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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: B. Tech. (CE + RP) **Semester –**

Subject (Course): Momentum Transfer **Max. Marks : 100**

Course Code : CHCE 2003 **Duration : 3 Hrs**

No. of page/s: 5

Instructions:

Write all your assumptions clearly, wherever necessary.

Sections A is compulsory and contains **five questions** (each carrying 12 marks). Attempt only **two questions** out of the **three questions** (each carrying 20 marks) in the **Section B.**

Section A

1. Fluid properties and hydrostatics **[12]**

a. What do you understand by fluid statics, fluid kinematics and fluid dynamics? (3)

b. What is the unit of viscosity in SI unit? (2)

c. How do you calculate the vertical and the horizontal force on a submerged surface in an incompressible fluid? Write only the formulae and the description of each term in it. (3)

d. What are the conditions for between the center of gravity and center of buoyancy or metacenter for a solid body to be in stable equilibrium when it is fully submerged and when it is floating above the fluid? (2)

e. What should be the relation between the cohesive forces of fluid particles and the adhesive forces between the fluid and solid molecules for a fluid wetting a solid surface (contact angle = acute angle)? (2)

2. Flow Description **[12]**

a. The measurement of a fluid property is easy in the Eulerian or Lagrangian description? (2)

b. The local derivative is a Eulerian description or a Lagrangian description? (1)

c. The material derivative is a Eulerian description or a Lagrangian description? (1)

d. Which one of the two derivatives is used to define generation term of mass/momentum/energy in Reynold's Transport theorem? (1)

e. If the fluid velocity is $v = 3x\,i + x^2 y\,j$ and the temperature profile is $T = 2xt + yt^2$, then what will be the rate of temperature change measured by a probe at (1,1)? What will be the actual rate of heating of the fluid at that point? (2+3)

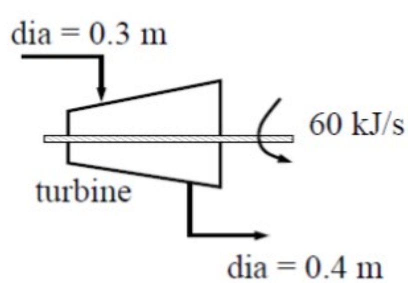
3. Energy balance and its application in fluid mechanics **[12]**

If an incompressible fluid is flowing in a pipe in steady-state flow.

What will be the most general energy balance equation? (1)

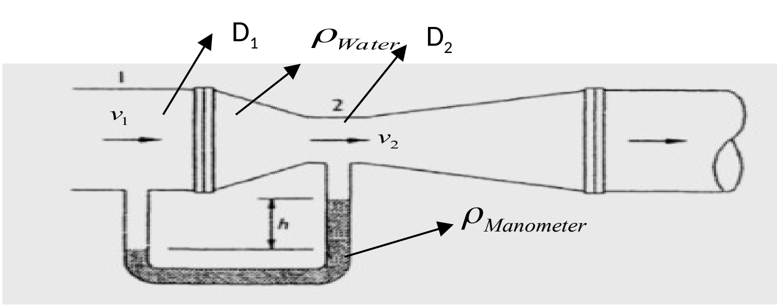
What assumption will be applied if the flow is (i) isothermal (ii) insulated (iii) no shaft work (iv) no viscous/frictional loss? (4)

A turbine (shown in the figure) is supplied with 0.6 m^3/s of water from a 0.3m diameter pipe; the outlet pipe has 0.4m diameter. Assume flow to be steady, incompressible, and nonviscous. Determine the pressure drop across the turbine if the rate at which work is produced by the turbine is 60kJ/s. (7)



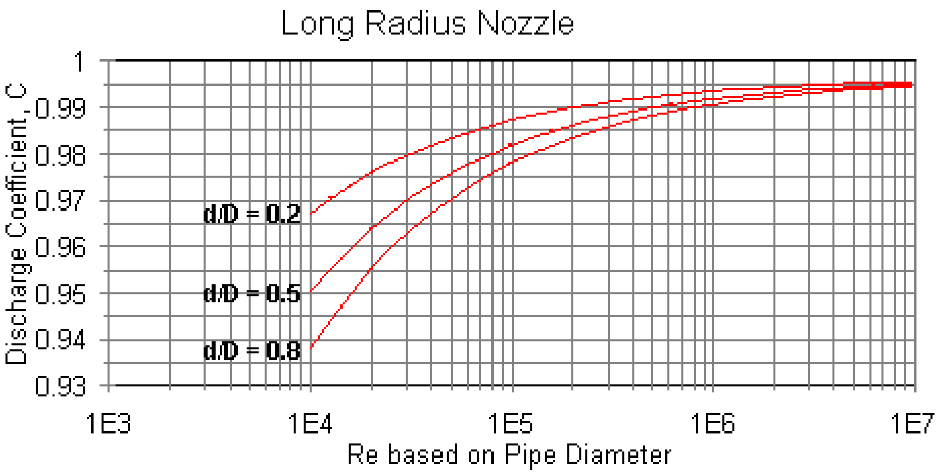
4. Flow measuring devices **[12]**

(a) Derive the formula for measuring the velocity in the Venturi-meter shown below? (6)



(b) Calculate the volumetric flow rate if D_1 = 20 mm, D_2 = 10 mm, h = 3 cm, $\rho_{water} = 10^3\ kg/m^3$

$\rho_{manometer} = 13.6 \times 10^3\ kg/m^3$, g = 10 m/s^2. Assume for first iteration C_v = 0.96. Only two iterations are required. Hint: (Reynold number is calculated using the velocity at the pipe diameter and not the throat diameter) (6)



5. Pumps **[12]**

What do you understand by a positive displacement pump and the centrifugal pump? What do you understand by cavitation? How does it change with the temperature at the suction of the pump? Draw a characteristic curve of discharge vs head for a centrifugal pump at a given rotation speed. (2 + 2 + 1 + 2).

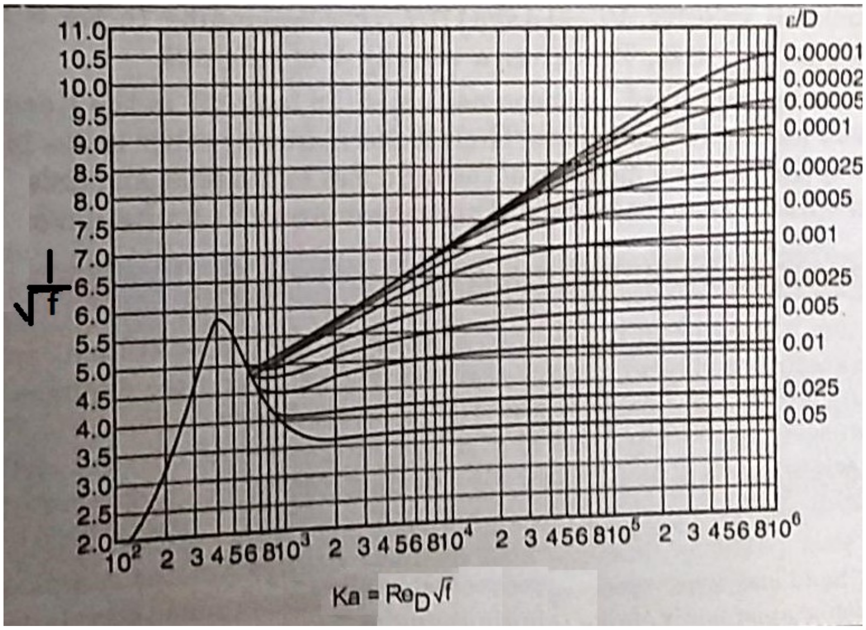
A centrifugal pump is operating with net discharge 10 m^3/s. The rotation speed of the propeller is 100 rpm. It is taking water from a tank filled with the height 2 m below the centerline of the pump. It is discharging the water to a tank at the height of 8 m above than the centerline of the pump. The pump efficiency is 70%. How much power is required? (5)

Section B

Attempt only two question of the three questions

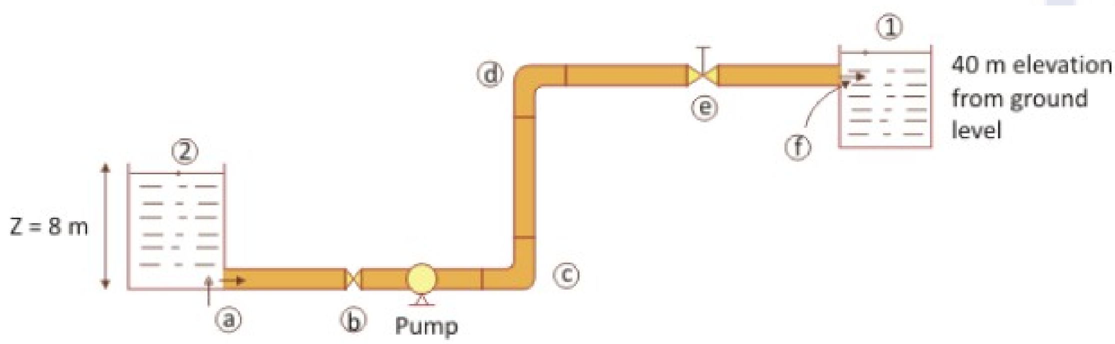
7. **[20]**

A hydrocarbon oil (viscosity 0.025 Pa-s and density 900 kg/m3) is transported using a 0.6 m diameter, 10 km long pipe. The maximum allowable pressure drop across the pipe length is 10^6 Pa. The roughness (ϵ/D) of the pipe is 0.01. Calculate the discharge rate (m^3/s) of the oil. Hint: Use the Darcy Weisbach formula to get the expression of Karman number (Ka).



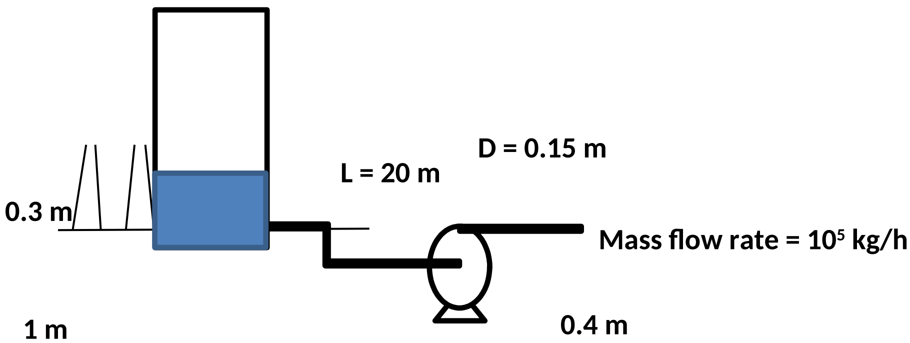
8. **[20]**

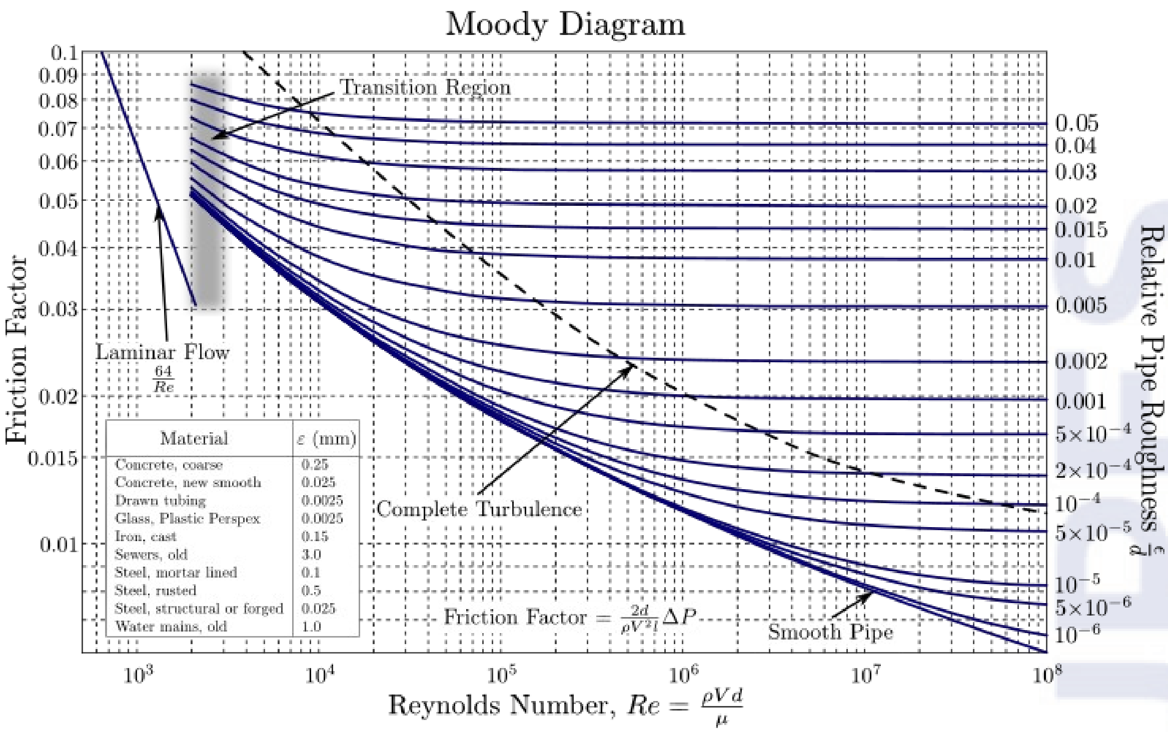
A pump delivers water $\rho = 1000\, kg/m^3, \eta = 10^{-3}\, Pa - s$ from one reservoir to another reservoir at 6×10^{-3} m^3/s through 140 m of 0.05-m-diameter pipe. See the figure below for several pipe–fittings installed on the pipe-line. The surface of the pipe is rough (ϵ/D = 0.001). Calculate the power of the pump required for the water–transfer. Use Moody's chart given in problem 9.



9. **[20]**

Calculate the Net Positive Suction Head for a pump handling 100,000 kg/hr flow of water coming from an atmospheric storage tank. The line size of pump suction line is 150 mm and the suction line is 20m long. The pump suction nozzle is 0.4 m above ground level. The tank is elevated on a 1 m high platform. The minimum liquid level in the tank is 300 mm. Water viscosity is 10^{-3} Pa-s. Water density = 10^3 kg/m3. Water vapor pressure at 25^0C = 0.032 bar absolute. Atmospheric pressure = 1 bar absolute (10^5 Pa).


D = 0.15 m
L = 20 m
0.3 m
Mass flow rate = 10^5 kg/h
1 m
0.4 m


Moody Diagram
Transition Region
Laminar Flow
$\frac{64}{Re}$
Complete Turbulence
Smooth Pipe
Friction Factor = $\frac{2d}{\rho V^2 l}\Delta P$
Friction Factor
Reynolds Number, $Re = \frac{\rho V d}{\mu}$
Relative Pipe Roughness $\frac{\varepsilon}{d}$
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.015
0.01
10^3
10^4
10^5
10^6
10^7
10^8
0.05
0.04
0.03
0.02
0.015
0.01
0.005
0.002
0.001
5×10^{-4}
2×10^{-4}
10^{-4}
5×10^{-5}
10^{-5}
5×10^{-6}
10^{-6}
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