Code: 9A14403

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B.Tech II Year II Semester (R09) Regular Examinations, April / MAY 2012

FLUID MECHANICS AND HEAT TRANSFER

(Mechatronics)

Time: 3 hours Max Marks: 70

All questions carry equal marks

A total of five questions are to be answered with at least two questions from each part

Use separate booklets for Part A and Part B

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PART- A

1 (a) Explain about pressure and state Pascal's law.
(b) Define pressure and what are the different units of pressure.

2 (a) Define and explain stream line, path line and streak line in fluids.
(b) For the following flow, find the equation of the streamline passing through (1, 1) v= 3xi – 3yj.

3 A horizontal pipe 50 mm diameter carrying glycerin has shear stress at the pipe boundary as 196.2 N/m^2. Find the pressure gradient, mean velocity and Reynolds number. Take glycerin density as 1275.3 kg/m^3 and μ = 60.442 x 10^{-2} N-s/m^2.

4 (a) Explain the design specifications of a Pelton wheel.
(b) A Pelton wheel has a tangential velocity of 15 m/sec. The water is being supplied under a head of 36 m at the rate of 20 lit/sec. The bucket deflects the jet through an angle of 160^0. If the coefficient of velocity of the nozzle is 0.98, find the power produced by the turbine.

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PART- B

5 (a) Explain the Newtons law of cooling.

(b) A furnace wall is made of 75 mm thick fire clay brick and 6.4 mm thick mild steel plate. The inside surface of brick is at 647^0C and outside air temperature is 27^0C. Determine:
(i) The heat loss per m^2 area of the furnace wall and outside surface temperature of the steel plate.
(ii) If 18 steel bolts each of 19 mm diameter are used for fixing the steel plate on the brick wall per m^2 area of the wall, what is the percentage increase in the heat flux? Take k (brick) = 1.1 w/m ^{0}C, k (steel) = 39 w/m ^{0}C to (outside heat transfer coefficient) = 68 w/m^2 ^{0}C.

6 (a) Define Reynolds number and wat is its significance.

(b) Water is heated from 15^0C to 50^0C passing through a tube of 2.5 cm diameter. The velocity of water is 1.2 m/min. The enter surface of the is heated by an electric heater providing uniform heat flux of 15 KW/m^2. Find out (i) The length of the tube required (ii) Tube surface temperature at the exit. Take the properties of water at average temperature as = 995 kg/m^3, C_P = 4.175 KJ/kg ^{0}C, K = 0.615 w/m ^{0}C, = 0.8×10^{-3} NS/m^2.

7 (a) Discuss about the laws of black body radiation.

(b) Determine the heat lost by radiation per meter length of 8 cm diameter pipe at 300^0c. If (i) located in a large room with red brick walls at a temperature of 27^0C. (ii) Enclosed in a 16 cm diameter red brick conduit at a temperature of 27^0C. Take $\in$ (pipe) = 0.79 and $\in$ (brick conduit) = 0.93.

8 (a) Explain the working principle of a heat pipe.

(b) Find out the length of a tube required for following heat transfer where air is heated by exhaust gases. The heat transfer rate is 3350 KJ/hr. inside and outside diameters of tube are 5 cm and 6 cm respectively. h_i (inside for air) = 100 w/m^2 ^{0}c h_o (outside for gas) = 160 W/m^2 ^{o}c. Thi = 350^0c Tho = 150^0c, T_{ci} 50^0C t_{co} = 100^0c neglect the tube resistance and assume that the flow arrangement is parallel. If the flow arrangement is counter, what is percentage saving in tube length?

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PART- A

1 (a) Discuss factors which affect the viscosity of a liquid.
(b) What do you mean by a single column manometer?

2 Explain boundary layer thickness, displacement thickness, momentum thickness and energy thickness.

3 Using Hagen- Poiseuille equation derive an expression for the head loss in a diameter D and length L in terms of Reynolds number and velocity head.

4 (a) Define specific speed of a turbine and derive an expression for the same.
(b) Show that pelton turbine is a low specific speed turbine.

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PART- B

5 (a) Distinguish between steady and unsteady state heat conduction.

(b) Hot air at temperature of 40^0C is flowing through steel pipe of 10 cm diameter. The pipe is covered with two layers of different insulating materials of thickness 4 cm and 3 cm and there corresponding conductivities are 0.1 and 0.32 W/m- K. The inside heat transfer coefficient is 50 w/m^{2}k and outside heat transfer coefficient is 10 W/m^2-K. Assuming the atmospheric temperature of 10^0 c, find heat lost from 40 m length of pipe. Neglect the resistance of steel pipe.

6 (a) Define the thermal boundary layer thickness.

(b) A steam pipe 5 cm in diameter is lagged with insulating material of 2.5 cm thick. The surface temperature is 80^0C and emissivity of the insulating material surface is 0.93. Find the total heat loss from 10 m length of pipe considering the heat loss by natural convection and radiation. The temperature of the air surrounding the pipe is 20^0c. Also find the overall heat transfer coefficient and heat transfer coefficient of radiation.

7 (a) Explain Kirchoff's law.

(b) Two large parallel planes with emissivity 0.6 are at 900 K and 300 K. A radiation shield with one side polished with = 0.05 while the emissivity of the other side is 0.4 is proposed to be used. Which side of the shield should face the hotter plane if the temperature of the shield is to keep minimum?

8 (a) Define effectiveness of the heat exchanger.

(b) A single shell and 4-pass counter flow heat exchanger is used as an economizer in a steam power plant. The flue gases, (cp = 1060 j/kg K) enters at 250^0c and leaves at 150^0C with a flow rate of 0.5 kg/s. The feed water enters at 50^0C with a rate of 0.35 kg/s. Determine NTU and $\in$ of the heat exchanger.

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PART- A

1 (a) Define surface tension.
(b) Derive the relationship between surface tension and pressure inside a droplet of liquid in excess of outside pressure.

2 Explain the principle of orifice meter and derive the equation to find the rate of flow of water through a pipe using the same.

3 Explain hydraulic gradient and total energy lines with the help of example and draw sketches.

4 Explain with a neat sketch of Francis turbine in detail.

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PART- B

5 Derive the heat conduction equation in Cartesian coordinate system.

6 (a) Define the velocity boundary layer thickness for flow inside a duct.

(b) Air at 20^0C flows over a plate 60 cm x 30 cm with a velocity of 20 m/s. The critical reynold number is 5 x 10^5. Calculate the heat flow per hour from the surface of plate assuming the flow is parallel to 60 cm side. Temperature of the plate is 100^0 C. The properties of air at mean temperature of 60^0 C are ; = 1.06 kg/m^3(density) C_p = 1008 J/kgK ; K = 0.0285 w/m ; Pr = 0.708 = 18.97 x 10^{-6} m^2/s.

7 (a) Define emissivity and Stefan – Boltzmann constant.

(b) A long cylindrical heater 2.5 cm in diameter is maintained at 660^0C and has surface emissivity of 0.8. The heater is located in a large room whose walls are at 27^0C. How much will the radiant transfer from the heater be reduced if it is surrounded by a 30 cm diameter radiation shield of aluminium having an emissivity of 0.2? What is the temperature of the shield?

8 (a) Define LMTD for counter flow arrangement.

(b) Water enters a counter – flow double pipe heat exchanges at 38^0. Flowing at 0.076 kg/s. It is heated by oil (Cp = 1880 J/kgK) flowing at the rate of 0.152 kg/s and an inlet temperature of 116^0C. For an area of 1.3 m^2 and U = 340 w/m^2K. Determine the total heat transfer rate.

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PART- A

1 (a) Show that the fluid pressure always acts normal to a surface.
(b) Give a complete classification of different types of manometers with neat sketches.

2 (a) Derive Bernoulli's equation from Euler's equation of motion Mention the assumptions.

3 (a) Describe with the help of neat sketches, the variation of drag coefficient for a cylinder over a wide range of Reynolds number.
(b) Find the loss of head when a pipe of diameter 200 mm is suddenly enlarged to a diameter of 400 mm. The rate of flow of water through the pipe is 250 lps.

4 Explain unit and specific quantities with respect to turbines.

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PART- B

5 (a) Explain the Fourier law of heat conduction.

(b) Consider a hallow steel sphere of r_1 = 10 cm and r_2 = 20 cm. The thermal conductivity of steel is 10 w/mK. The inside surface is maintained at 230^0C and the outside surface dissipates heat by convection with h= 20 w/m^2k. Into atmosphere T_∞= 30^0C. Determine the thickness of asbestos insulation (k= 0.5 w/mK) required to reduce the heat loss by 50%.

6 (a) Air flows over a thin plate with a velocity of 2.5 m/s. The plate is 100 cm x 100 cm. Estimate the boundary layer thickness at the trailing edge of the plate and the force necessary to hold the plate. Take properties of air: μ = 0.86 x 10^{-5} NS/m^2, = 1.12 kg/m^3.

(b) A light oil with 20^0C inlet temperature flows at a rate of 500 kg/min through 15 cm ID pipe which is enclosed by a jacket containing condensing stream at 150^0C. If the pipe is 10 m long, find the outlet temperature of the oil. Take properties of oil at 85^0C :
 = 880 kg/m^3; Cp = 2100 J/kg k ; K = 0.12 W/MK = 3.6 x 10^{-6} m^2/s.

7 (a) Consider two large parallel plates, one at 900 K with emissivity 0.8 and the other at 250 Kwith emissivity 0.5. A radiation shield is placed in between these two plates with an emissivity 0.2 on both sides. Calculate the reduction in heat transfer between the plants as a result of radiation shield and also determine the equilibrium temperature of the radiation shield.

8 (a) What are the factors to be considered in the heat exchanger design?

(b) A fluid whose Cp = 800 J/kg k flows through a counter flow heat exchanger at 300^0C with a flow rate of 2.4 kg/s and is heated to 700^0C by passing another fluid (Cp = 960 J/kgk) with a flow rate of 2 kg/s at 1000^0C. If the cooling fluid is to be increased to 800^0C keeping all flow conditions same, find out an increase in heat transfer area.

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