BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
SEMESTER I, 2016-17
CHE F212: FLUID MECHANICS
COMPREHENSIVE EXAMINATION

A

Date: 12/12/2016 **Duration: 3 Hrs**
Day: Monday **Max. Marks: 100**

Instructions:
1. **Take suitable assumption wherever necessary.**
2. **Take ambient temperature and pressure as 27^{o}C and 1 atm; g = 9.81 m/s^2; ρ_{water}= 1000 kg/m^3**

CLOSED BOOK

Q.1. Choose the most appropriate answer among the given choices:
(Right answer: 1 Mark and Wrong answer: -0.25 Marks)

1. The pressure difference between inside and outside of a liquid drop is given by:
a.) 2σ/d b.) 4σ/d c.) 8σ/d d.) 16σ/d

2. A soap bubble of initial radius r is to be blown up. The surface tension of the soap film is σ. The surface energy needed to double the diameter of the bubble without change of temperature is:
a.) $4\pi r^2\sigma$ b.) $12\pi r^2\sigma$ c.) $24\pi r^2\sigma$ d.) $16\pi r^2\sigma$

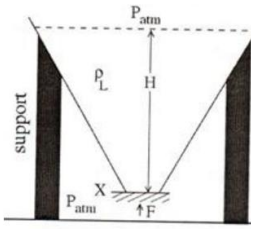
3. Poise (P) is the unit of dynamic viscosity and one Poise is equal to:
a.) 1 Ns/m^2 b.) 1 lb/ft.hr c.) 1 g/cm.s d.) 1 kg/m.s

4. At a location where g = 31.0 ft/s^2, 3 slugs is equivalent to how many pounds mass:
a.) 90.00 b.) 93.00 c.) 0.01 d.) 96.522

5. How deep can a diver descend in ocean water (specific weight=64 lb_f/ft^3) without damaging his watch which will withstand an absolute pressure of 80 lb_f/in^2?
a.) 146.9 ft b.) 180 ft c.) 1.02 ft d.) 1.25 ft

6. What is the force required (in Newtons) to hold a spherical balloon stationary in water at depth of *h* from the air-water interface? The balloon is of radius 0.1 m and is filled with air.
a.) $\frac{4\pi g}{3}$ b.) $\frac{0.1\pi gh}{4}$ c.) $\frac{0.1\pi gh}{8}$ d.) $\frac{0.04\pi gh}{3}$

7. A conical tank with a bottom of cross-sectional area A is filled with water and is mounted on support, as shown in figure. What is the force F with which plate X must be pushed up to prevent water from leaking? Assume that the density of air is negligible as compared to the density of water ρ_L.



a.) $\rho_L Vg$ b.) $\rho_L AHg$ c.) $\frac{\rho_L Vg}{2}$ d.) $\frac{\rho_L Vg}{3}$

8. The pressure intensity is the same in all directions at a point in a fluid
a.) only when the fluid is frictionless b.) only when the fluid is at rest having zero velocity
c.) when there is no motion of one fluid layer relative to an adjacent layer
d.) regardless of the motion of one fluid layer relative to an adjacent layer

9. In turbulent flow
a.) the fluid particles move in an orderly manner b.) momentum transfer is on molecular scale only
c.) shear stress is caused more effectively by cohesion than momentum transfer
d.) shear stresses are generally larger than in a similar laminar flow

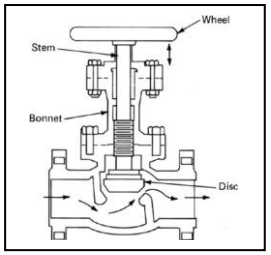
10. Stoke's law is valid when the particle Reynolds number is

a.) <1 b.) <10 c.) < 2300 d.) <5 x 10^5

11. Pressure drop in packed bed for turbulent flow is given by which of the following equation:
a.) Kozney-Karman b.) Blake-Plummer c.) Oswalt-de-waele d.) Bernoulli's

12. Cavitation occurs in a centrifugal pump when
a.) the suction pressure < vapor pressure of the liquid at that temperature
b.) the suction pressure > vapor pressure of the liquid at that temperature
c.) the suction pressure = vapor pressure d.) the suction pressure = developed head

13. Froude number is the ratio of
a.) shear stress to gravitational stress b.) drag stress to shear stress
c.) inertial stress to shear stress d.) inertial stress to gravitational stress



14. Figure to the right indicate which of the following valves:
a.) Gate valve b.) Glove valve c.) Butterfly valve d.) Check valve

15. Flow rate of high velocity flue gas discharge through a stack to the atmosphere can be most conveniently measured by a:
a.) Pitot tube b.) Manometer c.) Rotameter d.) Piezometer

16. Friction factor at a given Reynolds number for a hydraulically smooth pipe can be increased by:
a.) increasing the length of the pipe b.) decreasing the diameter of the pipe
c.) by increasing the roughness d.) none of these

17. Which of the following may be treated as variable orifice flow-meter?
a.) rotameter b.) pitot tube c.) V-notch d.) all '*a*', '*b*' & '*c*'

18. Pressure recovery coefficient is defined as the ratio of:
a.) viscous forces to gravitational forces b.) pressure forces to viscous forces
c.) pressure forces to inertial forces d.) viscous forces to inertial forces

19. For a rectangular duct of width b and height h, the hydraulic diameter is given by:
a.) 2bh/(b+h) b.) 4bh/(b+h) c.) bh/2.(b+h) d.) (b+h)/2bh

20. Particulate fluidization is characterized by:
a.) uniform expansion of bed b.) non-uniform expansion of bed
c.) aggregation of particles in the bed d.) bubbling of the bed

21. Consider a bed consisting of mixture of different particles of mean diameter $\overline{D}_p$. The surface-mean diameter of the mixture $\overline{D}_s$, from the mass fraction in each size range x_i is:

a.) $\sum_{i=1}^{n}\left(\frac{x_i}{\overline{D}_{pi}}\right)$ b.) $\sum_{i=1}^{n}\left(x_i\overline{D}_{pi}\right)\Big/\sum_{i=1}^{n}x_i$ c.) $\sum_{i=1}^{n}\left(x_i\overline{D}_{pi}^{2}\right)\Big/\sum_{i=1}^{n}\overline{D}_{pi}$ d.) $1\Big/\sum_{i=1}^{n}\left(\frac{x_i}{\overline{D}_{pi}}\right)$

22. Which of the following statements are true for a *bluff body*, at critical Reynolds number:
a.) Do not show the drop in drag coefficient b.) Shows the decrease in drag coefficient
c.) Shows increase in drag coefficient d.) Do not show the rise in drag coefficient

23. Euler's equation of motion states that at every point, the
a.) fluid momentum is constant b.) force per unit mass equals acceleration
c.) rate of mass outflow and inflow are equal d.) pressure gradient is constant

24. In which of the following body shapes, the pressure drag is large compared to the friction drag?
a.) sphere b.) cylinder c.) Vertical flat plate d.) Horizontal flat plate

25. Paper pulp is an example_____fluid.
a.) Dilatant b.) Bingham Plastic c.) Newtonian d.) Pseudoplastic

26. Given a pipe of diameter D, the entrance length necessary to achieve fully developed laminar flow is proportional to (Re is Reynolds number)
a.) D.Re b.) D/Re c.) D/Re^2 d.) $D.Re^2$

27. For a particle settling in water at its settling velocity, which of the following is true?
a.) Buoyancy = weight + drag b.) weight=buoyancy + drag
c.) Drag = buoyancy + weight d.) drag = weight

28. Applying a pressure drop across a capillary result in a volumetric flow rate of Q under laminar flow conditions. The flow rate, for the same pressure drop, in a capillary of the same length, but half the radius is: a.) Q/2 b.) Q/4 c.) Q/8 d.) Q/16

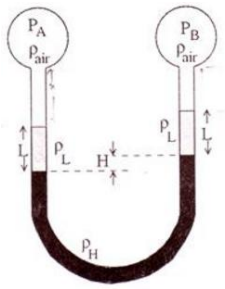
29. Water is flowing under laminar conditions in a pipe of length L. If the diameter of the pipe is doubled, for a constant volumetric flow rate, the pressure drop across pipe
a.) Decrease 2 times b.) Decrease 16 times c.) Increase 2 times d.) Increase 16 times

30. In case of a pressure driven laminar flow of a Newtonian fluid of viscosity (μ) through a horizontal circular pipe, the velocity of the fluid is proportional to
a.) μ b.) $\mu^{0.5}$ c.) μ^{-1} d.) $\mu^{-0.5}$

Q.2. Fill up the blanks with most appropriate answers: [3 M each]

1. The sphericity of a particle of cubicle shape is_____ .

2. For the manometer setup shown in the figure, the pressure difference $P_A - P_B$ is given by_____ .

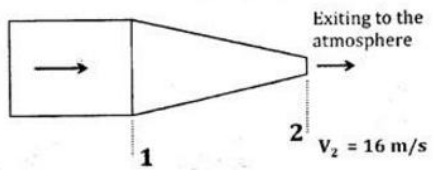


3. For an incompressible flow, the x and y-component of the velocity vector are $u = 2(x+y)$; $v = 3(y+z)$ where x, y, z are in meters, all velocities are in m/s. Then the z-component of the velocity vector (w) of the flow for the boundary condition w=0 at z = 0 is:_____.

4. Water is pumped at a rate of 36 m^3/hr, from a tank 2 m below the pump, to an overhead pressurized vessel 10 m above the pump. The pressure values at the point of suction from the bottom tank and at the discharge point to the overhead vessel are 120 kPa and 240 kPa, respectively. All pipes in the system have the same diameter. Neglecting frictional losses, what is the power (in kW) required to deliver the fluid?

5. An incompressible fluid is flowing through a contraction section of length L and has a 1-D (x-direction) steady state velocity distribution, $u = u_0\left(1+\frac{2x}{L}\right)$. If u_0 = 2 m/s and L = 3 m, the convective acceleration (in m/s^2) of the fluid at L is_____.

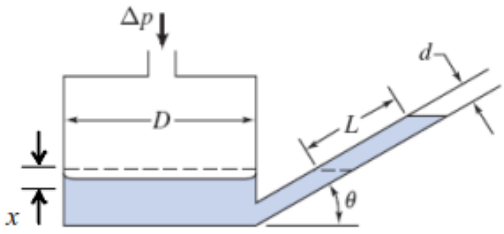
6. Water is flowing through a nozzle, as shown in figure and exiting to the atmosphere. The relationship between the diameters of the nozzle at locations 1 and 2 is $D_1 = 4\ D_2$. The average velocity of the stream at location 2 is 16 m/s and the frictional loss between location 1 and location 2 is 10,000 Pa. Assuming steady state and turbulent flow, the gauge pressure in Pa, at location 1 is_____.



7. Consider a liquid (density = 1000 kg/m^3) flowing through a packed bed of particles (density of particles = 2500 kg/m^3). Assuming that the porosity of the bed is 0.5, the pressure drop per unit length (Pa/m) under incipient fluidization condition is _____

8. The inclined manometer shown in figure has D = 12 d and SG = 0.85. The angle θ, required to provide a 5:1 increase in liquid deflection, L, compared with the total deflection in a regular U-tube manometer is_____ degrees.

9. For the deflection L = 5 cm, the pressure drop Δp across the manometer is _____ N/m^2.



10. For the same deflection as in question '9' the sensitivity of above inclined manometer is: _____.

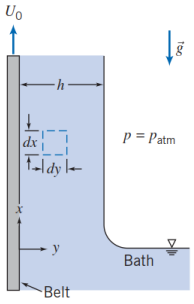
Q.3 The Moody diagram gives the Darcy friction factor, f, in terms of Reynolds number and relative **8**

roughness. The *Fanning friction factor* for pipe flow is defined as

$$f_F = \frac{\tau_w}{\frac{1}{2}\rho \overline{V}^2}$$

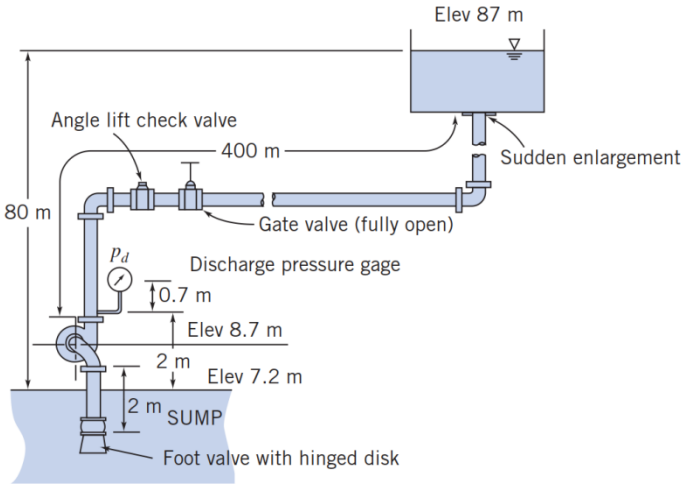
where τ_w is the wall shear stress in the pipe. Show that the relation between the Darcy and Fanning friction factors for fully developed pipe flow is given by $f = 4f_F$.

Q.4 A continuous belt, passing upward through a chemical bath at speed U_0, picks up a liquid film of thickness h, density ρ, and viscosity μ. Gravity tends to make the liquid drain down, but the movement of the belt keeps the liquid from running off completely. Assume that the flow is fully developed and laminar with zero pressure gradient, and that the atmosphere produces no shear stress at the outer surface of the film. State clearly the boundary conditions to be satisfied by the velocity at $y = 0$ and $y = h$. Obtain an expression for the velocity profile. **12**



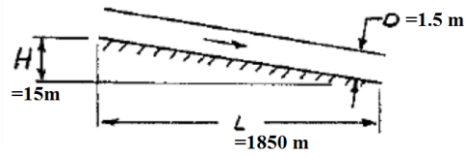
(OPEN BOOK)

Q.1. A pump in the system shown draws water from a sump and delivers it to an open tank through 400 m of new, 10 cm diameter commercial steel pipe. The vertical suction pipe is 2 m long and includes a foot valve with hinged disk and a 90° standard elbow. The discharge line includes two 90° standard elbows, an angle lift check valve, and a fully open gate valve. The design flow rate is 800 L/min. Find the head losses in the suction and discharge lines. Calculate the NPSHA. Assume pressure at the pump entrance and exit as atmospheric. **12**



Q.2. The pressure drop through a particle bed can be used to determine the external surface area and the average particle size. Data for a bed of crushed ore particles show $\Delta p/L$ = 84 (lb_f/in.^{2})/ft for airflow at a superficial velocity of 0.015 ft/s. The measured void fraction is 0.47, and the estimated sphericity ϕ_s is 0.7. Calculate the average particle size and the surface area per unit mass if the solid has a density of 4.1 g/cm^3. How sensitive is the answer to an error of 0.01 in ε? **12**

Q.3. Your favorite professor likes mountain climbing, so there is always a possibility that the professor may fall into a crevasse in some glacier. If that happened today, and the professor was trapped in a slowly moving glacier, you are curious to know whether the professor would reappear at the down-stream drop-off of the glacier during this academic year. Assuming ice is a Newtonian fluid with the density of glycerine but a million times as viscous, you decide to build a glycerin model and use dimensional analysis and similarity to estimate when the professor would reappear. Assume the real glacier is 15 m deep and is on a slope that falls 1.5 m in a horizontal distance of 1850 m. Develop the dimensionless parameters and conditions expected to govern dynamic similarity in this problem. If the model professor reappears in the laboratory after 9.6 hours, when should you return to the end of the real glacier to provide help to your favorite professor? **16**



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