DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING
UNIVERSITY OF TORONTO

MIE 312F – FLUID MECHANICS I
Examiner: Professor M. Paraschivoiu

FINAL EXAMINATION – DECEMBER, 2001

Exam Type: D

Note: Allowable aids are a textbook, personal notes and a hand calculator.
An examination is an exercise in communication.
All 5 questions are of equal value.

1. The rectangular gate shown in figure 1 is a homogeneous mass of 180 kg, 1.2 m wide into the paper, hinged at A and restrained by a stop at B. The tank contains water and immiscible oil at 20°C. The oil–water interface is 1.5 m below the air–oil interface. The hinge is located 2 m below the air–oil interface. Find the force on the stop B.

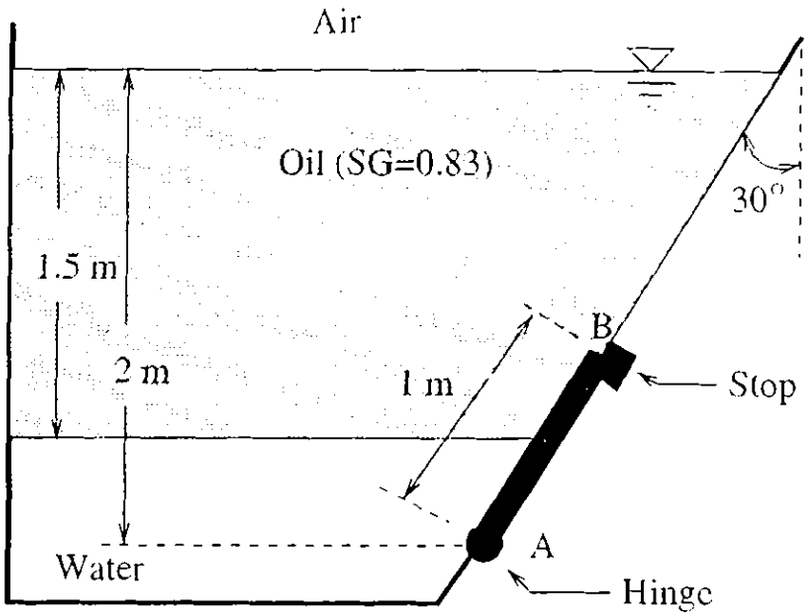

Figure 1.

2. A ship is to be powered by a rotating circular cylinder of length H and diameter D at angular speed ω in air having a density ρ and a viscosity μ.
   a) Clearly explain your choice of combining variables.
   b) Write in dimensionless form the relation between power (P) and the above parameters.
   c) A model is constructed to 1/20 scale and is tested. To achieve dynamic similarity, identify the dimensionless groups that must be matched for the model and the actual ship.

3. Air at 20°C flows in a duct of diameter 0.6 m and is discharged to atmosphere. The exit is choked by a cone with base diameter 0.75 m and vertex angle 90° as shown in figure 2. Flow in the duct is controlled by moving the vertex of the cone into the duct, the air then escaping along the sloping sides of the cone. The mean velocity in the duct is 15 m/s and the air leaves the cone (at the 0.75 m diameter) with a mean velocity of 60 m/s parallel to the sides. Assume frictional effects to be negligible.
   a) Calculate the jet sheet thickness (h) when the air leaves the cone.
   b) Calculate the net axial force exerted by the air on the cone.

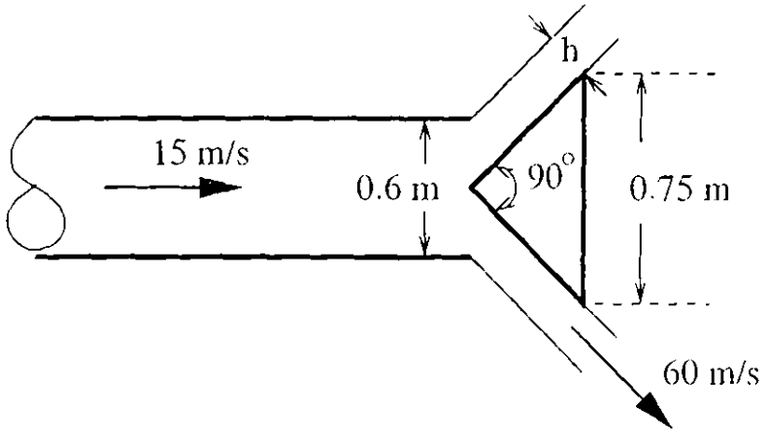

Figure 2.

4. A square cylinder floats with half of its volume in air as shown in figure 3. If the wind velocity U is 10 m/s and the water is stationary, estimate the speed at which the wind forces the cylinder through the water. Assume that the drag coefficient for half of the object (based on frontal area) does not change with Reynolds number and therefore is the same in air and in water.

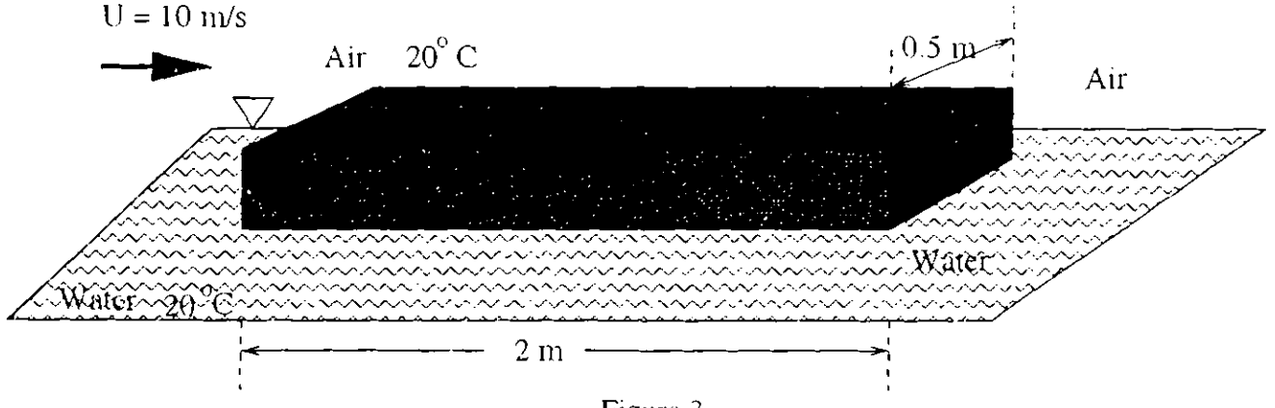

Figure 3.

5. Water at 20°C flows through a galvanized iron pipe of constant diameter (80 mm) at a flow rate of 0.12 m^3/s. The fluid discharges to atmospheric pressure as shown in figure 4. Find the horizontal net force F in the bolts without neglecting viscous losses. The wheels on which the pipe rests are frictionless.

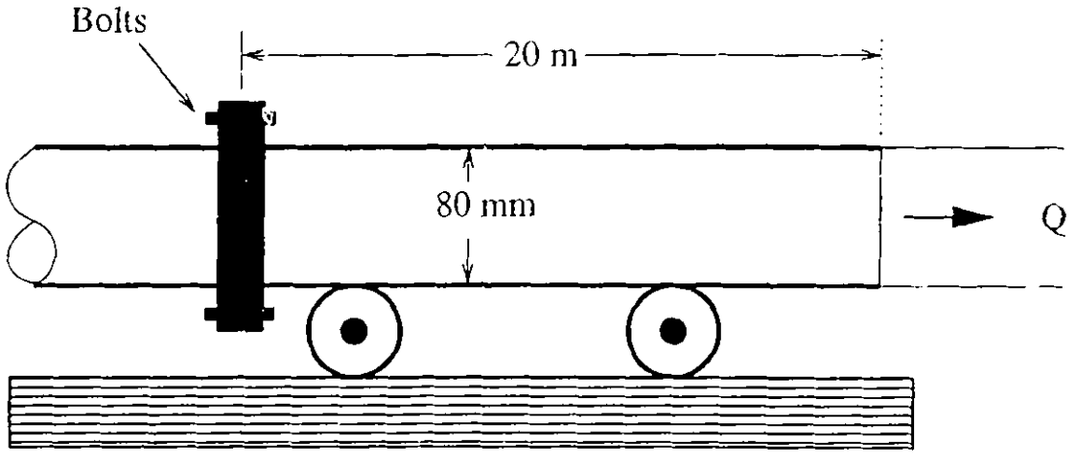

Figure 4.