ASSIGNMENT #3 FOR SEMM2313.

Question 1

A semi-circular curved structure as shown in Fig Q1 is filled with water and weighs 30 kN. The diameter of the curved structure is 4 m and it is secured to the floor using six (6) equally spaced bolts along its length. Assuming water properties at standard atmospheric condition,

a) sketch and label the hydrostatic forces on the curved structure and its location.

b) determine the horizontal force per-unit length acting on the curved structure.
[FH = 0 N]

c) determine the vertical force per-unit length acting on the curved structure.
[FV = 173.802 N]

d) calculate the force in each bolt required to secure the curved structure.
[F(bolt) = 23.967 N]

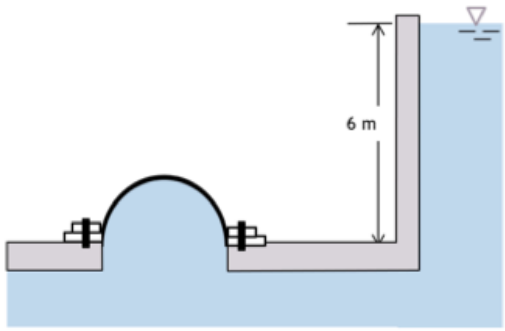


Figure Q1

Question 2

A container ship is a type of cargo ship that is specifically designed to transport standardized cargo containers. A standard average mass of each container is 1200 kg that has rectangular shape made of metal that can be easily loaded, unloaded, stacked, and transported over long distances. Consider a typical container ship that has the dimension of 300 m long, 50 m broad, and has a draft, h (depth below the waterline) of 12 m when unloaded. Assume that the ship is practically rectangular in shape.

a) Define buoyancy and explain the principle that governs it.

b) Using the principle of buoyancy, determine the maximum number of container that can be transported in the ship provided that the maximum draft, h max of 20 m when loaded. Given that the density of sea water is 1020 kg/m^3.
[102000 max number of container]

c) Briefly explain the two (2) factors that would affect the stability of the ship when loaded with containers.

Question 3

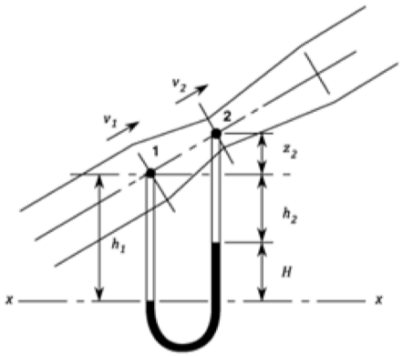
a) A venturi meter is commonly employed to measure fluid flow rates by determining the pressure difference across the meter with the aid of a U-tube manometer. Other than the venturi meter, name two alternative techniques for measuring flow rate.

b) A venturi meter is connected at the main and throat sections by tubes filled with the fluid (fuel oil) being metered by a differential mercury manometer, see Fig Q3. Based on the Bernoulli and Continuity equations, show that the flow rate-head correlation for the set-up to be. Subscript m refers to mercury and f that of to fuel oil.

$$\frac{v_1^2}{2g}\left(\frac{d_1^2}{d_2^2}-1\right)=H\left(\frac{\gamma_m}{\gamma_f}-1\right)$$

c) Determine the rate of flow of fuel oil through the venturi meter. The main diameter of the venturi meter is 3.5 cm and the throat diameter 2 cm. The relative density of the oil relative to water is 0.82 and the difference of level of the mercury columns is 12 cm. Use a direct application of Bernoulli's theorem taking the relative density of mercury to water as 13.6 and Cd as 0.95.

$\left[Q=0.95\times\frac{\pi 0.35^2}{4}v_1\right]$



Question 4

a) Starting from Reynolds's Transport Theorem (RTT), derive the expression for the rate of change of mass for the system with two inlets and one outlet.

b) A fume hood in the tribology laboratory, used for chemical titration, is equipped with one intake and three exhausts. Given that each of the exhaust diameter is half of the intake diameter and air enters steadily at 1 m/s. Assuming that the air is incompressible,

i) sketch the possible control volume for the system,

ii) determine the outlet air velocity for each of the exhaust, and
[V_{outlet} = 1.333 m/s]

iii) determine the total exhaust volume flowrate if the inlet diameter is 200 mm.
[Q1 = 0.031 m^3/s]

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Question 5

a) State one major difference and one similar assumption between the Energy equation and the Bernoulli equation.

b) As the engineer for your company, you have been assigned to design a pipeline system. The information given to you is that the pipeline is horizontal and has a pipe with a diameter of 0.6 meters. It will be used to transport oil with a specific gravity of 0.825, flowing at a rate of 0.44 m^3/s. There will be four identical pumps installed along the pipeline, and these pumps should maintain a pressure of 20 bar on the suction side and 24.1 bar on the discharge side. The main goal of this project is to ensure the proper flow of oil through the system while minimizing head loss. You were informed that the maximum allowable head loss is 6.0 meters for every 1000 meters of pipe at the discharge line. Your first task as an engineer for this project is to determine the maximum allowable distance between the pumps to optimize the design and maintain efficient oil flow. Sketch and show your detail calculations. (Note: 1 bar = 100 kPa).
[Max distance = 8443.25 m]

Question 6

a) State two factors that affect the force exerted by water flowing through a bend to the bend itself.

b) Water flows into a horizontal bend as shown in Figure Q6. The inlet and outlet diameter is 200 mm and 100 mm, respectively. If the inlet pressure is 100 kPa, determine the outlet pressure of the bend when the volumetric flow rate is 0.03 m^3/s. Assume steady flow and no losses along the bend.
[P2 = 93155 N/m^2]

c) Determine the magnitude and directions of the forces exerted by the water flow on the bend.
[Fx = 3712 N, Fy = 648 N]

d) Briefly describe the change of the magnitude and the directions of the forces if the flow rate is maintained but the fluid is changed to oil which has lower specific gravity? Explain your answers.

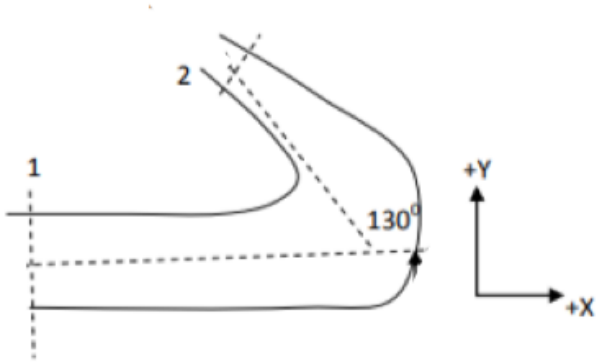

Figure Q6

Question 7

a) What is the main function of the Reynolds Transport Theorem (RTT)? Derive the conservation of mass equation for the system with two inlets and two outlets, assuming the flow is steady, uniform, and incompressible.

b) The oil storage tank A as shown in Figure Q7 is scheduled to be emptied for cleaning purposes during the annual shutdown. Given that tank A has a 3 m diameter and 8 m height. The outlet nozzle is placed at the bottom of the tank and has a diameter of 50 mm. Assume that the tank is open to atmospheric pressure.

i) By using Reynolds Transport Theorem (RTT), find the expression for the rate of change of the height.

ii) By using Bernoulli's equation, determine the expression for the outlet velocity.

iii) If the valve is fully opened, and the original oil level inside the tank is 80%, determine the time taken to empty the tank.
[t = 4113 s]

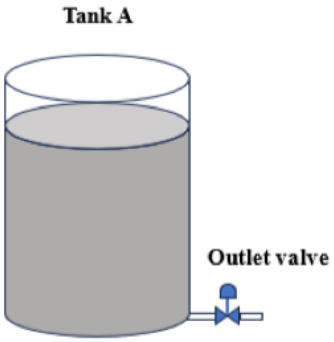

Figure Q7

Question 8

Figure Q8 shows a water jet flowing over a smooth vane attached rigidly to two anchors. The jet has 25 mm thickness and its width is 75 mm. The water jet hits the vane at 25 m/s.

a) List two assumptions in your solution.

b) Determine the horizontal and vertical forces exerted by the jet to the vane, and their directions as well.
[Fx = 233 N , Fy = 1325 N]

c) What will happen to the magnitude of the forces if the anchors move to the right? Or to the left?

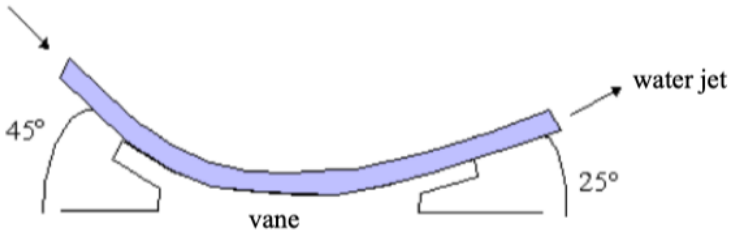

Figure Q8

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Question 9

a) For a very rough pipe wall, the friction factor is constant at high Reynolds numbers. For a pipe length L1 the pressure drop over the length is $\Delta p1$. If the mass flow rate of the fluid in the pipe is doubled, what does the relation of the new pressure drop, $\Delta p2$ to the original pressure drop, $\Delta p1$?
[$\Delta p2 = 4 \times \Delta p1$]

b) Your family just bought a bungalow, but there is a problem with the water flow rate. Your father asked you to improve the flow rate of water on the top floor. The poor flow rate is due to three reasons: (i) The water pressure at the water meter is poor (P = 200 kPa gage); (ii) the piping has a small diameter (D = 1.27 cm) and (iii) has become imperfect and roughened, increasing its roughness = 0.04). (ϵ / D The top floor of the house is 15 m higher than the water meter.

Since you have taken a fluid mechanics course, you are considering installing a booster pump while keeping the original pipes. The booster pump has an outlet pressure of 300 kPa. Determine what will be the water flow rate at your house after installing the booster pump. Neglect minor losses.
[Q = 0.247 m^3/s]

Question 10

a) State two advantages of similitude analysis in solving fluid mechanics problems.

b) A low-speed wind turbine is to be installed at a coastal area. The power, P, generated by the wind turbine is a function of its diameter, D, number of blades, n, rotational speed, N, wind velocity, V, and air density, ρ. Determine a set of dimensionless variables or π–terms to describe the wind turbine design problem using the Buckingham-π theorem method. Use D, V and ρ as the repeating variables.
$$\left[\frac{P}{\rho D^2 V^3} = \int\left(n, \frac{ND}{V}\right)\right]$$

c) In a wind tunnel testing, a wind turbine model of 50 cm in diameter generates 2.7 kW power. Wind speed used in the testing is 40 m/s and the wind turbine rotational speed is 4800 rpm. Determine the power generation by the 10:1 scaled wind turbine prototype if the average coastal area wind speed is 8 m/s. The air density in the wind tunnel and air density at the coastal area is 1.3 kg/m^3.
[P_{model} = 2160 Watt]