UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
JANUARY 2022 SEMESTER

COURSE : VEB1052 - ENGINEERING FLUID MECHANICS

DATE : 10 APRIL 2022 (SUNDAY)

TIME : 9.00 AM - 12.00 NOON (3 HOURS)

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **ELEVEN (11)** pages in this Question Booklet including the cover page and appendices.

ii. **DOUBLE-SIDED** Question Booklet.

1. a. Differentiate between fluid viscosity and drag force. Relate fluid viscosity to drag force.

[5 marks]

b. A flat plate of 50 m^2 is being pulled over a fixed flat surface at a constant velocity of 45 cm/s. An oil film of unknown viscosity separates the plate and the fixed surface by a distance of 0.1 cm. If the force required to pull the plate is measured to be 31.7 N, compute the viscosity. Assume the viscosity of the fluid is steady.

[5 marks]

c. An oil tank is located at a location where the barometric reading is 755 mmHg. Take the specific gravity of the oil and mercury as 0.85 and 13.6, respectively. Compute

i. the local atmospheric pressure, and

[3 marks]

ii. the absolute pressure at a depth of 5 m in the oil tank.

[5 marks]

d. **FIGURE Q1** shows a manometer attached to a tank containing three different fluids, i.e., oil, water and mercury. Compute the difference in elevation of the mercury column in the manometer, y.

[7 marks]

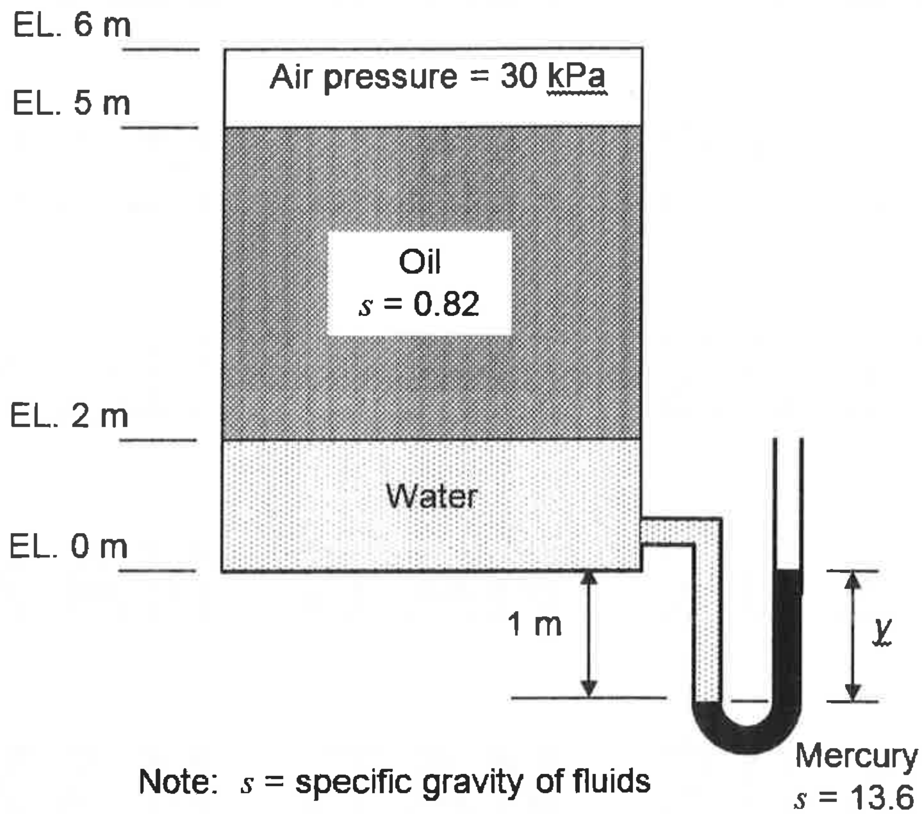

FIGURE Q1

2. a. **FIGURE Q2a** shows a heavy car plunged into a lake during an accident and landed at the bottom of the lake on its wheels. The door is 1.2 m high and 1 m wide, and the top edge of the door is 8 m below the free surface of the water. The opening mechanism of the door window is manual operated and is waterproof. Assume that the bottom surface of the lake is horizontal, and the passenger cabin is well-sealed so that no water leaks inside.

i. Compute the hydrostatic force acting on the door of the submerged car, assuming that the door can be approximated as a vertical rectangular plate.

[4 marks]

ii. The driver trapped in the submerged car is a strong man who can lift 60 kg. Assume that the car opening handle is 0.9 m away from the hinges. Evaluate if the driver can open the door. Validate your judgement using some numerical evidence.

[10 marks]

iii. Under the circumstance as mentioned in **Part 2(ii)**, recommend a practical way to open the car door without breaking the glass window. Show the detailed steps of survival and support your recommendation with the fundamental physics.

[4 marks]

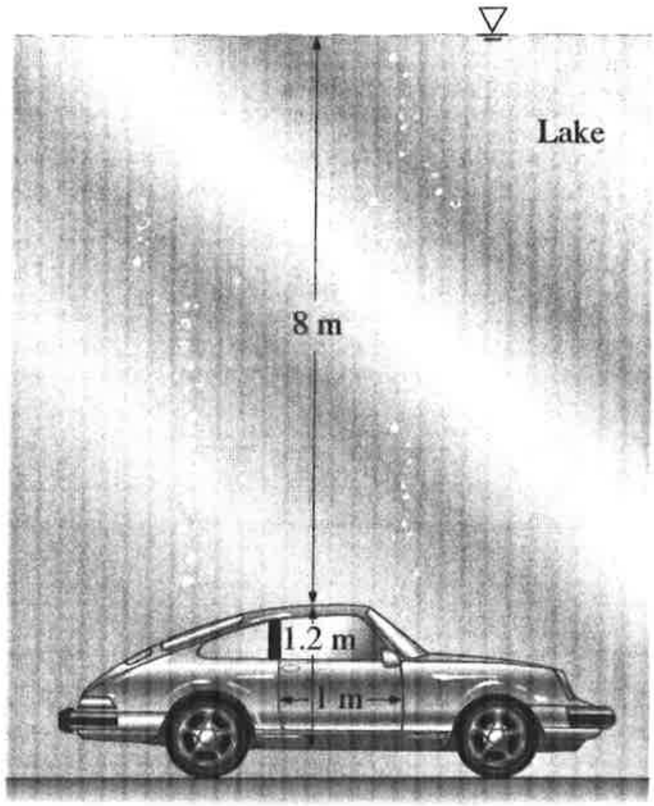

FIGURE Q2a

b. A rectangular concrete block is lowered into the sea using a crane attached to the deck of a ship. The rectangular block is tied to a rope. The specific gravity of the concrete block and seawater are 2.300 and 1.025, respectively. Neglect buoyant force in air and the weight of the ropes.

a. Prepare a free-body diagram of the concrete block in the sea.

[3 marks]

b. Write the equation for the apparent weight of the concrete block in the sea.

[2 marks]

c. The rectangular concrete block is replaced with a material with a specific gravity of 0.95. Predict the observation.

[2 marks]

3. a. Differentiate laminar flow and turbulent flow.

[6 marks]

b. **FIGURE Q3b** shows a garden hose attached with a nozzle used to fill a bucket. Classify the types of flow (steady or unsteady) at the hose, at the nozzle exit, and water flowing from the nozzle.

[3 marks]

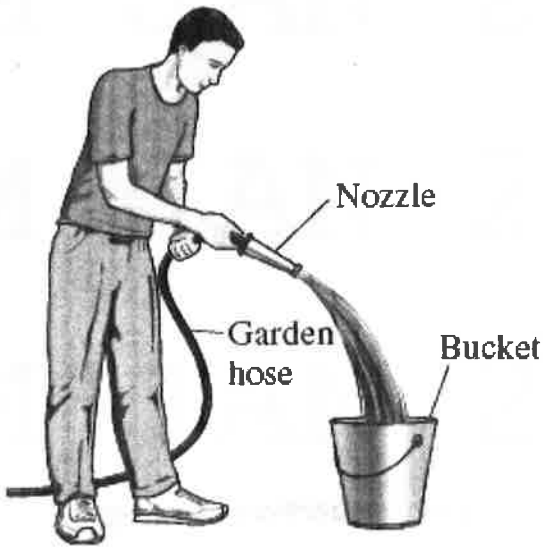

FIGURE Q3b

c. **FIGURE Q3c** shows a siphon consisting of a pipe of 15 cm diameter used to empty oil (s = 0.8) from a tank. The siphon discharges to the atmosphere at an elevation of 1.00 m. The oil surface in the tank is at an elevation of 4.00 m. The centerline of the siphon pipe at its highest point X is at an elevation of 5.50 m. Calculate

i. the discharge in the pipe, and

[5 marks]

ii. the gauge pressure at point X.

[4 marks]

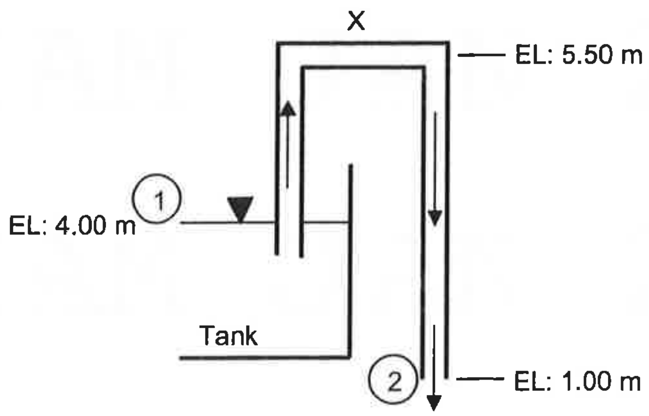

FIGURE Q3c

d. **FIGURE Q3d** shows a water jet with a cross sectional area, A, striking a flat plate at an angle, θ from the normal to the plate with a velocity, u. The plate moves with a velocity, v as shown in the figure. Give an expression for the force exerted by the jet.

[7 marks]

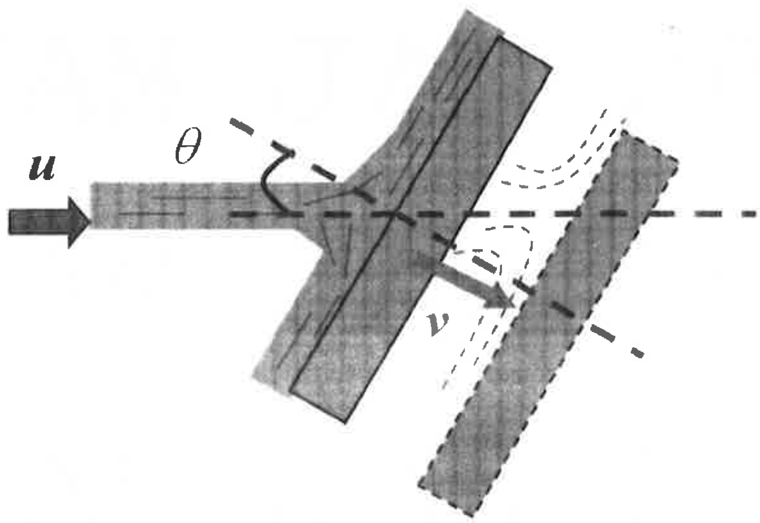

FIGURE Q3d

4. **FIGURE Q4** shows two new cast-iron pipes in series connected to two reservoirs. Both pipes are 300 m long and have diameters of 0.6 m and 0.4 m, respectively. The elevation of the water surface in Reservoir A is 80 m. The discharge of water from reservoir A to Reservoir B is 0.54 m^3/s. Assume a square-edge entrance (K_e = 0.5), a sudden contraction at the junction (K_c = 0.21) and a submerged pipe exits to still water at reservoir B (K_o = 1). Take the kinematic viscosity of the water as ν = 1.31 x 10^{-6} Pa.s and the roughness height of the pipes as e = 0.26 mm. Determine the elevation of the surface of Reservoir B.

[25 marks]

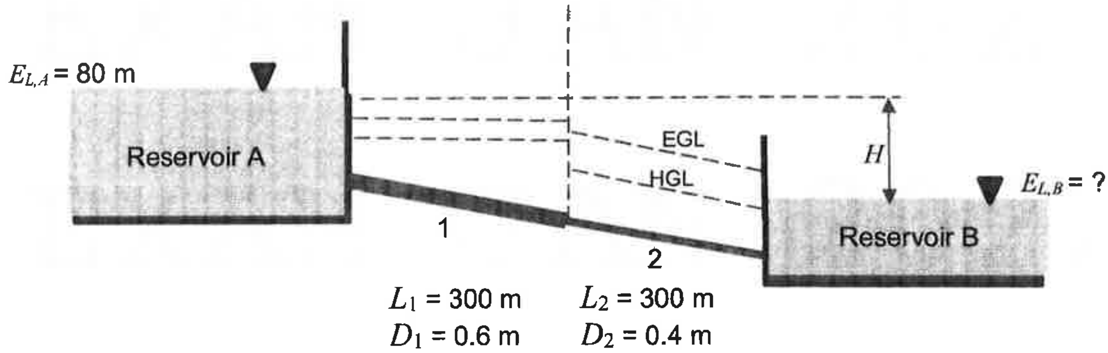

FIGURE Q4

- END OF PAPER-

APPENDIX I

$$\tau = \mu \frac{dV}{dy}$$

$$Y_P = \frac{I_o}{A\bar{y}} + \bar{y}$$

$$I_o = \frac{bh^3}{12}$$

$$\mathrm{Re} = \frac{VD}{\nu}$$

$$h_f = f \frac{L}{D} \frac{v^2}{2g}$$

$$h_L = K_L \frac{v^2}{2g}$$

APPENDIX II

TABLE A.1 **Physical properties of water at standard sea-level atmospheric pressure**[a]

Temperature, T	Specific weight, γ	Density, ρ	Absolute viscosity,[b] μ	Kinematic viscosity,[b] ν	Surface tension, σ	Saturation vapor pressure, p_v	Satur'n vapor pressure head, p_v/γ	Bulk modulus of elasticity, E_v
°F	lb/ft³	slugs/ft³	10^{-6} lb·sec/ft²	10^{-6} ft²/sec	lb/ft	psia	ft abs	psi
32°F	62.42	1.940	37.46	19.31	0.00518	0.0885	0.204	293,000
40°F	62.43	1.940	32.29	16.64	0.00514	0.122	0.281	294,000
50°F	62.41	1.940	27.35	14.10	0.00509	0.178	0.411	305,000
60°F	62.37	1.938	23.59	12.17	0.00504	0.256	0.592	311,000
70°F	62.30	1.936	20.50	10.59	0.00498	0.363	0.839	320,000
80°F	62.22	1.934	17.99	9.30	0.00492	0.507	1.173	322,000
90°F	62.11	1.931	15.95	8.26	0.00486	0.698	1.618	323,000
100°F	62.00	1.927	14.24	7.39	0.00480	0.949	2.20	327,000
110°F	61.86	1.923	12.84	6.67	0.00473	1.275	2.97	331,000
120°F	61.71	1.918	11.68	6.09	0.00467	1.692	3.95	333,000
130°F	61.55	1.913	10.69	5.58	0.00460	2.22	5.19	334,000
140°F	61.38	1.908	9.81	5.14	0.00454	2.89	6.78	330,000
150°F	61.20	1.902	9.05	4.76	0.00447	3.72	8.75	328,000
160°F	61.00	1.896	8.38	4.42	0.00441	4.74	11.18	326,000
170°F	60.80	1.890	7.80	4.13	0.00434	5.99	14.19	322,000
180°F	60.58	1.883	7.26	3.85	0.00427	7.51	17.84	318,000
190°F	60.36	1.876	6.78	3.62	0.00420	9.34	22.28	313,000
200°F	60.12	1.868	6.37	3.41	0.00413	11.52	27.59	308,000
212°F	59.83	1.860	5.93	3.19	0.00404	14.69	35.36	300,000
°C	kN/m³	kg/m³	N·s/m²	10^{-6} m²/s	N/m	kN/m² abs	m abs	10^6 kN/m²
0°C	9.805	999.8	0.001781	1.785	0.0756	0.611	0.0623	2.02
5°C	9.807	1000.0	0.001518	1.519	0.0749	0.872	0.0889	2.06
10°C	9.804	999.7	0.001307	1.306	0.0742	1.230	0.1255	2.10
15°C	9.798	999.1	0.001139	1.139	0.0735	1.710	0.1745	2.14
20°C	9.789	998.2	0.001002	1.003	0.0728	2.34	0.239	2.18
25°C	9.777	997.0	0.000890	0.893	0.0720	3.17	0.324	2.22
30°C	9.765	995.7	0.000798	0.800	0.0712	4.24	0.434	2.25
40°C	9.731	992.2	0.000653	0.658	0.0696	7.38	0.758	2.28
50°C	9.690	988.0	0.000547	0.553	0.0679	12.33	1.272	2.29
60°C	9.642	983.2	0.000466	0.474	0.0662	19.92	2.07	2.28
70°C	9.589	977.8	0.000404	0.413	0.0644	31.16	3.25	2.25
80°C	9.530	971.8	0.000354	0.364	0.0626	47.34	4.97	2.20
90°C	9.467	965.3	0.000315	0.326	0.0608	70.10	7.40	2.14
100°C	9.399	958.4	0.000282	0.294	0.0589	101.33	10.78	2.07

[a] In these tables, if (for example, at 32°F) μ is given as 37.46 and the units are 10^{-6} lb·sec/ft² then $\mu = 37.46 \times 10^{-6}$ lb·sec/ft².
[b] For viscosity, see also Figs. A.1 and A.2.

APPENDIX III