.Homework for 16.00
Introduction to Aerospace Engineering and Design
Professor Annalisa Weigel

Problem Set #2
Handed out 12 Feb 2004
Due 19 Feb 2004

1. (20 points) Problem 3.7. A Venturi device is shown in problem 3.7 on page 61 in the text. Suppose air flows over the U-tube manometer. Solve for $\square_2$. The density of air and that of the liquid are $\square_a$ and $\square_l$, respectively. [Please note book errata; density of air is 1.161 kg/m^3.]

2. (40 points) FoilSim for aerodynamic calculations (courtesy of NASA and R. Shea)
Go to http://www.lerc.nasa.gov/WWW/K-12/airplane/foil2.html to use the FoilSim program.
Click on the "Flight Test" button. Set the airspeed to 200mph, and set the altitude to 5000ft. Click on the "Shape/Angle" button. Set the angle to 2.5 degrees, and set the surface are to 300 square feet.

(a) Set the velocity to 50 mph and record the lift. Increase the airspeed slider to 100 mph. Record lift. Increase the velocity to 150 mph and record lift again. Finally increase the velocity to 200 mph and record lift. Describe the change that you observe in lift as velocity changes. Graph velocity versus lift by hand for these points.
(b) Return the velocity to 100 mph. Set the angle at 2.5° and record lift. Repeat, setting the angle for 5.0°, 7.5°, and 10° and record the lift for each setting. Graph your results by hand. At what point will the airfoil not turn a flow? Complete your graph with a stall at an angle of 12°. Will lift be generated at an angle of 0°? Explain.
(c) Return the angle setting to 2.5° and set the surface area to 100 ft^3. Record the value for lift. Double the surface area. How is lift affected? Record lift. Double the surface area two additional times and record lift. Graph lift versus surface area from the data recorded. Explain how an airplane can slow its velocity for landing and still maintain sufficient lift to avoid a stall.
(d) Set the surface area back to 100 ft^3. Set the camber at 0. Record lift. Increase camber to 0.25, 0.30, 0.35, 0.40, 0.45, and 0.50, and record the changes in lift for each setting. Graph camber versus lift with the data recorded. Is it possible for camber adjustment to initiate a stall? Explain.
(e) Return the camber setting to 0. Adjust the altitude slider to 15,000 ft, 25,000 ft, 35,000 ft, and 45,000 ft; and record lift at each setting. Graph lift versus altitude with the data collected above, and predict the next two points on the graph. Is lift affected by an increase in altitude? List possible reasons for any changes observed.
(f) An airplane is beginning its descent at an altitude of 1,500 ft and a beginning velocity of 200 mph. Gradually decrease altitude and velocity, and note the change that occurs in lift. Record your observations. Explain how the lift force can be maintained while velocity and altitude are being decreased as the airplane approaches landing. Check your explanation using the FoilSim demonstrator. Summarize your results.
(g) An airplane travels 40,000 ft horizontally from the point where it began its descent at an altitude of 1,500 ft. Draw a diagram of the descent, showing the vertical and horizontal components, and calculate the angle of descent for the airplane.

3. (40 points) Paper Airplane Design
Design and build a paper airplane that has either the longest time aloft or travels the greatest distance.

(a) Use only one sheet of 8_ x 11 unlined printer paper for your airplane. Determine the wing area by breaking areas of the wings down into triangles and rectangles. Measure and calculate the wing area.
(b) Using the same launch angle and velocity for each trial, fly your airplane through five trials. The trial flights must be completed indoors to eliminate wind effects. Measure the wing surface area, and distance traveled or time aloft (depending on the objective of your design), for each trial. Make a data table and record your results. Graph the wing area/time or area/distance data for each set of trials. Does the graph look like what you expected to see, and why? Using formulas available in Excel or other spreadsheet software, calculate the mean, median, standard deviation, 25th percentile and 75th percentile of your time aloft or distance traveled data. Write a summary of your results.
(c) Cut 1 inch off the trailing edge of the wings. Place the cut-off pieces within the folds of the airplane so the mass remains constant. Repeat the trial flights, data collection, graphing, statistics and written summary in the same manner as (b) above.
(d) Bring your paper airplanes to class on February 19 for an in-class "fly-off" competition.