

The Open University of Sri Lanka  
Faculty of Engineering Technology  
Department of Mechanical Engineering



Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX3512/MEX3212 <b>Basic Thermo Fluids</b>
Academic Year	: 2019/20
Date	: 25 <sup>th</sup> Friday , September 2020
Time	: 1400-1700hrs

### General Instructions

1. Read all instructions carefully before answering the questions.
2. Answer **five (05)** Questions only. All questions carry equal marks.
3. Relevant charts/ codes are provided.
4. This is a Closed Book Test (CBT).
5. Answers should be in clear handwriting.
6. Do not use Red colour pen.
7. Take the specific gas constant (R) for air as  $0.287 \text{ kJ} / \text{kg} \cdot \text{K}$ .
8. Density of Water is  $1000 \text{ kg} / \text{m}^3$
9. For air  $C_v = 0.718 \text{ kJ} / \text{kg} \cdot \text{K}$  and  $C_p = 1.005 \text{ kJ} / \text{kg} \cdot \text{K}$

- Q1 (a) Write the first law of thermodynamics: (5 marks)
- (b) Six grams of air is contained in the cylinder shown in figure Q1. The air is heated until the piston moves up by 50 mm. The spring is not compressed initially. The atmospheric pressure,  $P$  is 1 bar. Calculate the following.
- (i) temperature when the piston leaves the stops (5 marks)
- (ii) work done by the air on the piston. (5 marks)
- (iii) Change of internal energy of the air if the heat supplied the air is 1kJ. (6 marks)

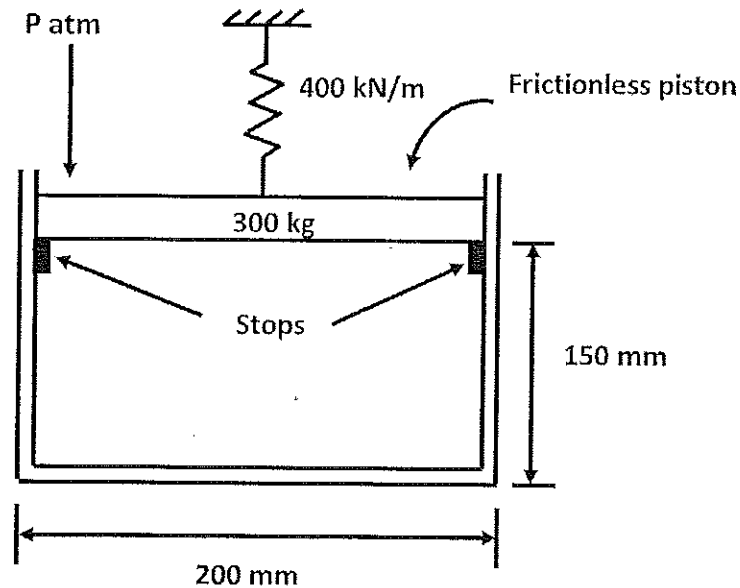


Figure Q1

- Q2 (a) Write the steady flow energy equation and explain each term. (5 marks)
- (b) Prove that the following relationship is true for an isentropic process. (5 marks)

$$T_2 = T_1 \left( \frac{P_2}{P_1} \right)^{\frac{\gamma-1}{\gamma}},$$

Where  $P_1, T_1$  are the pressure and temperature at stage 1 and  $P_2, T_2$  are the pressure and temperature at stage 2 of the isentropic process.  $\gamma$  is the ratio of specific heat at constant pressure ( $C_p$ ) and constant volume ( $C_v$ )

- (c) Air is expanded isentropically in a nozzle from 13.8 bar and 150°C to a pressure of 6.9 bar. The inlet velocity to the nozzle is very small and the process occurs under steady conditions. Calculate the exit velocity from the nozzle if it is laid in a horizontal plane and the inlet velocity is 10 m/s. For air  $\gamma = 1.4$ . (10 marks)

Q3 (a) Draw a  $p - V$  diagram for Diesel cycle and name all the processes. (4 marks)

(b) A Diesel cycle, with a compression ratio of 18, operates on air with a low pressure of 200 kPa and a low temperature of 200°C. The maximum temperature of the cycle is 3080 K. If the work output is 1000 kJ/kg, determine the thermal efficiency. (For air  $C_p = 0.718 \text{ kJ/kg.K}$  and  $C_v = 1.005 \text{ kJ/kg.K}$ ) (16 marks)

Q4 Figure Q4 shows the temperature distribution through a furnace wall constructed from fire bricks, high temperature block insulation and a steel casting plate. The thermal conductivity of the fire brick is  $1.13 \text{ W/m.K}$ . The Stefan Boltzmann constant ( $\sigma$ ) is  $5.67 \times 10^{-8} \text{ W/m}^2 \text{ K}^4$ . The temperatures of the interfaces are given in the figure.

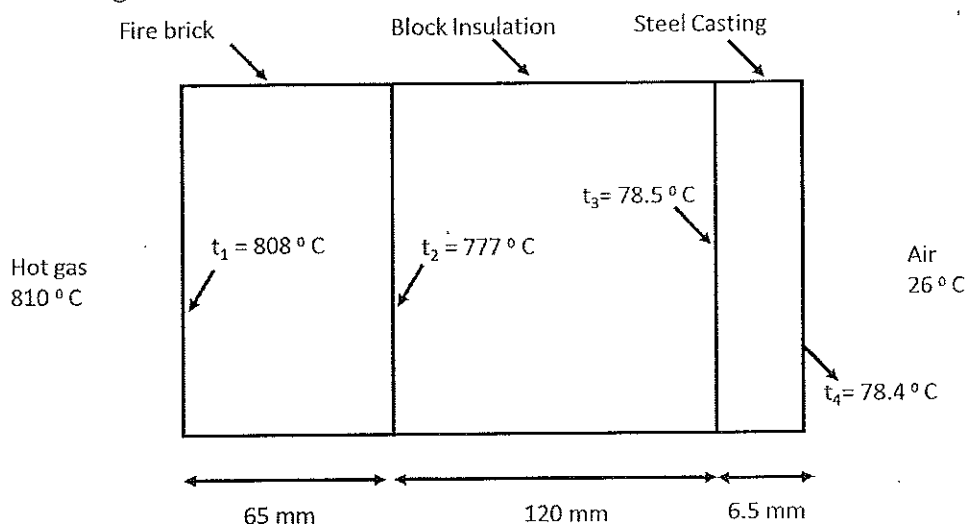


Figure Q4

Determine the following:

- rate of heat transfer per unit area of furnace wall (4 marks)
- thermal conductivities of block insulation and steel (4 marks)
- combined heat transfer coefficient for the outside surface of the furnace wall (4 marks)
- heat exchange by radiation between the hot gas and inside surface of furnace wall, if the emissivity ( $\epsilon$ ) of the fire brick wall surface is 0.82. (4 marks)
- convective heat transfer coefficient for the inside surface of the furnace wall (4 marks)

- Q5 (a) Define the term “centre of pressure” for a surface submerged in a liquid. (4 marks)
- (b) Figure Q 5 shows a rectangular gate AB that separates water and glycerin (specific weight  $12.36 \text{ kN/m}^3$ ) in a container. Determine:
- (i) net hydraulic force on gate AB (8 marks)
- (ii) centre of pressure of gate AB (8 marks)

For a rectangular plate the first moment of area about the centre of gravity is given by  $bh^3/12$  where  $b$  is the width and  $h$  is the height of the plate.

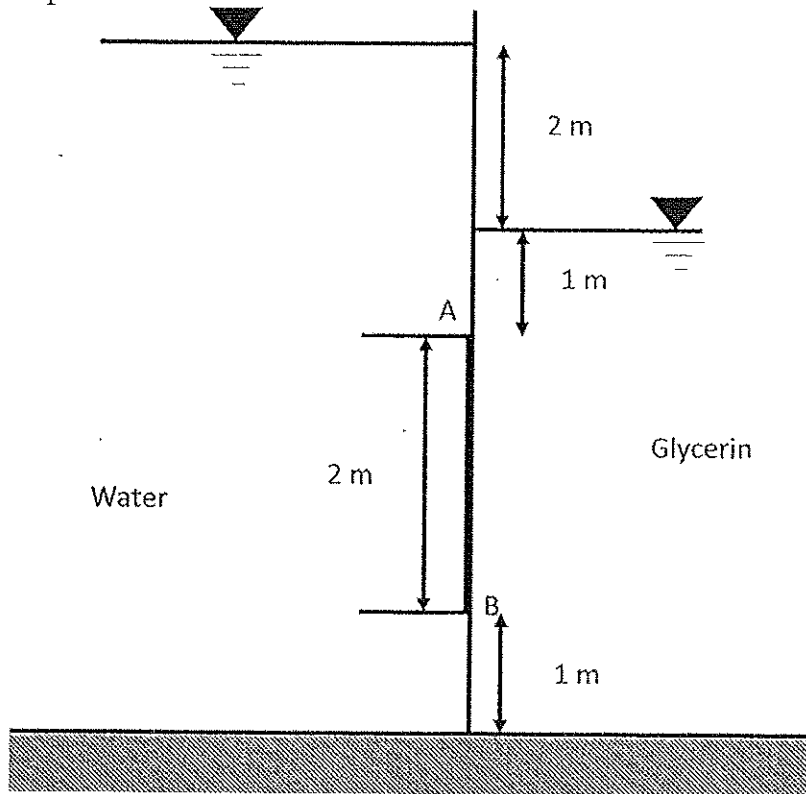


Figure Q5

- Q6 (a) Define the terms “gauge pressure” and “absolute pressure”. (6 marks)
- (b) A differential manometer is attached to two tanks, as shown in figure Q6. The specific gravities of SAE 30 oil, Carbon Tetrachloride and Mercury are 0.89, 1.59 and 13.6 respectively. Find the pressure difference between Chamber A and Chamber B. (14 marks)

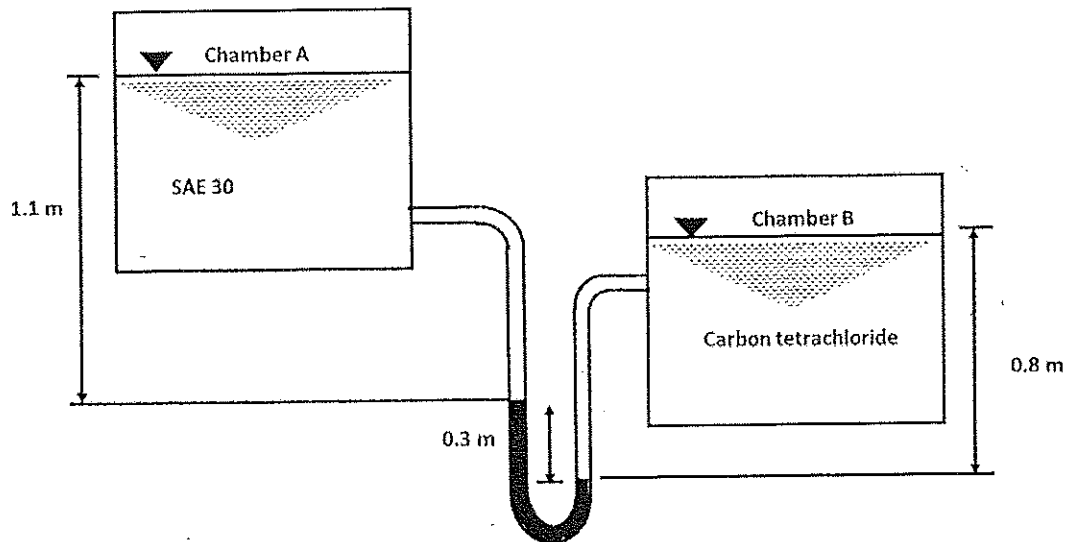


Figure Q6

- Q7 (a) Explain what is meant by “metacentric height” of an object floating in a liquid. (5 marks)
- (b) A right circular solid cylinder of radius  $r_0$  and height  $h$  floating in water with end faces horizontal and stable equilibrium as shown in figure Q 7. The specific gravity of the cylinder material is  $S_1$ . Show that (15 marks)

$$\frac{r_0}{h} \geq \sqrt{2 S_1 (1 - S_1)}$$

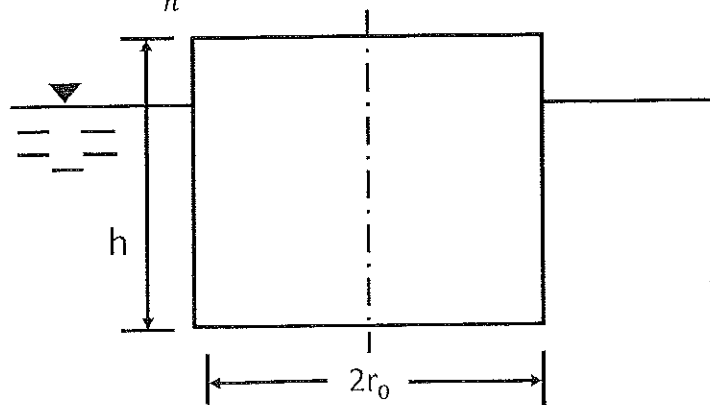


Figure Q7

Q8 Water flows through a nozzle attached to the end of a laboratory sink faucet as shown in figure Q 8. The flowrate is  $0.6 \text{ l/s}$ . The nozzle inlet and exit diameters are  $16 \text{ mm}$  and  $5 \text{ mm}$ , respectively, and the nozzle axis is vertical. The mass of the nozzle is  $0.1 \text{ kg}$ . The pressure at section A is  $464 \text{ kPa}$ . Find the following.

- Weight of the water in the conical section. (6 marks)
- Velocity of flow at the sections A and B. (4 marks)
- Force required to hold the nozzle in place. (10 marks)

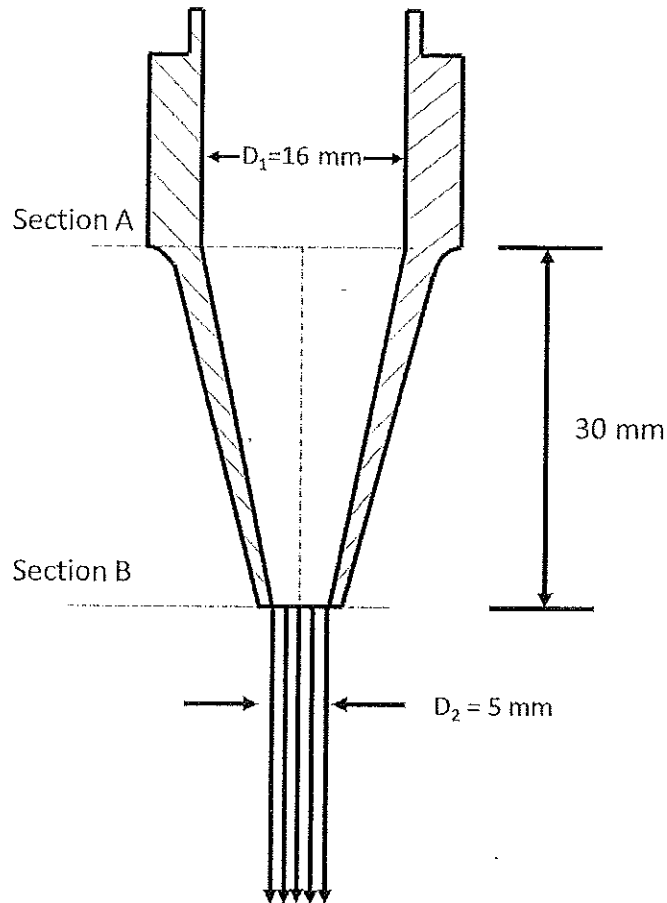


Figure Q8

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