Code No: RR222102 **Set No. 1**

II B.Tech II Semester Supplementary Examinations,
November/December 2005
ENGINEERING THERMODYNAMICS
(Aeronautical Engineering)

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

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain with a neat sketch the working principle of a constant volume gas thermometer.
   (b) Explain the concept of temperature and equality of temperature. [8+8]

2. One kg of gas at pressure $825KN/m^2$ and temperature 327^0C expands to pressure $90KN/m^2$. Until the volume becomes five times the initial volume according to the law pv^n = C. Determine
   (a) the value of index
   (b) Work done
   (c) Heat transferred
   (d) Change in internal energy. [16]

3. (a) Explain the principle of increase in entropy.
   (b) Nitrogen gas at 500 kPa, 400K is contained in a closed piston-cylinder assembly that has an initial volume of $750cm^3$. The nitrogen is heated isothermally and expands until the pressure is reduced to 100 kPa. During this process the work done by the gas amounts to 0.55 kJ. Determine whether the process is reversible or irreversible and calculate the entropy change. [6+10]

4. (a) Using Maxwell's relations deduce the two Tds equations.
   (b) Derive the equation

$$\frac{(\partial V/\partial T)_s}{(\partial V/\partial T)_p} = \frac{1}{\gamma - 1}$$

   [8+8]

5. (a) Determine the specific volume of steam at 200 bar and 400^0C by the following methods
      i. ideal gas equation,
      ii. Van der Walls equation,
      iii. the compressibility factor,
      iv. tabulated value in steam table.

(b) Steam at 9 bar, 300^0C enters a turbine with a velocity of 40 m/s and leaves the turbine at 0.5 bar with a velocity of 180 m/s. Determine the quality of the leaving steam using Mollier diagram and power developed, given the flow rate is 1.5 kg/s. [8+8]

6. Two kg mole of Carbon di oxide at a pressure of 1.8 bar, 80^0C is mixed in a thermally insulated vessel with 3 kg-mole of Nitrogen is at equilibrium, Determine the final temperature and pressure and the change in entropy of the mixture. [16]

7. In an air standard diesel cycle, the compression ratio is 16, and at the beginning of isentropic compression, the temperature is 15^0C and the pressure is 0.1Mpa. Heat is added until the temperature at the end or the constant pressure process is 1480^0C. Calculate

   (a) The cut off ratio.

   (b) The heat supplied per Kg of air

   (c) The cycle efficiency and

   (d) The mean effective pressure. [16]

8. Steam is supplied, dry saturated at 40 bar to a steam turbine. The condenser pressure is 0.035 bar. Calculate for the Ranking cycle for the following.

   (a) The work output neglecting pump work.

   (b) The feed pump work.

   (c) The heat rejected by condenser and the amount of cooling water required through the condenser if the temperature rise of the water is 5.5^0C

   (d) The heat supplied

   (e) The Rankine efficiency. [16]

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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. [6+10]

2. In a vessel 10 kg of oxygen is heated in a reversible, non flow, constant volume process so that the pressure of oxygen is increased two times that of the initial value. The initial temperature is 20^oC. Calculate
   (a) the final temperature,
   (b) the change in internal energy,
   (c) the change in enthalpy and
   (d) the heat transfer. Take R = 0.259 kj / kg K and C_v = 0.652 kj / kg K for oxygen. [16]

3. (a) Explain the significance of Clausius inequality
   (b) A cylinder contains $0.5m^3$ of a gas at 0.1 MPa and 90^0 C,. The gas is compressed to a volume of $0.125m^3$. 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 [6+10]

4. (a) Using Maxwell's relations deduce the two Tds equations.
   (b) Derive the equation

$$\frac{(\partial V/\partial T)_s}{(\partial V/\partial T)_p} = \frac{1}{\gamma - 1}$$

   [8+8]

5. (a) List out the various non - flow processes when the First law of thermodynamics is applied to closed system.
   (b) Derive the relationship between the two principle specific heats and characteristic gas constant for a perfect gas.
   (c) Find the molecular weight and gas constant for the gas whose specific heats are as follows:
   C_p = 1.967KJ/KgK C_v = 1.507 KJ/KgK [6+4+6]

6. (a) An air tank of volume $10m^3$ is at 70kPa and 100^0C. Now water is injected into the tank keeping the temperature at 80^0C. Determine the mass of water required to be injected so that the tank is just filled with saturated vapour.
   (b) If the water injection continues upto 30%more than what is required for saturated vapour calculate the total pressure in the tank. [8+8]

7. (a) Derive an expression for thermal efficiency of Atkinson cycle.
   (b) Find the air standard efficiency of Atkinson cycle if the compression ratio is 5 and pressure at the end of heat reception is 2.5 times that at the beginning. Take adiabatic index as 1.41. [8+8]

8. (a) List out the advantages of vapour refrigeration system over air refrigeration system.
   (b) A Freon-12 installation has the following data:
   Capacity = 15 tons
   Evaporator temperature = -10^0C
   Condenser temperature = 30^0C
   Temperature of the refrigerant super heated as gas in evaporator = -5^0C
   Temperature of the refrigerant sub cooled as liquid is condenser = + 25^0C
   Number of cylinders in compressor = 2
   Bore = 1.5 times stroke
   Speed = 960 rpm
   Determine
      i. Refrigerating effect/kg
      ii. Mass of refrigerant circulating/min.
      iii. Theoretical piston displacement/min
      iv. Coefficient of performance
      v. Theoretical power
      vi. Heat removed in condenser/kg
      vii. Bore and stroke or compressor. [4+12]

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1. (a) Discuss the concept of continuum in thermodynamics.
   (b) What do you mean by property? Distinguish between intensive and extensive Properties.
   (c) Discuss where the following quantities can be used as properties are not.
      i. $\int$ P dV+ $\int$ V dP
      ii. $\int$ P dV
      iii. $\int$ V dP. [4+4+8]

2. In a steady flow apparatus 140kJ of work is done by each kg of fluid. The specific volume of the fluid, pressure and velocity at the inlet are $0.37m^3$/kg, 600 kpa and 16 m/s. The inlet is 32 m above the floor and the discharge pipe is at the floor level. The discharge conditions are $0.62m^3$/kg, 100kpa and 300m/s. The total heat loss between the inlet and discharge is 9kJ per kg of fluid. Find whether specific internal energy increase or decrease. [16]

3. (a) What is absolute temperature scale? Develop this scale from Carnot theorem
   (b) A reversible engine during a cycle of operation interacts with three thermal reservoirs maintained at 200K,300K and 400K. It receives 5 MJ of heat from the reservoir at 400K and produces a net positive work of 840 kJ. Find the amount and direction of heat interaction with other reservoirs. [8+8]

4. Starting from first law and using second law derive the Gibb's equations and hence deduce the Maxwell's relations. [16]

5. Steam at a pressure of $6.8MN/m^2$ and at a temperature of 375^0C is isentropically expanded to a pressure of $1.0MN/m^2$. It is then reheated at constant pressure it has a temperature of 300^0C. It is further isentropically expanded to a pressure of $0.14MN/m^2$. Using steam table, determine
   (a) the condition of steam after both isentropic expansion,
   (b) the heat transfer per kg of steam to carry out the constant pressure process. Sketch the processes on T-s and h-s diagram. [16]

6. (a) An air tank of volume $10m^3$ is at 70kPa and 100^0C. Now water is injected into the tank keeping the temperature at 80^0C. Determine the mass of water required to be injected so that the tank is just filled with saturated vapour.

(b) If the water injection continues upto 30%more than what is required for saturated vapour calculate the total pressure in the tank. [8+8]

7. An air standard duel cycle has a compression ratio of 16, and compression begins at 1 bar, 50^0C. The maximum pressure is 70 bar. The heat transferred to air at constant pressure is equal to that at constant volume. Estimate

   (a) The pressure and temperature at the cardinal points of the cycle.

   (b) The cycle efficiency and

   (c) The mean effective pressure of the cycle. Take $C_v = 0.718$KJ/KgK and $C_p = 1.005$ KJ/KgK. [16]

8. (a) Sketch the Rankine cycle on P-V and T-S diagram and explain clearly different process of the cycle. State in what respect it differs from carnot cycle working between the same temperature limits.

   (b) Dry and saturated steam at pressure 11 bar is supplied to a turbine and expended isentropicelly to a pressure or 0.07 bar. Calculate the following.

      i. Heat supplied
      ii. Total change of entropy
      iii. Heat rejected
      iv. Theoretical thermal efficiency. [8+8]

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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 300^0k; 100kpa. Assume all the mass heats up uniformly, how long will it take to increase the temperature 10^0c. [8+8]

2. (a) Derive an expression for heat transfer in polytropic process.
   (b) A household refrigerator contains fresh food and it is closed one kwh of electric energy is consumed in cooling the food and internal energy of the system decreases by 500kJ as the temperature drops. Find the magnitude and direction of heat transfer for the process. Assume the entire refrigerator and its contents as a system. [8+8]

3. (a) What is absolute temperature scale? Develop this scale from Carnot theorem
   (b) A reversible engine during a cycle of operation interacts with three thermal reservoirs maintained at 200K,300K and 400K. It receives 5 MJ of heat from the reservoir at 400K and produces a net positive work of 840 kJ. Find the amount and direction of heat interaction with other reservoirs. [8+8]

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^oC to 400^oC by a heat source at 600^oC. What is the irreversibility in the process? Assume for iron C_p=0.450kJ/kgK. [6+10]

5. (a) Determine the equation of perfect gas pV = m RT from the kinetic energy of gases where.
   P = absolute pressure of gas in N/m^2
   V = Volume of gas in m^3
   m = mass of gas in Kg
   T = absolute temperature of gas in ^{0}K.
   (b) What is the difference between the Universal Constant and characteristic constant of a gas ? How many times is former bigger than the later?
   (c) Carbon dioxide at 25^0 C and 101.3 KPa has a density of $1.799Kg/m^3$. Determine
      i. The characterstic gas constant for CO_2

ii. The molecular mass of CO_2 based on the gas constant. [6+4+6]

6. (a) Calculate the constant volume and constant pressure specific heats of a gas mixture consisting of 1 kg of Oxygen and 2 kg of nitrogen at a pressure of 1.5 bar and temperature 20^0 C.

   (b) Also determine the change in internal energy, enthalpy and entropy of the mixture when it is heated under constant volume to a temperature of 100^0 C. [8+8]

7. (a) Explain with the help of suitable graphs the variation of the efficiency of the diesel cycle with compression ratio and cut-off ratio.

   (b) In an air standard diesel cycle, the compression ratio is 15.Compression begins at 0.1MPa, 40^0c. the heat added is 1.675 MJ/Kg. Find

   i. The maximum temperature of the cycle.
   ii. The work down per Kg of air.
   iii. The cycle efficiency.
   iv. The temperature at the end of the isentropic expansion.
   v. The cut-off ratio.
   vi. The mean effective pressure of the cycle. [6+10]

8. (a) Sketch the Rankine cycle on P-V and T-S diagram and explain clearly different process of the cycle. State in what respect it differs from carnot cycle working between the same temperature limits.

   (b) Dry and saturated steam at pressure 11 bar is supplied to a turbine and expended isentropicelly to a pressure or 0.07 bar. Calculate the following.

   i. Heat supplied
   ii. Total change of entropy
   iii. Heat rejected
   iv. Theoretical thermal efficiency. [8+8]

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