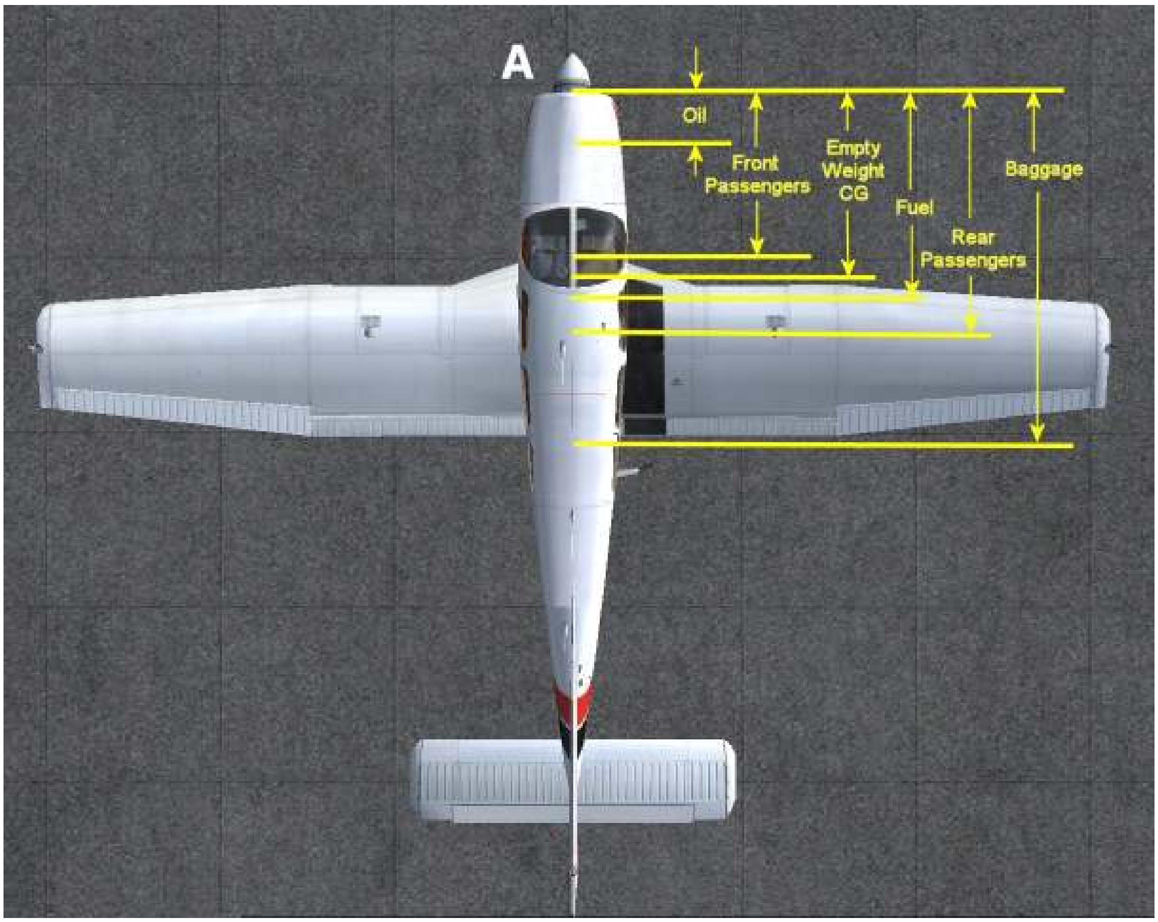
If we look at a seesaw, in order for the seesaw to be in balance, the multiplication of the weight at the end by the distance of the weight from the CG – the center of gravity – the balancing point of the seesaw – must be equal for both sides.



$$90 \times 1 = ? \times 3$$

So in this case, 30 lbs on the long side would balance the seesaw.

Our goal is to calculate the location of the Center of Gravity of the airplane so we can be sure it is within safe limits, not too far forward and not too far to the rear. For the plane we have been flying (Piper Cherokee 180) we will use the base of the propeller (point A in the picture) as the reference point to calculate the moment arm for each component of the airplane. When we add the weights and moments of all the components together, we can then calculate the distance of the Center of Gravity from the reference point for the fully loaded airplane.



For this plane, the distances for these components are as follows:

Moment Arm Distance:
Empty weight of Airplane CG = 86.45 in
Oil = 27.50 in
Pilot and Co-Pilot = 80.50 in
Rear Passengers = 118.10 in
Baggage area = 142.80 in
Fuel CG = 95

As an example of how to perform a weight and balance calculation, we will calculate the location of the Center of Gravity of the airplane *before* we put the passengers and baggage in the plane. To do this, we multiply the weight of each component by their distance from the reference point (Aft Arms) and then calculate, by adding, the total weight and the total of the moments, like so:

	Weight (lbs)	*Aft Arm (in)*	*Moment (in-lbs)*
Empty Weight	1461	86.45	126,295.5
Oil	27.5	80.5	412.5
Fuel	300	95	28,500.0
Total	1,788.5	X	155,208.0

Given the fact that the moment of the CG of the airplane is equal to the sum of the CG of each of its components, the distance of the CG from the reference of the empty airplane is

155,208 / 1,788.5 = 86.78 in

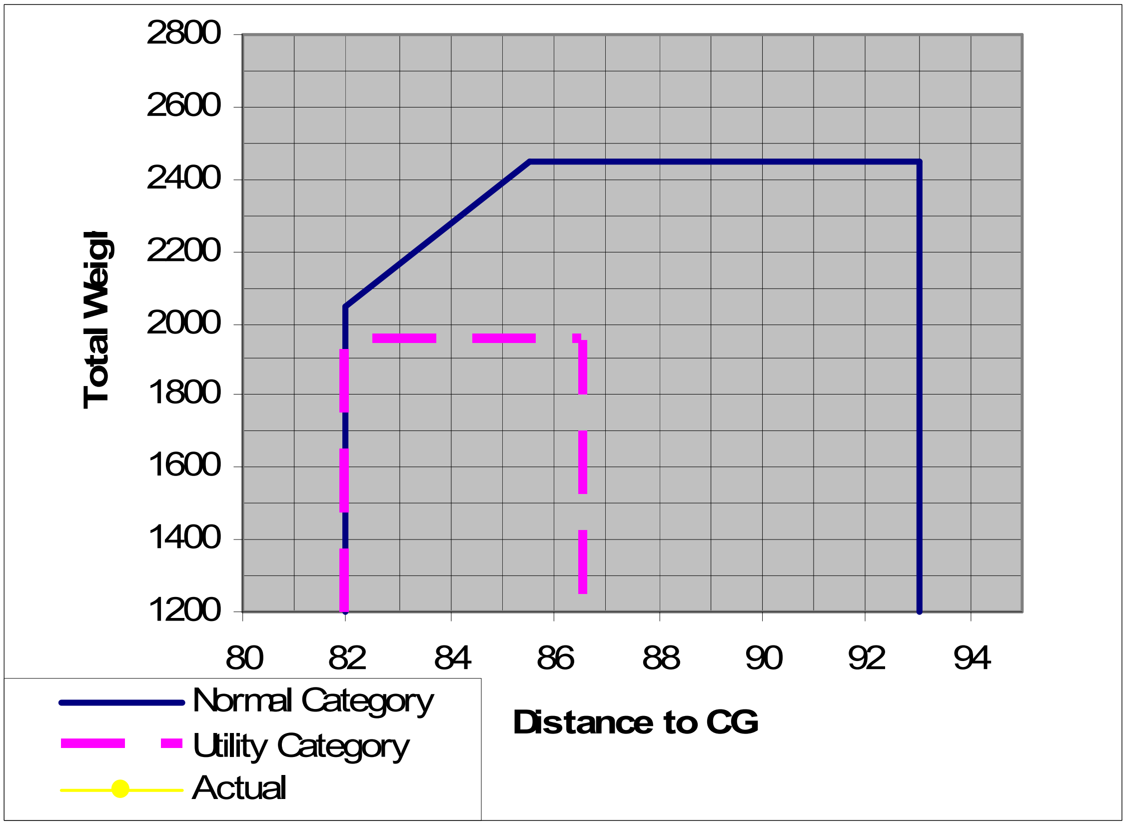
Problem: Assuming you are going to pilot the airplane with your instructor, the weights of the following are:

Pilot = Your weight
Instructor = 185 lbs
Baggage = 35 lbs

Fill in the rest of the following chart, and then calculate and plot the distance to the Center of Gravity (***CG***) of the fully loaded airplane versus the total weight of the airplane on the following graph to determine if the airplane will be within safe limits to fly.

	Weight (lbs)	*Aft Arm (in)*	*Moment (in-lbs)*
Empty Weight	1461	86.45	126,295.5
Oil	27.5	80.5	412.5
Full Fuel	300	95	28,500.0
Pilot & Instructor	______	80.50	________
Rear Passengers	0	118.10	0
Baggage	35	142.80	________
Total	_______	***CG***	________

CG = Total Moment / Total Weight = ____________



2800
2600
2400
2200
2000
1800
1600
1400
1200
Total Weigl
80
82
84
86
88
90
92
94
Distance to CG
Normal Category
Utility Category
Actual