# B.E. CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAMINATION 2018

## MECHANICS OF FLUIDS

### Part-I

*Use separate answer scripts for each part.*

*Time: Three hours*

*Full marks: 100*
*(50 marks for each part)*

*Answer any **three** questions. All questions carry equal marks. 2 marks reserved for neat and* well organized answer script. *Assume any missing data.*

1 (a) For the velocity field given below, determine whether one, two or three dimensional flow, steady or unsteady flow. Also find the directionality.

$\vec{V} = ax^2\hat{i} + bxz\hat{j}$, where a & b are constants.

(b) Consider the flow described by the velocity field $\vec{V} = x(1 + At)\hat{i} + y\hat{j}$ with $A=0.5s^{-1}$. For the point (1,1,0) find the equation of the streamline through the point at t=0.

(c) What is stream function?

(d) An engineering department is evaluating a sophisticated $80000 laser system to measure the difference in water level between two large water storage tanks. It is important that small differences be measured accurately. You suggest that the job can be done with a $200 manometer arrangement. An oil less dense than water can be used to give a 10:1 amplification of meniscus movement; a small difference in level between the tanks will cause 10 times as much deflection in the oil levels in the manometer. Determine the specific gravity of the oil required for 10:1 amplification.

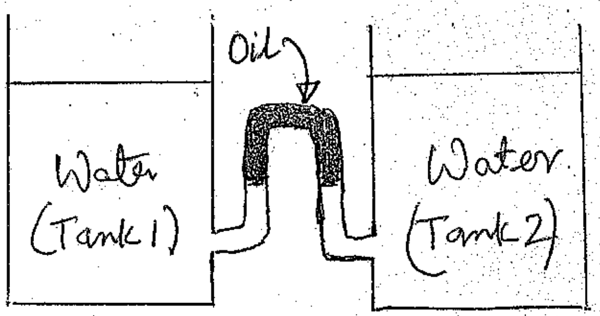


Figure 1

3+4+3+6

2 (a) A flat plate orifice of 50 mm diameter is located at the end of a 100 mm diameter pipe. Water flows through the pipe and orifice at 0.05 $m^3/s$. The diameter of the water jet downstream from the orifice is 35 mm. Calculate the external force required to hold the orifice in place. Neglect friction on the pipe wall.

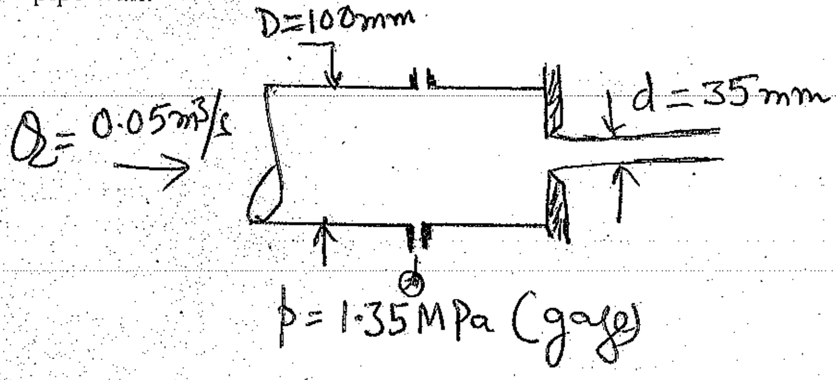


Figure 2

(b) Discuss the working principle of a pitot tube

(c) Tiny hydrogen bubbles are being used as tracers to visualize a flow field (V=ui+vj). All the bubbles are generated at the origin (x=0, y=0). Draw a streakline at t=2s. The velocity field is unsteady and obeys the equations

$u=1$ m/s, $v=1$ m/s for $0 \leq t < 1$s.

$u=2$m/s, $v=0$ for $1 \leq t \leq 3$s.

8+4+4

3 Spray heads in an agricultural spraying system are to be supplied with water through 150m of drawn aluminium tubing from an engine driven pump. In its most efficient operating range pump output is 350$m^3$/hr at a discharge pressure not exceeding 450kPa (gage). For satisfactory operation, the sprinklers must operate at 200kPa or higher pressure. Minor losses and elevation changes may be neglected. Determine the smallest standard pipe size that can be used. Assume that standard sizes for the tubing decrease in 6mm steps below 25mm, increase in 12.5 mm steps from 25mm to 75mm, increase from there in 25mm steps to 150mm, and increase in 50 mm steps thereafter. You may use the Moody diagram and relative roughness vs. pipe diameter plot attached.

16

4 (a) A venturi meter with a 75 mm diameter throat is placed in a 150 mm diameter line carrying water at 25°C. The pressure drop between the upstream tap and the venture throat is 300 mm of mercury. Compute the rate of flow.

(b) Two water reservoirs are connected by two galvanized iron pipes (in parallel). having diameter 75 mm and 50 mm. The difference in water level in the reservoirs is 10.5 m. Compute the volume flow rate in each pipe.

8+8

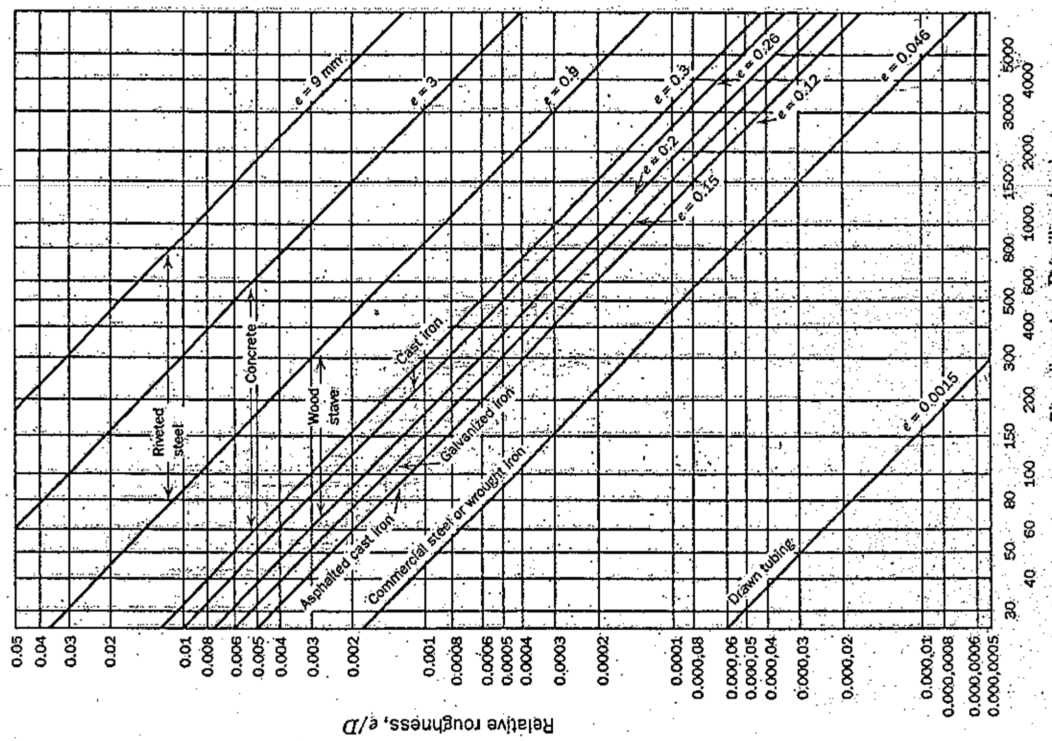


Fig. 8.15 Relative roughness for pipes of common engineering materials. (Data from [6], used by permission.)

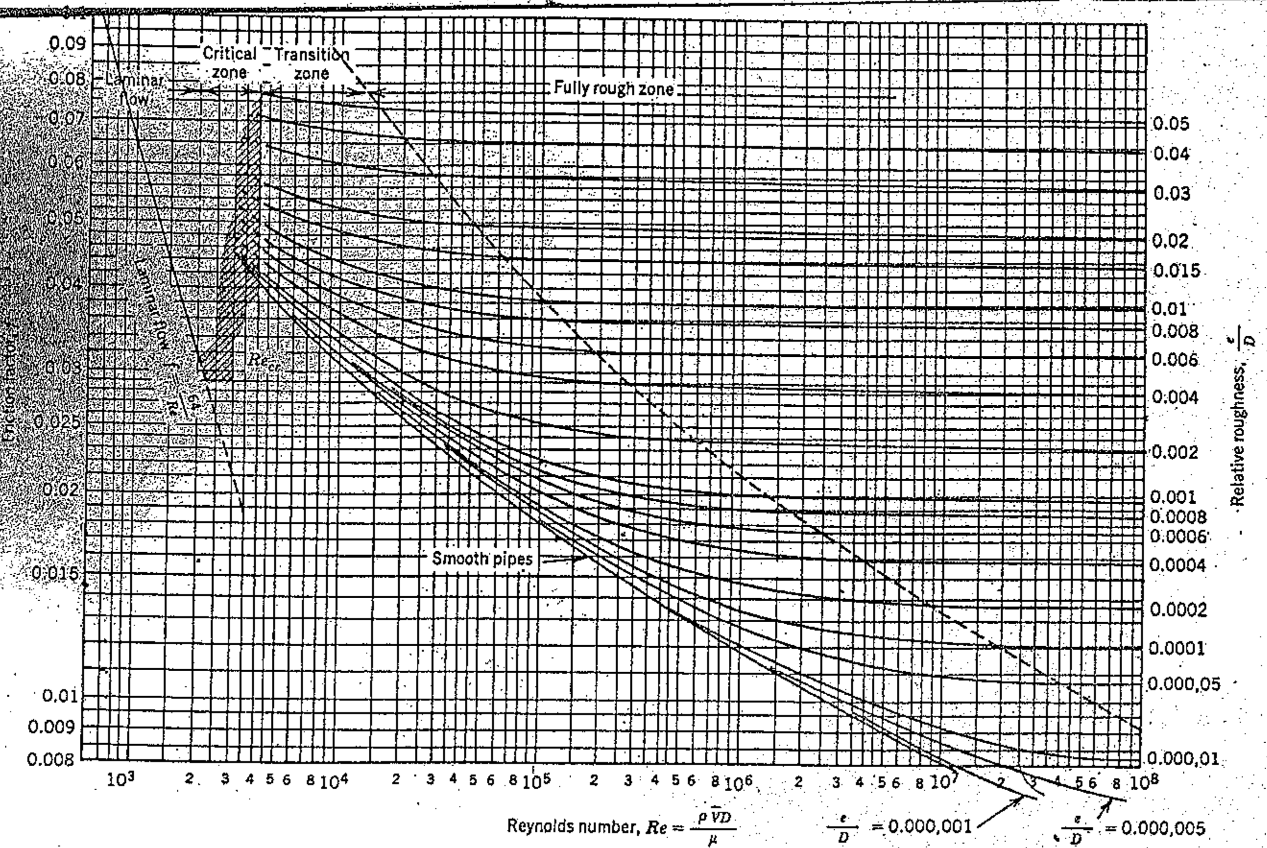


Fig. 8.14 Friction factor for fully developed flow in circular pipes. (Data from [6], used by permission.)

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Full Marks 50

## PART II

Answer any two questions. State all the assumptions. Assume missing data (if any)

| No. of Questions | | Marks |
|---|---|---|
| 1(a) | Consider the velocity field $\vec{V} = ay\hat{i} - bx\hat{j}$ ; a=1 $s^{-1}$ and b=2$s^{-1}$.<br>(i) What are the directionality and dimensionality of the flow?<br>(ii) Is the flow rotational? What is the magnitude the vorticity?<br>(iii) Derive the equation of streamline passing through the point (1,1).<br>(iv) Derive the expression for acceleration vector. Evaluate the magnitude of the components of acceleration at point (1,1). | (3x4) |
| 1(b) | Give reasons and justify the following statements.<br>(i) The pressure recovery in case of venturimeter is more than that in case of an orificemeter.<br>(ii) Rotameter is an area meter and not a head meter.<br>(iii) $C_D$ vs Re curve for flow around a sphere shows an abrupt decrease in drag coefficient at Re = 3X $10^5$ | (2+4+3+4) |

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| No. of Questions | | Marks |
|---|---|---|
| 2. | A centrifugal pump with the characteristics given below is to be used to supply water to a house from a nearby lake at 30°C. The water surface in the vented storage tank in the house is 2 m higher than the lake surface. There is 50 m (total straight length + total equivalent length for fittings) of steel pipe of 50 mm inside diameter connecting the lake, pump and house. The total length (straight length and total equivalent length of fittings) of steel pipe from the lake to pump inlet is 15 m. The pump suction is 0.5m higher that the lake surface.<br>(i) What flow rate of water can be delivered to the house?<br>(ii) What is the head developed by the pump?<br>(iii) What is the pump efficiency?<br>(iv) What motor power is needed?<br>The friction factor vs Reynolds number graph is attached. | (25) |

| Capacity $m^3$/hr | Head, m | Efficiency, % |
|---|---|---|
| 10 | 15.0 | 38 |
| 20 | 14.7 | 52 |
| 30 | 14.3 | 60 |
| 40 | 13.5 | 64 |
| 50 | 12.0 | 63 |
| 60 | 9.7 | 56 |
| 70 | 6.0 | 45 |

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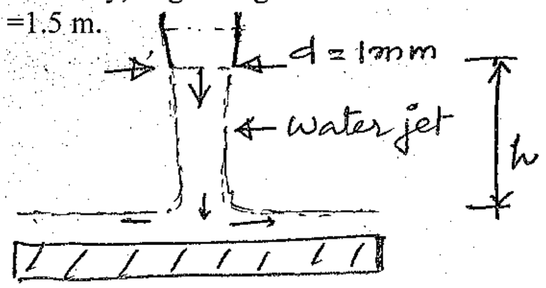
| No. of Questions | | Marks |
|---|---|---|
| 3(a) | A uniform jet of water leaves a 1 mm diameter nozzle and flows directly downward. The jet speed at the nozzle exit plane is 1.5 m/s. The jet impinges on a horizontal disk and flows radially outward in a flat sheet. Obtain a general expression for the velocity the liquid stream would reach at the level of the disk. Develop an expression for the force required to hold the disk stationary, neglecting the mass of the disk and water sheet. Evaluate for h =1.5 m.   FIG. 1 | (15) |
| 3(b) | An oil of 0.87 specific gravity and 6 centipoise viscosity flows through a pipeline . An orifice with opening diameter of one -half of the inside pipe diameter is used to measure the flow. It is proposed to replace this orifice with a venturi with throat diameter equal to the orifice diameter. If the coefficient of the orifice is 0.61 and that of venturi is 0.98 and the flow rate is unchanged, calculate: (i)The ratio of the venturi reading to the orifice reading (ii) The ratio of the net pressure loss due to the venturi installations to that found with orifice. | (10) |

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| No. of Questions | | Marks |
|---|---|---|
| 4. | In the fluidized bed roasting of zinc sulfide, flotation concentrate of the sulfide in particle sizes averaging 50 microns is roasted at 650°C and about 1.2 atm. The bed density is 1.6 gm/cm$^3$ at minimum fluidization condition. The solid density is 4.2 gm/cm$^3$ for the particles. Assume that the particles are spherical. The molecular weight and viscosity of the gas are 29 and 0.015 cp, respectively.<br><br>(i)Calculate the porosity of the fluidized bed at minimum fluidization condition.<br><br>(ii) Calculate the minimum fluidization velocity.<br><br>(iii)Calculate the terminal velocity<br><br>(iv)The operating gas velocity is twice the minimum fluidization velocity. Calculate the pressure drop per unit length, porosity of the bed and the percentage increase of bed height at operating condition.<br><br>Ergun equation for spherical packing is given below<br><br>$\frac{(-\Delta P_f)g_c}{L}\frac{D_p}{\rho V_o^2}\frac{\varepsilon^3}{(1-\varepsilon)} = 150\frac{(1-\varepsilon)}{N_{\mathrm{Re}p}} + 1.75$ | (5+5+5+10) |

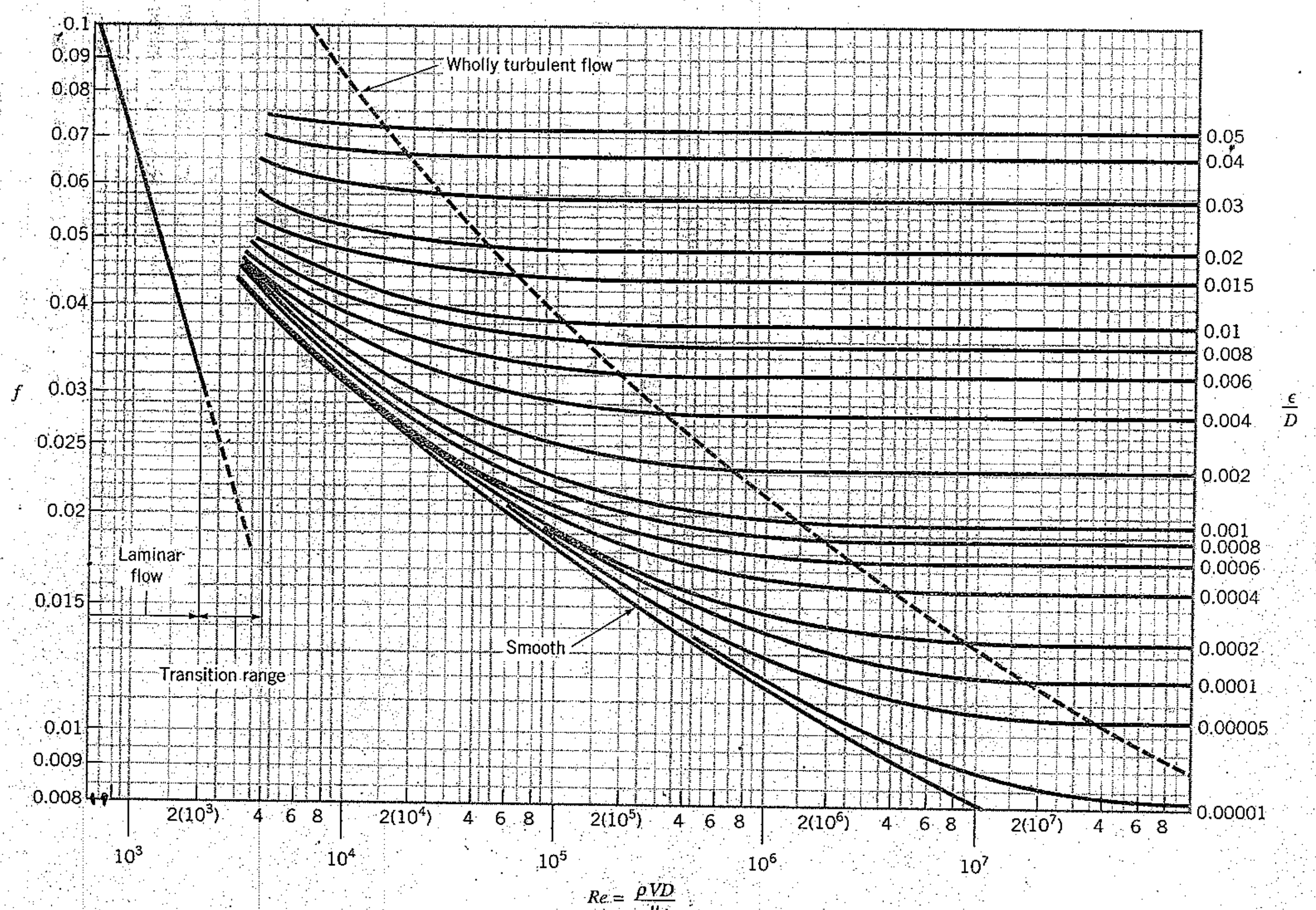


**FIGURE 8.20** Friction factor as a function of Reynolds number and relative roughness for round pipes—the Moody