B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING
SECOND YEAR SECOND SEMESTER EXAMINATION 2025

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) Explain the terms path function and point function. **4**

(b) Illustrate the terms 'extensive and 'intensive' properties. Give examples. **6**

(c) What is a quasi-equilibrium process? Explain how it can be achieved . **8**

(d) What is the difference between gauge pressure and absolute pressure? **2**

Q.2

(a) State the first law of thermodynamics for a closed system undergoing a thermodynamic cycle. Hence, derive the first law for the closed system undergoing a change of state. **10**

(b) List the forms of energy that contribute to the internal energy of a system. **3**

(c) Determine the specific kinetic energy and specific potential energy of a mass which is moving at a uniform velocity of 30 m/s at a constant height of 50 m above a datum level where g = 9.8 m/s^2. **4**

(d) A water jet that leaves a nozzle at 50 m/s at a flow rate of 100 kg/s is to be used to generate power by striking the buckets located on the perimeter of a wheel. Determine the power generation potential of this water jet. **3**

Q.3

(a) What are the different mechanisms for transferring energy to or from a control volume? **6**

(b) Water is being heated in a closed pan on top of a range while being stirred by a paddle wheel. During the process, 30 kJ of heat is transferred to the water, and 5 kJ of heat is lost to the surrounding air. The paddle-wheel work amounts to 500 N$\cdot$ m. Determine the final energy of the system if its initial energy is 12.5 kJ. **4**

(c) Find an expression for the work done by a system during a polytropic process given by PV^n = constant. **5**

(d) Prove that for a stationary closed system undergoing an isobaric process, the heat added to the system is equal to the change in enthalpy of the system. **5**

Q.4

(a) Explain how the dryness fraction of highly wet steam is measured. **12**

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

Pressure in the steam main = 13 bar
Pressure after throttling = 1.25 bar
Temperature after throttling = 140 ^0C

Determine the dryness fraction of the steam in the main pipeline. **8**

Q.5

(a) Draw the following processes for conversion of subcooled water to superheated steam. For each case, draw the saturated liquid and vapour lines and identify the subcooled zone, the saturation zone and the superheated zone:

(i) an isobaric process and (ii) an isothermal process. **6**

(b) 1 m^3 of saturated liquid water at 200°C is expanded isothermally in a closed system until its quality is 80 percent. Determine the total work produced by this expansion, in kJ. Sketch the process on *T-s* plane. **6**

(c) A mass of 5 kg of saturated water vapor at 150 kPa is heated at constant pressure until the temperature reaches 200°C. Calculate the work done by the steam and the heat transferred to the steam during this process. Draw the process on *T-s* plane. 8

Q.6

(a) What is a fire tube boiler and what is a water tube boiler? Which type of boiler is suitable for generating steam at a high pressure? **6**

(b) Draw a neat sketch of a fire tube or a water tube boiler and label its different parts. **14**

Q.7

(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**