MAE571, Fall 2014 Homework #3

Hard copy of lab report is due Wednesday, October 29, at start of class. Information for submitting (optional) videos will be given separately.

Safety is the most important concern for any lab experiment. This exercise is in the spirit of a "kitchen table experiment". We expect the experiment to be simple and safe to execute. Using a burner, oven, or electric heater to directly heat your apparatus is not necessary and not recommended.

A team of up to three people are allowed to collaborate on this assignment. If the experiment is done by a team, please submit a single report for the team. In doing so, it is understood that all team members will receive the same score. Please fill the attached Cover Sheet as the cover of the report whether the work is done by an individual or a team. In the latter case, all team members must make nontrivial contribution(s) to the collaborative effort. This should be addressed in the cover page. For this assignment, sharing video/photographic equipments or discussing techniques on photo processing or video editing does not count as collaboration. Sharing raw material (wax, rubber, salt, water, colored dye, etc.) also does not count as collaboration. On the other hand, each team must craft their own toy wing(s) and design their own experiment. Sharing the key apparatus - the dish pan and toy wing(s) - will count as collaboration.

1. In the very first page of Acheson's textbook, the author describes a simple experiment:

> Take a shallow dish and pour in salty water to a depth of 1 cm. Make a model wing with a length and span of 2 cm or so, ensuring that it has a sharp trailing edge. (One method is to cut the wing out of an india rubber with a knife.) Dip the wing vertically in the water and turn it to make a small angle of attack α with the direction in which it is to be moved. Put a blob of ink or food colouring around the trailing edge; a thin layer of this should then float on the salt water.
>
> Now move the wing across the dish. giving it a clean, sudden start. If α is not too large there should be a strong anticlockwise vortex left behind at the point where the trailing edge started, as in Fig. 1.1.

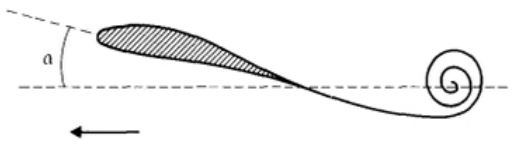

Fig. 1.1. The starting vortex.

Try to replicate this experiment. Use colored dye to visualize the flow field and make video(s) or take picture(s) of the key outcome that demonstrates the process of vortex shedding. Your report should include a description of the basic apparatus and relevant parameters used in the experiment. (For example, what is the physical dimension of the toy wing? What is it made of? What is the depth of water in the pan? What is the salinity, in g/kg, of the salty water used in the experiment?) Relevant details of the procedure of the experiment should also be recorded. For example, after initially pouring salty water into the pan, how long do you wait for the water body to settle before performing the experiment? (Remember that the wing is supposed to start from rest with respect to the fluid body.) You are also encouraged to test the robustness of your results. For example, would a minor modification of the toy wing lead to a dramatic change of the outcome? What would happen if fresh water, instead of salty water, is used? A good lab report is one that provides insights. Partial credit will be given even if the experiment fails to produce the trailing vortex, provided that the discussion of the work is insightful. In that case, the photo(s) and/or video(s) of the failed experiment should still be included in the report. (100%)

2. *Bonus problem*: On the day we did the in-class demonstration of the toy wing experiment, we also serendipitously observed another phenomenon: After leaving the dish pan (covered by about 1 cm deep of fresh water with a few drops of colored dye) on top of the glass of an overhead projector for about 10 minutes, multiple honeycomb-like cells began to emerge. We believe that was Bénard-Marangoni convection in action: The warmer surface of the glass at bottom and the cooler air in contact with the free surface of the water makes the convection possible, when the vertical temperature gradient exceeds a certain threshold. Try to reproduce this phenomenon. (You might use the same dish pan for Prob 1 but design a mechanism to maintain a vertical contrast of temperature.) A photo of the multiple convective cells and a brief description of the experimental setup under which the cells emerge will be sufficient as the answer for this problem. Bonus points will be given only when the experiment successfully produces multiple convective cells. (10%)

MAE 571, Fall 2014, HW3 Cover Sheet

1. Indicate (A) or (B). If (B), provide additional detail of the names of team members and the division of labor.

(A) _____ I performed the experiment(s) in this assignment all by myself.

Name: _____

(B) _____ This work is a team effort.

Team members and individual contributions

Name	Contributions

2. Further information

_____ Supplemental video(s) have been submitted separately as part of the report.

_____ Additional work for the bonus problem is included in this report.

Instructor comment:

Score: