Code No: A109210305 **R09** **Set No. 2**

II B.Tech I Semester Examinations,November 2010
THERMODYNAMICS
Common to Mechanical Engineering, Aeronautical Engineering, Automobile Engineering

Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Derive an expression for the mean effective pressure of an otto cycle.
   (b) A petrol engine with compression ratio of 5 develops 24 kW indicated power and consumes 8 litres of fuel per hour. The specific gravity of fuel is 0.78 and its calorific value is 45 MJ/kg. Calculate the indicated thermal efficiency and relative efficiency. Take $\gamma = 1.4$. [7+8]

2. (a) Prove the equivalence of Kelvin Planck and Clausius Statements
   (b) Air at 15^0C and 1.05 bar occupies a volume of 0.02 m^3. The air is heated at constant volume until the pressure is 4.2 bar and then cooled at constant pressure back to the original temperature . calculate
      i. The net heat flow to or from the air and
      ii. The net entropy change, sketch the process on T-S diagram. [7+8]

3. (a) Determine the expansion for the heat transfer in a closed system isochoric process?
   (b) A gas turbine receives gases from the combustion chamber at 7.5 bar and 600^0 C, with a velocity of 100 m/s. The gases leave the turbine at 1 bar with a velocity of 45 m/s. Calculate the work done if the expansion is isentropic. Assume $\gamma = 1.333$ and $C_p = 1.11kJ/kg.K$ [7+8]

4. In a Rankine cycle steam turbine, steam enters at 30 bar, 400^0C and exhausts at 0.05 bar. Calculate
   (a) the cycle thermal efficiency, work ratio and steam rate.
   (b) If turbine and pump efficiencies are 0.8 and 0.5 respectively, what is the thermal efficiency?
   (c) If boiler efficiency is 0.8, find the power plant thermal efficiency. [15]

5. (a) State and explain steam Calorimetry.
   (b) The following data were obtained in a test on a combined separating and throttling calorimeter: Pressure of steam sample =12 bar, pressure of steam at exit = 1 bar, temperature of steam at the exit $=150^0$C, discharge form separating calorimeter =0.5 kg/min, discharge from throttling calorimeter =10 kg /min. Determine the dryness fraction of the sample steam. [7+8]

6. A certain quantity of air initially at a pressure of 7 bar and 280^0C has a volume of 0.045 m^3 .It undergoes the following processes in the following sequence in cycle

(a) Expands at constant pressure to 0.1 m^3

(b) Follows polytrophic process with n= 1.4 and

(c) A constant temperature process (which completes) evaluate the following

i. Heat received in cycle

ii. Heat rejected in cycle

iii. Efficiency of cycle. [15]

7. A mixture of ideal gases consists of 3 kg of nitrogen and 6 kg of CO_2 at a pressure of 250 kpa and a temperature of 23^0C. Find

(a) the mole fraction of each constituent

(b) equivalent weight of the mixture

(c) equivalent gas constant of the mixture

(d) partial pressures and partial volumes

(e) volume and density of mixture

(f) C_p and C_v of mixture. If the mixture is heated at constant volume to 60^0C find the internal energy, enthalpy, and entropy of mixture. Find the changes in internal energy, enthalpy, and entropy of mixture if the heating is done at constant pressure. Take γ for $CO_2$and N_2 be 1.286 and 1.4. [15]

8. A fluid is confined in a cylinder by a spring loaded friction less piston so that the pressure in the fluid is a linear function of the volume (p=a + b V). The internal energy of the fluid is given by the following equation U = 32 + 3.15 pV .where U is in kj , p in kpa and V in cubic meter. If the fluid changes from an initial state of 120kpa, 0.025 m^3 to a final state of 300 kpa,0.056 m^3, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer. [15]

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Code No: A109210305 **R09** **Set No. 4**

II B.Tech I Semester Examinations,November 2010
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Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
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1. (a) State and explain avagadro's law. Show that the product of gas constant and molecular mass has the same value for all gases.
   (b) One hundred kg of CO_2 is to be stored in a 0.5 m^3 container at 100^0C. Compare the required pressure using the ideal gas law and the van der waals equation of state. [5+10]

2. (a) Define the first law of thermodynamics and discuss why it is known as the law of conservation of energy.
   (b) Prove that internal energy is a property of a thermodynamic system. [7+8]

3. (a) Prove that Partial pressure fraction = Mole fraction = Volume fraction of a constituent of a mixture of gases.
   (b) 4 kg of CO_2 at 50^0C and 1.4 bar are mixed with 8 kg of nitrogen at 150^0C and 1 bar to form a mixture at a final pressure of 0.7 bar. The process occurs adiabatically in a steady flow apparatus. Calculate
      i. the final temperature of mixture
      ii. change in entropy. [7+8]

4. (a) Derive an expression the air standard thermal efficiency of Dual cycle.
   (b) An air-standard diesel cycle has a compression ratio of 16 and a cut-off ratio of 2. At the beginning of compression the cylinder volume is 0.001415 m^3, the air pressure is 1 bar and the temperature is 49.5^0C. Calculate the thermal efficiency. [7+8]

5. (a) Determine an expression for the work done in a closed isothermal process?
   (b) Gas from a bottle of compressed helium is used to inflate an inelastic flexible balloon, originally folded completely flat to a volume of 0.65 m^3. If the barometer reads 760 mm Hg, what is the amount of work done upon the atmosphere by the balloon? Sketch the system before and after the process. [7+8]

6. A gas turbine plant operates on Brayton cycle between the temperature limits 27^0C and 600^0C
   (a) Determine the pressure ratio at which the cycle efficiency approaches carnot cycle efficiency
   (b) Determine the efficiency at a pressure ratio of 9.5 and compare it with carnot efficiency for the given temperatures. [15]

7. (a) Steam enters a turbine at 700 kPa, 250^0C and exhausts at 15 kPa. The efficiency of the turbine is 0.8. Calculate

   i. the power output per kg of steam, and

   ii. the quality of steam leaving the turbine.

   (b) A closed vessel of 1.5 m^3 capacity contains steam at 3 bar and 0.8 dryness fraction. Steam at 10 bar and 0.9 dryness fraction is supplied until the pressure inside the vessel reaches 5 bar. Calculate the mass of steam in the vessel [7+8]

8. An engine working on Carnot cycle absorbs Q_1 units of heat from a source at T_1 and rejects Q_2 units of heat to a sink at T_2. Te temperature of the working fluid is θ_1 and θ_2, where $\theta_1 < T_1$ and $\theta_2 > T_2$,
   If $\theta_1 = T_1$-KQ_1 and $\theta_2 = T_2$+kQ_2
   where k is constant, then show that efficiency of the engine is given by:
   $\eta = 1 - \frac{T_2}{T_1 - 2kQ_1}$. [15]

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Code No: A109210305 **R09** **Set No. 1**

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Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
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1. (a) Describe Otto gas power cycle with the help of P-V and T-S diagram. Derive an expression for its air standard efficiency.
   (b) The compression ratio in an air standard Otto cycle is 7.5. At the beginning of compression process the pressure is 96 KN/m^2 and temperature is 300 K. The heat added to air per cycle is 1750 KJ/kg of air. Calculate
      i. Thermal efficiency
      ii. The m.e.p of the cycle. [7+8]

2. (a) State Avogadro's hypothesis.
   (b) A gas mixture contains 1 kg of O_2 and 3 kg N_2.The pressure and temperature of the mixture are 1 bar and 27^0C determine
      i. mass fraction and mole fraction of each constituent
      ii. average molecular weight of mixture
      iii. partial pressures of constituents
      iv. specific gas constant
      v. mixture volume
      vi. mixture density. [7+8]

3. (a) State and prove carnot theorem?
   (b) A gas from its initial pressure and volume and mass equal to 650 kN/m^2, 0.6 m^3 and 0.65 kg respectively expands to its environment at and equal to 100 kN/m^2 and 295 K respectively though a reversible process. Calculate specific availability function if the system is a closed one. Take
   C_v = 0.82 kJ/Kg K, R = 0.31 kJ/Kg K. [7+8]

4. A gas turbine operaters on Brayton cycle with intake air at 1.5 bar and 25^0C. The air is compressed to 16 bar and heated in a combustion chamber to 550^0C. The hot air expands in the turbine to 1 bar. Find
   (a) the power developed,
   (b) thermal efficiency of the cycle. Take $\gamma = 1.4$ and $C_p = 1.005$ kJ/kgK. [15]

5. (a) Dry and saturated steam expands isothermally from 20 bar to 2.2 bar in a cylinder. Calculate
      i. change in enthalpy,

ii. change in internal energy,
iii. change in entropy,
iv. heat transferred, and
v. work done. Assume non-flow process

(b) In a cylinder steam expands from 5 bar to 0.75 bar according to hyperbolic law $PV^{1.13} = C$. If steam is initially dry and saturated calculate per kg of steam a)work done b)heat transfer. [8+7]

6. A certain quantity of air initially at a pressure of 8 bar and 280^0C has a volume of 0.035 m^3. It undergoes the following processes in the following sequence in cycle

(a) Expands at constant pressure to 0.1 m^3

(b) Follows polytrophic process with n= 1.4 and

(c) A constant temperature process (which completes the cycle) Evaluate the

i. heat received in cycle
ii. heat rejected in cycle
iii. efficiency of cycle. [15]

7. (a) Show that energy of an isolated system remains unchanged?

(b) A system comprises a stone of mass 20 kg and a drum containing 1000 kg of water. Initially the stone is 50 m above the water and the stone and water are at the same temperature. The stone is then made to fall into water. Determine change in internal energy, kinetic energy, potential energy heat transfer, and work transfer for the changes of state given below?

i. The stone is to just enter water.
ii. The stone just comes to rest in drum, and
iii. The heat transferred to surroundings is such that water and stone remain in the same temperature. Assume g = 9.81 m/s^2. [5+10]

8. (a) Explain the following

i. Concept of continuum
ii. Causes of irreversibility

(b) Air at a pressure of 50 bar and a volume of 0.25 m^3 is expanded at constant pressure until the volume is Doubled. It is then expanded according to $PV^{1.3}$ =constant, until the volume is 0.85 m^3. Calculate the work done in each process. [7+8]

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Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
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1. (a) Prove that change of entropy in irreversible process during which heat transfer takes place and work done is zero is greater than $\frac{\delta Q}{T}$
   (b) A reversible engine with 45% thermal efficiency discharges 1500 kJ/min at 30^0C to a pond. Find the temperature of the source which supplies heat to the engine and power developed by the engine. [7+8]

2. (a) How throttling helps in estimating the dryness fraction of steam.
   (b) A vessel of volume 1 m^3 capacity contains steam at 20 bar and 0.85 dryness fraction Steam is blown off until the pressure drops to 10 bar. The valve is then closed. Determine mass of steam blown off. Assume process as throttling. [8+7]

3. (a) State the methods of improving thermal efficiency of steam power plant working on Rankine vapour cycle and describe them with necessary diagrams.
   (b) Describe an ideal vapour compression refrigeration cycle. [7+8]

4. In an air-standard Brayton cycle, the air enters the compressor at 1 bar and 25^0C. The pressure after compression is 3 bar. The temperature at turbine inlet is 625^0C. Calculate per kg of air
   (a) heat supplied,
   (b) heat rejected,
   (c) work available at the shaft,
   (d) temperature of air leaving the turbine, and
   (e) cycle efficiency. [15]

5. (a) Derive enery equation for a closed system undergoing
      i. Isochoric process
      ii. Isothermal process
      iii. Polytropic process between state 1 to state 2.
   (b) When a closed system executes a certain non- flow process the work and heat Interactions per degree rise in temp. at each temp attained are given by $\frac{dW}{dT} = (4 - 0.08T)\, KJ/K \frac{dQ}{dT} = 1.00KJ/K$ Calculate for the Increase (or) decrease in the Internal energy of the system if it is to operate between the temperature limits of 200^0C and 500^0 C. [7+8]

6. (a) Define mass fraction, mole fraction, volume fraction and partial pressure fraction of a constituent of a mixture of gases.

   (b) A vessel of 0.5 m^3 capacity contains 0.75 g of carbon monoxide (molecular weight =28) and 1 kg of air at 20^0C calculate

      i. partial pressure of each constituent
      ii. total pressure in vessel
      iii. gravametric analysis of air to be taken as 23.3 % oxygen (molecular weight =32)and 76.7% nitrogen (molecular weight =28). [7+8]

7. Two vessels A and B both containing nitrogen are connected by a valve which is opened to allow the contents to mix and achieve the equilibrium temperature of 27^0C. Before mixing the following information is known about the gases in the two vessels

Vessel A	vessel B
p=1.2 Mpa	p=0.6 Mpa
T=60^0C	t=20^0C
Contents = 0.6 kg mol	Contents = 2.4 kg mol

Calculate final equilibrium pressure and the amount of heat transferred to the surroundings .If vessel had been perfectly insulated calculate the final temperature and pressure which would have been reached. [15]

8. A piston and cylinder machine containing a fluid system has a stirring device in the cylinder. The pistons frictionless and it is held down against the fluid due to the atmospheric pressure of 101.325 kpa. The stirring device is turned 12,000 revolutions with an average torque against the fluid of 1.5 Nm. Meanwhile the piston of 0.5 m diameter moves out 0.8 m. Find the net work transfer for the system. [15]

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