04 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

# Examination Control Division

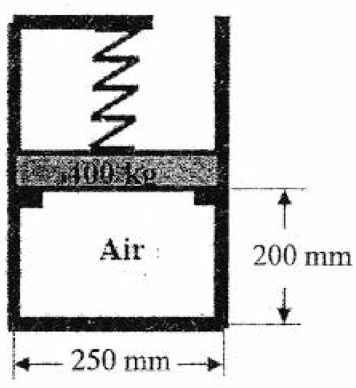
**2074 Chaitra**

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

## *Subject:* - Fundamentals of Thermodynamics and Heat Transfer *(ME402)*

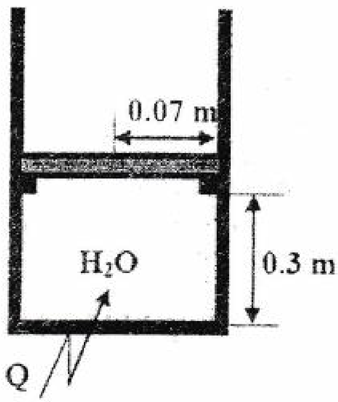
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. State and explain Zeroth law of thermodynamics. Also write down its application. [4]
2. Compare heat and work with suitable examples. Prove that work is a path function. [4]
3. Define pure substance. Explain why quality is necessary to define the state of a two phase mixture. [4]
4. Differentiate between steady state work applications and steady state flow applications. Write down the function of turbine and nozzel. Derive governing equations for them when they operate under steady state condition. [6]
5. State second law of thermodynamics for an isolated system and define entropy generation. Differentiate between reversible and irreversible processes with reference to entropy. [6]
6. Explain the working of simple vapor compression refrigeration cycle with corresponding process in P-h and T-s diagram. [6]
7. Derive an expression for steady state heat transfer through a composite cylinder consisting three different materials. [6]
8. Air (0.01 kg) is contained in a piston cylinder device restrained by a linear spring (k = 500 kN/m) as shown in figure below. Spring initially touches the piston but exerts no force on it. Determine the temperature at which piston leaves the stops when heat is supplied to the system. [Take R = 287J/kg. K, $P_{atm}$ = 100 kPa and g = 9.81 $m/s^2$] [6]

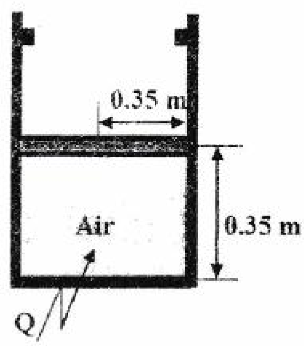


9. A piston cylinder device shown in figure below contains water initially at a pressure of 125 kPa with a quality of 50%. Heat is added to the system until it reaches to a final temperature of 800°C. It takes a pressure of 600 kPa to lift the piston from the stops. Sketch the process on P-V and T-V diagrams and determine: [8]

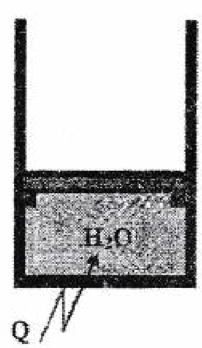
   i) The mass of $H_2O$ in the system and
   ii) The total work transfer




10. A piston cylinder device shown in figure below contains 3.06 kg of air initially at a temperature of 34°C. Heat is supplied to the system until it reached to a final temperature of 950°C and a final pressure of 5 MPa. Sketch the process on P-V and T-V diagrams and determine the total work transfer and total heat transfer. [Take R = 287J/kgK and $c_v$ = 718J/kgK] [8]




11. A piston cylinder device shown in figure below contains 1.5 kg of water initially at 100 kpa with 10% of quality. The mass of the piston is such that a pressure of 400 kpa is required to lift the piston. Heat is added to the system from a source at 500°C until its temperature reaches 400°C. Sketch the process on p-V and T-V diagrams and determine the total entropy generation during the process. [8]




P.T.O

12. The compression ratio of an air standard Otto cycle is 8. At the beginning of the compression process, the pressure and temperature of air are 100 kPa and 20°C respectively. The heat added per kg of air during the cycle is 2000 kJ/kg. Determine: [8]

 i) The pressure and temperature at the end of each process of he cycle
 ii) The thermal efficiency
 iii) The mean effective pressure

 [Take R = 287 J/kg.k and $c_v$ = 718 J/kg.k]

13. A gas turbine blade is modeled as a flat plate. The thermal conductivity of the blade materials is 15W/mK and its thickness is 1.5mm. The upper surface of the blade is exposed to hot gases at 1000°C and the lower surface is cooled by air bled of the compressor. The heat transfer coefficients at the upper and lower surfaces of the blade are 2500W/m$^2$K and 1500 W/m$^2$K respectively. Under steady state conditions, the temperature, at the upper surface of the blade is measured as 850°C, determine the temperature of the coolant air. [6]

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