SOME PROBLEMS FROM PAST FINALS

In flow visualization studies one means is to use small particles to mark the fluid flow paths. The particles must follow the fluid motions to some specified degree of accuracy. What factors are of importance in this problem to evaluate how closely the particles do follow the flow? What is the nature of the dependency of the relative velocity of the particle and the fluid?

There are three main thickness measures used in boundary layer analysis. These are the boundary layer thickness, the displacement thickness, and the momentum thickness. I would like you to explain each of these to me in terms of the physics involved; i.e., in terms of what occurs in the flow. Make sure you include compare the different measures. What I want is a ***clear explanation*** of each with regard to what they mean. Equations won't do.

Similar measures of the boundary layer can be made via the integral analysis of von Karman. Again details and equations are not wanted, but what is needed is a ***clear explanation*** of what is assumed and what must be done to obtain the measures cited in problem 2 from the von Karman analysis.

What are the assumptions for the following and where can they be applied?
(a) ideal flow, (b) exact solution, (c) B.L. theory, (d) slow motion, (e) potential flow.

For a compressible flow, use an H-S diagram to explain

(a) friction without heat transfer
(b) heat transfer without friction for addition of heat
(c) heat transfer without friction for removal of heat
(d) heat transfer and friction

Notes what happens in each case for all Mach Number conditions. Indicate the type of line over which the change occurs and indicate any change in the stagnation condition.

In turbulent flow, eddy diffusivities can be defined for heat, mass, and momentum transport. A reasonable, but certainly not exact, approach can be made for the prediction of temperature or concentration distributions based on such eddy diffusivities.

(a) What do you need to accomplish such a prediction?
(b) How would you proceed to make such a prediction?
(c) What are the key assumptions? One of these involves the variation of the heat and mass fluxes across the flow.
(d) What physical picture (mechanism) can you give for the approach you selected?

Explain the differential method and Von Karmen integral method in boundary layer studies. Why do we need integral methods? To use the integral method, what other assumptions may you need?

Turbulent flow is highly time dependent and not reproducible. How can we still study it? Briefly describe the approach we use to study turbulent flow.

Set up the equations and boundary conditions for the flow above a rotating disk. The flat disk rotates at a constant angular velocity ω (see the figure below) in a incompressible fluid otherwise at rest. The rotation rate ω causes the flow near the disk to be greater than a slow motion but not turbulent.

Describe briefly the concept behind the Oseen analysis for the drag of a sphere.

For the flow you dealt with in your FLUENT project, list all the possible assumptions which can be made, although some of them may not be employed by the FLUENT software.

Explain why there is an entrance effect in capillary flow? For this flow, an error can be introduced in a viscosity measurement if the capillary is short so that entrance effects are important. Suggest two means that can be used to eliminate this error either by further experimentation or calculation. Because of pressure drop limitations, a longer capillary can not be used.

Explain why dimensional reasoning is important when considered in terms of an equation that is the description of a flow; i.e., N-S equation.

From the movie, we know that turbulent flow is not reproducible. However, we still can study turbulent flow. Explain why!

The Reynolds equation can be integrated to give an equation that relates the velocity gradient to the Reynolds stress. Prandtl used a mixing length concept to obtain the logarithmic velocity distribution equation from the partially integrated Reynolds equation. State what assumptions are necessary to obtain this. Can you suggest what effect would be on the resulting velocity distribution if each of the assumptions were not made.

In rheological measurements, an error is often introduced in the viscosity because the length is to short to neglect entrance effects. Suggest two ways to account for this error either by further experimentation or calculation. Unfortunately, because of the size pump available, a long capillary in which one could ignore the entrance, cannot be used.

Prandtl's mixing length analysis for the log distribution cannot be used to obtain the drag force of the wall of a tube by evaluating the velocity gradient at the wall. Discuss and explain why this is true!

a) The eddy viscosity equation is given on page 239 by eq. (14-30) as

$$u_x u_y = - \epsilon \, (dU_x/dy)$$

What is its value at the centerline? Discuss and explain why this is true!

Some more questions:

a) What is the importance of Reynolds number on the large and small scales in turbulence? Justify your answer by using concepts such as energy dissipation

b) Determine the eddy viscosity from the logarithmic velocity profile equation for the logarithmic region and obtain its value at the centerline.

c) Explain mixing in terms of momentum transfer. Does this have anything to do with the Reynolds stress?

Let us investigate the analogy between compressible flow and open-channel flow that was illustrated in the film clip in class. In this film clip we observed surface waves that could be pictured as sound waves and observed the parallel to the Mach cone for compressible flow. The surface wave that was observed has a speed in still liquid given by:

V = surface velocity wave = (gy)

where y is the depth in a wide, open channel. Can you suggest what you think is analogous to a) the Mach number, b) the speed of sound, c) sonic flow in the throat of a nozzle, d) changes in density of the flowing gas, and e) the shock wave.

Hint: The equation above can be cast into a form of a dimensionless group that is discussed in Chapter 11 (see Table 11-1). The interpretation of this group is key to the analysis.

Prandtl's mixing length analysis for the log distribution cannot be used to obtain the drag force of the wall of a tube by evaluating the velocity gradient at the wall. Discuss and explain why this is true!

Why is the velocity gradient large early (upstream) in the boundary layer development and then becomes less further downstream.

What is the importance of Reynolds number on the large and small scales in turbulence. Justify your answer by using concepts such as energy dissipation.

What is the boundary layer assumption? What is the difference between a boundary layer solution and the solution using the von Karman integral momentum theory? For this later, what information is needed for a solution?

In rheological measurements, an error is often introduced in the viscosity because the length is to short to neglect entrance effects. Suggest two ways to account for this error either by further experimentation or calculation. Unfortunately, because of the size pump available, a long capillary in which one could ignore the entrance, cannot be used.
