Team Modeling Project for 16.540

Due Date: **4 May 2006**

Credit: 20% of course grade

Project Objective: Formulate and implement a model of an internal flow phenomenon which makes a clear statement about some aspect of the flow which you: i) find interesting and ii) view as being of technical importance.

You will be graded on the technical content of your modeling and also on how well you communicate the important ideas of the research. The latter is included because the instructors regard the clear statement of ideas and results as one measure of how well the material has been "digested" and internalized by you.

a) Do you explain the objective of the model in a simple manner?
b) Have you defined, in a reader-accessible manner, the approximations you made?
c) Is the development of the model technically correct and have you explained and justified the methods that are applied?
d) Is the discussion of your principal results clear?
e) Do the figures you present elucidate important trends?
f) Do you refer to other literature to support the development of your model or a description of the results?
g) Do you compare and contrast your model to other methods that have been applied?
h) Did you present arguments (either *a priori* or *a posteriori)* that justify the modeling approach
i) Did you define what new insight your model provides?
j) Have you made specific suggestions for modeling similar problems in the future?
k) Is your writing clear and concise?

Ground Rules/Project Attributes:

You will be working in teams of 3-5 students

The project will be selected from a short list of topics. The project is intended to broaden your knowledge and thus *should not be related to your thesis research*.

The attributes of the project include:
a) Relates to an internal flow problem which is of interest to someone (Why are you working on this topic?)

b)   Addresses a specific technical question to be answered (What question are you trying to answer?)

c)   Includes analysis (this covers computational simulation also) and synthesis (What is it that you need to do to give a useful answer to the problem? How are you going to do it?)

A short list of suggested topics for projects are given below.   **The project topics are not limited to this list** or even to the areas covered in lectures. Other topics (for example swirling flows, vortex breakdown, instability of fluid flows, jet mixing, deeper looks at secondary flow, or even compressible internal flows) can be used. **If you choose a topic that is not on the list, however, you need to first discuss it with the instructors and get approval for the project.** Two teams can work **separately** on a given project, but, if so, there needs to be explicit agreement between the teams and the instructors about what aspects each team will address.

The philosophy is that the project is not aimed at code development, but it certainly can make use of existing codes. We would like you to engage the material in a *substantial* way and thus expect that the project might need approximately 20-30 hours.

Project Deliverables:

For the project each team is to turn in a single report in the format of a journal article (for example, an article in *ASME J. Turbomachinery*). The length limit is 30 units (including references) where each unit is *either* a double-spaced typed page or one figure.   For reference typical journal limits are 36 units, so that this length limit is a substantial fraction of a journal paper.

Weekly Meetings with Course Instructors:

We have found in the past that it is useful to have weekly meetings with the course instructors, starting early in the process. These will be scheduled when the projects are chosen.

Suggested Projects

1) Mechanisms of inlet vortex formation - computational demonstration of the inlet vortex formation.   Quantification of the vortex circulation.   There are two separate mechanisms and either or both can be examined.   As far as the instructors know, this has not been done in the literature.

2) Vorticity generation and downstream mixing in lobed mixers – What is the "mechanism" for the normal vorticity to evolve into streamwise vorticity?

3) Secondary flow in curved inlets. The Cambridge-MIT silent aircraft design has an S-curved inlet, with a thick boundary layer entering.   What is the effect of the boundary layer properties on separation, how could separation be avoided, what might vortex generators do, what sort of flow control could be used?

4) Upstream effects of an engine on inlet distortion. We saw in class that the stagnation pressure distribution in front of a fan could be greatly altered by the presence of an engine.   How strong an effect is this?   When does it occur?

5) Diffusing of a flow which has an embedded streamwise vortex.   This project would investigate "vortex breakdown" which occurs when a vortex is subjected to an adverse pressure gradient or even the situation of streamwise vorticity in a constant area duct. The key issue is the generation of a theta-component of vorticity and thus a retardation of the flow in the inner part of the duct.

6) Averaging for a purpose—what are some useful averages that correspond to different situations (see Cumpsty and Horlock)?   When does it make a difference what average one takes?   How can one categorize the situation?

7) We have discussed the horseshoe vortex in front of a strut in qualitative terms.   What is the quantitative behavior?   What is the circulation of the vortex?   What is the vorticity distribution? What is the secondary flow? For different boundary layer thicknesses, or different strut thicknesses, how does the stand-off distance of the vortex scale?

8) Taylor column – The photographs of the small cylinder being dragged across a container of rapidly rotating fluid are spectacular in showing the two-dimensional nature of the flow.   What happens as the rotation rate is decreased?   How does the drag change? When does the Taylor column cease to exist?

9) Secondary flow in a bend.   It was predicted (and experimentally demonstrated) that the direction of the secondary flow in a bend, or a rotating straight pipe, would not grow monotonically as implied by the simple Squire-Winter analysis but will oscillate.   This project would examine how well the simple predictions capture the features of an "actual" flow and where they break down.