B. TECH. (FTBE) Second Year Second Semester Examination 2023

THERMAL ENGINEERING

Time: Three hours Full Marks: 100

Answer any ***five*** questions.
All parts of the same question must be answered at the same place.
Assume any relevant data if unfurnished.

Q.1

(a) What is total energy? Identify the different forms of energy that constitute the total energy. **4**

(b) In what forms can energy cross the boundaries of a closed system? Explain in brief. **4**

(c) Find an expression for the work done by a system comprising an ideal gas during a polytropic process, given by PV^n = constant, in terms of P_1, V_1, P_2, V_2 *and* n. **6**

(d) A system undergoes a reversible process 1-2 given by the equation P = $100\cdot(V^2+8/V)$ kPa. Determine the work done during the process, if volume changes from 1 to 3 m^3. **6**

Q.2

(a) Write the first law of thermodynamics for the following cases:

(i) a closed system undergoing a change of state.

(ii) a control volume under steady state steady flow process. **6**

(b) Show that for a stationary closed system undergoing an isobaric process, the heat transferred to the system may be expressed in terms of its change of enthalpy. **6**

(c) Superheated steam initially at 100 kPa and 160°C is contained in a piston–cylinder device fitted with stops. The water is allowed to cool at constant pressure until it exists as saturated vapour and the piston rests on the stops. Then the saturated vapour is cooled further until the temperature reaches to 90°C. Sketch, with respect to the saturation lines, the process curves passing through the initial, intermediate, and the final states of the steam on the *T-v* diagram. Label the *T*, *P*, and *v* values for end states on the process curves. Find the dryness fraction and the pressure at the final state. **8**

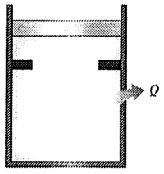

Fig. Q.2 (c)

Q.3

(a) Explain how the dryness fraction of relatively dry steam is measured. **10**

(b)The following observations are obtained from a combined separating and throttling calorimeter:

Pressure in the steam main = 0.8 MPa

Pressure after throttling = 0.1 MPa
Temperature after throttling = 125 ^0C
Mass collected in the separator in 12 minutes = 0.6 kg
Mass collected in the condenser in 12 minutes = 4.0 kg
Determine the dryness fraction of the steam in the main pipeline. **10**

Q.4

(a) What is a fire tube boiler and what is a water tube boiler? What are the functions of boiler mountings? Name two boiler mountings and state their appropriate locations on the boiler. **10**

(b) Draw a neat sketch of a fire tube boiler and label its different parts. **10**

Q.5

(a) Draw the schematic diagram of a simple steam power plant and draw the Rankine cycle on *T-s* diagram. **12**

(b) Find the energy transfer rates across different components of the above plant. Hence find the thermal efficiency of the Rankine cycle. **8**

Q.6

(a) Draw the schematic diagram of a steam power plant with one stage of reheating. Draw the corresponding cycle on *T-s* diagram.
Discuss the utility of reheating. **14**

(b) What is the benefit of using regenerative feed heating in a vapour power plant? Name different types of feed heaters used for regenerative feed heating and their relative advantages and disadvantages. **6**

Q.7

(a) What is the utility of air standard cycle analysis? State the assumptions of air standard cycle analysis. **8**

(b) Derive the expression for the thermal efficiency of a dual combustion air standard cycle in terms of appropriate dimensionless parameters. **12**

Table 1: Properties of saturated steam

T_{sat} (^0C)	P_{sat} (kPa)	v_f (m^3/kg)	v_g (m^3/kg)	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kgK)	S_g (kJ/kgK)
90	70.13	0.0010361	2.3610	376.91	2660.0	1.1905	7.4789
99.62	100	0.0010432	1.6945	417.46	2675.4	1.3026	7.3595
170.44	800	0.0011149	0.2441	721.13	2769.1	2.0462	6.6628

Table 2: Properties of superheated steam (P=100 kPa)

T_{sup} (^0C)	v (m^3/kg)	h (kJ/kg)	u (kJ/kg)
100	1.69	2676	2507.0
150	1.94	2776	2583.0