Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

B.E. Sem-III Regular / Remedial Examination December 2010

Subject code: 130502 Subject Name: Fluid Flow Operation

Date: 14 /12 /2010 Time: 10.30 am – 01.00 pm

Instructions: Total Marks: 70

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Answer the following questions in brief: **09**

(i) Distinguish between compressible and incompressible fluid

(ii) State the physical significance of Reynolds number.

(ii) Mention name and working principle of instrument used for measurement of dynamic pressure.

(iv) Define viscosity and momentum flux.

(v) State the assumptions necessary to derive the Bernoulli's theorem

(vi) Calculate hydraulic radius and equivalent diameter for a duct of square cross section of side 'b'.

(vii) Write down the force balance equation when a particle attains its terminal settling velocity.

(viii) Enlist various types of variable area meter and head meter used for flow measurement.

(ix) Define NPSH for a centrifugal pump.

(b) Explain the concept of hydrostatic equilibrium and derive an expression used for the measurement of pressure distribution in deep gas container. **05**

Q.2 **(a)** What is meant by time dependent and time independent fluid? Classify the same with suitable examples. **04**

(b) What pressure drop per unit length is required in order to pump water at 25 ^{0}C through a pipe of 5-cm diameter at rate of 68 cm^3 / sec? Viscosity of water at 25 ^{0}C is 1 cP. **03**

(c) Write the importance of kinetic energy correction factor. Calculate the kinetic energy correction factor for the following velocity distribution in circular pipe of radius r_0. **07**

$$\frac{u}{u_m} = \left(1 - \frac{r}{r_0}\right)^m$$

OR

(c) Provide general definitions of volumetric flow rate and mass flow rate through a surface. Show that the mean velocity for laminar fully developed flow in a pipe of circular cross section is equal to half the velocity at the centerline. The velocity profile is parabolic. **07**

Q.3 **(a)** Derive the Hagen-Poiseuille equation for the volumetric flow rate in a straight circular pipe (fully developed laminar flow). **05**

(b) A horizontal pipe of diameter D_1 has sudden expansion to a diameter D_2. At what ratio of diameters D_1 / D_2 would the differential pressure on either side of the expansion be maximum? What is the corresponding loss of head and differential pressure head? **05**

(c) Starting from the total energy balance equation for a flow of compressible fluid, show that the maximum velocity $u_{max} = \sqrt{p_w v_w}$ for isothermal condition, where p_w and v_w show pressure and specific volume at down stream condition. **04**

OR

Q.3 **(a)** Brine is to be pumped through a 35-m smooth copper tube having inside diameter of 2.5-cm. The flow rate is 94.7 $\times$ 10 $^{-3}$ m^3 /min. Calculate the head loss due to friction and pressure drop from friction. **05**

Data given: Specific gravity of brine = 1.18, Viscosity of brine = 2.5 cP and

$$f = 0.0014 + \frac{0.125}{R_e^{0.32}}$$

(b) Derive an expression of head loss due to sudden expansion of flow area for steady flow of incompressible fluid. **05**

(c) Use conservation laws of mass and momentum to derive an expression for the velocity *C* of an infinite pressure wave, which propagates in an otherwise, still fluid. The thickness of the wave- front can be assumed to be infinitely small so that one-dimensional approximations are applicable. **04**

Q.4 **(a)** Explain / define the following: **05**

(i) Gate valve (ii) Globe valve (iii) Check valve (iv) BWG (v) Schedule number

(b) What size of orifice would give a pressure difference of 41-cm water column for the flow of styrene of specific gravity of 0.9 at 0.055 m^3/sec in a 250-mm diameter pipe? Take $C_d = 0.62$ **04**

(c) What is meant by cavitation and priming? Explain the different characteristic curve of the centrifugal pump with neat sketches. **05**

OR

Q.4 **(a)** Benzene at 37^{o}C is pumped at the rate of 9.09 m^3/hr from the reservoir. The reservoir is at atmospheric pressure. The gauge pressure at the end of the discharge line is 345 kN/m^2. The discharge is 3.048-m, and the pump suction is 1.22-m above the level in reservoir. The velocity through discharge line is 1.9232 m/sec. The friction in the suction line is known to be 3.45 kN/m^2, and that in the discharge line 37.9 kN/m^2. The mechanical efficiency of the pump is 0.6. The density of benzene is 865 kg/m^3, and its vapor pressure at 37 ^{0}C is 26.2 kN/m^2. Calculate (a) the developed head of the pump and (b) the total power input. **05**

(b) Starting with the Bernoulli and Continuity equations, show that the following expression gives the discharge measured by a venturimeter. **05**

$$Q = C_d \, A_1 \, A_2 \sqrt{\frac{\frac{2g\,(P_1 - P_2)}{\rho\, g} + (Z_1 - Z_2)}{A_1^{\,2} - A_2^{\,2}}}$$

Write a short note on devices used for prevention of leakages around the moving parts of machinery **04**

Q.5 **(a)** Liquid in a tank is drained through a pipe at tank bottom. The time t is taken to drain the liquid is to be determined. We hypothesize that the time depends on the liquid height h in a tank above the exit pipe, the liquid velocity V in the exit pipe, the exit pipe diameter D and the liquid properties density and viscosity, ρ, and μ respectively. Use the Rayleigh method to obtain an expression for the time in terms of the pertinent variables. **06**

(b) Water trickles by gravity over a bed of particles, each 1-mm diameter in a bed of diameter 6-cm and height 2-m. The water is fed from a reservoir whose diameter is much larger than that of the packed bed, with water maintained at a height of 0.1-m above the top of the bed. The bed has a porosity of 0.31. Calculate the volumetric flow rate of water if its viscosity is 1- cP. **06**

(c) Explain why the velocity measured by the Pitot-static tube is higher than that measured by the venturimeter. **02**

OR

Q.5 Answer as directed.

(a) The power required by an agitator in a tank is a function of the diameter of the agitator, number of rotations of the impeller per unit time, viscosity and density of liquid. From dimensional analysis using Buckingham's π method, obtain a relation between power and the four variables. **06**

(b) With neat sketch explain the distinct modes of fluidization, which depends on the relative density of the solids. **05**

(c) A "U"-tube manometer containing mercury of density 13600 kg/m^3 is used to measure the pressure drop along a horizontal pipe. If the fluid in the pipe has a specific gravity of 0.8 and the manometer reading is 0.6m, what is the pressure difference measured by the manometer? **03**

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