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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Third Semester, B.E. - Mechanical Engineering

Semester End Examination; Dec - 2017 / Jan - 2018

Basic Thermodynamics

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer **FIVE** full questions, selecting **ONE** full question from each unit*
ii) Use of Data handbook is Permitted.

UNIT - I

1 a. Distinguish between the following :
i) Open and Closed system ii) Process and Cycle
iii) Path function and Point function. 6

b. What is an ISO thermal process? Derive an expression for work done in an ISO thermal process. 6

c. A cylinder contains 1 kg of fluid at an initial pressure of 20 bar. The fluid is allowed to expand reversibly according to the law PV^2 = constant until the volume is doubled. The fluid is cooled reversibly at constant pressure until the piston regains its original position. Heat is then supplied reversibly with the piston locked firmly in position, until the pressure rises to the original value of 20 bar. Calculate the net work done by the fluid for an initial volume of 0.05 m^3. Sketch the process on P-V diagram. 8

2 a. Define heat and work separately. What are the similarities between heat and work? 6

b. An iron casting of mass 50 kg at 300ºC is cooled by dipping into an oil tub containing 100 kg of oil at 20ºC. The casting is removed from the oil when the cooling has stopped. Find the final temperature of the casing assuming no losses. Take C_p of Iron = 480 J/kg ºK and C_p of oil = 3200 J/ kgºK. 6

c. A spherical balloon has an initial diameter of 25 cm and contains air at 1.2 bar. Because of heating the diameter of the balloon increases to 30 cm and during the heating process, the pressure is found to be proportional to the diameter. Calculate the work done during the process. 8

UNIT - II

3 a. State the first law of thermodynamics for a closed system undergoing a process and hence prove that internal energy is a property of the system. 8

b. Show that enthalpy $h = U+PV$ for a process starting from the first law of thermodynamics expression. 4

c. A system receives 200 kJ of heat at constant volume process and rejects 220 kJ at constant pressure during which 40 kJ of work is done on the system. The system is brought to its original state by adiabatic process. Calculate the adiabatic work, if the initial internal energy is 240 kJ. Calculate the internal energy at all point. Represents the process on P-V diagram. 8

4 a. Define steady flow process. Explain with neat sketch and example. Write steady flow energy equation. 6

b. 2 kg of superheated steam per second is passed through steam turbine whose exit is connected to a condenser. The heat lost from the turbine is 10 kW. The properties of steam at inlet and outlet are given as P_1= 2 MPa, h_1 = 3140 kJ/ kg, C_1 = 50 m/s, P_2 = 0.1 MPa, h_2 = 2680 kJ/kg and C_2 = 200 m/s. Neglecting PE changes determine power output of turbine. 8

c. At the inlet to a certain nozzle, the enthalpy of fluid entering is 3021 kJ/kg and the velocity is 61 m/s. At the exit of the nozzle, the enthalpy of the fluid is 2787 kJ/kg. Assuming that the nozzle is horizontal and adiabatic, find the velocity of fluid at exit. 6

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UNIT - III

5 a. Define pure substance and give two examples for pure substance. 4

b. Draw T-V diagram with relevant details on the plot for pure water. 6

c. A vessel of volume 0.04 m^3 contains a mixture of water and steam in saturated condition at a temperature of 250ºC. The mass of liquid water is 9 kg. Find the pressure, mass, specific volume enthalpy, entropy and internal energy of the mixture system. 10

6 a. What is a throttling process? What are its important applications? 4

b. With the help of a neat sketch, explain the working of combined separating and throttling calorimeter. 8

c. In a test on a combined separating and throttling the following data were obtained. Pressure of steam sample = 15 bar, pressure of steam at exit = 1 bar, temperature of steam at exit 150ºC, water collected from separating calorimeter = 0.2 kg/min and discharge collected at exit = 10 kg/min. Determine the dryness fraction of steam sample. 8

UNIT - IV

7 a. Define two statement of second law of thermodynamics and show that violation of clasius statement violates kelvin plank statement of second law. 10

b. A Carnot engine operates between the two reservoirs at temperature of 627ºC and 27ºC. The engine drives the reversible refrigerator which operates between 27ºC and -23ºC. The heat transfer to the heat engine is 2000 kJ and the net output of the combined system of engine and refrigerator is 200 kJ. Evaluate the net heat transfer from the reservoir at -23ºC to the refrigerator and the net heat transfer to the reserves at 27ºC. 10

8a. Define the heat engine and heat pump. Prove that "All reversible engines working between the same two temperature limits have the same efficiency". 10

b. A reversible engine supplied with two constant temperature sources at 900ºK and 600ºK and rejects heat to a constant temperature sink at 300ºK. If the engine develops 100 kW while rejecting 3600 kJ/min of heat. Determine heat supplied by each source per minute and efficiency of the engine. 10

UNIT - V

9 a. Define entropy and show that entropy is a property of the system. 6

b. What is principle of increase of entropy? Show that entropy of system and surrounding put together always increases. 6

c. In a heat exchanger 45 kg of water / minute is heated from 0ºC to 115ºC by hot gases which enter the heat exchanger at 225ºC. If the flow rate of gas is 90 kg/min. Find the net change of entropy. Take C_p of gas = 1.0 kJ/kg.ºK. Assume no losses. 8

10 a. Starting from $T.ds = du + Pdv$ expression derive an expression for change in entropy for an ideal gas. 6

b. Show that entropy change of a system during an irreversible process is always greater than $\frac{dQ}{T}$ *or* $(S_2 - S_1) > \frac{\delta Q}{T}$ 6

c. A heat engine is supplied with 278 kJ of heat at a constant fixed temperature of 283ºC and heat rejection takes place at 5ºC. Following are the hypothetical heat rejections. Classify whether the cycle is reversible , irreversible and imposable 8

i) 208 kJ/kg of heat rejected ii) 139 kJ/kg of heat rejected iii) 70 kJ/kg of heat rejected.

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