II B.Tech. I Semester Supplementary Examinations, May -2005
THERMODYNAMICS & FLUID MECHANICS
(Common to Mechatronics and Production Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Distinguish between closed and open systems by giving practical examples.
   (b) A computer in a closed room of volume 200m^3 dissipates energy at a rate of 10kW. The room has 50kg wood, 25kg steel and with all material at 300^{0}k; 100kpa. Assume all the mass heats up uniformly, how long will it take to increase the temperature 10^{0}c.

2. Two kg of air at a pressure and temperature of 15 bar and 300^{0}C respectively expands polytropically to 1.5 bar. Find
   (a) Work done
   (b) Final Temperature
   (c) Heat transfer and
   (d) Change in internal energy,
   If the index of the process is 1.25. Also derive the expressions used for work and heat transfer.

3. (a) Explain the need for heat engines and refrigerators considering the limitations of the first law of thermodynamics.
   (b) Two kg of air at 500kPa, 80^0 C expands adiabatically in a closed system until its volume is doubled and its temperature becomes equal to that of the surroundings which is at 100kPa, 5^0 C. For this process, determine
      i. the maximum work, and
      ii. the change in availability.

4. (a) Explain : partial molal properties
   (b) Define chemical potential and express the same in terms of partial molal Helmholtz function.

5. Steam enters the high pressure turbine of a steam power plant which operates on the ideal reheat Rankine cycle at 6MPa and 450^{0}C and leaves as saturated vapor. Steam is then reheated to 400^{0}C before it expands to a pressure of 7.5kPa. Heat is transferred to the steam in the boiler at a rate of 4×10^4kJ/s. Steam is cooled in the condenser by the cooling water from a nearby river, which enters the condenser at 15^{0}C. Show the cycle on a T-s diagram with respect to saturation lines, and determine the pressure at which reheating takes place, the net power output, the thermal efficiency and the minimum mass flow rate of the cooling water required.

6. (a) Why should a mercury column in a thin glass tube be depressed while a water column be lifted up ?

   (b) The barometric pressure at sea level is 760 mm of mercury while on a mountain top it is found to be 735 mm. If the specific weight of air is 11.8 N/ m^3 calculate the height of the mountain.

7. (a) What are the uses and properties of stream tubes ?

   (b) Calculate the unknown velocity components in the following so that the equation of continuity is satisfied .

   i. u = A(x^2 + y^2) , v = ?

   ii. u = ? , v = Axy

8. (a) Differentiate between pressure drag and shear drag What are the factors that influence the total drag on a body.

   (b) A kite 60cm × 60cm weighing 2.943N assumes an angle of 10^0 to the horizontal. The string attached to the kite makes an angle of 45^0 to the horizontal. If the pull on the string is 29.43N when the wind is flowing at a speed of 40km/hr. Find the coefficient of drag and lift. Density of air is given as 1.25 kg/m^3.

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1. (a) Explain thermodynamic system, surroundings and universe, illustrate the same with examples.
   (b) Distinguish between closed system, open system and isolated system with suitable examples.

2. 2 m^3 of hydrogen at a pressure of 1 bar and 20^0C is compressed isentropically to 4 bar. The same gas is expanded isothermally to the original volume. Finally, the gas pressure is restored to the original volume by a constant volume heat rejection process. Determine
   (a) pressure, volume and temperature at each end of operation
   (b) the heat added during the isothermal process
   (c) the heat rejected during constant volume process and
   (d) change in internal energy during each process.
   Assume R = 4.206 kj / kg K & C_p = 14.25 kj / kg K.

3. (a) Prove that Kelvin-planck statement and Clausius statement of Second law of thermodynamics are equivalent.
   (b) Two reversible heat engines A and B are arranged in series with A rejecting heat directly to B through an intermediate reservoir. Engine A receives 200 kJ of heat from a reservoir at 421^0 C, and engine B is in thermal communication with a sink at 4.4^0 C. If the work out put of A is twice that of B find
      i. the intermediate temperature between A and B,
      ii. the efficiency of each engine and
      iii. the heat rejected to the cold sink.

4. (a) Prove that irreversibility is created (entropy generated) whenever heat transfer with finite temperature difference occurs.
   (b) Explain the significance of entropy.

5. Consider a steam power plant which operates on a Rankine cycle and has a net power output of 150MW. Steam enters the high pressure turbine at 10MPa and 500^0C and the low pressure turbine at 1MPa and 500^0C. Steam leaves the consider as a saturated liquid at a pressure of 10kPa. The adiabatic efficiency of the turbine is 80%,and that of the pump is 95%, Show the cycle on a T-s diagram with respect to saturation lines, and determine the quality (or temperature, if superheated) of the steam at the turbine exit, the thermal efficiency of the cycle and the mass flow rate of steam.

6. (a) How does the pressure vary with depth in a static fluid ? Derive the relevant equation.

   (b) A metal plate of size 60 cm × 60 cm and 1 mm thick and weighing 25 N is to be lifted up edgewise with a uniform velocity of 2m/sec. in the gap between two flat surfaces. The plate is in the middle of the gap of width 2mm and the gap contains oil of relative density 0.85 and viscosity 1.6poise. Calculate the vertical force required for this job.

7. (a) The velocity components in a flow field are given by u = 2xy and v = a^2 + x^2- y^2 , show that the flow is possible. Obtain the relevant stream function.

   (b) Verify whether the following functions are valid potential functions

      i. ϕ = A xy ,
      ii. ϕ = m log x ,
      iii. ϕ = A(x^3- y^3) and
      iv. ϕ = A cos x

8. (a) Differentiate between

      i. Stream lines body and bulb body
      ii. Friction drag and pressure drag.

   (b) The air is flowing over a cylinder of diameter 10cm and of infinite length with a velocity of 15 cm/sec. Find the total drag, shear drag, pressure drag on 1m length of the cylinder if the total drag coefficient is 1.5 and shear drag coefficient is 0.25. The density of air is given as 1.25 kg/m^3.

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1. (a) What is thermodynamic equilibrium? Explain the significance of it in quasi-static process?
   (b) Identify the proper type of system in each case and explain the reason for your choice.
      i. Electric generator
      ii. Domestic tea kettle
      iii. Electric fan
      iv. A living human being.

2. One kg of fluid enters a nozzle with a velocity of 300m/min and enthalpy of 2990 kJ/kg. The enthalpy of the fluid at exit is 2760 kJ/kg. The nozzle is placed horizontally and neglects the heat loss from the nozzle. Determine
   (a) The velocity of the fluid at the exit
   (b) The mass flow rate, if the inlet area of the nozzle is 0.095 m^2 and the specific volume at inlet is 0.19m^3/kg.
   (c) The exit area of the nozzle if the specific volume at exit is 0.5 m^3/kg.

3. (a) State the corollaries of II law of thermodynamics.
   (b) A perfect gas(air) is cooled in a cylinder-piston arrangement reversibly at constant pressure from a temperature of 200^0C to 30^0C . Calculate the change of entropy per kg of air.

4. (a) Deduce an expression for the non-flow availability for a system.
   (b) A 2-kg piece of iron is heated from room temperature of 25^0C to 400^0C by a heat source at 600^0C. What is the irreversibility in the process? Assume for iron C_p=0.450kJ/kgK.

5. (a) Derive the expression for the cycle efficiency and mean effective pressure of a dual cycle and draw p-v and T-s diagrams ?
   (b) Discuss the important differences between Diesel cycle and Dual cycle?

6. (a) Define fluid surface tension property . What are its examples?
   (b) The velocity distribution in a viscous flow over a plate is given by u = 4y - y^2 where u is velocity at distance y from the plate. If the coefficient of dynamic viscosity is 1.5 Pa.sec, determine the shear stress at y=0 and at y=2.

7. (a) What is velocity potential function ? What is its use in the fluid flow analysis.

   (b) For the given three dimensional flow field described by
   $V = (x+ y)i + (y+z) j + (x^2 + y^2+ z^2) w$ find the components of rotation at (1,1,1).

8. (a) Explain momentum thickness, energy thickness and displacement thickness.

   (b) Find the frictional drag on one side of the plate 20cm wide and 50cm long placed longitudinally in a steam of crude oil (specific gravity 0.925, kinematic viscosity 0.9 stoke) flowing with undisturbed velocity of 5 m/sec. Also find the thickness of boundary layer and the shear stress of the trailing edge of the plate.

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1. (a) Define and explain the concept of Zeroth law of thermodynamics.
   (b) What are the different scales of temperature? Establish a mathematical relation between the Centigrade scale and the Fahrenheit scale.

2. The rate of heat transfer to the surrounding from a person at rest is about 400kJ/hour. Suppose that the ventilation system fails in a auditorium containing 100 people. Assume energy goes in to the air of volume 1500m^3 initially at 300^{0}K and 101 kpa. Find the rate (degrees per minute) of the air temperature change.

3. (a) State and prove Carnot's theorems.
   (b) A cylinder-piston contains water at 200 kpa, 200^{0}C with a volume of 20 litres. The Piston is moved slowly, compressing the water to a Pressure of 800 kPa. The loading on the Piston is such that PV = C. Assume the room temperature as 20^{0}C and show that this process does not violate the second law of thermodynamics.

4. (a) Explain : "Available energy" and "Availability" and "Irreversibility".
   (b) Define Melmholtz and Gibbs free energy function.

5. (a) Derive the expression for the cycle efficiency and mean effective pressure of a dual cycle and draw p-v and T-s diagrams ?
   (b) Discuss the important differences between Diesel cycle and Dual cycle?

6. (a) What is differential manometer ? Explain how it works?
   (b) Find the pressure in N /m^2 represented by a column of 10 cm of water, 4 cm of oil of relative density 0.89 and 2 cm of mercury of specific gravity 13.6. Specific weight of water is 9810 N / m^3.

7. (a) In a two dimensional flow the fluid velocity components are given by u = x-4y and v= -y-4x. Show that the velocity potential exists and determine its form as well as stream function.
   (b) What does the smoke emitting from a lighted cigarette represent? Stream line or path line or streak line. Why?

8. (a) State the different types of energy of a flowing fluid. Define and give expressions for them.

(b) A pipe carrying water tapers from cross section of $0.3m^2$ at A to $0.14\ m^2$ at B. The average velocity at A is 1.8 m/sec and the pressure 441 kN/m^2 (gauge). If frictional effects are negligible, determine the pressure at B which is 5.5 m above the level of A.

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