14CH306

Hall Ticket Number:

III/IV B. Tech (Regular) DEGREE EXAMINATION

OCTOBER, 2016 **Chemical Engineering**

Momentum Transfer

Third Semester

Time: Three Hours **Maximum :** 60 Marks

Answer Question No.1 compulsorily. (1X12 = 12 Marks)

Answer ONE question from each unit. (4X12=48 Marks)

1. Answer all questions (1X12=12 Marks)

1. Explain the following:

a	Define unit processes. Any chemical Change.
b	Write the equation to calculate separation time in gravity decanter 100.mu/(rhoA-rhoB) where mu is in cPa and rho is in kg/m^3 and t is in Hr.
c	Define boundary layer Part of fluid influenced by solid boundary interms of shear rate and strear stress gradients.
d	Define mass velocity Velocity multiplied by density..
e	What in the relation between velocity and radius in a horizontal pipe line. For a Newtonian and incompressible fluid under steady state-isothermal flow velocity varies parabolically with radius in laminar flow. And in turbulent flow exponentially.
f	Define kinetic energy correction factor. $$\frac{1}{S}\int\left(\frac{u}{\bar{\bar{V}}}\right)^3 ds$$
g	Write continuity equation for compressible fluid $$d(\rho u S) = 0$$
h	Define drag coefficient $$\frac{F_D/A_p}{[1/2]\rho u^2}$$
i	Write Burke-Plummer equation $$\frac{\Delta P}{L} = 1.75\frac{\rho \bar{V}_0^2}{\emptyset_S D_P}\frac{(1-\varepsilon)}{\varepsilon^3}$$
j	Pieces of tubing are connected by Soldering, compression fittings…
k	What are different forces acting in Rotameter

	Drag, gravity and buoyancy.
l	Classify positive displacement pumps. Rotary and reciprocating

UNIT - I

2.a	Explain Rayleigh's method of dimensional analysis. Rayleigh's method is based on dimensional homogeneity. Therefore dependent variable is expressed as product of independent variables raised to empirical powers. The equations obatained by dimensional homogeneity are solved. Regrouping is done to obtain reduced number of groups which are dimensionless.	3x2 = 6M
2.b	With the help of neat sketch explain the principle of U-tube manometer Manometer is an important device for measuring pressure difference. With respect to above figure applying hydrostatic equilibrium at plane 2-3. $p_a + \frac{g}{g_c}[(Z_m + R_m)\rho_B - R_m\rho_A - Z_m\rho_B] = p_b$ Simplification of this equation gives… $p_a - p_b = \frac{g}{g_c} R_m(\rho_A - \rho_B)$	3x2=6M

Or

3.a	Explain boundary layer formation in straight tubes and horizontal plates In straight tubes boundary layer reaches to the center of tube in laminar flow for incompressible Newtonian fluid. A very thin boundary layer is formed in case of high turbulent flows. In between these flows boundary layer spreads from solid wall to anywhere near center of tube.	3+3M
b	Show that in a gravity decanter the position of the liquid – liquid interface in the separator depends on the ratio of the densities of the two liquids and on the elevation of the overflow line. Applying principle of hydrostatic equilibrium $Z_B\rho_B + Z_{A1}\rho_A = Z_{A2}\rho_A$ Solving for ZA1 gives… $Z_{A1} = Z_{A2} - Z_B\frac{\rho_B}{\rho_A} = Z_{A2} - (Z_T - Z_{A1})\frac{\rho_B}{\rho_A}$ Interms of Z_T $Z_{A1} = \frac{Z_{A2} - Z_T(\rho_B/\rho_A)}{1 - \rho_B/\rho_A}$	3x2=6 M

UNIT – II

4.a	a) Derive an expression for velocity distribution in a horizontal pipeline. And for any element of general radius r it follows that $\frac{dp}{dL}+\frac{2\tau_{rz}}{r}=0$ Therefore the shear stress profile is $\frac{\tau_{rz}}{r}=\frac{\tau_w}{r_w}$, which is a linear shear stress profile. $\tau_{rz}=0$ at center of pipe and $\tau_{rz}=\tau_w$, the maximum value at the wall. Integrating the above differential equation and solving for integrating constant the velocity profile is $V_z=\frac{\tau_w r_w}{2\mu}\left[1-\left(\frac{r}{r_w}\right)^2\right]$ Therefore V_z at $r=0$ is equal to $V_{z,max}=\frac{\tau_w r_w}{2\mu}$	2+2+2 = 6 M
4.b	Derive an expression for shear stress distribution in cylindrical tube of incompressible flow of fluids. And for any element of general radius r it follows that $\frac{dp}{dL}+\frac{2\tau_{rz}}{r}=0$ Therefore the shear stress profile is $\frac{\tau_{rz}}{r}=\frac{\tau_w}{r_w}$, which is a linear shear stress profile. $\tau_{rz}=0$ at center of pipe and $\tau_{rz}=\tau_w$, the maximum value at the wall.	2+2+2 = 6 M

Or

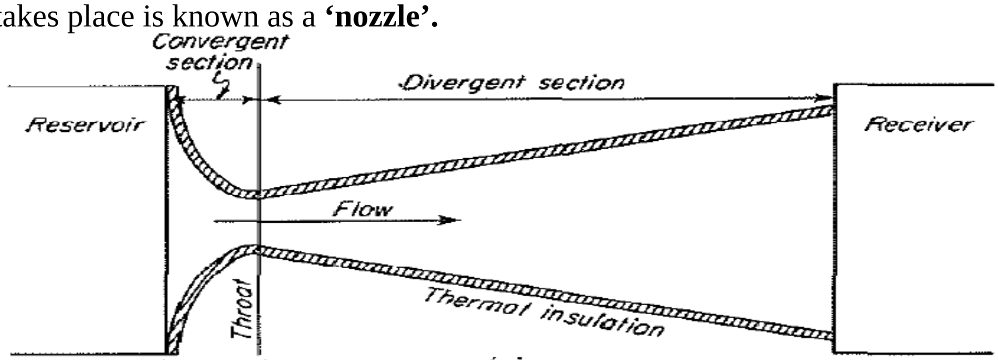
5.a	Derive the relation between average velocity and maximum velocity in a horizontal pipeline Integrating the above differential equation and solving for integrating constant the velocity profile is $V_z=\frac{\tau_w r_w}{2\mu}\left[1-\left(\frac{r}{r_w}\right)^2\right]$ Therefore V_z at $r=0$ is equal to $V_{z,max}=\frac{\tau_w r_w}{2\mu}$ Expression for cross sectional average of velocity $\bar{V}_z$ can be derived as follows $$\bar{V}_z=\frac{\int_0^S V_z\,dS}{\sum_0^S ds}=\frac{1}{\pi r_w^2}\sum_0^{r_w}\frac{\tau_w r_w}{2\mu}\left[1-\left(\frac{r}{r_w}\right)^2\right]2\pi r dr=\frac{\tau_w r_w}{4\mu}$$ The it follows that $\frac{\bar{V}_z}{V_{z,max}}=0.5$	2+2+2=6 M
	In a natural gas pipe line at station 1, the pipe diameter is 0.61 m and the velocity is 15 m/s and the density is 39 kg/m^3. At station 2, the pipe diameter is 0.914 m and the density is 24 kg/m^3. Calculate the velocity at station 2 and the mass flow rate. $(0.61/0.914)^2$x39/24x15=U; MFR=39x15x3.14x0.61x0.61/4 = 170.88 kg/s	3+3=6M

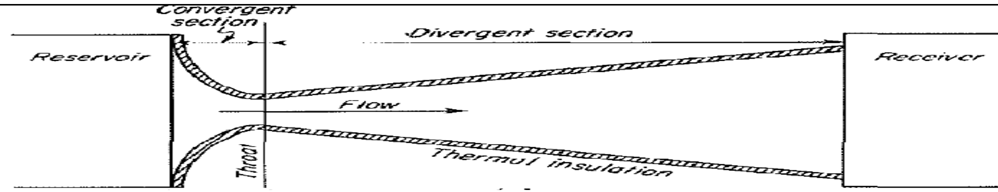
UNIT – III

6.a	Derive steady flow total energy balance equation for the flow of compressible fluids Assumptions 1. Steady state flow. 2. 1-D flow. 3. Gravity effect negligible. 4. C_P are constant and Cp/Cv is constant.	6x1= 6 M

	5. Internal fluid friction is negligible. 6. No shaft work. Total Energy Balance Equation $$dH + d\left(\frac{u^2}{2}\right) + gdZ = dQ$$	
6.b	Derive Ergun equation for flow through beds of solids. $$\bar{V} = \frac{\bar{V}_O}{\varepsilon}$$ $$n\left[\frac{\pi}{4}D_e^2 L\right] = SL\epsilon$$ $$n[\pi D_e L] = \frac{6}{\emptyset_S D_P} SL(1-\varepsilon)$$ $$D_e = \frac{2}{3}\emptyset_S D_P \frac{\varepsilon}{(1-\epsilon)}$$ $$\frac{\Delta P}{L} = \frac{72\lambda_1 \mu \bar{V}_0}{\emptyset^2 D_P^2}\frac{(1-\varepsilon)^2}{\varepsilon^3}$$ $$\frac{\Delta P}{L} = 3f\lambda_2 \frac{1}{\emptyset_S D_P}(\rho \bar{V}_0^2)\frac{(1-\varepsilon)}{\varepsilon^3}$$ $$\frac{\Delta P}{L} = \frac{150\mu \bar{V}_0}{\emptyset^2 D_P^2}\frac{(1-\varepsilon)^2}{\varepsilon^3} + 1.75\frac{\rho \bar{V}_0^2}{\emptyset_S D_P}\frac{(1-\varepsilon)}{\varepsilon^3}$$	6x1= 6M

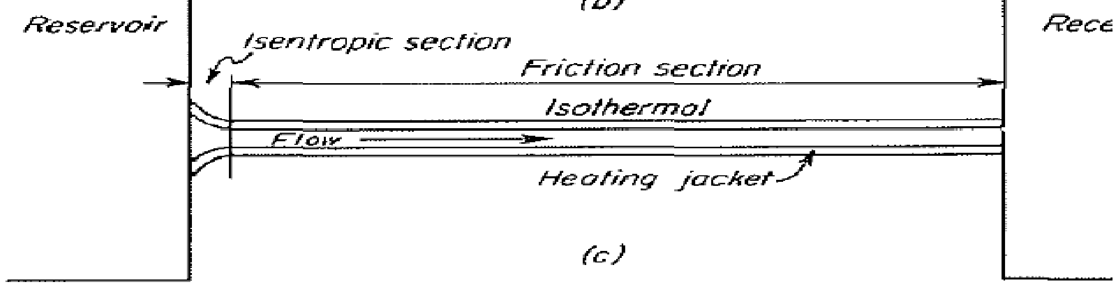
Or

7. a	Explain different processes of compressible flow. 1. **Isentropic flow:** Reversible adiabatic flow. Therefore stagnation temperature is constant along flow. The conduit in which isentropic flow takes place is known as a **'nozzle'.**  2. **Irreversible adiabatic flow**: Also known as adiabatic frictional flow	2+2+ 2 = 6 M



3. **Isothermal frictional flow:** Temperature throughout the flow is constant. Constant cross sectional area conduit is considered. Flow is neither isentropic nor adiabatic. Stagnation temperature is varying

(b)



(c)

7. b	Derive an expression for terminal velocity of spherical particles settling in a fluid by gravity in stokes law regime. $$F_g - F_b - F_D = 0$$ $$m\left(\frac{\rho_p - \rho_f}{\rho_p}\right) = \frac{C_D \rho_f A U^2}{2}$$ $$m = \left[\frac{\pi}{6} d^3\right] \rho_f$$ $$A = \frac{\pi}{4} d^2$$ $$C_D = \frac{24\mu_f}{dU\rho_f}$$ $$u_t = \frac{g D_p^2 (\rho_p - \rho_f)}{18\mu}$$	M

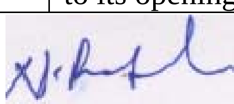
UNIT – IV

8.a	a) Explain working principle of centrifugal pump. The discharge connection is mounted concentrically with the eye of the high speed rotary device called impeller. Radial vanes are cast integrally in the impeller. Fluid that enters the eye of the impeller due to the vacuum created by the impeller by emptying the fluid in the pump by centrifugal action fills the space available between the vanes and leaves the periphery of the impeller at a higher velocity compared to that at the entrance of the impeller. For a well designed pump the space between the vanes is completely filled by the liquid and there is no cavitation. The fluid leaving the impeller periphery is collected in the spiral casing called volute. Fluid leaves though the discharge connection at higher pressure. The kinetic energy of the fluid is converted to pressure energy in the volute. The torque applied to shaft of the impeller imparts kinetic energy to the	6x1=6 M

	fluid through the impeller.	
8.b	A horizontal venturi meter having a throat diameter of 20 mm is set in a 75-mm-ID pipeline. Water at 15 ^{0}C is flowing through the line. A manometer containing mercury under water measures the pressure difference over the instrument. When the manometer reading is 500 mm. what is the flow rate in m^3/h? $Q = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$ Cd=0.98 assumed; a_1=3.14/4x0.02x0.02= a_2=3.14/4x0.075x0.075= g=9.81 m/sq.s; h=0.5(13.6-1) m;	2+1+1= 4M

Or

9.a	Explain working principle of orifice meter The principle of the orifice meter is identical with that of the venturi. The reduction of the cross section of the flowing stream in passing through the orifice increases the velocity head at the expense of the pressure head, and the reduction in pressure between the taps is measured by the manometer. Bernoulli's equation provides a basis for correlating the increase in velocity head with the decrease in pressure head.	Fig=2 M 4 M
	Explain working principle of pitot tube. The pitot tube is a device to measure the local velocity along a streamline. The principle of the device is shown in Fig. 8.27. The opening of the impact tube *a* is perpendicular to the flow direction. The opening of the static tube *b* is parallel to the direction of flow. The two tubes are connected to the legs of a manometer or equivalent device for measuring small pressure differences. The static tube measures the static pressure *Po* since there is no velocity component perpendicular to its opening.	4x1=4 M; Fig=2 M



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