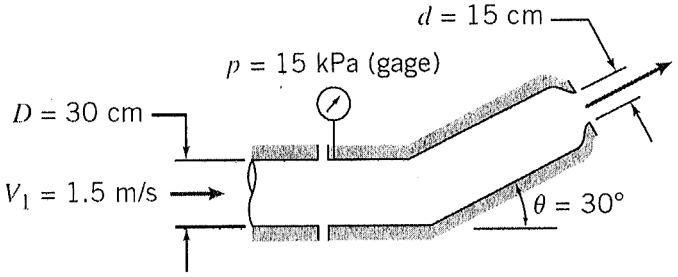
B. E. CHEMICAL ENGINEERING 2nd YEAR 1ST SEMESTER SUPPLEMENTARY EXAMINATION 2023

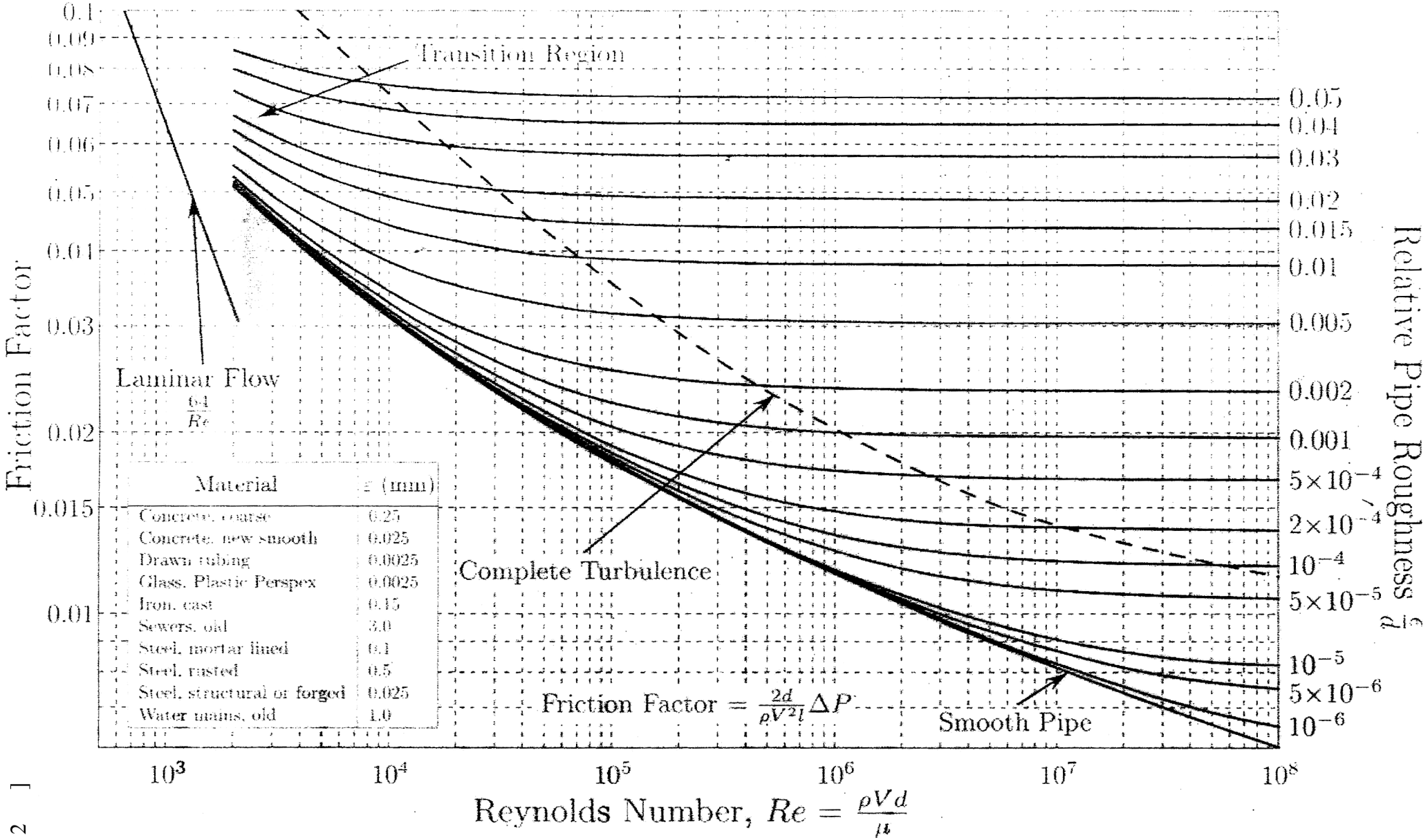
SUBJECT: MECHANICS OF FLUIDS Time: Three hours Full Marks 100

Use separate answer script for each Part

PART I (50 MARKS)

No. of Questions/ CO		Marks
1.(CO1)	A velocity field is given by $\vec{V} = 3y\cos(\omega t)\hat{i} - 9x\cos(\omega t)\hat{j}$ What is the directionality and dimensionality of the flow? Derive the equation of the streamline at time 'to' passing through (xo,yo) point. Is this incompressible and irrotational flow? Justify your answer.	(2+4+4 +4)
2. (CO2)	Water flows steadily through the nozzle shown, discharging to atmosphere. Calculate the horizontal component of force in the in the flanged joint.  FIG1	(10)
3.(i) (CO3)	125-mm-diameter pipeline conveying water at 10°C contains 50 m of straight galvanized pipe, 5 fully open gate valves, 1 fully open angle valve, 7 standard 90_ elbows, 1 square-edged entrance from a reservoir, and 1 free discharge. The entrance conditions are p1=150 kPa and z1=15 m, and exit conditions are p2=0 kPa and z2=30 m. A centrifugal pump is installed in the line to move the water. What pressure rise must the pump deliver so that the volume flow rate will be Q = 50 L/s?	
	OR	
3(ii) (CO3)	Consider a packed bed consisting of spherical particles (ρ_p= 1300 kg/m^3) of average diameter 1 mm. The bed is 1 m in diameter by 4 m long. Water (ρ=1000 kg/m^3) is used to fluidize the bed. At minimum fluidizing condition the void fraction, ϵ of the bed is 0.4. At the operating condition the bed height is increased by 2 times. Calculate (i) void fraction of the bed at operating condition (ii) the pressure drop across the bed under such condition, (ii) operating flow rate of water. Ergun equation for flow through packed bed having spherical particles is given below: $\frac{(-\Delta P_f)g_c}{L}\frac{D_p}{\rho V_o^2}\frac{\varepsilon^3}{(1-\varepsilon)} = 150\frac{(1-\varepsilon)}{N_{Re\,p}} + 1.75$; V_o is the superficial velocity.	(16)
4. (CO4)	A venturi-meter is fitted in a pipe of 25 cm diameter inclined at 30° to the horizontal to measure the upward flow rate of a liquid having a specific gravity of 0.8. The ratio of areas of main pipe and throat is 5 and the throat is 1 m from the inlet along its length. The difference in manometer head is 40 mm mercury (ρ_{Hg}=13600 kg/m3). Assume that the discharge coefficient is 0.94. Calculate the mass flow rate through the venturi-meter and the net pressure drop across the venturi-meter.	(10)

Moody Diagram



Material	ϵ (mm)
Concrete, coarse	0.25
Concrete, new smooth	0.025
Drawn tubing	0.0025
Glass, Plastic Perspex	0.0025
Iron, cast	0.15
Sewers, old	3.0
Steel, mortar lined	0.1
Steel, rusted	0.5
Steel, structural or forged	0.025
Water mains, old	1.0

Ref. No.: Ex/Che/PC/B/T/213/2023(S)

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MECHANICS OF FLUID

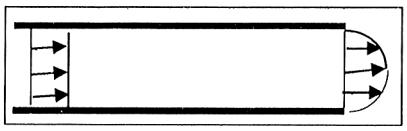
Part II **(50 MARKS)**

Answer any two questions

Assume any missing data

1 (a) An incompressible fluid flows steadily in the entrance region of a two-dimensional channel of height $2h$. The uniform velocity at the channel inlet, U_1 is 5 m/s. The velocity distribution at a section downstream is

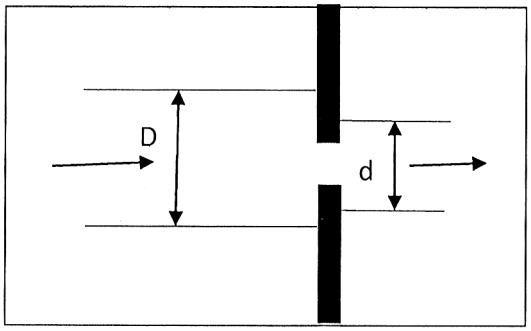
$$\frac{u}{u_{max}} = 1 - \left(\frac{y}{h}\right)^2$$



Evaluate the maximum velocity at the downstream section. Calculate the pressure drop that would exist in the channel if viscous friction at the walls could be neglected.

(b) In which case, form drag would be higher- flow over a plate normal to flow or flow over a plate parallel to flow? Explain.

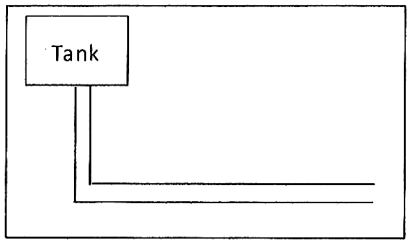
© Explain whether form drag will increase or decrease if a patch of sand paper is added to the nose of a moving ball? (17 + 4 + 4)



2(a) A vertical plate has a sharp-edged orifice at its centre. A water jet of speed 5 m/s strikes the plate concentrically. Obtain an expression for the external force needed to hold the plate in place, if the jet leaving the orifice also has a speed 5 m/s.

(b) Explain whether the length of the entrance region in fluid flow through a pipe would be greater in turbulent or laminar flow? (20 + 5)

3. A fire protection system is suppled from a water tower 25 m tall. The pipe is 200m and can be considered to be smooth. The pipe contains one gate valve; other minor losses may be neglected. The pipe diameter is 5 cm. Determine the maximum flow rate through the pipe.



The loss for flow through gate valve in terms of $\frac{L_e}{D}$ is 8. For turbulent flow, the friction factor may be calculated from

$f = \frac{0.316}{Re^{0.25}}$, where re is Reynolds number. (25)