GX654

OLLSCOIL NA hÉIREANN
The National University of Ireland

National University of Ireland, Galway

Trinity Examinations 2000/2001

Second Year Mechanical and Biomedical Engineering Examination

INTRODUCTION TO FLUID MECHANICS

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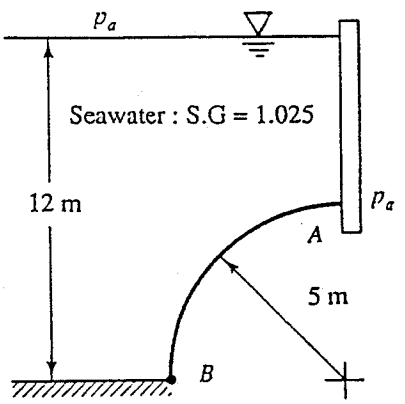
Attempt *Three* Questions
Time Allowed : 2 Hours

For every question attempted, produce at least one sketch or diagram which is clearly and accurately labelled with symbols and appropriate dimensions. State the assumptions your analyses are based upon.

The Equations Sheet, Tables of Physical Properties and Moments of Inertia are attached.

1. Gate AB in ***Figure 1*** is a quarter-circle 8 m wide, hinged at B and resting against a smooth wall at A. Calculate the reaction forces at point A and at point B. [20 points]

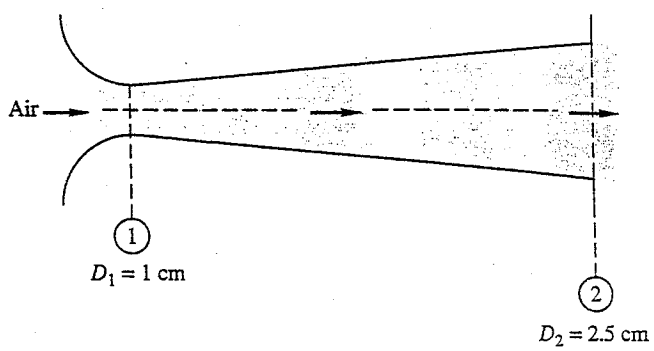
Figure 1



2. The converging-diverging nozzle shown in ***Figure 2*** expands and accelerates dry air to supersonic speeds at the exit, where $p_2 = 8$ kPa and $T_2 = 240$ K. At the throat, $p_1 = 284$ kPa, $T_1 = 665$ K and $V_1 = 517$ m/s. For steady compressible flow of an ideal gas, estimate:

   (i) the mass flow in kg/h, and
   (ii) the velocity V_2. [20 points]

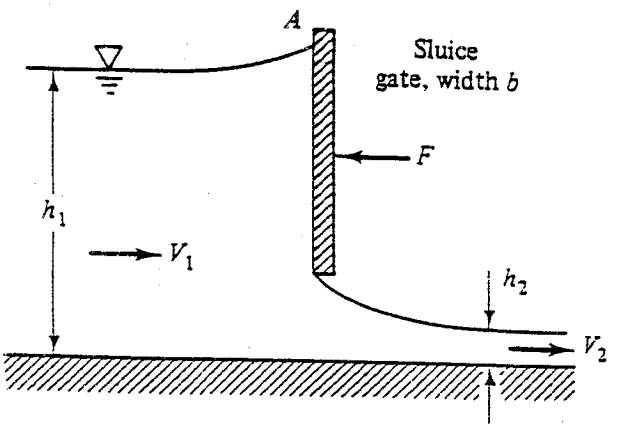
Figure 2



3.(a) Water flow in open channels can be controlled and measured with the sluice gate shown in ***Figure 3***. At a moderate distance upstream and down stream of the gate, sections 1 and 2, the flow is uniform and the pressure is hydrostatic. Derive an expression for the force F, required to hold the gate, as a function of ρ, V_1, g, h_1 and h_2. Neglect friction in your analysis. Why does the water level rise at point A on the gate? [12 points]

(b) Calculate the force F if $h_1 = 3$ m, $h_2 = 0.5$ m and $V_1 = 1.15$ m/s. [8 points]

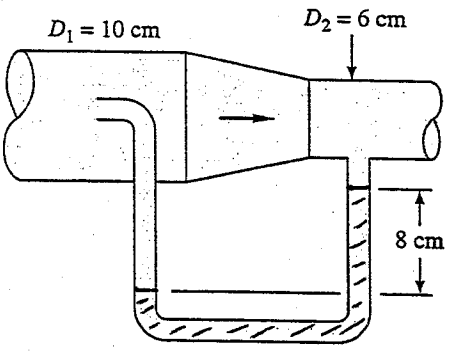
Figure 3



4. In ***Figure 4*** the flowing fluid is CO_2 at 20° C. Neglect losses. If $p_1 = 170$ kPa and the manometer fluid is Meriam red oil (SG = 0.827), calculate:

(a) p_2, and [10 points]
(b) the gas flow rate in m^3/h. [10 points]

Figure 4



5. Consider incompressible flow in the entrance of a circular tube, as in ***Figure 5***. The inlet flow is steady and uniform, $u_1 = U_0$. The flow at section 2 is developed pipe flow with a laminar velocity distribution described by $u_2(r) = u_{max}(1 - r^2/R^2)$.

Find the wall drag force F as a function of (p_1, p_2, ρ , U_0 , R). [20 points]

Figure 5