04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Chaitra

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 *(ME402)*

- ✓ 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. Sketch P-V, T-V and P-T diagrams for an ideal gas undergoing [4]
   i) Constant volume cooling process
   ii) Constant temperature heat rejection process
2. Differentiate between heat transfer and work transfer. Derive the mathematical expression for work transfer for an isobaric process. [4]
3. Define pure substance. State two property rules and give examples. [4]
4. Write down general mass conservation and energy conservation equations for a control volume. Also reduce them for a control volume operating under unsteady state condition. [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. [2+4]
6. Differentiate between power cycle and refrigeration cycle. Sketch P-V and T-S diagram for ideal otto and ideal diesel cycles. Also write down the expressions for their efficiencies. [6]
7. Write down the expression for thermal resistance for a hollow cylinder and connective fluid layer. Use them to derive overall heat transfer coefficient for a hallow cylinder subjected to convection of both sides. [6]
8. A piston–cylinder device shown in **Figure P.8** contains 0.05 m^3 of a gas initially at 200 kPa. At this state, a linear spring that has a spring constant of 150 kN/m is touching the piston but exerting no force on it. Now heat is transferred to the gas, causing the piston to rise and to compress the spring until the volume inside the cylinder triples. If the cross-sectional area of the piston is 0.25 m^2, determine the final pressure inside the cylinder. [6]

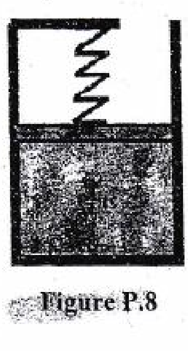

Figure P.8

9. A rigid container with a volume of 0.170 m^3 is initially filled with steam at 200 kPa, 300^{0}C. It is cooled to 90^{0}C. [8]

(a) At what temperature 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? [*Refer the attached tables for the properties of steam*]

10. Nitrogen (5 kg) is contained in a piston cylinder device shown in **Figure P.10** initially at a pressure of 800 kPa and a temperature of 127^0C. There is a heat transfer to the system until the temperature reaches to 527^0C . It takes a pressure of 1500 kPa to lift the piston. Sketch the process on $P - V$ and $T - V$ diagrams and determine the total work and heat transfer in the process. [Take $R = 297\ J/kgK$ and $c_V = 743\ J/kgK$] [8]

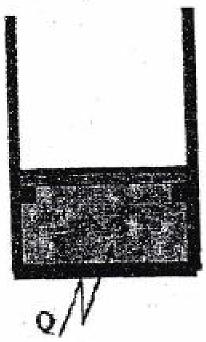

Figure P.10

11. A heat pump having a COP of 5 maintains a building at a temperature of 24°C by supplying heat at a rate of 72000 KJ/h when the surrounding is at 0°C. The heat pump runs 12 hrs in a day and the electricity costs Rs 10/Kwh. [8]

a) Determine the actual and minimum theoretical cost per day.

b) Compare the actual operating cost with the cost of direct electric resistance heating.

12. The pressure and temperature at the end of suction stroke are 100 kPa and 27°C respectively. Maximum temperature during the cycle is 1600°C and the compression ratio is 16. Determine: [8]

i) The percentage of stroke at which cut-off takes place

ii) The temperature at the end of the expansion stroke and

iii) The thermal efficiency [Take $\gamma = 1.4$ and R = 287 J/kg.K]

13. The heat flux at the surface of an electrical heater is 3500 W/m^2. The heater surface temperature is 120°C when it is cooled by air at 50°C. What is the average convective heat transfer coefficient? What will be the heater temperature be if the power is reduced so that heat flux is 2500 W/m^2? [6]

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