00351

The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX3212 Basic thermo-fluids**
Academic Year	:	2014/15
Date	:	31 – 08 - 2015
Time	:	9.30am – 12.30pm
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. Answer **any 5** questions only.
4. Take acceleration due to gravity and the density of water as 9.81N/kg and 1000kg/m^3 respectively where necessary.

Q1 (a) On what factors does the heat conduction through a solid depend? ***6 marks***

(b) A furnace wall consists of 200mm layer of bricks, 6mm layer of steel plate and an insulation material. The maximum temperature of the wall is 950°C, on the surface of the brick wall to the furnace side. The minimum temperature is 50°C on the outside of the wall. The heat loss through the wall is 800W/m^2. The thermal conductivities for bricks, steel and the insulation material are 1.52, 45, and 0.12 in W/mK respectively. Find the following.

(i) Thickness of the insulation material layer ***9 marks***

(ii) Convection heat transfer coefficient on the outside surface of the insulation if the surrounding temperature is 30°C ***5 marks***

Q2 (a) Overall Heat Coefficient for a parallel flow heat exchanger is given by the following equation.

$$U = \frac{Q}{A\left[\frac{\Delta t_1 - \Delta t_2}{ln\left(\frac{\Delta t_1}{\Delta t_2}\right)}\right]}$$

With the aid of a diagram showing the temperature variations, define the different terms of the above equation, with the SI units of measurement. ***5 marks***

(b) In a parallel counter flow heat exchanger the temperature of hot fluid and cold fluid are shown in Figure Q2.

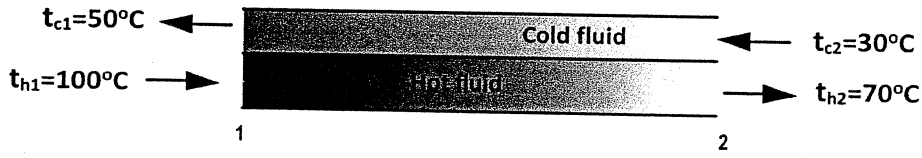

Figure Q2

(i) Find the rate of heat transfer to the cold fluid if the mass flow rate of cold fluid is 0.005 kg/s. ***8 marks***

Take specific heat capacity of the cold fluid as 3kJ/kgK.

(ii) Find the overall heat transfer coefficient, if the effective area of conduction heat transfer of the heat exchanger is 0.01m^2. ***7 marks***

Q3 (a) A flat plate is immersed in a fluid at an angle θ as shown in Figure Q3 (a) below. The distance to the center of pressure from the free surface measured from point O, parallel to the plate surface is $\bar{y}$. Show that the value of $\bar{y}$ is given by the following equation. ***6 marks***

$$\bar{y} = \frac{2}{3}\left(\frac{y_1^3 - y_2^3}{y_1^2 - y_2^2}\right)$$

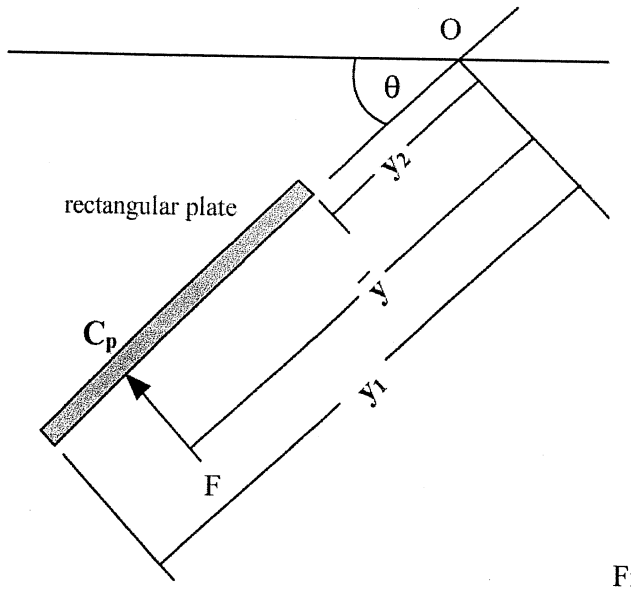

Figure Q3(a)

(b) Figure Q3 (b) shows a dam of a reservoir with a vertical wall and a inclined wall.

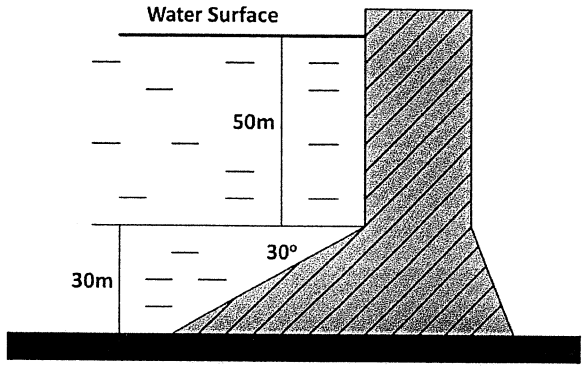

Figure Q3(b)

Calculate the following.

(i) Magnitudes of fluid thrusts per unit length acting on vertical and inclined surfaces separately. ***8 marks***

(ii) Distance to Center of pressure for each of the two dam sections measured from the free water surface. ***6 marks***

Q4 (a) Explain the following. ***4 marks***

(i) Center of Buoyancy (ii) Meta Center

(b) A rectangular pontoon floats in sea water of density 1025kg/m^3. The length and the breadth of the pontoon are 8m and 7m respectively. The height of it is 3m. The pontoon weighs 600kN and it carries a boiler of 2m diameter on its upper deck which weighs 400kN as shown in Figure Q4.

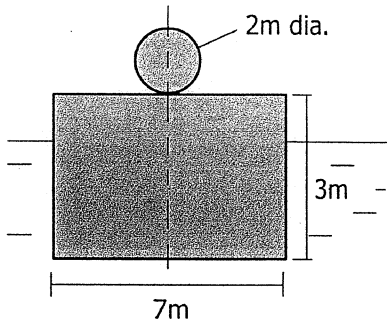

Figure Q4

Find the following.

(i) Submerged depth of the pontoon. ***4 marks***

(ii) Distance to the center of gravity of the system from the bottom edge of the pontoon. ***6 marks***

(iii) Meta-Centric height. ***6 marks***

You may use the following formulae with usual meanings for the abbreviations, if not mentioned.

Second moment of area of a rectangle

$$I = \frac{bd^3}{12}$$

Distnace between the Center of Bouyancy and the Meta Center

$$BM = \frac{I}{V}$$

Q5 (a) Show that the force, F, exerted by a jet of water striking on a stationary object can be expressed as: ***4 marks***

$$F = Q\rho\Delta u$$

Where,

$Q = Fluid\ volume\ flow\ rate$

$\rho = Density\ of\ fluid$

$\Delta u = Velocity\ change\ in\ the\ direction\ of\ force$

(b) A flat plate is hinged at its top edge as shown in Figure Q5. The weight of the plate is 10kN. A jet of water with 50mm in diameter strikes on the plate at its midpoint with a velocity of 50m/s.

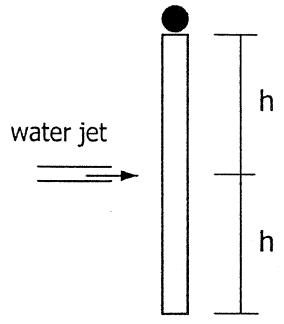

Figure Q5

Find the following.

(i) The horizontal force that should be applied at the lower edge of the plate to keep it vertically. ***8 marks***

(ii) The angle of deflection where the plate remains in equilibrium under the action of fluid thrust and without external force at the lower edge. ***8 marks***

Q6 (a) Explain the terms, Ultimate Analysis and Proximate Analysis for a fuel. ***6 marks***

(b) The chemical formula of alcohol is C_2H_6O. Calculate the stoichiometric air/fuel ratio by mass for the combustion of C_2H_6O. ***8 marks***

(c) C_2H_6O is combusted with 20% excess atmospheric air. Find the mass of combustion products per 1kg of alcohol. ***6 marks***

Relative atomic weights: C – 12, O – 16, H – 1, N - 14

Composition of atmospheric air by volume: 20% Oxygen, 80% Nitrogen

Q7 A cylinder contains 1kg of air with a pressure of $2MN/m^2$. The volume of air is $0.05m^3$. The air expands pushing a piston according to the law PV^2 = Constant, until the volume becomes double. The air is then cooled at constant pressure until the volume reaches initial volume. Then heat is added at constant volume until the pressure becomes initial value.

(a) Sketch the process on P-V axes. ***4marks***

(b) Find,

(i) Minimum pressure ***4marks***

(ii) Work done during the expansion process. ***6marks***

(iii) Work done on the gas during constant pressure process ***2marks***

(c) If 1200J of heat is lost from air during expansion process, find out the change in internal energy of air. ***4 marks***

Q8 (a) Describe the operation of a gas power plant, indicating different components and their functions, and thermodynamic cycle. ***8 marks***

(b) Define the efficiency in terms of enthalpy changes, for a gas power plant. ***6 marks***

(c) Explain briefly how the efficiency of a gas power plant could be improved. ***6 marks***