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# The Open University of Sri Lanka
# Faculty of Engineering Technology

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| Study Programme | : | Diploma in Technology/Bachelor of Technology (Engineering) |
| Name of the Examination | : | Final Examination |
| **Course Code and Title** | : | **MEX3235 Thermo- Fluids** |
| Academic Year | : | 2013/14 |
| Date | : | 27th August 2014 |
| Time | : | 0930-1230hrs |
| Duration | : | 3 hours |

**General instructions**

1. Read all instructions carefully before answering the questions.
2. Answer five questions selecting at least **two** questions from each section. All questions carry equal marks.
3. You may obtain tables of Thermodynamic and transport properties of fluids on request.
4. Density of water 1000 kg/m$^3$. Acceleration due to gravity = 9.81 m/s$^2$
5. For air Cp = 1.005 kJ/kgK, Cv = 0.718 kJ/kgK R = 0.287 kJ/kgK $\gamma$ = 1.4

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## SECTION 1

(1) (a) Explain clearly the difference between a non-flow and a steady flow process.

(b)

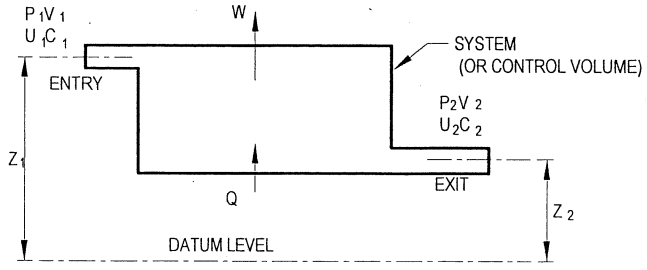



**Fig. Q1**

Figure Q1 illustrates a thermodynamic system of a fluid flow, and inlet and exit conditions are also shown with usual notations.The system does work of W and heat of Q is transferred.

Derive the general steady flow energy equation for this system.

(c) Air is expanded isentropically in a convergent nozzle from 14bar and 167°C to a pressure of 7bar and the process occurs under steady-state conditions. Inlet air velocity is 10m/s. Calculate the exit temperature and velocity of air stream assuming the nozzle is laid in a horizontal plane.

(2) (a) Explain briefly the air-standard Diesel cycle with the aid of a P-V diagram

(b) Thermal efficiency of an air-standard Diesel cycle is given by

$$\eta_{th} = 1 - \left[\frac{1}{r_v}\right]^{\gamma-1} \left\{\frac{r_c^{\gamma} - 1}{\gamma(r_c - 1)}\right\}$$

Define the parameters of $r_v$ and $r_c$ with reference to p-v diagram drawn in section (a) above.

(c) In an air-standard Diesel cycle, initially air is taken in at a temperature of 27°C and a pressure of 0.1MPa. The volumetric compression ratio for the cycle is 18 and heat added per cycle is 2000kJ/kg. Per unit mass of air determine the

(i) temperatures and pressures at the end of each process of the cycle
(ii) cycle efficiency.

(3) A simple Rankine cycle works between a boiler pressure of 20bar and a condenser pressure of 0.08bar. The steam condition at inlet to turbine is superheated with a temperature of 350°C. After isentropic expansion through the turbine steam enters the condenser where it is condensed to saturated liquid water.

Determine the
(i) dryness fraction at the end of expansion in the turbine.
(ii) pump work
(iii) turbine work
(iv) thermal efficiency of the cycle

(4) (a) Show that under steady state conduction heat transfer rate **Q** for a hollow cylinder is given by

$$Q = \frac{2\pi kL(t_i - t_0)}{\ln(r_0/r_i)}$$

Where $r_i$, $r_0$ = inner and outer radii
$t_i$, $t_0$ = temperature of inner and outer surfaces
k = constant thermal conductivity within the given temperature range.
L = length of the tube

(b) (i) The outer surface of a steel pipe carrying steam has a temperature of 120°C. The outer surface of the pipe loses heat by convection to atmospheric air at 30°C. The diameter of the pipe is 25mm . If the convection heat transfer coefficient of the surface is 15W/m²K calculate the rate of heat loss per unit length of the tube.

(ii) It is necessary to reduce the rate of heat loss by 30%. The thickness of the insulation to be used should be 30mm. Determine the k value of the insulation needed assuming the same surface heat transfer coefficient and the surface temperature.

## SECTION 2

(5) (a) The catchment reservoir and service reservoir of a town water supply system lie 65 km apart and have a difference of 200 m in their water levels. These reservoirs are connected by a single pipe that can carry 0.4 $m^3/s$. Calculate the diameter of the pipe. Consider only friction losses and for each pipe take friction factor ***f*** =0.008. Darcy's formula for head loss is given in usual notations as

$$h_f = \frac{4fu^2l}{2gd}$$

(b)

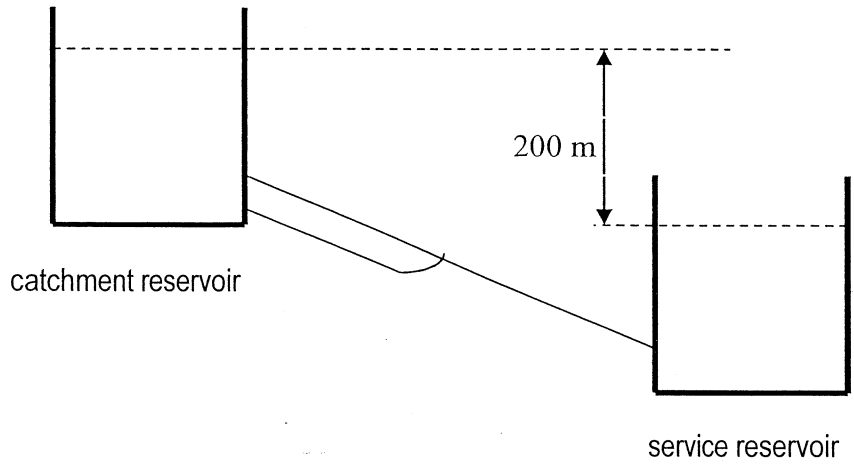



Fig.Q5

Subsequently it became necessary to increase the flow rate by another 0.20 $m^3/s$. This was achieved by laying second pipe of the same diameter in parallel over a part length of the original pipe as shown in figure Q5. Find the necessary length of the second pipe.

(6) Attempt three (03) of the following.

a) What is the basis on classification of hydraulic machines?. Explain

b) Describe the principle and working of a reciprocating pump.

c) State the advantages of centrifugal pumps over reciprocating pumps.

d) Explain the working principle of a centrifugal pump.

e) What is meant by cavitations? Explain how to minimize the cavitations.

(7) (a) State Bernoulli's theorem and assumptions for steady flow of an incompressible fluid.

(b)

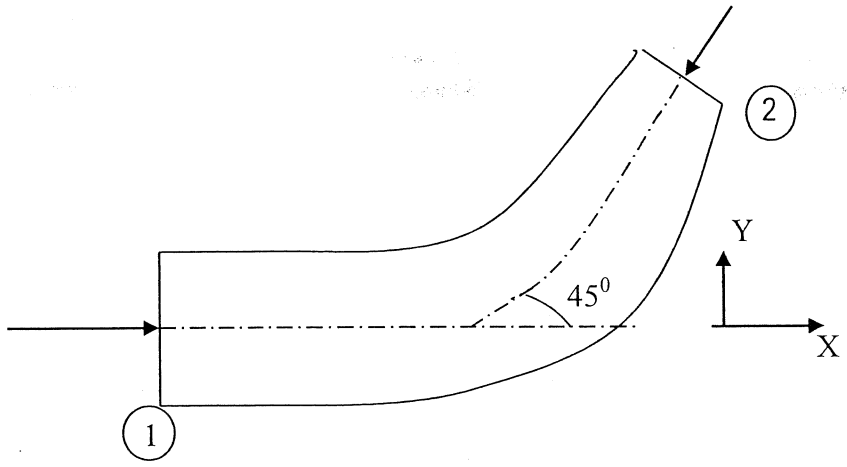



Fig. Q7

A $45^0$ reducing pipe bend (in a horizontal pipe) tapers from 600 mm at inlet to 300 mm diameter at out let as shown in Fig. Q7. The gauge pressure at inlet is 150 kPa and the rate of flow of water through the bend is 0.3 $m^3/s$. Neglecting friction calculate the resultant force exerted by the water on the bend.

(8)

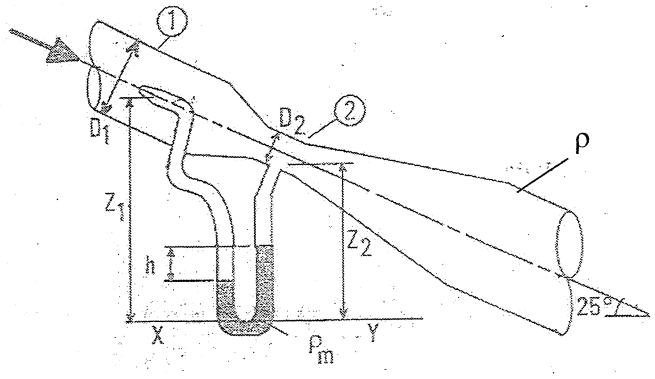



Fig. Q8

Figure Q8 shows a pitot and static tube arrangement connected to a venturi meter fixed to a pipeline carrying water. Assuming a steady incompressible flow with no losses,

i) show that the flow rate Q is given by

$$Q = \frac{\pi {D_2}^2}{4}\left\{2gh\left(\frac{\rho_m}{\rho} - 1\right)\right\}^{1/2}$$

ii) If h = 0.075m, $\rho_m / \rho = 13.6$, $D_2 = 0.2$m, hence or otherwise determine the flow rate in the pipe.

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