

# CBCS Scheme

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15AE33

## Third Semester B.E. Degree Examination, June/July 2017 Aerothermodynamics

Time: 3 hrs.

Max. Marks: 80

- Note: 1. Answer any FIVE full questions, choosing one full question from each module.  
2. Use of Thermodynamic Data Handbook/Charts/Tables is permitted.**

### Module-1

- 1 a. With suitable sketches/examples distinguish between :  
i) Closed and open systems    ii) path and point functions    iii) Thermal and mechanical equilibrium. (06 Marks)
- b. State zeroth law of thermodynamics and extract the concept of temperature from it. Name any four types of thermometers and their corresponding thermometric property. (05 Marks)
- c. Sir Isaac Newton proposed a temperature scale in 1709. On this scale, temperature was a linear function of Celsius scale. The reading on this at Ice point ( $0^{\circ}\text{C}$ ) and normal human body temperature ( $37^{\circ}\text{C}$ ) were  $0^{\circ}\text{N}$  and  $12^{\circ}\text{N}$  respectively. Obtain the relation between the Newton scale and Celsius scale. (05 Marks)

OR

- 2 a. Derive an expression for : i) Shaft work    ii) Spring work. (05 Marks)
- b. Air in a cylinder at an initial volume of  $0.01\text{m}^3$  and the initial pressure 6MP expands following a quasi-static process given by  $PV^{1.4} = \text{constant}$ . If the final volume of the gas is  $0.025\text{m}^3$ . Determine the work done by gas. (05 Marks)
- c. Show that work is a path function and not a property. (03 Marks)
- d. Write down two similarities and two dissimilarities between heat and work. (03 Marks)

### Module-2

- 3 a. Write the first law of thermodynamics for a closed system undergoing  
i) a cycle    ii) a process. (04 Marks)
- b. A stationary mass of gas is compressed from an initial state of  $0.3\text{m}^3$  and  $0.105\text{MPa}$  to a final state of  $0.15\text{m}^3$  and  $0.105\text{MPa}$ , the pressure remaining constant during the process. There is a transfer of  $37.6\text{kJ}$  of heat from the gas during the process. How much does the internal energy of the gas change? (05 Marks)
- c. A mass of  $0.5\text{kg}$  of pure substance at pressure  $P = 1\text{bar}$  and  $T = 323\text{K}$ , Occupies volume  $V = 0.15\text{m}^3$ . Given internal energy =  $31.5\text{kJ}$ , evaluate specific enthalpy. (04 Marks)
- d. Define specific heat at i) Constant pressure and    ii) Constant volume. (03 Marks)

OR

- 4 a. Write down Steady Flow Energy Equation and explain all the terms involved. (04 Marks)
- b. How do you apply SFEE for : i) Steam Nozzle    ii) Steam turbine? (05 Marks)
- c. A turbine operates under steady flow conditions receiving steam at the following state: pressure  $1.2\text{MPa}$ , temperature  $188^{\circ}\text{C}$ , enthalpy  $2785\text{kJ/kg}$ , velocity  $34\text{m/s}$  and elevation  $3\text{m}$ . The steam leaves the turbine in the following state: pressure  $20\text{KPa}$ , enthalpy  $2512\text{kJ/kg}$ , velocity  $100\text{m/s}$  and elevation  $0\text{m}$ . Heat is lost to the surroundings at the rate of  $0.29\text{kJ/s}$ . If the steam flow rate is  $0.42\text{kg/s}$ . determine the power output from the turbine. (07 Marks)

Module-3

- 5 a. State Kelvin Plank and Clausius statements of second law of thermodynamics and show that they are equivalent. (06 Marks)
- b. Represent schematically and explain: i) heat engine ii) refrigerator. Prove that:  $(COP)_{HP} = (COP)_R + 1$ . (05 Marks)
- c. A reversible refrigerator operates between  $35^\circ\text{C}$  and  $-12^\circ\text{C}$ . If heat rejected to  $35^\circ\text{C}$  is 1.3 kW determine the rate at which heat is leaking into the refrigerator. (05 Marks)

OR

- 6 a. State and prove Clausius inequality. (04 Marks)
- b. Describe the working of Carnot engine and show that  $\eta = 1 - \frac{T_2}{T_1}$ . Represent Carnot cycle in P-V and T-S diagram. (04 Marks)
- c. Define entropy and prove that it is a property of the system. (03 Marks)
- d. For an ideal gas undergoing finite change of state from 1 to 2 derive an expression for change in entropy. (05 Marks)

Module-4

- 7 a. Define the following : i) Pure substance ii) Saturation pressure  
iii) Triple point iv) Critical point. (04 Marks)
- b. Sketch and explain P-T diagram of water. (06 Marks)
- c. Find the enthalpy and entropy of steam when the pressure is 2MPa and the specific volume is  $0.09 \text{ m}^3/\text{kg}$ . (06 Marks)

OR

- 8 a. Derive and explain Maxwell's equations. (08 Marks)
- b. Show that for an ideal gas,  $C_p - C_v = R$ . (04 Marks)
- c. 1 kg of air at a pressure of 8 bar and temperature  $100^\circ\text{C}$  undergoes a reversible polytropic process following the law  $PV^{1.2} = \text{constant}$ . If the final pressure is 1.8 bar determine final specific volume, temperature and increase in entropy. Assume  $R = 0.287 \text{ kJ/kg K}$  and  $\gamma = 1.4$ . (04 Marks)

Module-5

- 9 a. Explain Air standard cycle. (04 Marks)
- b. Explain working of diesel cycle with the help of P-V and T-S diagrams. Derive an expression for the efficiency of diesel cycle in terms of its compression and cut-off ratios. (08 Marks)
- c. A diesel engine has a compression ratio of 14 and cut off takes place at 6% of stroke. Find its Air-standard efficiency. (04 Marks)

OR

- 10 a. Explain Rankine cycle with the help of a sketch and T-S diagram. Derive an expression for thermal efficiency of Rankine cycle. (06 Marks)
- b. Consider a steam power plant operating on a simple Rankine cycle. Steam enters the turbine at 3MPa and  $350^\circ\text{C}$  and is condensed in the condenser at a pressure of 75 KPa. Determine the thermal efficiency of the cycle. (06 Marks)
- c. How can we increase the efficiency of the Rankine cycle? (04 Marks)

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