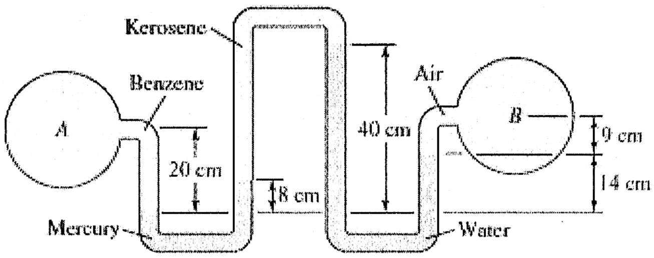
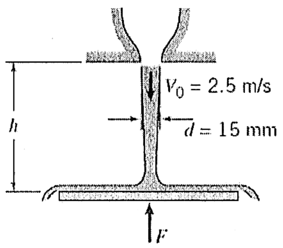
Ref. No. Ex/Che/PC/B/T/213/2025

B. E. CHEMICAL ENGINEERING 2nd YEAR 1ST SEMESTER EXAMINATION 2025

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

o. of Questions/ CO	Answer all the questions. Assume the missing data (if any)	Marks
1(i)/ 1	Consider the flow described by the velocity field V= 4yt i – 2xj; What are the dimensionality and directionality of flow? Derive the equation of stream line passing through the point (1,1,0) at time t=1 s. Is the flow irrotational?	1+4 +4
1(ii)	A concentric cylinder viscometer may be formed by rotating the inner member of a pair of closely fitting cylinders. The annular gap is small so that a linear velocity profile exists in the liquid sample. Consider a viscometer with an inner cylinder of 7.5 cm and 15 cm height and a clearance gap width of 0.0025cm. A torque of 0.021 N.m is required to turn the inner cylinder at 100 rpm. Determine he viscosity of the liquid in the clearance gap of the viscometer.	6
2(i)/ 1	As measured by NASA's Viking landers, the atmosphere of Mars, where g=3.71 m/s2, is almost entirely carbon dioxide and the surface pressure averages 700 kPa. The temperature is cold and drops of exponentially T=To exp (-cZ), where c=1.3x10-5 m-1 and To = 250 K . Find the analytical formula for the variation of pressure with the altitude. Calculate the altitude where the pressure on Mars has dropped to 1 Pa.	5+3
	 FIG.1  FIG.2	
2(ii) /4	Find the pressure difference between point A and B (refer to FIG 1). The density of Benzene, Kerosene, water and air are 810kg/m^3, 870 kg/m^3, 1000 kg/m^3 and 1 kg/m^3 respectively.	7
3./2	A uniform jet of water leaves a 15 mm diameter nozzle and flows directly downward. The jet speed at the nozzle exit plane is 2.5 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 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=3 m	15

[Turn over

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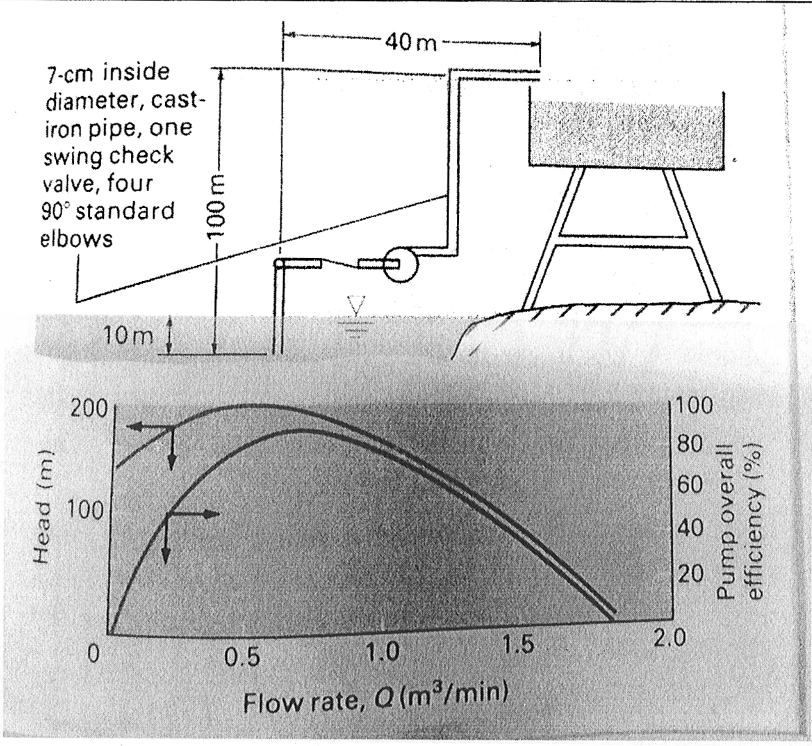
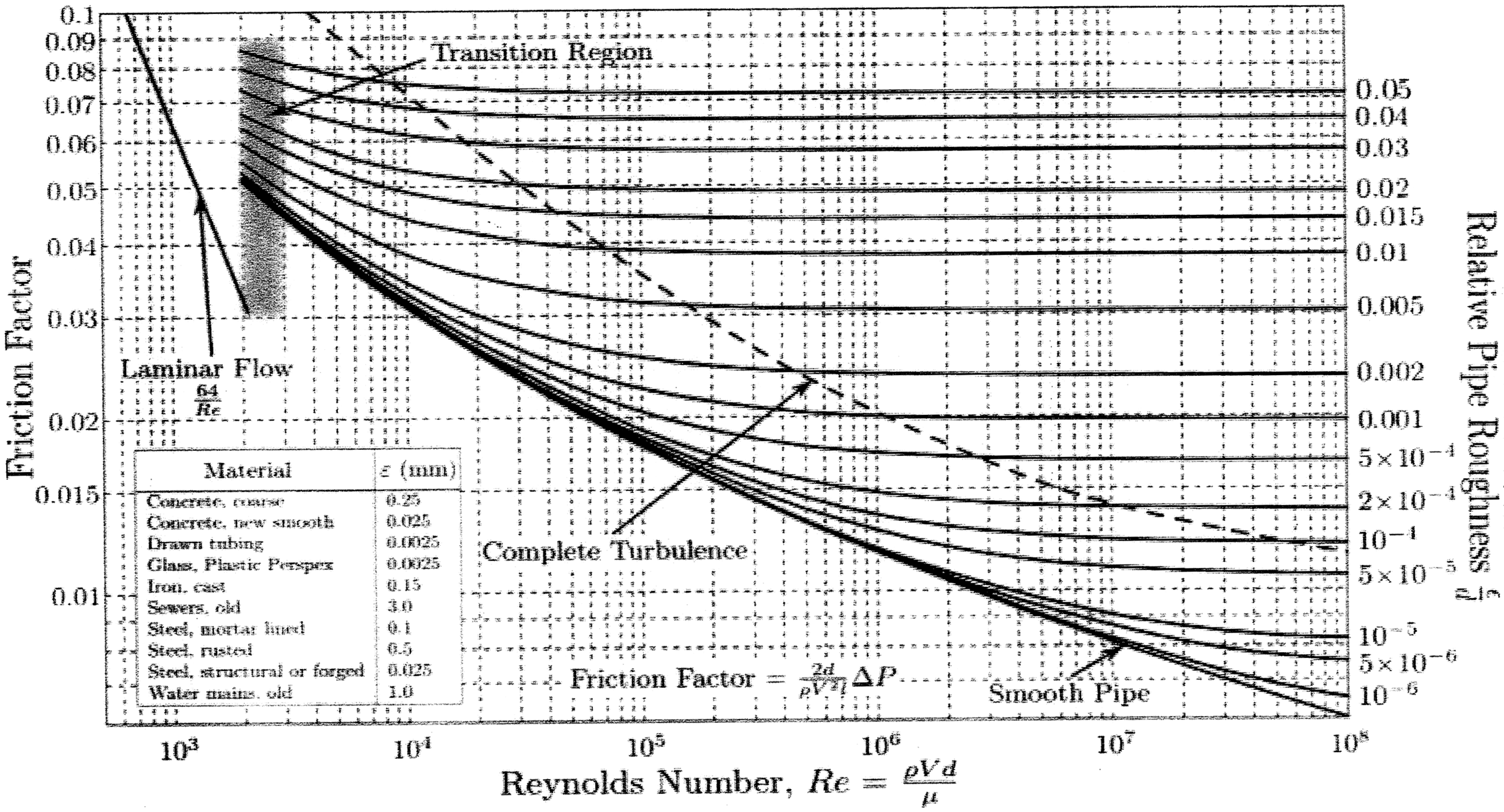
No. of Questions /CO		Marks
4.	 **Fig.3**	
6/3	**A centrifugal pump has the head and efficiency characteristics shown in Fig. 3 and delivers water at 30°C from the lake to the reservoir through cast iron piping (ε=0.25 mm)** **(i) Determine the flow rate and average velocity of water through the piping, which has screwed connections. What is the head developed by the pump? What is the pump efficiency? What motor power is needed?** **(ii) Plot the EGL and HGL.** **Data: Type of fitting — Loss coefficient (7cm pipe)** **90° elbow — 0.8** **Swing check valve — 2.0**	**20+5**

Moody Diagram



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Q/ CO		Marks
5/3	**A liquid reactant is pumped through a catalytic reactor which consists of a horizontal cylinder packed with catalyst sphere of diameter D_p=2.0mm. Tests summarized in Table 1 show the pressure drops (-Δp) across the reactor at two different volumetric flow rates Q. If the maximum pressure drop is limited by the pump to 350 kPa, what is the upper limit on the flow rate?**	

Table 1

Q (m^3/hr)	**-Δp, kPa**
0.34	**66.2**
0.68	**166.2**

Ergun equation for flow through packed bed is as follows (12)

$$\frac{(-\Delta P_f)}{L}\frac{D_p}{\rho V_o^{\,2}}\frac{\varepsilon^3}{(1-\varepsilon)} = 150\frac{(1-\varepsilon)\mu}{\rho V_o D_p} + 1.75$$

6/4

(i) Why the Rotameter is called as 'Area-meter'? What is the working principle of a Rotameter? (5)

(ii) 'The angle of diverging section of Venturimeter is less than 7°': Explain the reason. (5)

(iii) Water at 30°C flows through the orifice shown in Fig. 1, which is monitored by a mercury manometer. If d=3cm, what is the h when the flow rate is 25 m^3/h? Calculate the net pressure drop across the flowmeter (between upstream and downstream after pressure recovery) ? Km is the loss coefficient. (8)

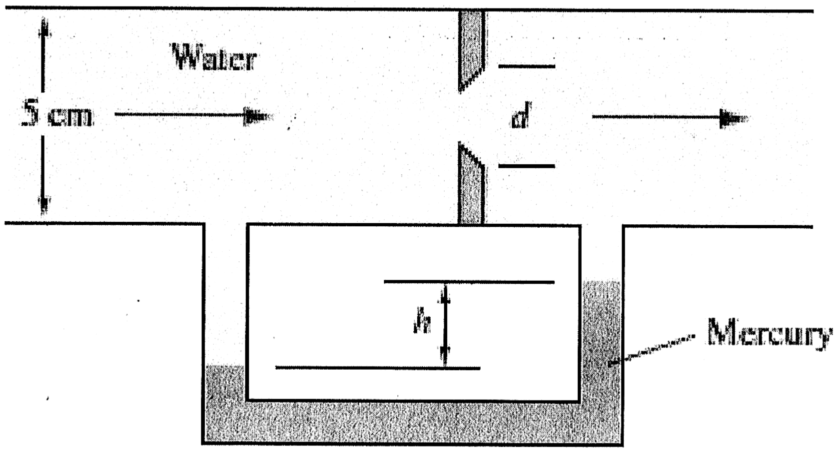
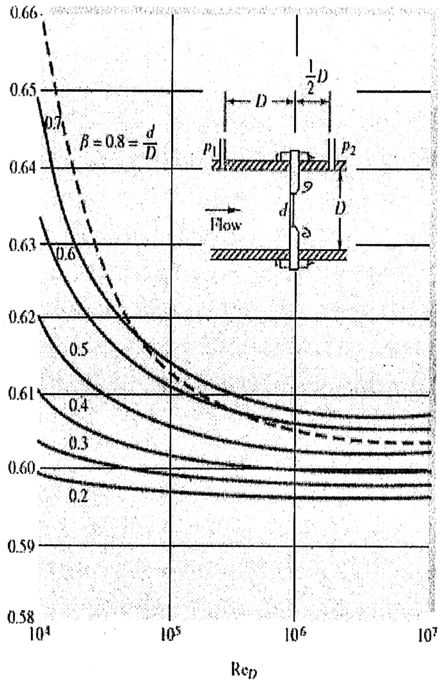
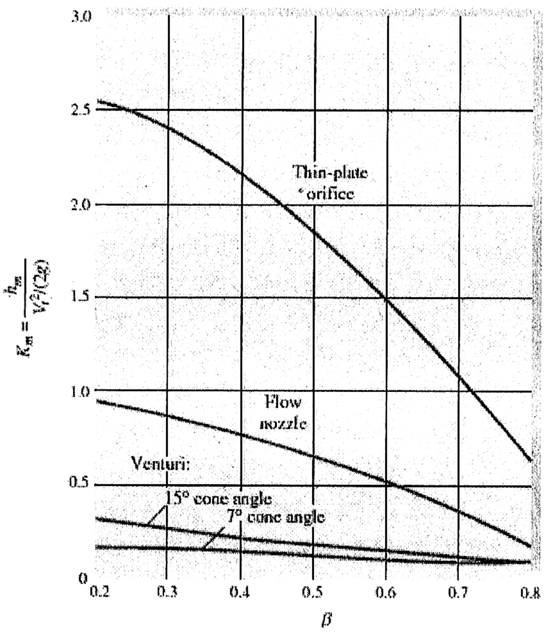


FIG4


0.66
0.65
0.64
0.63
0.62
0.61
0.60
0.59
0.58
C_d
0.7
0.6
0.5
0.4
0.3
0.2
$\beta = 0.8 = \frac{d}{D}$
D
$\frac{1}{2}D$
p_1
p_2
Flow
d
D
10^4
10^5
10^6
10^7
Re_D


3.0
2.5
2.0
1.5
1.0
0.5
0
$K_m = \frac{h_m}{V_t^2/(2g)}$
Thin-plate orifice
Flow nozzle
Venturi:
15° cone angle
7° cone angle
0.2
0.3
0.4
0.5
0.6
0.7
0.8
β