



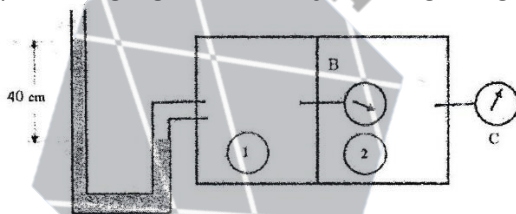
THE ENGINEERING JUNCTION

TRIBHUWAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
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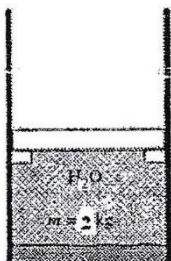
Exam	Back		
Level	BE	Full Marks	80
Program	BCE, BME, BGE	Pass Marks	32
Year / Part	I/I	Time	3 hrs.

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

- ✓ Candidates are required to give their answer 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 thermodynamic process. Sketch P-V, T-V and P-T diagrams for an ideal gas undergoing expansion in the piston-cylinder arrangement without any stops, until the final volume is doubled of the initial volume. [4]
 2. Define work transfer. Derive the expression for heat and work for adiabatic process. [4]
 3. What is an equation of state? Derive an expression for heat and work for adiabatic process. [4]
 4. Write down the statement of first law of thermodynamics for an isolated system. Derive the expressions for mass flow rates at the inlet and outlet of a control volume. [6]
 5. Define isentropic process. Derive isentropic relations for an ideal gas. [6]
 6. Sketch an air standard diesel cycle on P-V and T-S diagrams and derive an expression for its efficiency in terms of compression ratio and cut-off ratio. [6]
 7. Derive an expression with appropriate diagram for conduction heat transfer through a composite cylinder consisting of three layers of different materials. [6]
 8. A large chamber is separated into two compartments which are maintained at different pressures, as shown in figure below. The local barometer reads 740 mm of Hg and pressure gauge B reads 30 kPa vacuum pressures. The U-tube nanometer connected to compartment 1 contains mercury end its reading is 40 mm of Hg. Determine the absolute pressure in each compartment and reading of pressure gauge C. [Take $P_{Hg}=13600\text{kg/m}^3$, $g=9.81\text{m/s}^2$] [6]



9. A piston cylinder device shown in figure below contains 2 kg of water with an initial temperature and volume of 80°C and 0.05m³. It requires a pressure of 400kPa to lift the piston from the stops. The system is heated until its temperature reaches 250°C. Sketch the process on P-v diagram and determine the total work transfer. [8]



10. An ideal gas undergoes a thermodynamic cycle consisting of the following three processes in series. [8]
Process 1-2: constant volume, $V_1 = 0.1 \text{ m}^3$, $P_1 = 100 \text{ kPa}$, $U_2 - U_1 = 150 \text{ kJ}$
Process 2-3: expansion with $PV = \text{constant}$
Process 3-1: constant pressure, $W_{31} = -60 \text{ kJ}$
- Sketch the process on P-V and T-V diagram.
 - Calculate network for the cycle.
 - Calculate net heat for the cycle.
 - Calculate the heat transfer for the process 1-2.
 - Calculate heat transfer for the process 2-3.
 - Calculate the heat transfer for the process 3-1.
 - Is this power cycle or a refrigerator cycle?
11. It is desired to maintain an auditorium hall at 25°C throughout the year. For this it is planned to use a reversible air conditioning unit which can be used as a refrigerator in summer and a heat pump in winter. The outside temperature in summer is 45°C and in winter it falls down to 3°C . The heat loss through walls, roof, windows and doors is estimated as 50 kW . Determine minimum theoretical power required to operate the air conditioning unit in summer and in winter. [8]
12. An ideal Brayton cycle has a pressure ratio of 8. The air temperatures at the compressor and turbine inlets are 300 K and 1300 K respectively. Determine: [8]
- The air temperatures at the exits of the compressor and turbine,
 - The back work ratio, and
 - The thermal efficiency of the cycle.
- [Take $\gamma = 1.4$ and $c_p = 1005 \text{ kJ/kgK}$]
13. The hot combustion gas of a furnace is separated from the ambient air by a brick wall of 4.2 m thick with thermal conductivity of 1.5 W/mK and surface emissivity of 0.85 . Under steady state conditions, an inner surface temperature of brick wall is measured to be 850°C . The ambient air temperature is 20°C and the convection heat transfer coefficient between the surface and air is $20 \text{ W/m}^2\text{K}$. What is the brick outside surface temperature? [$\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$] [4]

