THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING – 2ND YEAR DEGREE

SECOND SEMESTER EXAMINATIONS - 2021

CE 223 – FLUID MECHANICS

DATE: WEDNESDAY, 3RD NOVEMBER 2021 – 8:20 A.M.

VENUE: STRUCTURES LECTURE THEATRE (SLT)

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATES

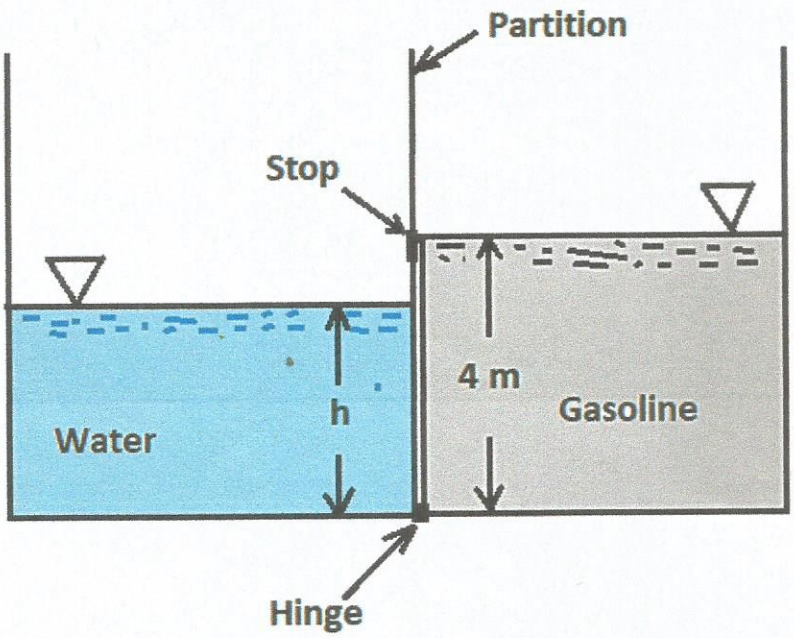
1. You have 10 minutes to read the paper before the examination starts. You must **not** begin writing during this time.
2. **There are SEVEN (7) Questions in this paper. You are required to answer any FIVE (5) Questions.**
3. Use only ink. Do not use pencils for writing except for drawings and sketches.
4. Start each question on a new page and show all your calculations in the answer book provided. No other material will be accepted.
5. Write on **one side of the page only** and keep the margins clear.
6. Calculators and drawing equipment are permitted in the examination room. Information sheet on cable profiles, photocopies of AS 3600-2001 and ONESTEEL Reinforcing Data are allowed in the examination room. Note and textbooks are not allowed.
7. **Write your NAME and Student NUMBER clearly on the front page. Do it now.**
8. Marks for each of the question are given within parenthesis at the end of each question.
9. **Switch your mobile phone OFF.**

Question One

In a stationary incompressible fluid, pressure variation is given by $p_1 = \gamma h + p_2$. Develop an expression for the pressure variation in a liquid in which the specific weight increases with depth, ***h***, as $\gamma = 2Kh + \gamma_0$, where ***K*** is a constant and γ_0 is the specific weight at the free surface.
(8 Marks)

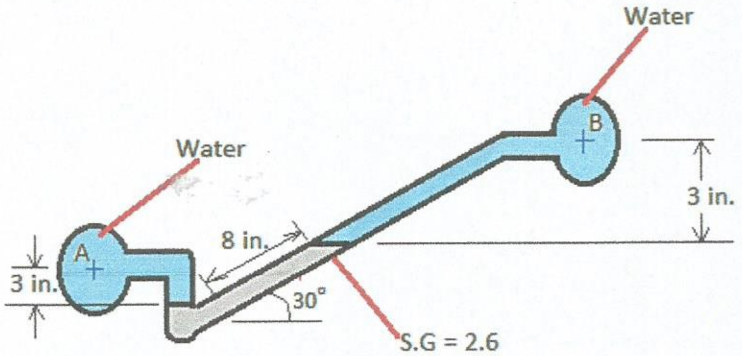
Question Two

An open tank has a vertical partition and on one side contains gasoline with a density ρ =**700 kg/m3** at a depth of **4 m**, as shown in the figure below. 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? **(8 Marks)**



Question Three

For the inclined-tube manometer shown below, the pressure in pipe A is **0.9 psi**. The fluid in both pipes A and B is water, and the gage fluid in the manometer has a specific gravity of **2.6**. What is the pressure in Pipe B corresponding to the differential reading shown? **(8 Marks)**

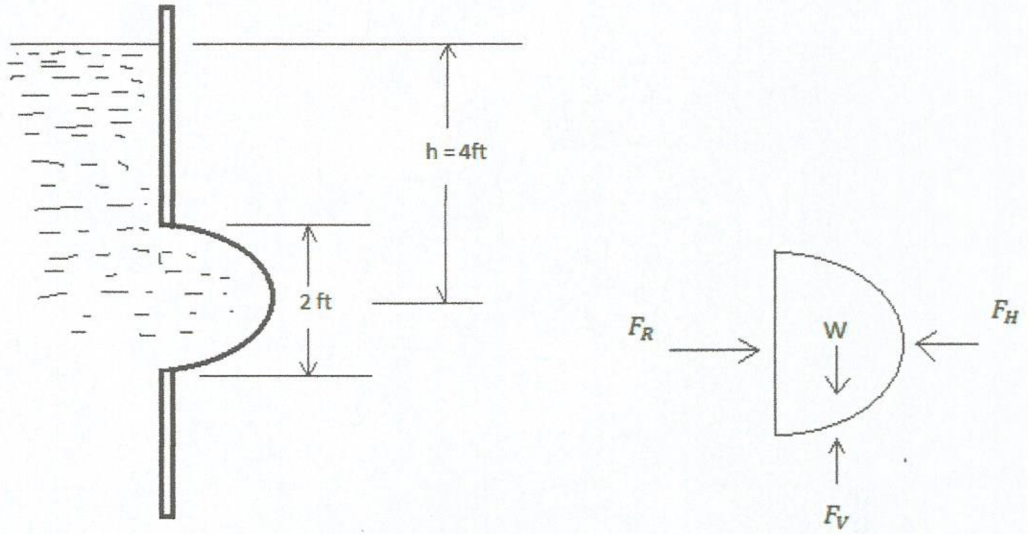


Question Four

A **2-ft-** diameter hemispherical plexiglass "bubble" is to be used as a special window on the side of an above-ground swimming pool. The window is to be bolted onto the side of an above-ground swimming pool and faces outward, covering a **2-ft**-diameter opening in the wall. The center of the opening is **4 ft** below the surface.

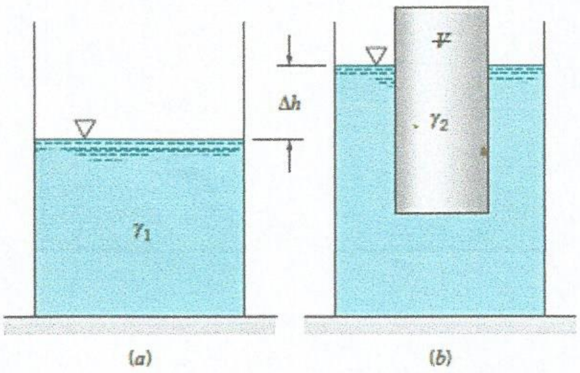
Prove that the horizontal and vertical components of the force of the water on the hemisphere are approximately (**784 lb** to the right – horizontal) and (**131 lb** down on the bubble – vertical).

(Specific Gage fluid weight of water is **62.4 lb/ft3**.) **(8 Marks)**



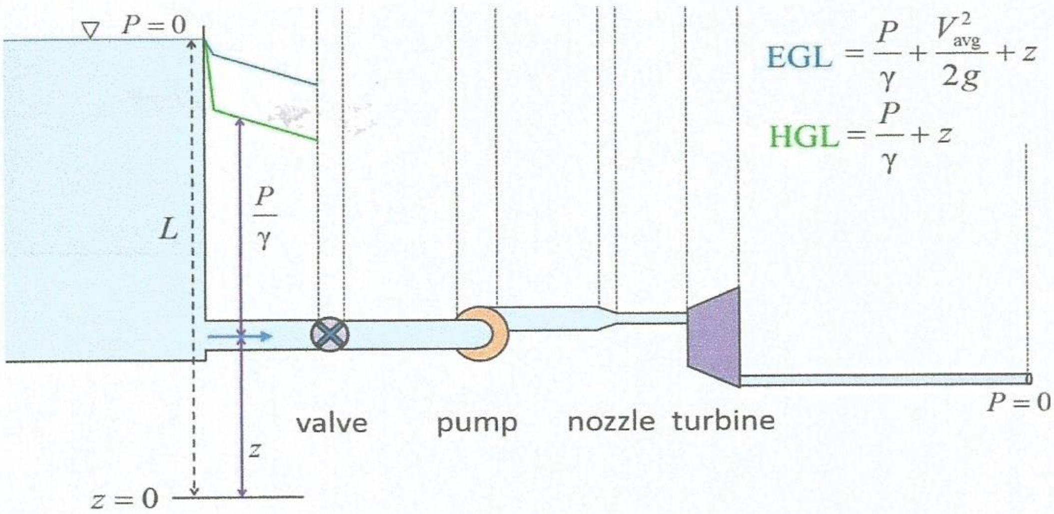
Question Five

A tank of cross-sectional area **A** is filled with a liquid of specific weight γ_1 as shown in the figure. Show that when a cylinder of specific weight γ_2 and volume ∀ is floated in the liquid, the liquid level rises by an amount $\Delta h = (\gamma_2/\gamma_1)\ \forall/A$. **(8 Marks)**



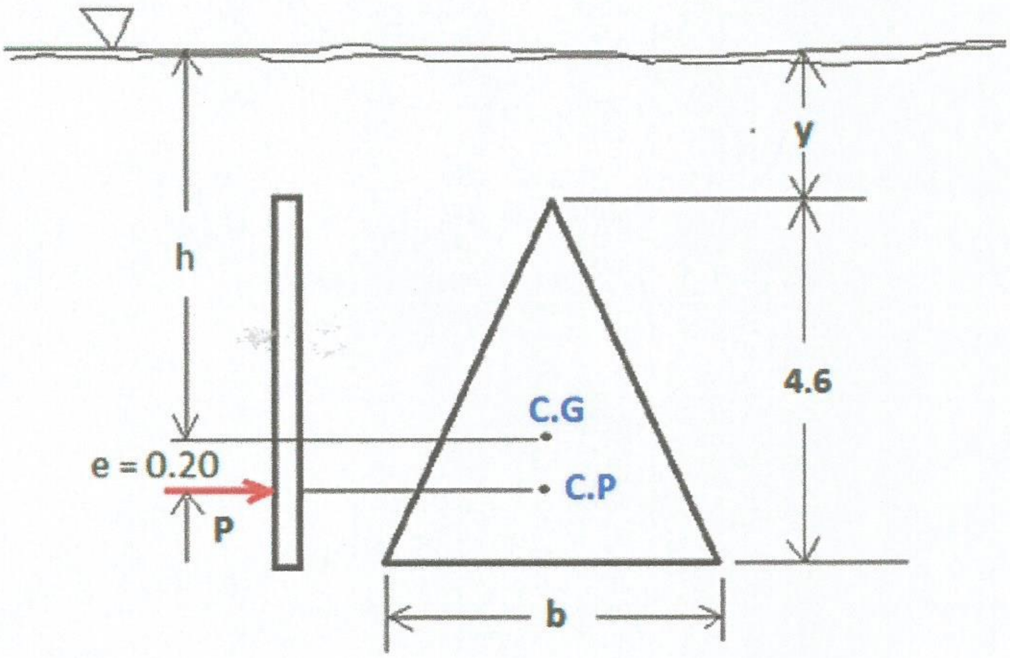
Question Six

The energy grade line and the hydraulic grade line are well defined by the equations on the diagram. The flow path on the diagram consists of a valve, pipes, a pump for boosting the flow, a reducing nozzle and a turbine that extracts from the flow. You are required to complete drawing the EGL and the HGL diagrams of the flow part shown in the diagram. **(8 Marks)**



Question Seven

A vertical triangular plate whose height is 3.6 m. has its base horizontal and vertex upper most in the water surface. **(8 Marks)**

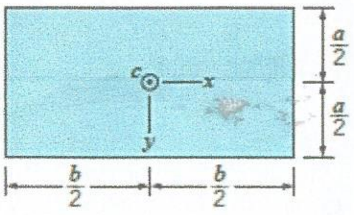


END OF EXAMINATION

CE 223 EXAM FORMULA SHEET

1. $dp = \gamma dh$

2. Centroidal Coordinators and Moments of Inertia



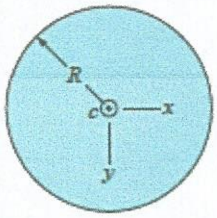
$A = ba$

$I_{xc} = \frac{1}{12} ba^3$

$I_{yc} = \frac{1}{12} ab^3$

$I_{xyc} = 0$

(*a*) Rectangle

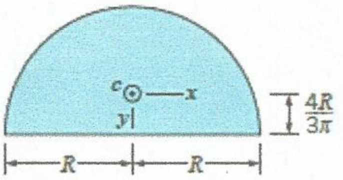


$A = \pi R^2$

$I_{xc} = I_{yc} = \frac{\pi R^4}{4}$

$I_{xyc} = 0$

(*b*) Circle



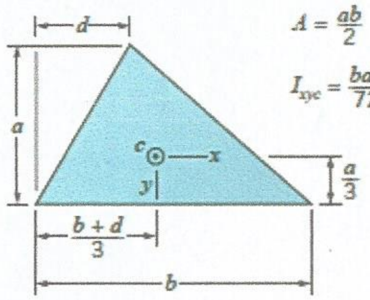
$A = \frac{\pi R^2}{2}$

$I_{xc} = 0.1098 R^4$

$I_{yc} = 0.3927 R^4$

$I_{xyc} = 0$

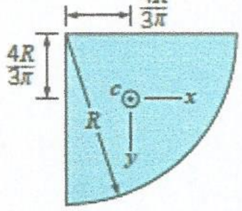
(*c*) Semicircle



$A = \frac{ab}{2}$ $\quad I_{xc} = \frac{ba^3}{36}$

$I_{xyc} = \frac{ba^2}{72}(b - 2d)$

(*d*) Triangle



$A = \frac{\pi R^2}{4}$

$I_{xc} = I_{yc} = 0.05488 R^4$

$I_{xyc} = -0.01647 R^4$

(*e*) Quarter circle

3. 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	$\frac{\partial p}{\partial r} = \rho r \omega^2, \quad \frac{\partial p}{\partial \theta} = 0, \quad \frac{\partial p}{\partial z} = -\gamma$

4. Conversions:

From metres to feets
Multiply by 3.28

From metres to inches
Multiply by

From inch to feet
Divide by 12

From square inch to square foot
-Divide by 144

5. 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 $= H$