Dr. Ra[illegible] [illegible] · 20/11/2023

(M) (48)

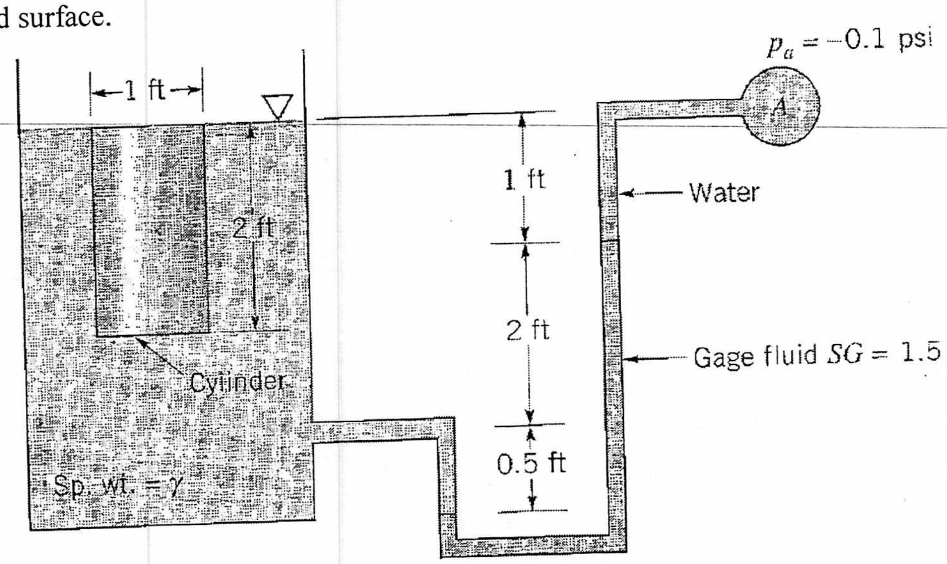
National Institute of Technology Hamirpur
Department of Chemical Engineering
Fluid Mechanics (CH-211)
2^{nd} year (Semester III)
End Semester Examination

Max. Marks : 50 **Time: 3 Hours** **Date: 20/11/23**

Note:(i)Make appropriate assumption if needed (ii)Answer all sub-question at one place.

1(a) Water flows through a pipe with a inlet velocity of 2m/s. Initially pipe diameter was 4cm and runs for 10m before diameter changes to 8cm, where, it was connected with a valve having loss coefficient of 1.2 and further runs for 12meter and then connected to very large tank. Calculate head loss in the pipe and power consumed to pump the fluid. Take fanning friction factor, f = 0.005. 5

1(b) If a 1-ft-diameter, 2-ft-long cylinder floats in an open tank containing a liquid having a specific weight, γ. A U-tube manometer is connected to the tank. The pressure in the pipe bulb at A is 0.1 psi below atmospheric pressure, the various fluid levels are as shown in the figure. Determine the weight of the cylinder. Note that the top of the cylinder is flush with the fluid surface. 5

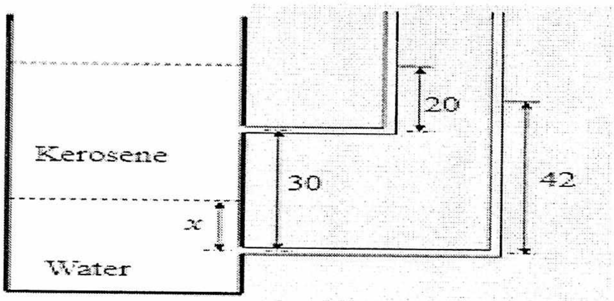


2(a) A centrifugal pump having diameter of 29cm is rotating at 1800rpm to lift water to 35m of height at a flow rate of $3m^3/s$ and pump efficiency of 80%. Find out the head developed in a geometrically similar pump with flow rate of $5m^3/s$ and pump speed of 1450rpm. What is the diameter of impeller in the second pump? 5

2(b) A pump is used to lift water with suction velocity (V_s) of 1m/s. At the place of operation, atmospheric pressure is 100kPa(absolute), whereas, vapor pressure is 3kPa (absolute). The suction lift of the pump is 6m and total loss of head due to friction is 0.3m. Calculate the Net Positive Suction Head (NPSH) of the pump. 5

3(a) Consider a rigid solid sphere falling with a constant velocity in a fluid. The following data are known at the conditions of interest: viscosity of the fluid = 0.1Pas, acceleration due to gravity = 10 ms^{-2}, density of the particle = 1180 kgm^{-3} and density of the fluid = 1000 kgm^{-3}. Find the diameter in mm of the largest sphere that settles in the Stokes' law regime (Reynolds number ≤ 0.1). 3

3(b) A vertical cylindrical vessel has a layer of kerosene (of density 800 kg/m^3) over a layer of 5 water (of density 1000 kg/m^3). L-shaped glass tubes are connected to the column 30 cm apart. The interface between the two layers lies between the two points at which the L-tubes are connected. The levels (in cm) to which the liquids rise in the respective tubes are shown in the figure below. Find the distance (x in cm) of the interface from the point at which the lower L-tube is connected.



3(c) A three-dimensional velocity field is given by $\boldsymbol{V}=5x^2y\boldsymbol{i}+Cy\boldsymbol{j}-10xyz\boldsymbol{k}$, where $\boldsymbol{i}$, $\boldsymbol{j}$ and $\boldsymbol{k}$ are the unit vectors in $\boldsymbol{x}$, $\boldsymbol{y}$ and $\boldsymbol{z}$ directions respectively, describing a Cartesian coordinate system. The coefficient $\boldsymbol{C}$ is a constant. If $\boldsymbol{V}$describes an incompressible fluid flow, what is the value of $\boldsymbol{C}$? **2**

4(a) Find the discharge from a 100mm diameter external mouthpiece, fitted to a side of a large vessel if the head over the mouthpiece is 4 meters. Discharge coefficient is 0.8. **2**

4(b) Consider the steady, laminar, fully developed flow of an incompressible Newtonian fluid through two horizontal circular straight pipes 1 and 2 of equal length. The volumetric flow rates in two pipes are same. The diameter of pipe 2 is thrice the diameter of pipe 1, i.e., $d_2 = 3d_1$. What is the ratio of shear stress at wall of pipe 1 to pipe 2. **2**

4(c) Water flows through a smooth circular pipe under turbulent conditions. In the viscous sub-layer, the velocity varies linearly with the distance from the wall. The Fanning friction factor is defined $f = \frac{\tau_w}{\rho\bar{u}^2/2}$, where, τ is the shear stress at the wall of the pipe, ρ is the density of the fluid and $\bar{u}$ is the average velocity in the pipe. Water (density = 1000 kg m^{-3}, viscosity = 10^{-3} kg m^{-1} s^{-1}) flows with an average velocity of 1 m s^{-1} through the pipe. For this flow condition, the friction factor f is 0.005. Find out the velocity at a distance of 0.05 mm from the wall of the pipe (in the viscous sub-layer). **4**

4(d) What is physical significance of (i) Weber number (ii) Mach number **2**

5(a) A fluid have free stream velocity of 1.5 m/s and flows over a thin square plate of side 2m. Find out the boundary layer thickness and shear stress at the trailing end point of plate. Also, find out the surface resistance of the plate. Take specific gravity of fluid is 0.8 and kinematic viscosity is 10^{-5} m^2/s. **4**

5(b) A man weighing 80Kg descends to ground from an aeroplane with the help of a parachute, which is hemispherical and comes down with a velocity of 20m/s. Find out the diameter of parachute. Take density of air = 1.25 g/m^3 and drag coefficient C_D = 0.4. **3**

5(c) Starting from Navier-Stokes equation for one dimensional flow, derive Bernoulli's equation. **3**

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