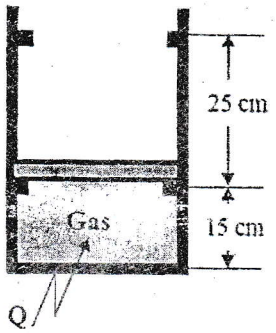
TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Bharda

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE, BME, BGE	Pass Marks	32
Year / Part	I / I	Time	3 hrs.

Subject: - Fundamental of Thermodynamics and Heat Transfer *(ME 402)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. Define a thermodynamic property and thermodynamic state. List two important features of a thermodynamic property. [4]
2. Define work transfer and heat transfer with examples. Also derive a mathematical expression of displacement work for an ideal gas undergoing an adiabatic process. [4]
3. Explain how saturation curve is formed on T-V diagram. [4]
4. Define unsteady state work applications. Derive general mass and energy conservation equations for an open system undergoing a process in which a fluid is being supplied into a piston cylinder device through a valve. [6]
5. Define refrigerator and its COP. Explain how first law and second law of thermodynamics can be applied to analyze the performance of the refrigerator. [6]
6. Derive an expression of thermal efficiency of an ideal Rankine cycle. Sketch P-V and T-S diagrams of the cycle. [6]
7. Define thermal resistance. Write the expression of thermal resistance for plane wall, hollow cylinder and convective layer. Differentiate between free and forced convection with examples. [6]
8. A piston cylinder arrangement as shown in figure below contains gas initially at $P_1=P_{atm}=100kPa$ and $T_1= 20°C$. The cross sectional area of the piston is 0.01 m^2 and has a mass of 50kg and is initially resting on the bottom stops. Heat is added to the system until it touches the upper stops. [6]
   a) Sketch the process on P-V and T-V diagrams.
   b) Determine the total work transfer.



Q/N

9. A rigid container with a volume of 0.2 m^3 is initially filled with steam at 200kPa, 200°C. It is cooled to 100°C. [8]

   a) At what temperature and pressure does a phase change start to occur?
   b) What is the final pressure?
   c) What mass fraction of the water is liquid in the final state?
   d) Sketch the process on P-V and T-V diagrams.

   [Refer attached table for the properties of steam]

10. Air enters the turbine at 1MPa and 327°C with a velocity of 100m/s and exits at 100 kPa and 27°C with low velocity. Heat loss from the turbine surface is 1200kJ/min and power output of the turbine is 240kW. For an inlet area of turbine 800cm^2, determine the velocity and volumetric flow rate of air at turbine exit. [Take R = 287 J/kgK and C_p=1005 J/kgK] [8]

11. Air enters a gas turbine at 1MPa and 1500K and exists at 100kPa. If its isentropic efficiency is 80%, determine the turbine exit temperature. (Take r = 1.4 and C_p = 1005 J/kgK) [8]

12. An ideal Otto cycle has a compression ratio of 8. At the beginning of the compression process, air is at pressure 95kPa and temperature 27°C, and 750 kJ/kg of heat is transferred to air during the heat addition process. Determine:

    (i) pressure and temperature at the end of the heat addition process,
    (ii) the net work output per kg of air and
    (iii)the thermal efficiency of the cycle. [Take R=287J/kgK and Cv = 718 J/kgK] [8]

13. The walls of furnace 4m×3m are constructed from a inner fire brick (k=0.4 W/mK) wall 30cm thick, a layer of ceramic blanket insulation (k = 0.2 W/mK) 10cm thick and steel protective layer (k = 50 W/mK) 4 mm thick. The inside temperature of the fire brick layer was measured as 500°C and the temperature of the outside of the insulation as 50°C. Determine:

    a) The rate of heat loss through the wall.
    b) The temperature at the interface between fire brick layer and insulation layer, and
    c) The temperature at the outside surface of the steel layer. [6]

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