

KATHMANDU UNIVERSITY  
End Semester Examination  
July/August 2024

Level : B.E.  
Year : II  
Time : 2 hrs. 30mins.

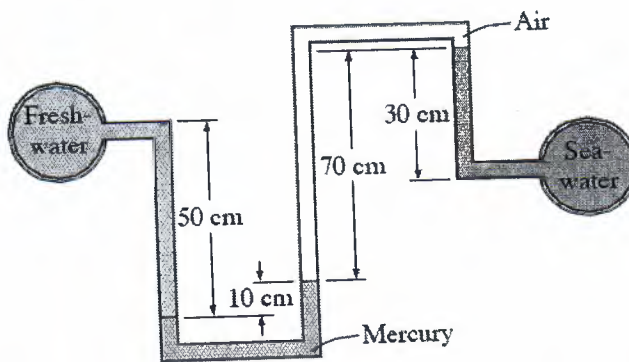
Course : MEEG 218  
Semester : I  
F. M. : 40

29 JUL 2024

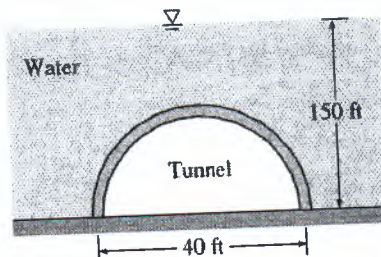
SECTION "B"  
[4Q. × 10 = 40 marks]

Attempt *ALL* questions. Assume suitable data if any is missing (Required data sheets are included)

1.
  - a. Draw a velocity profile on a circular pipe section for fully developed laminar flow. Explain briefly about no-slip boundary condition. [5]
  - b. Freshwater and seawater flowing in parallel horizontal pipelines are connected to each other by a double U-tube manometer, as shown in Figure. Determine the pressure difference between the two pipelines. Take the density of seawater at that location to be  $1035 \text{ kg/m}^3$ , and the density of mercury is  $13,600 \text{ kg/m}^3$ . [5]



2.
  - a. List various techniques of flow rate and velocity measurement. Explain two of the techniques in detail. [5]
  - b. A semicircular 40-ft-diameter tunnel is to be built under a 150-ft-deep, 800-ft-long lake, as shown in the figure below. Determine the total hydrostatic force acting on the roof of the tunnel. [5]



P.T.O.

3.

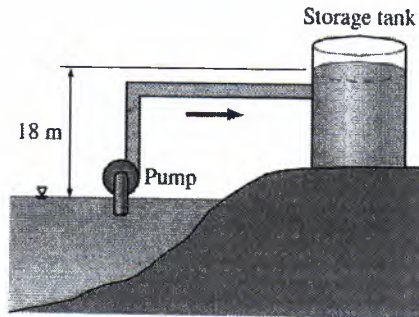
- a. The velocity components in a two dimensional flow are:

$$u = \frac{y^3}{3} + 2x - x^2y$$

$$v = xy^2 - 2y - \frac{x^3}{3}$$

Show that these components represent a possible case of an irrotational flow. [5]

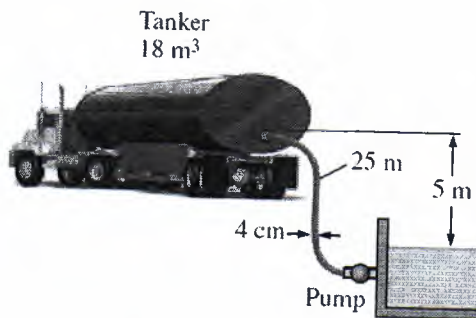
- b. Water is pumped from a lake to a storage tank 18 m above at a rate of 70 L/s while consuming 20.4 kW of electric power. Disregarding any frictional losses in the pipes and any changes in kinetic energy, determine (a) the overall efficiency of the pump-motor unit and b) the pressure difference between the inlet and the exit of the pump. [5]



4.

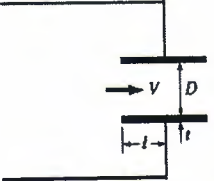
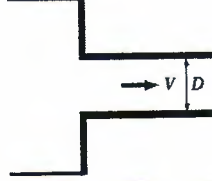
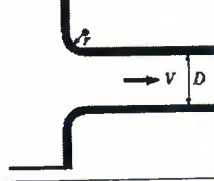
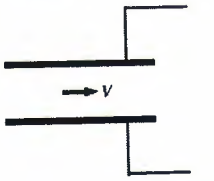

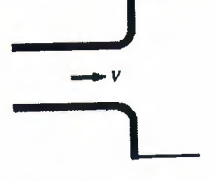
- a. Write a short note on Bernoulli Equation covering the following topics: Definition, mathematical formulation, static, dynamic and stagnation pressure, limitations of the use of the equation. [5]

- b. A vented tanker is to be filled with fuel oil with density of 920 kg/m<sup>3</sup> and viscosity of 0.045 kg/m.s from an underground reservoir using a 25 m long, 4 cm diameter plastic hose with a slightly rounded entrance and two 90 degree smooth bends. The elevation difference between the oil level in the reservoir and the top of the tanker where the hose is discharged is 5 m. The capacity of the tanker is 18 m<sup>3</sup> and the filling time is 30 min. Taking the kinetic energy correction factor at the hose discharge to be 1.05 and assuming an overall pump efficiency of 82 percent, determine the required power input to the pump. [5]



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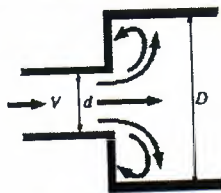
Loss coefficients  $K_L$  of various pipe components for turbulent flow (for use in the relation  $h_L = K_L V^2 / (2g)$ , where  $V$  is the average velocity in the pipe that contains the component)

<p><b>Pipe Inlet</b> Reentrant: <math>K_L = 0.80</math> (<math>t \ll D</math> and <math>l \approx 0.1D</math>)</p> 	<p>Sharp-edged: <math>K_L = 0.50</math></p> 	<p>Well-rounded (<math>r/D &gt; 0.2</math>): <math>K_L = 0.03</math> Slightly rounded (<math>r/D = 0.1</math>): <math>K_L = 0.12</math> (see Fig. 8-39)</p> 
<p><b>Pipe Exit</b> Reentrant: <math>K_L = \alpha</math></p> 	<p>Sharp-edged: <math>K_L = \alpha</math></p> 	<p>Rounded: <math>K_L = \alpha</math></p> 

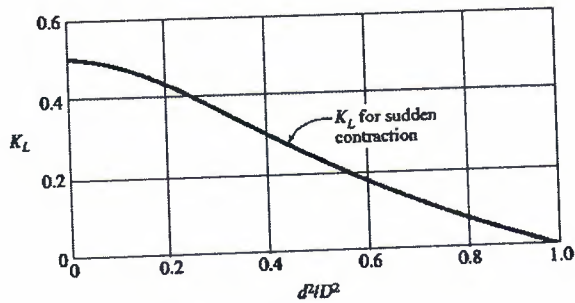
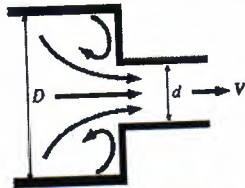
Note: The kinetic energy correction factor is  $\alpha = 2$  for fully developed laminar flow, and  $\alpha \approx 1.05$  for fully developed turbulent flow.

**Sudden Expansion and Contraction (based on the velocity in the smaller-diameter pipe)**

Sudden expansion:  $K_L = \alpha \left(1 - \frac{d^2}{D^2}\right)^2$

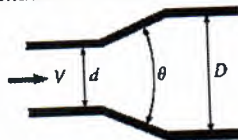


Sudden contraction: See chart.

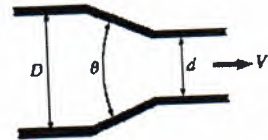


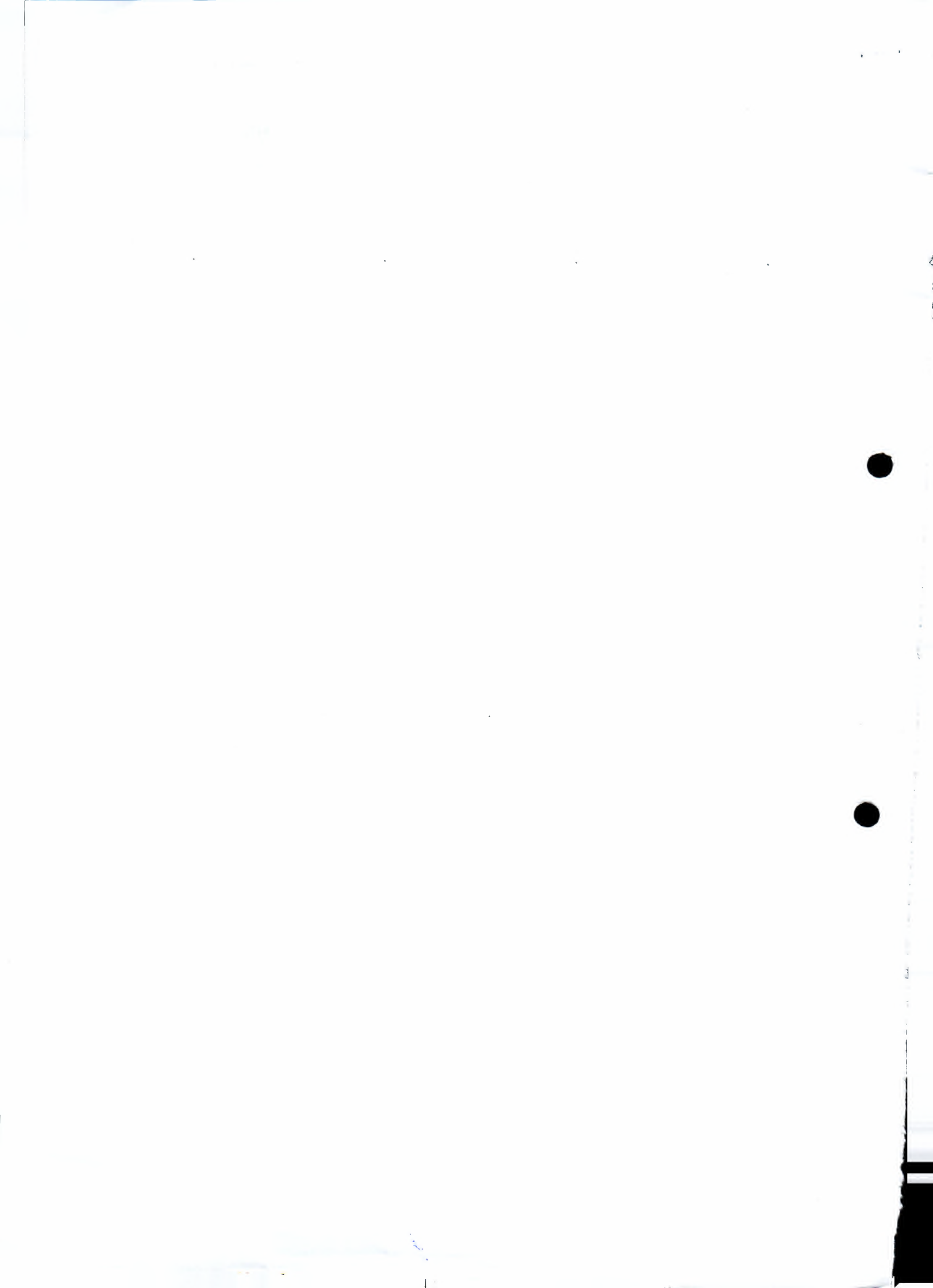
**Gradual Expansion and Contraction (based on the velocity in the smaller-diameter pipe)**

- Expansion (for  $\theta = 20^\circ$ ):  
 $K_L = 0.30$  for  $d/D = 0.2$   
 $K_L = 0.25$  for  $d/D = 0.4$   
 $K_L = 0.15$  for  $d/D = 0.6$   
 $K_L = 0.10$  for  $d/D = 0.8$



- Contraction:  
 $K_L = 0.02$  for  $\theta = 30^\circ$   
 $K_L = 0.04$  for  $\theta = 45^\circ$   
 $K_L = 0.07$  for  $\theta = 60^\circ$



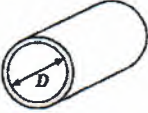
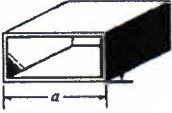
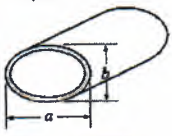



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Relevant equations and charts:

**Internal Flow**

Friction factor for fully developed *laminar flow* in pipes of various cross sections ( $D_h = 4A_c/\rho$  and  $Re = V_{avg} D_h/\nu$ )

Tube Geometry	a/b or $\theta^\circ$	Friction Factor f
Circle 	—	64.00/Re
Rectangle 	a/b 1 2 3 4 6 8 $\infty$	56.92/Re 62.20/Re 68.36/Re 72.92/Re 78.80/Re 82.32/Re 96.00/Re
Ellipse 	a/b 1 2 4 8 16	64.00/Re 67.28/Re 72.96/Re 76.60/Re 78.16/Re
Isosceles triangle 	$\theta$ 10° 30° 60° 90° 120°	50.80/Re 52.28/Re 53.32/Re 52.60/Re 50.96/Re

$$\frac{1}{\sqrt{f}} = -2.0 \log \left( \frac{\epsilon/D}{3.7} + \frac{2.51}{Re \sqrt{f}} \right)$$

$$\frac{1}{\sqrt{f}} \cong -1.8 \log \left[ \frac{6.9}{Re} + \left( \frac{\epsilon/D}{3.7} \right)^{1.11} \right]$$

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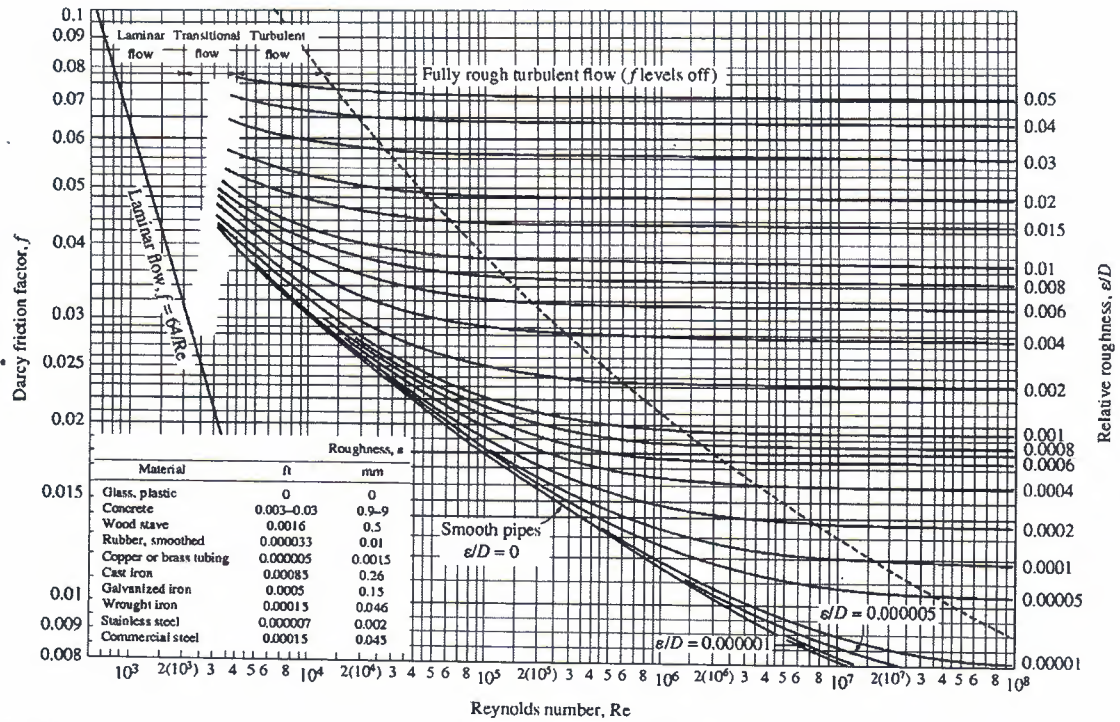
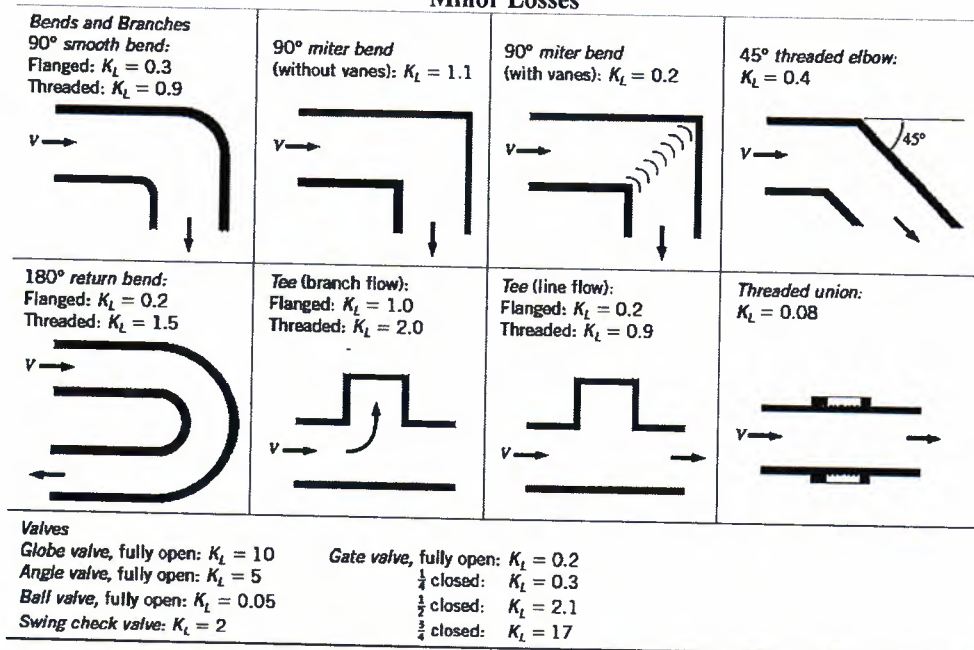


FIGURE A-12

The Moody chart for the friction factor for fully developed flow in circular pipes for use in the head loss relation  $h_L = f \frac{L}{D} \frac{V^2}{2g}$ . Friction factors in the turbulent flow are evaluated from the Colebrook equation  $\frac{1}{\sqrt{f}} = -2 \log_{10} \left( \frac{\epsilon/D}{3.7} + \frac{2.51}{Re \sqrt{f}} \right)$ .

Minor Losses



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Marks Scored:

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Time: 30 mins.

Registration No.:

Course : MEEG 218

Semester : I

F. M. : 10

Date

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SECTION "A"

[20Q. × 0.5 = 10 marks]

**Choose and mark [X] in the most appropriate option from each set of choices**

1. Property of a fluid by which molecules of different kinds of fluid are attracted to each other is called  
 adhesion                       cohesion                       surface tension                       viscosity
2. Stagnation point is the point in fluid mechanics where the velocity of the fluid at that point is  
 Infinite                       Constant                       Maximum                       Zero
3. Rain drops are spherical because of  
 Viscosity                       Air resistance                       Surface tension                       Atmospheric pressure
4. The velocity along the radial direction of the pipe,  $u(r)$  in the case of a hydrodynamically fully developed flow:  
 Remains constant  
 Varies  
 Depends on the location of the entrance region  
 Depends on the material
5. The pitot tube is used to measure  
 Velocity at stagnation point                       Stagnation pressure  
 Static pressure                       Dynamic pressure
6. The imaginary line drawn in the fluid in such a way that the tangent to any point gives the direction of motion at that point, is known as  
 Stream line                       Path line                       Streak line                       Potential line
7. A fluid particle is rotating at a speed of 12 rad/s. What is the vorticity of this particle?  
 12 rad/s                       24 rad/s                       48 rad/s                       6 rad/s
8. Which of the following parameter has the unit of force per unit length  
 Dynamic viscosity                       Kinematic viscosity  
 Surface tension                       Wall stress
9. A flow in which the viscosity of fluid is dominating over the inertia force is called  
 Steady flow                       Unsteady flow                       Laminar flow                       Turbulent flow
10. An open tank contains 1 m deep water with 50 cm depth of oil of specific gravity 0.8 above it. The pressure at the bottom of the tank will be  
 4 kN/m<sup>2</sup>                       10 kN/m<sup>2</sup>                       12 kN/m<sup>2</sup>                       14 kN/m<sup>2</sup>

11. Stream lines and path lines always coincide in case of  
 Steady flow       Laminar flow       Uniform flow       Turbulent flow
12. Equation of continuity is based on the principal of conservation of  
 Mass       Energy       Momentum       None of the above
13. The major loss of energy in long pipes is due to  
 Sudden enlargement       Sudden contraction  
 90 degree bend       Friction
14. In the case of an external parallel flow over a flat plat, which of the following drag can be neglected?  
 Pressure drag       Friction drag  
 Total drag       Both drags are significant
15. With the same cross-sectional area and immersed in same turbulent flow, the largest total drag will be on  
 a circular disc of plate held normal to flow       a sphere  
 a cylinder       a streamlined body
16. Irrotational flow is characterized by one in which  
 fluid flows along a straight line  
 fluid does not rotate as it moves along  
 net rotation of fluid particles about their mass centers remains zero  
 streamlines of flow are curved and closely spaced
17. A tank of diameter 2 m consists of a hole at the bottom of diameter 0.1 m. The velocity at which the water exists the hole is 6 m/s. Determine the height of the water in the tank.  
 1.83 m       2.22 m       3.04 m       4.33 m
18. The hydraulic grade line is  
 always above the centre line of pipe  
 never above the energy grade line  
 always sloping downward in the direction of flow  
 always above the energy grade line
19. Water is discharging from a tank of volume V through a hole which is at the bottom, with a volume flow rate of Q. Which of the following expression closely describes the time taken for the tank to become completely empty?  
 V/Q       Less than V/Q       More than V/Q       Half of V/Q
20. Which of the following is not a dimensionless parameter  
 Kinematic viscosity       Friction factor  
 Reynolds number       Pressure coefficient