# THE ENGINEERING JUNCTION

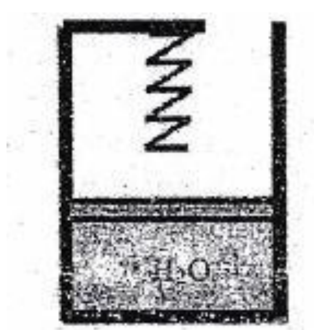
TRIBHUWAN UNIVERSITY
INSTITUTE OF ENGINEERING
**Examination Control Division**
**2071 Chaitra**

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

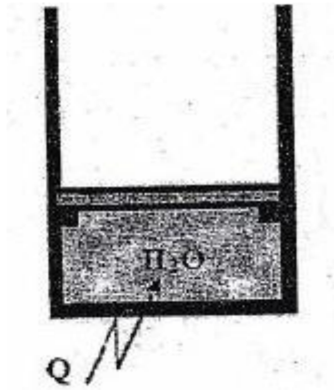
**Subject**: - Fundamentals of Thermodynamics and Heat Transfer (ME 402)

- ✓ 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. State and explain zeroth law of thermodynamics. Write down its application. [4]
2. Differentiate between stored energy and transient energy with examples. [4]
3. Define saturation pressure and saturation temperature. Explain why quality is necessary for a liquid vapor mixture. [4]
4. Derive general mass conservation and energy conservation equations for a control volume. [6]
5. Define entropy and isentropic process. Derive detail mathematical expression for entropy relation for an ideal gas in terms of pressure and temperature. [6]
6. Sketch the Rankine cycle on P-v and T-s diagrams and derive an expression for its efficiency. [6]
7. Derive an expression for overall heat transfer coefficient for composite plane wall consisting of two layers and subjected to convection medium on both sides. [6]
8. At the inlet and exhaust of a turbine the absolute steam pressure are 6000kPa and 4.0 cm of Hg, respectively. Barometric pressure is 65mm of Hg. Calculate the gauge pressure for the steam and the vacuum gauge pressure for the exhaust steam. ($\rho_{Hg}$ = 13600 kg/m$^3$ and g = 9.81 m/s$^2$) [6]
9. A piston cylinder arrangement shown in figure below contains water initially at $P_1$=100kPa, $x_1$=0.8 and $V_1$=0.01 m$^3$. When the system is heated, it encounters a linear spring (k =100kN/m). At this state volume is 0.015m$^3$. The heating continues till its pressure is 200 kPa. If the diameter of the piston is 0.15m, determine: [8]
   a) The final temperature and
   b) The total work transfer.




10. Air enters into a turbine at 2 MPa, 400°C and with a velocity of200 m/s and exits from the turbine at 100 kPa and 100°C with a velocity of 80 m/s. The power output of the turbine is 800 kW when the mass flow rate of air is 4.5 kg/s. Determine the rate of heat loss from the turbine surface, inlet and exit diameters. [8]
    [Take Cp = 1005 J/kg, k and R = 287 J/kg.h]
11. A piston cylinder device shown in figure below contains 1.5 kg of water initially 100 kPa with 10% of quality. The mass of the piston is such that a pressure 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. Determine the total entropy generation during the process. [8]




12. A power plant-operating on an ideal Brayton cycle delivers a power output of 80 MW. The minimum and maximum temperatures during cycle are 300 Kand 1500 K respectively. The pressure at the inlet and exit are 100 kPa and 1400 kPa respectively: [8]
i) Determine the thermal efficiency of the cycle
ii) Determine the power output from the turbine and
iii) What fraction of the turbine power output is required to drive the compressor?
[Take Cp = I 005 J/kgK, y = 1.4)

13. A 40 m long steel pipe (k = 50 W/mK) having an inside diameter 80 mm and outside diameter 120 mm is covered with two layers of insulation. The layer in contact with pipe is 30 mm thick asbestos (k = 0.15 W/mK) and the layer next to it is 20 mm thick magnesia (k = 0.1 W /mK). The heat transfer coefficients for the inside and outside surfaces are 240 $W/m^2K$ and 10 $W/m^2K$ respectively. If the temperature of the steam inside the pipe is 400°C and the ambient air temperature is 25°C. Determine: [6]
i) The inside overall heat transfer coefficient $U_i$,
ii) The outside overall heat transfer coefficient $U_o$,
iii) The heat transfer rate using $U_i$, and
iv) The heat transfer rate using $U_o$

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