PNG UNVERSITY OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING – 2ND YEAR DEGREE

SECOND SEMESTER EXAMINATIONS – 2022

CE 223 –FLUID MECHANICS

DATE: **2ND OF NOVEMBER 2022**

TIME ALLOWED: **3 HOURS**

STARTING TIME: **8:20 AM**

VENUE: **RKLT**

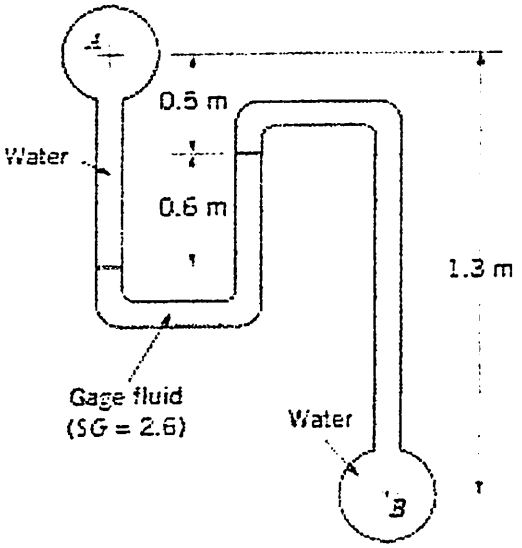
INFORMATION FOR CANDIDATES:

1. WRITE YOUR NAME AND ID NUMBER CLEARLY ON THE FRONT PAGE.
2. You have 10 minutes to read the paper. You must not begin writing during this time.
3. All answers must be written on the answer booklet provided. No other written material will be accepted.
4. Calculator only is allowed in the examination room. Notes and handouts are not allowed. MOBILE PHONE is not allowed.
5. There are six (6) questions in this exam paper. You are required to answer ANY FOUR of the six in order to collect a total of (40) marks.

QUESTION 1 (10 Marks)

(a) Define the terms static pressure, dynamic pressure and stagnation pressure. **(3 Marks)**

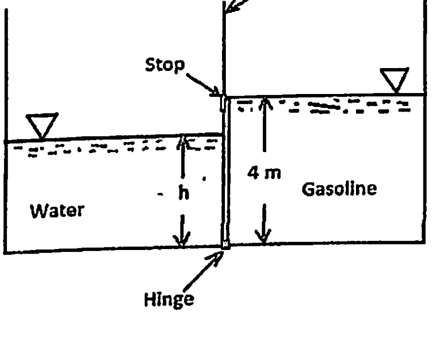
(b) Two pipes are connected by a manometer as in the figure given. Determine the pressure difference, $p_A - p_B$, between the pipes. **(7 Marks)**



QUESTION 2 (10 Marks)

(a) Explain the term hydrostatic pressure, with the help of diagrams, indicating the different types of surfaces that hydrostatic pressure can be applied on, giving examples of each. **(4 Marks)**

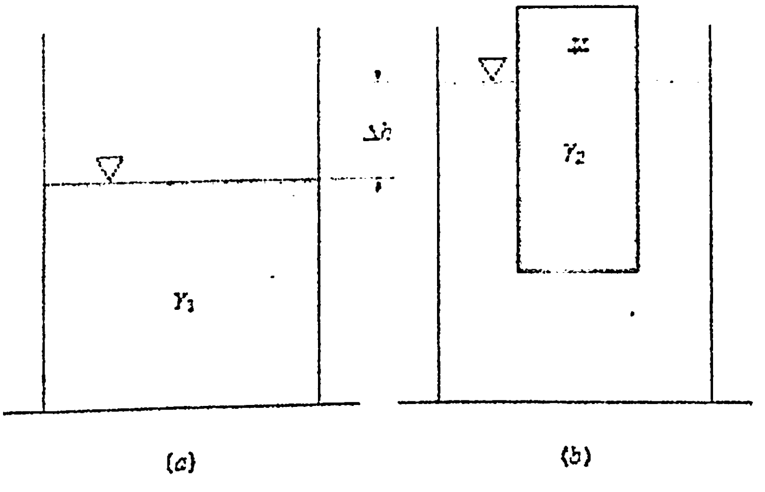
(b) An open tank has a vertical partition and on one side contains gasoline with a density $\rho = 700\ kg/m^3$ at a depth of 4 m. A rectangular gate that is 4 m high and 2 m wide, and hinged at one end is located in the partition. Water is slowly added to the empty side of the tank. At what depth, h, will the gate start to open? **(6 Marks)**



QUESTION 3 (10 Marks)

(a) Define the terms, Buoyant force, Metacentre, Center of gravity and the Centre of Buoyancy.**(4 Marks)**

(b) A tank of cross-sectional area, A, is filled with a liquid of specific weight γ_1, as in (a). Show that when a cylinder of specific weight γ_2 and volume $\forall$ is floated in the liquid, as in (b), the liquid level rises by an amount $\Delta h = \left(\frac{\gamma_2}{\gamma_1}\right) \forall / A$. **(6 Marks)**



QUESTION4 (10 Marks)

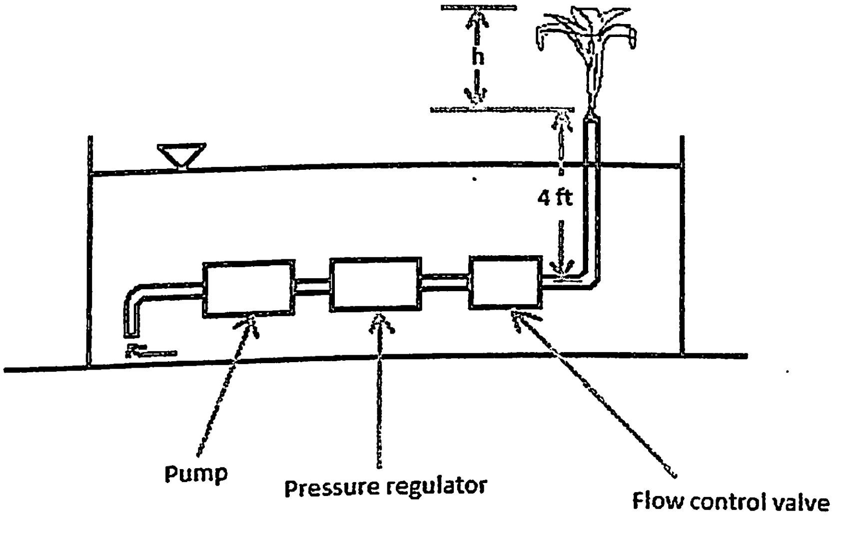
Water is pumped through a 60-m long, 0.3 m diameter pipe from a lower reservoir to a higher reservoir whose surface is 10 m above the lower one. The sum of the minor loss coefficient for the system is $K_L = 14.5$.When the pump adds 40 kW to the water the flowrate is 0.20 m^3/s.

If Power $\dot{W} = h_p \times Q \times \gamma$, determine the pipe roughness, ε, with the help of the moody chart.

Question 5 (10 Marks)

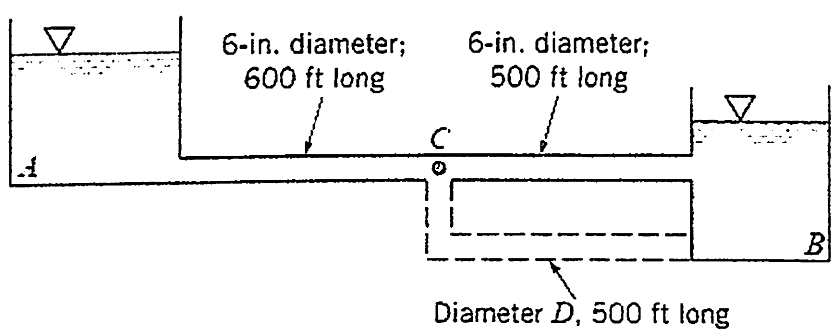
The fountain shown in the diagram is designed to provide a stream of water that rises h = 10 ft to h = 20 ft above the nozzle exit in a periodic fashion. To do this the water from the pool enters a pump, passes through a pressure regulator that maintains a constant pressure ahead of the flow control valve. The valve is electronically adjusted to provide the desired water height. With h = 10 ft, the loss coefficient for the pipe is $K_L = 50$.

Determine the valve loss coefficient K_L needed for h = 20 ft. All losses except for the flow control valve are negligible. The area of the pipe is 5 times the area of the exit nozzle.



QUESTION 6 (10 Marks)

The flowrate between tank A and tank B in the figure is to be increased by 30 % (i.e) from Q to 1.30 Q) by the addition of a second pipe (indicated by the dotted lines) running from node C to tank B. If the elevation of the free surface in tank A is 25 ft above that in tank B, determine the diameter, D, of this new pipe. Neglect minor losses and assume that the friction factor for each of the three pipes is 0.02.



End of Exams

CE 223 EXAM FORMULA SHEET

1. $dp = \gamma dh$

2. Fluid Statics

Pressure gradient in a stationary fluid	$\frac{dp}{dz} = -\gamma$
Pressure variation in a stationary incompressible fluid	$p_1 = \gamma h + p_2$
Hydrostatic force on a plane surface	$F_R = \gamma h_c A$
Location of hydrostatic force on a plane surface	$y_R = \frac{I_{xc}}{y_c A} + y_c$
	$x_R = \frac{I_{xyc}}{y_c A} + x_c$
Buoyant force	$F_B = \gamma \forall$
Pressure gradient in rigid-body motion	$-\frac{\partial p}{\partial x} = \rho a_x, \quad -\frac{\partial p}{\partial y} = \rho a_y, \quad -\frac{\partial p}{\partial z} = \gamma + \rho a_z$
Pressure gradient in rigid-body rotation	$\frac{\partial p}{\partial r} = \rho r \omega^2, \quad \frac{\partial p}{\partial \theta} = 0, \quad \frac{\partial p}{\partial z} = -\gamma$

3. Conversions:

From metres to feets
Multiply by 3.28

From inch to feet
Divide by 12

From square inch to square foot
-Divide by 144

4. Fluid Dynamics

Streamwise and normal acceleration	$a_s = V\frac{\partial V}{\partial s}, \quad a_n = \frac{V^2}{\mathcal{R}}$
Force balance along a streamline for steady inviscid flow	$\int \frac{dp}{\rho} + \frac{1}{2}V^2 + gz = C$ (along a streamline)
The Bernoulli equation	$p + \frac{1}{2}\rho V^2 + \gamma z =$ constant along streamline
Pressure gradient normal to streamline for inviscid flow in absence of gravity	$\frac{\partial p}{\partial n} = -\frac{\rho V^2}{\mathcal{R}}$
Force balance normal to a streamline for steady, inviscid, incompressible flow	$p + \rho \int \frac{V^2}{\mathcal{R}}\, dn + \gamma z =$ constant across the streamline
Velocity measurement for a Pitot-static tube	$V = \sqrt{2(p_3 - p_4)/\rho}$
Free jet	$V = \sqrt{2\frac{\gamma h}{\rho}} = \sqrt{2gh}$
Continuity equation	$A_1V_1 = A_2V_2$, or $Q_1 = Q_2$
Flow meter equation	$Q = A_2\sqrt{\frac{2(p_1 - p_2)}{\rho[1 - (A_2/A_1)^2]}}$
Sluice gate equation	$Q = z_2 b\sqrt{\frac{2g(z_1 - z_2)}{1 - (z_2/z_1)^2}}$
Total head	$\frac{p}{\gamma} + \frac{V^2}{2g} + z =$ constant on a streamline $= H$