B.E. CIVIL ENGINEERING SECOND YEAR FIRST SEMESTER – 2018

THERMODYNAMICS & HEAT POWER

Time : Three Hours **Full Marks :100**

Answer any **FIVE** questions.

Use of Steam Tables and Thermodynamic Tables are allowed.

Any unavailable data may be assumed with suitable reasons.

All parts of a question **MUST** be answered together

1. a) Air is contained in a Piston-cylinder arrangement . The initial volume of air inside the cylinder is $0.1m^3$ at which state the pressure inside is 100kPa. A spring attached to the free end of the cylinder is touching the piston at this state but exerts no force on it. Heat is now transferred to the system, causing it to expand compressing the spring until the volume is doubled, at which state the pressure of air in the cylinder is 300kPa. During the process the spring force is proportional to the displacement of the piston from its initial position.

   i) Show the process on a P-V diagram.

   ii) Considering the air inside the cylinder as the system, calculate the work done by the system during the process. What percentage of this work is done against the spring?

   b) Enumerate the similarities and differences between "Work" and "Heat". 15+5=20

2.a) Derive the First Law of Thermodynamics for a Steady-State, Steady-Flow Process with proper assumptions.

   b) Steam at 0.6MPa, 200^0C enters an insulated nozzle with velocity of 50m/s. It leaves at a pressure of 0.15MPa and a velocity of 600m/s. Determine the final temperature if the steam is superheated in the final state, or the quality if it is saturated in the final state. 10+10=20

3.a) State the two statements of the Second Law of Thermodynamics and prove that violation of the Clausius' statement leads to the violation of the Kelvin-Planck statement.

   b) Prove that it is impossible to construct an engine that operates between two given thermal reservoirs and is more efficient than a reversible engine operating between the same two reservoirs. 10+10=20

4.a) Explain the difference between a Heat Pump and a Refrigerator. Which one has a higher COP when operating between the same two Thermal Reservoirs?

b) Helium has the lowest normal boiling point of any of the elements, namely 4.2K. At this temperature helium has an enthalpy of evaporation of 83.3kJ/kmol. A Carnot Refrigeration cycle is to be analyzed for the production of 1 kmol of liquid helium at 4.2K from saturated vapor at the same temperature. What is the work input to the refrigerator and the coefficient of performance of the refrigeration cycle, assuming that the ambient at a temperature of 300k acts as the high temperature thermal reservoir for the refrigerator. 8+12=20

5.a) Show that "Entropy" is a property of a system.

b) Prove the Thermodynamic relations :

$$TdS = dU + PdV$$
$$TdS = dH - VdP$$

Using the above relations, find out the entropy change of an ideal gas with changes in temperature, pressure or volume. 8+12=20

6. a) Enumerate the assumptions of an "Air-Standard Cycle". Derive the expression of thermal efficiency of the Air-Standard Otto Cycle.

b) An Air-Standard Diesel cycle has a compression ratio of 18, and the heat transferred to the working fluid per cycle is 1800kJ/kg. At the beginning of the compression process the pressure is 0.1MPa and the temperature is 15^0C. Determine:

i) The pressure and temperature at each nodal point in the cycle.

ii) The thermal efficiency 10+10=20

7. a) In a Rankine cycle steam leaves the boiler and enters the turbine at 4 MPa, 400^0C. The condenser pressure is 10kPa. Determine the cycle efficiency without considering pump work.

b) Write short notes on the following:

Reversible Process; Triple point of steam 10+10=20