ASSIGNMENT #2 FOR SEMM2313.

Question 1

a) State one factor that will influence the magnitude of the hydrostatic force on a submerged surface.

b) Study Figure Q1 below and determine the horizontal and vertical forces on the curve CDE. The fluid is water and the radius of the semi-circular shape is 2 m and the distance AC is 3m. The width of the semi-circular shape is 3 m.

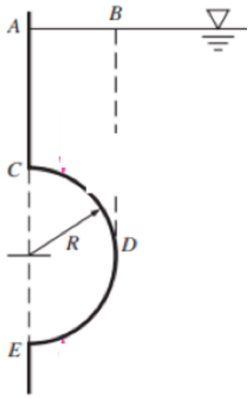

Figure Q1

Question 2

A barge of 70 tonne mass carries three cylindrical tanks of each 15-tonne mass. The barge is rectangular in shape with length, width and height of 10.5 m, 7.2 m and 2.4 m respectively. The centre of gravity of the barge and tanks is at its vertical centreline and 2.7 m above the submerged bottom. Assuming specific gravity of seawater, S = 1.025, determine the barge

a) draft, H in seawater
[H = 1.484 m]

b) stability of the barge when its longitudinal axis runs along its length.
[GM = 1.053 m > 0, stable]

Question 3

a) State three (3) assumptions need to be considered before Bernoulli's equation can be employed.

b) A vertical venturi meter was used to measure the flow rate inside the pipeline as shown in Figure Q3. The fluid flows upward, and the U-tube manometer uses mercury as the manometric liquid. Show that the differential head in the manometer, H, can be expressed as

$$H = \frac{V_1^2\left[\left(\frac{d_1}{d_2}\right)^4 - 1\right]}{2g\left(SG_{Hg} - 1\right)}$$

where:
V_1 : inlet velocity (m/s)
d_1 : inlet diameter (m)
d_2 : throat diameter (m)
g : gravity (m/s^2)
SG_{Hg} : specific gravity of mercury

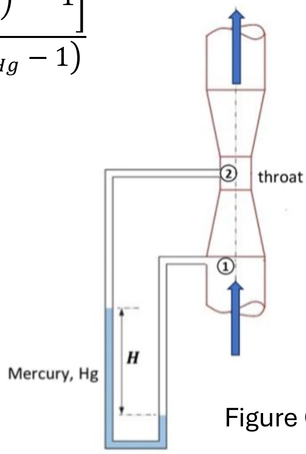

Figure Q3

c) If the inlet pipe diameter is 100 mm, the diameter at the throat area is half of the inlet diameter, and the water flows at 0.03 m^3 /s, determine the manometric head, H. Take the density of mercury as 13500 kg/m^3.
[H = 0.89 m]

Question 4

A cylindrical tank of cross-sectional area (A), contains water up to depth (H), and the water is discharge through an orifice at the bottom of the cylinder of an area (a).

a) Derive the actual velocity coming out of the orifice at the beginning of the discharge by using Bernoulli's equation.

b) Starting from Reynolds's Transport Theorem (RTT), derive the expression for the actual time required to emptying the tank.

$$\left[T = \frac{2A\left(H^{\frac{1}{2}}\right)}{C_d \cdot a \cdot \sqrt{2g}}\right]$$

c) Determine the time taken to empty the tank, if the tank diameter is 5 m, the water depth is 6 m, the water temperature is 30 °C, the orifice meter is 20 cm and the discharge coefficient Cd is 0.62.
[T = 18.59 min]

ASSIGNMENT #2 FOR SEMM2313.

Question 5

a) What are two key assumptions made to simplify the energy equation into Bernoulli's equation?

b) The turbine, operating at 85% efficiency, is installed in a system as shown in Figure Q5. Water enters the turbine through an inlet pipe of 20 cm diameter at 25°C with a velocity, V1 . The outlet pipe, with a diameter of 15 cm, discharges water with a velocity, V2 . The difference in mercury column height is 300 cm, with the specific gravity of mercury given as 13.6. Determine the power output of a turbine for a water flow rate of 0.5 m^3/s. Refer to the appendix or property tables in your textbook for additional information as needed.
[Power = 53619.29 Watt]

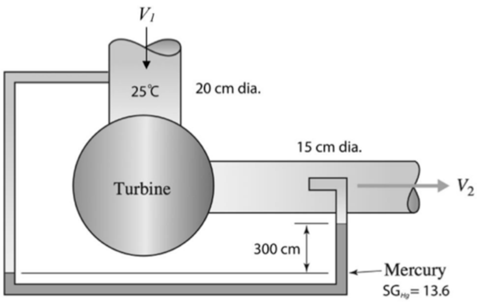

Figure Q5

Question 6

a) List two practical applications of the momentum equation in engineering systems and briefly explain their significance.

b) Water at temperature 40o C flows into a horizontal pipe with a 130° bend, as shown in Figure Q6.

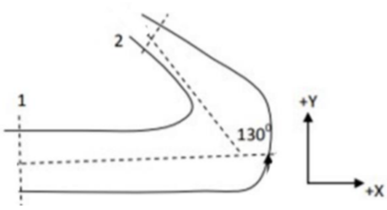

Figure Q6

(i) Using a clear diagram, identify and sketch the control volume involved in analysing the flow through the horizontal bend which is part of a piping system. Label all relevant surfaces and directions of velocity, forces, and flow.

(ii) Starting with the Reynold's Transport Theorem and the Newton's Second Law, derive the general expression for momentum in an unsteady flow within the pipe. Include all relevant terms for an unsteady flow.

(iii) The inlet and outlet cross-sections are circular, with diameters of 170 mm and 100 mm, respectively. If the inlet pressure is 125 kPa, determine the outlet pressure of the bend when the volumetric flow rate is 0.035 m3 /s. Assume steady flow and neglect losses along the bend.
[P_2 = 116.33 kPa]

(iv) Determine the magnitude and directions of the forces exerted by the water flow on the bend.
[Rx = 3577.56 N, to the left]
[Ry = 1885.30 N, upward]

Question 7

a) Fluid flows into a tank via two inlets and exits through a single outlet. From the Reynolds Transport Theorem, derive the continuity equation for steady condition of the flow.

b) A fluid enters steadily into a tank at the rate of 0.4 m3 /s via each of the inlets as shown in Figure Q7 and out of the tank via a single outlet. Assuming that the diameters of the inlets and outlet are equal, which is 0.2 m, determine the outlet velocity from the tank.
[V = 25.46 m/s]

c) If the inlet flow rate is doubled for inlet 1 only, determine the outlet velocity and its mass flow rate if the fluid density is 1.5 kg/m3 .

d) What would you suggest to the flow conditions in order to avoid the water to be full inside the tank? Explain your answer with appropriate justification.

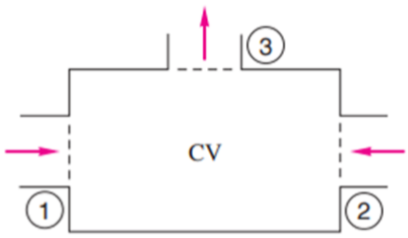

Figure Q7

Question 8

You are an engineer working in a hydroelectric power plant, responsible for optimizing turbine efficiency. Your primary task is to analyze the interaction between water jets and turbine blades to enhance power output. In this scenario, twenty water jets, each with a diameter of 2 cm, strike the turbine blades as illustrated in Figure Q8. The water jets exit the nozzles at a velocity of 50 m/s, forming an angle of 30° with the horizontal. The turbine blades are designed with an outlet angle, β_2 of 70°, and the water velocity at the blade outlet is 20 m/s. To optimize the turbine's performance,

a) List two assumptions used in your solution.

b) Determine the power output and the blade angles $\alpha 1$ and $\alpha 2$.
[Power output = 16.731 kW, $\alpha 1$ = 70.05°, $\alpha 2$ = 45°]

c) To improve the turbine's power output, what specific modifications should be made to the inlet, $\alpha 1$ and outlet blade angles, $\alpha 2$? Justify your answer using supporting formulas.

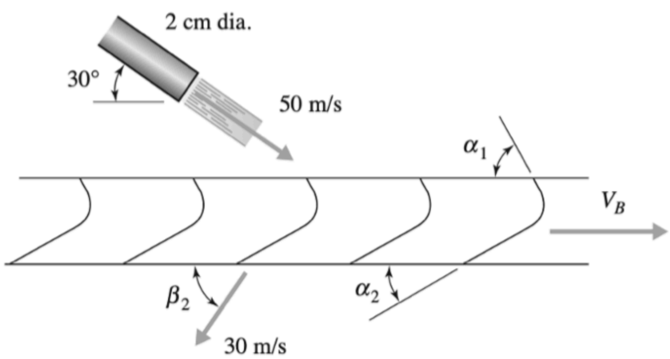

Figure Q8

ASSIGNMENT #2 FOR SEMM2313.

Question 9

(a) The drag force, F D of a submarine is a function of the mass density, ρ the viscosity, μ the velocity of submarine, V the diameter of the submarine, D and the surface roughness, ε. Determine the dimensional group using Buckingham π -Theorem.

$$\left[\pi_1 = \frac{F_D}{\rho V^2 D^2}, \pi_2 = \frac{1}{Re}, \pi_3 = \frac{\varepsilon}{D}\right]$$

(b) The drag force on a submarine moving below the free surface is to be determined by a 1 test on a 15 scale model in a water tunnel. The velocity of the prototype in sea water

(density, ρ = 1015 kg/m^3 , kinematic viscosity, v = 1.4 x 10^{-6} m^2 /s) is 2 m/s. The test is done in pure water at 20 °C (density, ρ = 998 kg/m^3 , viscosity, μ = 1.0 x 10^{-3} kg/ms). Determine the

i) speed of the water in the water tunnel for dynamic similitude, and
[V = 21.47 m/s]

ii) ratio of the drag force on the model to the drag force on the prototype.
[0.5037]

Question 10

a) By the aid of a diagram, describe the flow characteristic in a 90-degree pipe bend. Give two (2) suggestions for minimizing the loss coefficient associated with pipe bend.

b) Water flows at a rate of 0.5 m^3 /s from an upper reservoir to a lower reservoir through a carbon steel pipeline with a diameter of 0.5 meters, wall roughness value of 0.05 mm and driving a hydroturbine. The pipeline is 200 meters long and includes one (1) fully open gate valve with a loss coefficient, K = 0.2, installed after the pipe entrance and two (2) 90-degree elbow, each with a loss coefficient, K = 0.8, used as pipeline fitting. The water flow is steady and the elevation difference between the reservoirs is 50 meters. Assume the water has a density of 1000 kg/m^3 and a dynamic viscosity of 1.002 x 10^{-3} Pa·s.

i) determine the power generated by the turbine if the turbine efficiency is 85%.
[Power generated = 196.6 kW]

ii) sketch the Energy Grade Line (EGL) and Hydraulic Grade Line (HGL) for the hydroturbine system, ensuring appropriate labeling.