Code No: RR211401 **Set No.1**

II B.Tech. I Semester Regular Examinations, November -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) Define and explain the concept of Zeroth law of thermodynamics. [6]
   (b) What are the different scales of temperature? Establish a mathematical relation between the Centigrade scale and the Fahrenheit scale. [4+6]

2. Nitrogen(Cp=1.0kJ/kg^{0}k γ=1.4) expands through a nozzle at a steady flow rate of 1000 kg/hour from 6 bar to 3.5 bar velocity and temperature at inlet to the nozzle are 100m/s and 90^{0}C respectively. Find the exit area of the nozzle. [16]

3. (a) Explain the significance of Clausius inequality [8]
   (b) A cylinder contains 0.5 m^3 of a gas at 0.1 MPa and 90^{0}C,. The gas is compressed to a volume of 0.125 m^3. The final pressure is 600 kPa. Determine the work done and the change in entropy of the gas during the process. Assume R = 0.287 kJ/kgK and C_v = 0.713 kJ/kgK [8]

4. (a) Distinguish between available energy and availability. [8]
   (b) Air at 1 bar and 30^{0}C is heated in a reversible manner at constant pressure until its temperature reaches 205 ^{0}C. How much of the heat added is available energy (per kg of air heated) if the lowest sink temperature is 4^{0}C. Also prove the formula used in this calculation. [8]

5. Dry saturated steam is produced at a pressure of 4.0Mpa. The condenser pressure is 2.5kPa. The power to be delivered is 500MW. Determine for both the Carnot and Rankine cycles rate of steam flow, rate at which heat must be supplied and the cycle efficiency. Neglect the work of the boiler feed pump in the Rankine cycle. [16]

6. (a) What is capillarity ? What are the reasons for its presence? [6]
   (b) The relative density of a fluid is 1.26 and its dynamic viscosity is 1.5 Pascal second. Calculate its specific weight and kinematic viscosity. [10]

7. (a) For a two dimensional potential flow the velocity potential is given by ϕ = 4x (3y-4) . Determine the velocity at point (2,3). Determine also the stream function and its value at a point (2, 3). [8]
   (b) What are the cases of flow where uniform flow, non uniform flow, steady flow and unsteady flow are present. [8]

8. (a) What do you understand by the total drag and resultant force on a body and coefficient of drag and coefficient of lift. [8]

(b) A flat plate 1.5m ×1.5m moves at 50 km/hr in a stationary air of specific weight 1.15 kg /m^3. If the coefficient of drag and lift are 1.15 and 0.75 respectively determine

i. The lift force
ii. Drag force
iii. The resultant force
iv. The power required to keep the plate in motion

[8]

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1. (a) Explain thermodynamic system, surroundings and universe, illustrate the same with examples. [8]
   (b) Distinguish between closed system, open system and isolated system with suitable examples. [8]

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 [16]
   (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) Prove the statement "Of all engines which operate between given two thermal reservoirs the reversible engine possesses the maximum thermal efficiency". [8]
   (b) A heat engine is used to drive a heat pump. The heat transfer from the heat engine and from the heat pump are used to heat the water circulating through the radiators of a building. The efficiency of the het engine is 27% and C.O.P. of the heat pump is 4. Evaluate the ratio of heat transfer to the circulating water to the heat transfer to the heat engine [8]

4. (a) Explain : "Available energy" and "Availability" and "Irreversibility". [9]
   (b) Define Melmholtz and Gibbs free energy function. [7]

5. A Rankine cycle operates between a boiler pressure of 4 Mpa, 300^0C and a condenser pressure of 50 kpa. Determine the thermal efficiency of the cycle, the work ratio and specific steam flow rate? [16]

6. (a) Define bulk modulus of fluids. What is its significance? [8]
   (b) A cylindrical shaft of 90 mm diameter rotates about a vertical axis inside a fixed cylindrical tube of length 50 cm and 95 mm internal diameter. If the space between the tube and the shaft is filled by a lubricant of dynamic viscosity 2 poise, determine the power required to overcome viscous resistance when the shaft is rotated at a speed of 240 rpm. [8]

7. (a) What are the uses and properties of stream tubes ? [6]

(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

[10]

8. (a) Write Bernoulli's equation in the from of energy per unit mass, energy per unit weight and energy per unit volume. Indicate the meaning of each term of the equation and discuss its limitations. Mention some applications of Bernoulli's theorem. [8]

(b) A pipe through which water is flowing is having diameters 40cm and 20cm at the cross sections 1 and 2 respectively. The velocity of water at section 1 is given 5.0m/sec. Find the velocity head at the sections 1 and 2 and also the discharge. [8]

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1. (a) Differentiate between Microscopic and Macroscopic point of view. [6]
   (b) Prove that the difference between specific heat at constant pressure and specific heat at constant volume is gas constant. [6]
   (c) Explain what do you mean by thermal equilibrium. [4]

2. Steam enters a steam condenser with an enthalpy of 2090kJ/kg and velocity of 510 m/s. The condensate leaves the condenser with an enthalpy of 209 kJ/kg and with a velocity of 10m/s. Determine the heat received by the cooling water per kg of steam condensed [16]

3. (a) State and prove Clausius inequality. [7]
   (b) Explain the increase in entropy principle. [3]
   (c) A thermal energy source at 800 K loses 2000 kJ of heat to a sink at [6]
      i. 500 K and
      ii. 750 K.
      Determine which heat transfer process is more irreversible.

4. (a) Derive expression for the Gibbs Function of a mixture of inert ideal gases. [8]
   (b) Show that on a Mollier diagram (h-s diagram) the slope of a constant pressure line increases with temperature in the superheat region. [8]

5. (a) Explain the various methods by which the efficiency of the Rankine cycle can be increased. [8]
   (b) Consider a 300MW steam power plant which operates on a simple ideal Rankine cycle. Steam enters the turbine at 10MPa and 500^0C and is cooled in the condenser at a pressure of 10kPa. Show the cycle on a T-s diagram with respect to saturation lines, and determine the quality of steam at the turbine exit, the turbine efficiency of the cycle and the mass flow rate of the steam. [8]

6. (a) How does the pressure vary with depth in a static fluid ? Derive the relevant equation. [8]
   (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. [8]

7. (a) For steady incompressible flow verify whether the following values of velocity components are possible. [8]
   i. $u = 4xy + y^2$, $v = 6xy + 3x$
   ii. $u = 2x^2 + y^2$, $v = -4xy$
   iii. $u = -x (x+ y)$, $v = -y (x + y)$

   (b) Derive the equation of continuity for one dimensional flow using stream tube. [8]

8. (a) Explain the principle of venturimeter with a neat sketch . Discuss the relative merits and demerits of venturimeter with respect to orifice meter. [8]

   (b) A pipe line carrying oil of specific gravity 0.8 changes in diameter from 300mm at a position A to 500 mm diameter to a position B which is 5 m at higher level. If the pressure at A and B are 19.62 N /cm^2 and 14.91 N/cm^2 respectively and the discharge is 150 lit/sec. Determine the loss of head and direction of flow. [8]

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Code No: RR211401 **Set No.4**

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1. (a) What do you mean by reversible and irreversible processes? Give examples. [4+4+2]
   (b) What do you understand by cyclic and quasi static process? [6]

2. A cylinder closed at both ends contains a free piston, on one side of which is nitrogen and other side air. The initial pressure and volume of each being 1.03 bar and 0.5 m^3 respectively. Both the piston and cylinder are perfectly insulated. In the cylinder on the air side of the piston there is an electric heater which is used to heat the air. Heat is added to the air in this manner until the volume occupied by the nitrogen is 0.3 m^3. The initial temperature of each gas is 50^0C. Determine [16]
   (a) the final temperature of air and
   (b) the heat supplied to air.
   Assume Cp for air as 1.005 and R for air as 0.287 kj / kg K and $\gamma = 1.4$ for nitrogen. Also draw the PV diagram.

3. (a) Explain the significance of Clausius inequality [8]
   (b) A cylinder contains 0.5 m^3 of a gas at 0.1 MPa and 90^0C,. The gas is compressed to a volume of 0.125 m^3. The final pressure is 600 kPa. Determine the work done and the change in entropy of the gas during the process. Assume R = 0.287 kJ/kgK and C_v = 0.713 kJ/kgK [8]

4. (a) Deduce an expression for the non-flow availability for a system. [8]
   (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. [8]

5. The compression ratio of Diesel cycle is 16, the temperature and pressure at the beginning of the compression are 15^0C and 0.1 Mpa respectively. Heat is added until the temperature at the end of the constant pressure process is 1480^0C. Calculate [16]
   (a) the cut off ratio,
   (b) heat supplied per kg of air,
   (c) the cycle efficiency and
   (d) mean effective pressure.

6. (a) Define viscosity. Derive the equation for the viscosity. [8]

(b) The space between two parallel plates kept 3mm apart is filled with an oil of dynamic viscosity 0.2 N- Sec / m^2 . What is the shear stress on the lower fixed plate if the upper one is moved with a velocity of 1.5 m /sec? [8]

7. (a) Show that the stream lines and equipotential lines form a net of mutually perpendicular lines . [8]

(b) For the following velocity vector determine the magnitude of velocity at A (x=2 , y=-3 , z = 1 , t = 2) . Check whether continuity equation is satisfied. V = (10t + xy)i + (- yz -10t)j + (-yz + z^2 /2)k [8]

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

(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. [8]

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