KSCP Examination
2020/2021 Academic Session

September 2021

EAH221 – Fluids Mechanics for Civil Engineers

Duration : 3 hours

Please ensure that this examination paper contains **TWELVE (12)** printed pages before you begin the examination.

Instructions: This paper contains **SIX (6)** questions. Answer **FIVE (5)** out of **SIX (6)** questions.

All questions **MUST BE** answered on a new page.

1. (a). A closed vessel is divided into two compartments, which contain oil and water as shown in **Figure 1**.

Determine the value of h.

[7 marks]

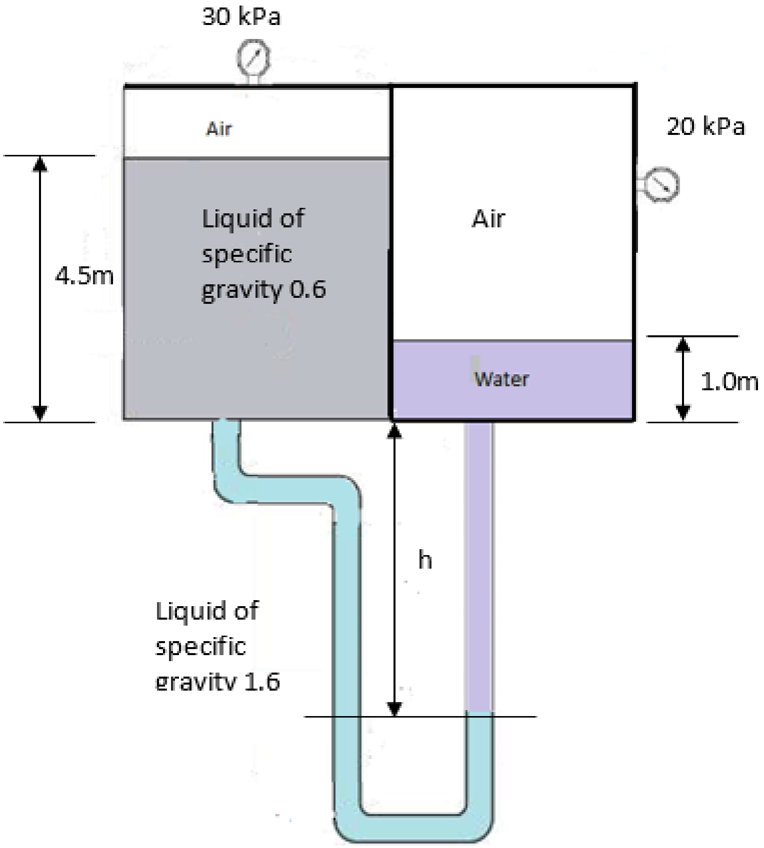


Figure 1

(b). A circular plate of 5 m in diameter has a circular hole of 2 m diameter with its centre 1.25 m above the centre of the plate as shown in **Figure 2**.

The plate is immersed in water at an angle of 45° to the horizontal and with its top edge 3.0 m below the free surface and the circular hole is located nearer to the water surface.

Given that moment of inertia of a circle is $I = \frac{\pi D^2}{64}$.

Calculate the force due to pressure on the plate and the depth of centre of pressure.

[13 marks]

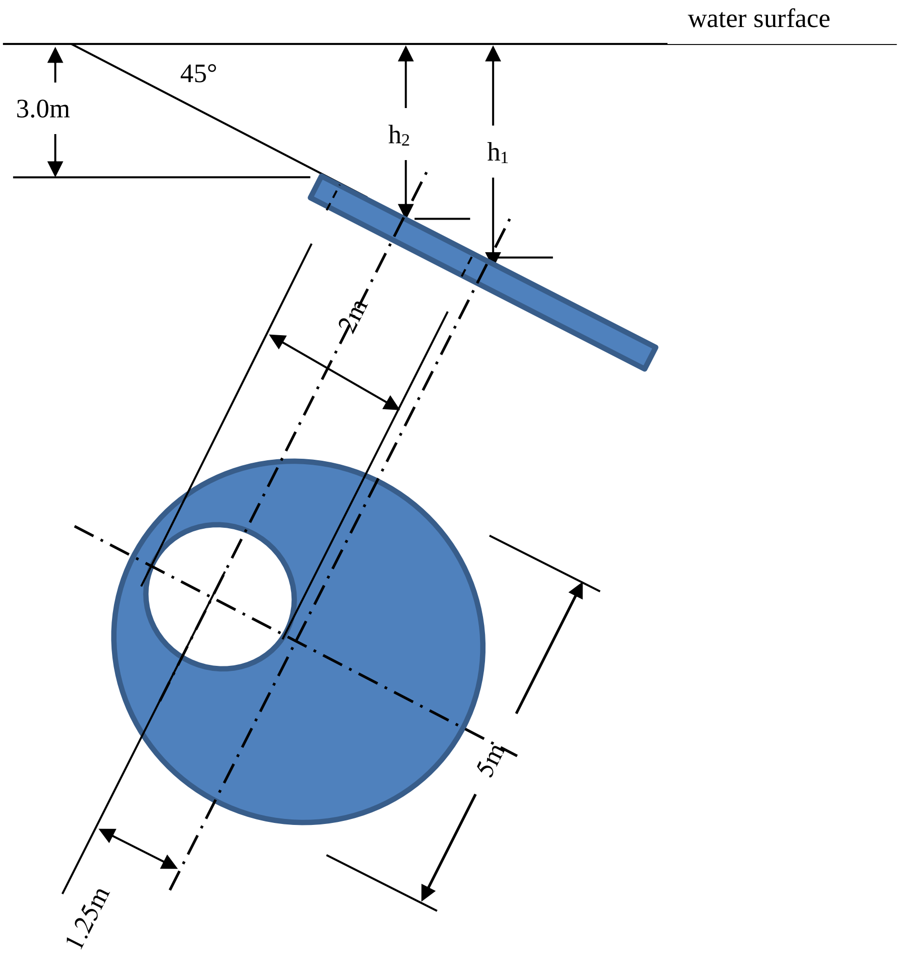


Figure 2

2. (a). Describe briefly the following conditions of equilibrium of a Floating Body.

   i) Stable Equilibrium

   ii) Unstable Equilibrium

   iii) Neutral Equilibrium

[5 marks]

(b). A solid cone of weight 7.5 kN is floating in oil of specific weight 9.0 kN/m^3 as shown in **Figure 3**. Determine the minimum apex angle to ensure that the cone floats with its apex downwards.

Given:

Centre of gravity for a cone is $c.g. = \frac{3}{4}H$ and

Moment of inertia of a circle from plan view $I = \frac{\pi D^4}{64}$

Volume of a cone $V = \frac{\pi r^2 h}{3}$

[15 marks]

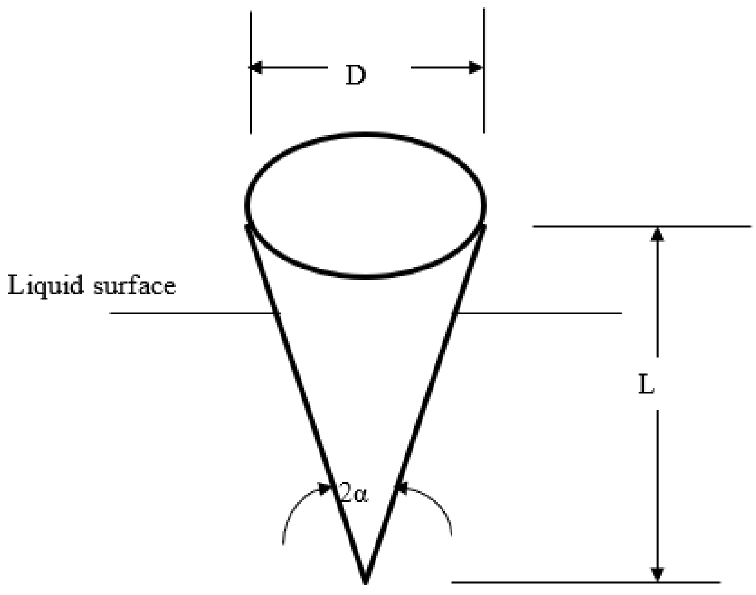


Figure 3

3. (a) i) Describe the principle and conditions for continuity of flow.

[4 marks]

ii) In **Figure 4,** oil flows through a pipe line which contracts from 500 mm diameter at A to 350 mm diameter at B and then forks, one branch being 120 mm diameter discharging at C and the other branch 250 mm diameter discharging at D. If the velocity at A is 2.0 m/s and the velocity at D is 4.0 m/s, calculate the discharge at sections C and D and the velocity at points B and C.

[10 marks]

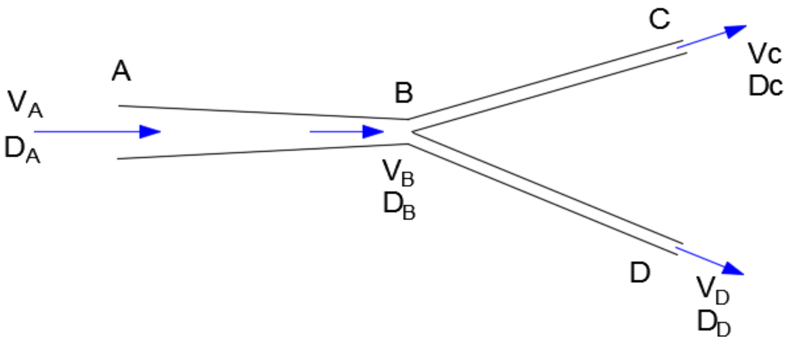


Figure 4

(b). In **Figure 5**, a siphon with a uniform circular bore of 90 mm diameter and consists of a bend pipe with its crest 2.0 m above water level discharging into the atmosphere at a level 3.8 m below water level. Determine the velocity of the flow, discharge and the absolute pressure at crest level if the atmospheric pressure is equivalent to 10 m of water. Neglect losses due to friction.

[6 marks]

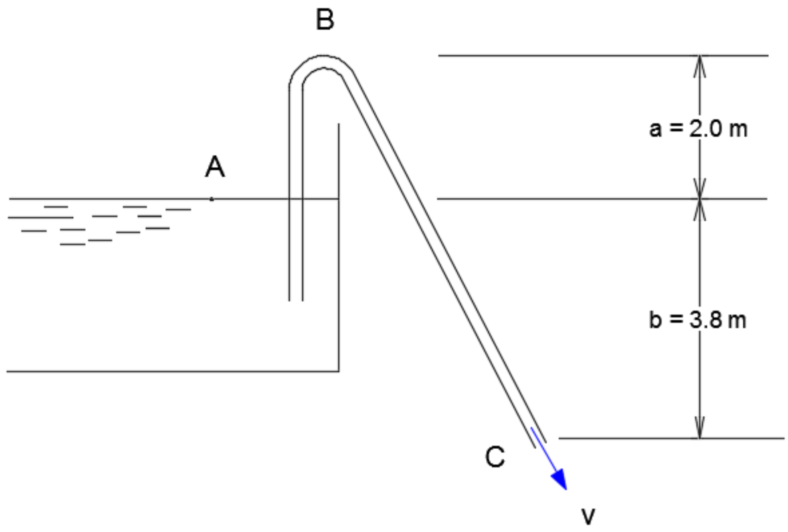


Figure 5

4. (a). i) Explain how provision can be made in Bernoulli's equation for loss of energy occuring between two points in the stream of liquid.

[4 marks]

ii) A conical tube carrying water is fixed vertically with its smaller end upwards. The velocity of flow down the tube is 5.0 m/s at the upper end and 2.0 m/s at the lower end. The tube is 1.5 m long and the pressure head at upper end is 3 m. The loss in the tube is expressed as $\frac{0.3\left(V_1 - V_2\right)}{2g}$ where v_1 and v_2 are the velocities at the upper and lower end, respectively. Calculate the pressure at the lower end.

[6 marks]

(b). A jet of water is discharged through a nozzle with an effective diameter, D of 85 mm and the velocity, v of 23.5 m/s.

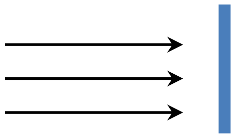
i) Calculate the power of the issuing jet

ii) If the nozzle is supplied from a reservoir which is 30 m above it, determine the head loss (cause by the nozzle) in the pipe and efficiency of power transmission. (Ignore friction losses in pipe)

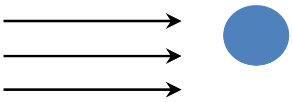
[10 marks]

5. (a) The flow around blunt and streamlined bodies will affect pressure drag and friction drag and ultimately produce different types of wakes. Using a diagram, distinguish the resulting pressure drag, friction drag and the resulting wake on each of the following shape:

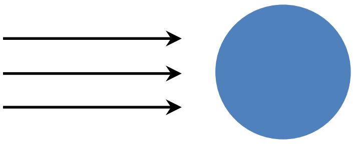
(i)



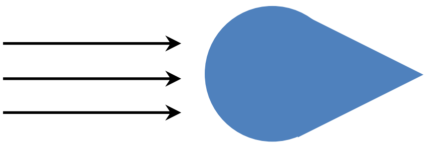
(ii)



(iii)



(iv)



[10 marks]

(b). A 0.5 m x 0.5 m square pile and 10.2 m long is to be driven into a river. If the velocity of the flow in the river is 2.5 m/s and temperature of 20° C, determine the drag force and the bending moment at the bottom of the pile.

[10 marks]

6. (a). Venturi tube is a short pipe with a constricted middle section. By applying Bernoulli's Theorem to a venturi meter, prove that the velocity in a venturi meter can be determined using the following equation:

$$v_1 = \sqrt{\frac{2g[\frac{p_1 - p_2}{\gamma} + (z_1 - z_2) - h_L]}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$$

[10 marks]

(b) A venturi meter and manometer can typically be used to measure volume flowrate. An apparatus as shown in **Figure 7** consisting of a venturi meter and manometer was installed in the hydraulic laboratory. Determine the volume flowrate for the manometer reading Δh. It is given that D_1, D_2, Z_1, Z_2 and Δh is 225 mm, 165 mm, 1.2 m, 1.75 m, and 0.35 m, respectively. The density of the flowing liquid and mercury is 1000 kg/m^3 and 13600 kg/m^3, respectively.

[10 marks]

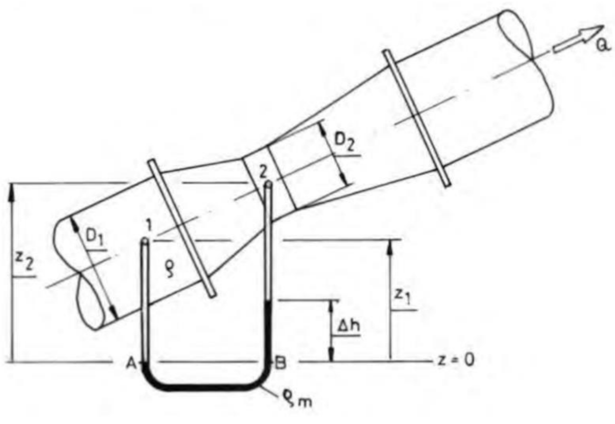


Figure 7

APPENDIX

Table 1 – Properties of Water

TABLE A.1 SI units [101 kPa (abs)]

Temperature (°C)	Specific Weight γ (kN/m^3)	Density ρ (kg/m^3)	Dynamic Viscosity η (Pa·s)	Kinematic Viscosity ν (m^2/s)
0	9.81	1000	1.75×10^{-3}	1.75×10^{-6}
5	9.81	1000	1.52×10^{-3}	1.52×10^{-6}
10	9.81	1000	1.30×10^{-3}	1.30×10^{-6}
15	9.81	1000	1.15×10^{-3}	1.15×10^{-6}
20	9.79	998	1.02×10^{-3}	1.02×10^{-6}
25	9.78	997	8.91×10^{-4}	8.94×10^{-7}
30	9.77	996	8.00×10^{-4}	8.03×10^{-7}
35	9.75	994	7.18×10^{-4}	7.22×10^{-7}
40	9.73	992	6.51×10^{-4}	6.56×10^{-7}
45	9.71	990	5.94×10^{-4}	6.00×10^{-7}
50	9.69	988	5.41×10^{-4}	5.48×10^{-7}
55	9.67	986	4.98×10^{-4}	5.05×10^{-7}
60	9.65	984	4.60×10^{-4}	4.67×10^{-7}
65	9.62	981	4.31×10^{-4}	4.39×10^{-7}
70	9.59	978	4.02×10^{-4}	4.11×10^{-7}
75	9.56	975	3.73×10^{-4}	3.83×10^{-7}
80	9.53	971	3.50×10^{-4}	3.60×10^{-7}
85	9.50	968	3.30×10^{-4}	3.41×10^{-7}
90	9.47	965	3.11×10^{-4}	3.22×10^{-7}
95	9.44	962	2.92×10^{-4}	3.04×10^{-7}
100	9.40	958	2.82×10^{-4}	2.94×10^{-7}

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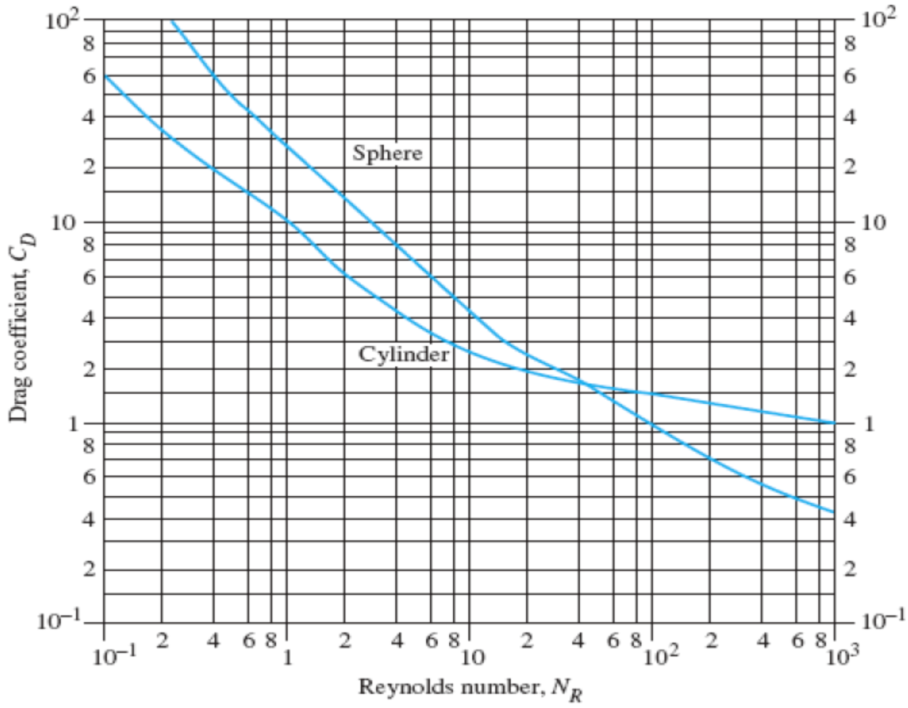
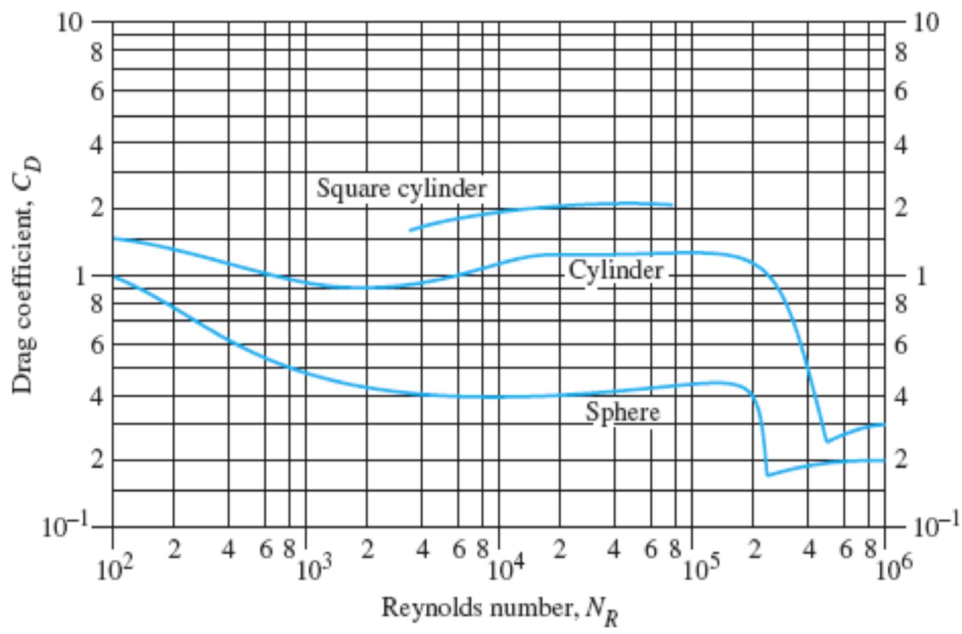


(a) C_D vs. N_R for lower values of N_R



(b) C_D vs. N_R for higher values of N_R

Figure 7 – Drag coefficients for spheres and cylinders

NOTE: 1 cP = 0.001 Ns/m .

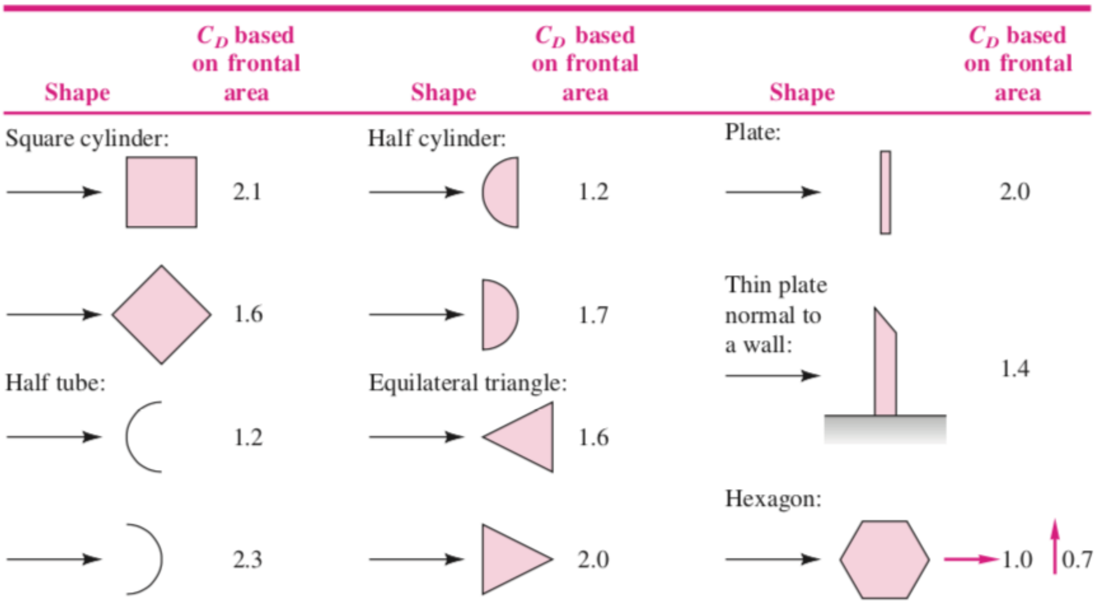


Figure 8 – Drag coefficients for spheres and cylinders (Re ≥ 10^4)

Moment /*Momen*

$$M_0 = \frac{FL}{2}$$

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