TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

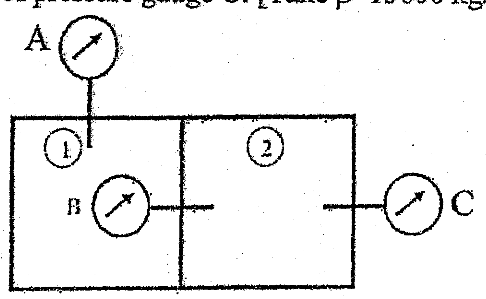
2076 Chaitra

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 *(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. State and explain equality of temperature. [4]
2. Derive a general expression for the displacement work transfer for a piston cylinder device. Also reduce it for an ideal gas undergoing isothermal process. [4]
3. Define quality and write why it is necessary. Derive an expression for specific volume of a two phase mixture in terms of quality. [4]
4. Write the general mass and energy equation for a control volume operating under unsteady state condition. Derive the mass conservation and energy conservation equation for a process in which gas is supplied to piston cylinder device through a valve and it can produce some work by displacing the piston. [6]
5. Define an isentropic process. Also derive isentropic relations for an ideal gas. [6]
6. Sketch an ideal Otto cycle on P-V and T-S diagrams. Also derive an expression for its efficiency in terms of compression ratio. [6]
7. Derive an expression for steady state heat transfer through a composite cylinder consisting of three layers. [6]
8. Three pressure gauges are connected to a container consisting of two compartments as shown in figure below. If the local barometer reads 760mm of Hg and pressure gauges A and B read 250kPa and 150kPa respectively, determine the absolute pressure in each compartment and reading of pressure gauge C. [Take ρ=13600 kg/m^3 and g=9.81m/s^2]. [6]



9. A closed rigid container of volume 0.5m^3 is placed on a plate. Initially the container holds two phase mixture of saturated liquid water and saturated water vapor at initial pressure P_1=100 kPa with a quality of 50%. After heating, the pressure in the container is P_2=150 kPa. Draw the P-V and T-V diagrams of the heating process and determine:
   a) the temperature at each state.
   b) the mass of the vapor present at each state. [8]

   [Refer the attached table for properties of water]

10. An adiabatic diffuser has air entering at 100kPa, 300K with a velocity of 200m/s. The inlet cross sectional area of the diffuser is 100mm^2. At the exit, the area is 860 mm^2 and velocity is 20m/s. Determine the exit temperature and pressure of the air. [Take c_p=1005 J/kgK, R=287 J/kgK] [8]

11. 2 kg of water at 100°C is mixed with 4kg of water at 20°C in an isolated system. Calculate the neat change in entropy due to the mixing process. [Take specific heat of water, c=4.18 kJ/K] [8]

12. Air is used as the working fluid in a simple ideal Brayton cycle that has a pressure ratio of 12, a compressor inlet temperature of 300K, and a turbine inlet temperature of 1000K. Determine the required mass flow rate of air for a net power output of 90MW. Also calculate thermal efficiency of the cycle. [Take c_p=1005 J/kgK, R=287 J/kgK, γ=1.4] [8]

13. An exterior wall of a house consists of 10cm of common brick (K=0.8W/mK) followed by a 4cm layer of gypsum plaster K=0.5 W/mK). What thickness of rock wool insulation (k=0.065 W/mK) should be added to reduce the heat transfer though the wall by 50%? [6]

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<u>Properties of Saturated Water-Pressure Table</u>

P	T	v_l	v_{lg}	v_g	u_l	u_{lg}	u_g	h_l	h_{lg}	h_g	s_l	s_{lg}	s_g
kPa	°C	m³/kg	m³/kg	m³/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K	kJ/kg.K
100	99.632	0.001043	1.6933	1.6943	417.41	2088.3	2505.7	417.51	2257.6	2675.1	1.3027	6.0562	7.3589
101.32	100.00	0.001043	1.6727	1.6737	418.96	2087.1	2506.1	419.06	2256.6	2675.7	1.3069	6.0476	7.3545
125	105.99	0.001048	1.3742	1.3752	444.25	2068.9	2513.2	444.38	2240.7	2685.1	1.3741	5.9100	7.2841
150	111.38	0.001053	1.1584	1.1595	467.02	2052.4	2519.4	467.18	2226.2	2693.4	1.4338	5.7894	7.2232
175	116.07	0.001057	1.0027	1.0038	486.89	2037.8	2524.7	487.08	2213.3	2700.4	1.4851	5.6866	7.1717
200	120.24	0.001060	0.8848	0.8859	504.59	2024.8	2529.4	504.80	2201.7	2706.5	1.5304	5.5968	7.1272

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Examination Control Division
2075 Chaitra

Exam.	Regular / Back		
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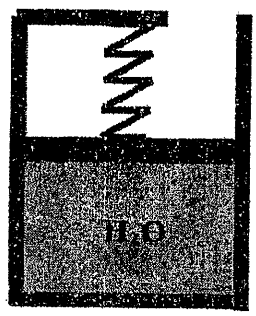
Programme	BCE, BME, BGE	Pass Marks	32
Year / Part	I / I	Time	3 hrs.

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**.*
- ✓ ***Steam tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. State and explain zeroth law of thermodynamics. Write down its application. [4]
2. Derive an expression for displacement of work transfer. [5]
3. Define the term saturation curve for two phase mixture, Quality and moisture content. [6]
4. Derive general energy conservation equation for control volume. [6]
5. Define reversible and irreversible process with reference to entropy. [3]
6. Sketch otto cycle on P-v and T-s diagram. Derive expression for its efficiency to relate to compression ratio. [6]
7. Explain mode of heat transfer with their types and specific differences with them. [6]
8. During operation of a lift, it can be subjected to a maximum gauge pressure of 500 kPa. If it is designed to lift a mass upto 900 kg, what should be diameter of piston-cylinder? [6]
9. A piston cylinder device with a linear spring initially contains water at a pressure of 4 MPa and 500°C with the initial volume being 0.1 m^3, as shown in figure below. If the piston is at the bottom, the system pressure is 300 kPa. The system now cools until the pressure reaches 1000 kPa. Sketch the process on P-v diagram and determine [8]
   a) the mass of H_2O
   b) the final temperature and volume, and
   c) the total work transfer



10. Air expands through an adiabatic turbine from 1100 kPa, 1000 K to 100 kPa, 100 K. The inlet velocity is 10 m/s and exit velocity is 100 m/s. The power output of turbine is 3600 kW. Determine mass flow rate of air and inlet and exit areas. [Take r = 287 J/KgK, C_p = 1005 J/KgK] [8]
11. Steam enters into a turbine at 2 MPa, 400°C with a velocity 200 m/sec and saturated vapour exits from turbine at 100 kPa with velocity 80 m/s. The power output of turbine is 800 kW, when mass flow rate is 1.5 kg/sec. Turbine rejects heat to surrounding at 300K. Determine rate at which entropy is generated within the turbine. [8]
    {h_1 = 3247.5 kJ/kg, s_1 = 7.1269 kJ/kg}
12. An air standard diesel cycle has a compression ratio of 22 and expansion ratio of 11. Determine its cut off ratio and the efficiency. [6]
13. A hollow cylinder with inner and outer diameter of 8 cm and 12 cm respectively has an inner surface temperature of 200°C and the outer surface temperature of 50°C. If the thermal conductivity of the cylinder material is 60 W/mK, determine heat transfer from the unit length of the pipe. Also determine the temperature at the surface at a radial distance of 5 cm from the axis of the cylinder. [8]

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Examination Control Division
2076 Ashwin

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Year / Part	I / I	Time	3 hrs.

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

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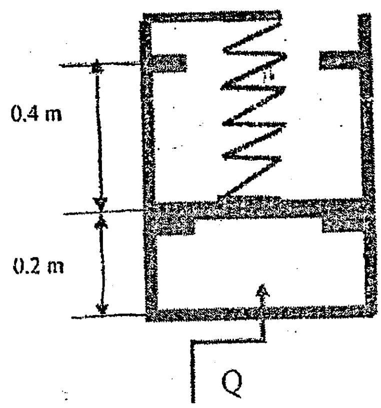
1. Differentiate between the microscopic and macroscopic view point in thermodynamic with examples. [4]
2. Differentiate between the stored energy and transient energy with examples. [4]
3. Define pure substance. Explain how saturation curve is formed on T-v diagram. [6]
4. Write down general energy equation for a heat exchanger, condenser, compressor, evaporator and throttling valve. [6]
5. Derive an expression for control mass formulation of second law of thermodynamics. [7]
6. Sketch the cycle on P-v and T-s diagrams for an ideal Diesel cycle and derive an expression for its efficiency in terms of compression ratio and cut-off ratio. [6]
7. Differentiate between steady state and unsteady state heat transfer. Derive an expression for steady state heat transfer through a composite cylinder consisting of two different materials. [6]
8. A piston cylinder arrangement with two set of stops is restrained by a linear spring (k=12 kN/m) as shown in figure below. The initial pressure of the gas is 500 kPa and the pressure required to lift the piston is 1000 kPa. Cross sectional area of the piston is 0.05 m^2. Heat is supplied to the gas until its pressure reaches 6000 kPa. Sketch the process on P-V diagram and determine the total work transfer. [8]



9. A closed rigid container with a volume of 0.2 m^3, initially contains a mixture of saturated liquid water and saturated water vapour at a pressure of 100 kPa with a quality of 40%. Heat is added to the system until its pressure reaches 200 kPa. sketch the process on P-v and T-v diagram and determine,
   a) The temperature at each state.
   b) The mass of vapour present at each state.
   c) If the heating is continued, determine the pressure at which the container holds only saturated vapour. [7]

10. Steam enters a nozzle operating at steady state with $P_1 = 10$ bar, $T_1 = 400°C$ and velocity of 10 m/s. The steam flows through the horizontal adiabatic nozzle. At the exit, $P_2 = 1.5$ bar and the velocity of 1075 m/s. The mass flow rate is 2 kg/s. Determine the exit area of the nozzle. [6]

11. 4kg of water at 25°C is mixed with 1 kg of ice at 0°C in an isolated system. Calculate the change entropy due to mixing process. [Take latent heat of ice L = 336 kj/kg, specific heat of water C = 4.18 kj/kg.k]. [6]

12. An ideal Brayton cycle has a pressure ratio of 12. The pressure and temperature at the compressor inlet are 100 kPa and 27°C respectively. The maximum temperature during the cycle 1200°C. If the mass flow rate is 8 kg/s, determine the power output and efficiency of the cycle. [Take Cp = 1.005 kj/kg.k, $\gamma = 1.4$] [7]

13. A square plate heater (10 cm × 10 cm) is inserted between two slabs having the same cross sectional areas. The left slab is 100 mm thick (k = 50 W/mK) and the right slab is 50 mm thick (k = 0.25 W/mK). The heat transfer coefficients for left and right slab outer surface are 250 W/m2K and 50 W/m2K respectively. The ambient air temperature is 25°C. If the rating of the heater is 1 kW, determine,
    a) Temperature at the heater surface
    b) Outer surface temperature of each slab [7]

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04 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2075 Ashwin

Exam.	**Back**		
Level	BE	**Full Marks**	80
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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.*
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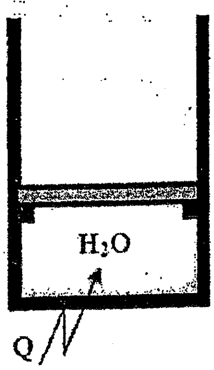
1. Define thermodynamic property. Explain intensive and extensive property with examples. [4]
2. Define polytropic process. Sketch polytropic processes with $n = 0, 1, \gamma$ and ∞ on a common P-V diagram. Derive and enprossion for work transfer for a polytropic process. [4]
3. Derive an expression for the specific volume of a two phase mixture in term of quality. Which takes more energy to vaporize 1 kg of saturated liquid water at 100°C or 120°C? Why? [4]
4. Define a cyclic process. Derive first law of thermodynamics for a control mass undergoing a cyclic process. Also write down the statements for a power cycle and refrigeration cycle. [6]
5. Define heat engine, heat pump and refrigerator. Explain how first and second law are applied to determine performance of heat engine. [6]
6. Explain the working principle of a Brayton cycle. Sketch the cycle on p-v and T-s diagrams and explain the variation of its efficiency with pressure ratio. [6]
7. Derive the overall heat transfer coefficient for composite for plane wall consisting of two layers with convection on both sides. [6]
8. A piston-cylinder device 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 doubles. If the cross-sectional area of the piston is 0.25 m^2, determine: [6]
   i) The final pressure inside the cylinder
   ii) The total work done by the gas
9. A piston cylinder device shown in figure below contain 2 kg of H_2O with an initial temperature and volume of 80°C and 0.05 m^3 respectively. It requires a pressure of 400 kPa to lift the piston from the stops. The system is heated until its temperature reaches 250°C. Sketch the process on P-v and T-v diagrams and determine the total work transfer. [8]



10. Air flows at a rate of 1.2 kg/s through a compressor, entering at 100 kPa, 25°C, with a velocity of 60 m/s and leaving at 500 kPa, 150°C, with a velocity of 120 m/s. Heat lost by the compressor to the surrounding is estimated to be 20 kJ/kg. Calculate the power required to drive the compressor and diameters to inlet and exhaust pipes. [8]
[Take R = 287 J/kgK and c_p = 1005 J/kgK]

11. Five kg of water at 30°C is mixed with 1 Kg of ice at 0°C. Assuming the process of mixing is adiabatic, find the change in entropy. Latent heat of ice = 336kJ/kg, C_p for water = 4.2kJ/kgK. [8]

12. In a Rankine cycle stream leaves the boiler and enters the turbine at 4Mpa, 400°C. The condenser pressure is 10 kPa. Determine the cycle efficiency. [8]

13. A steel pipe having an outer diagram of 4 cm is maintained at a temperature of 80°C in a room where the ambient temperature is 25°C. The emissivity of the surface is 0.8 and the convection heat transfer coefficient between the surface and air is 10 W/m^2K. Determine the total heat loss from the unit length of the pipe. [Take $\sigma = 5.67\times10^{-8}$ w/m^2k^4] [6]

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2074 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
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Year / Part	I / I	Time	3 hrs.

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

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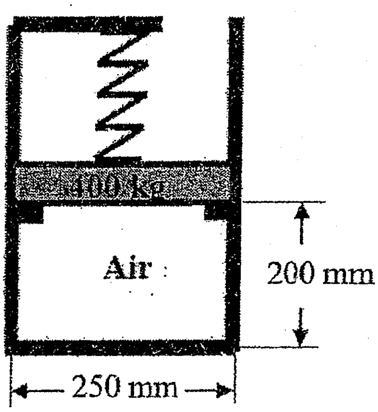
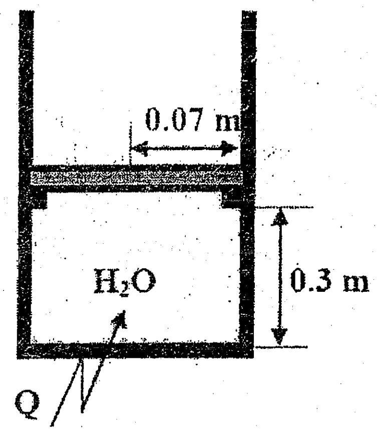
1. State and explain Zeroth law of thermodynamics. Also write down its application. [4]
2. Compare heat and work with suitable examples. Prove that work is a path function. [4]
3. Define pure substance. Explain why quality is necessary to define the state of a two phase mixture. [4]
4. Differentiate 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]

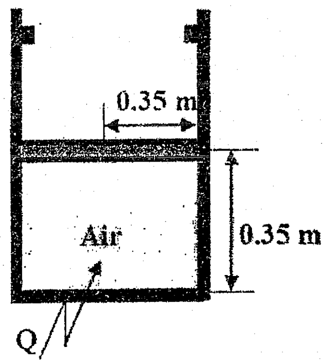


9. A piston cylinder device shown in figure below contains water initially at a pressure of 125 kPa with a quality of 50%. Heat is added to the system until it reaches to a final temperature of 800°C. It takes a pressure of 600 kPa to lift the piston from the stops. Sketch the process on P-V and T-V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

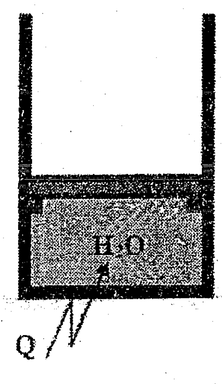
i) The mass of H_2O in the system and
ii) The total work transfer



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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04 TRIBHUVAN UNIVERSITY
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2073 Chaitra

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Year / Part	I / I	Time	3 hrs.

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

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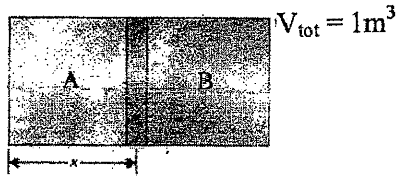
1. Define macroscopic and microscopic viewpoint as applied to the study of thermodynamics. Also list their features. [4]
2. Define stored energy and transient energy. Also list their features. [4]
3. Define quality. Explain why it is necessary to define the state of two phase mixture. Also derive an expression for specific volume of a two-phase mixture. [4]
4. Differentiate between steady state and unsteady state control volume. Derive mass and energy conservation equation for a process in which gas is being supplied to a rigid cylinder. [6]
5. Write down the similarities and differences between heat pump and refrigerator. Explain how first and second laws can be applied to analyze the performance of a heat pump. [6]
6. Sketch ideal Vapour compression refrigeration cycle and explain the processes on P-h and t-s diagram. Also write an expression for theoretical COP of the cycle used as heat pump. [6]
7. Differentiate between free and forced convection with examples. Write down the expressions for thermal resistance for a plane wall, a hollow cylinder and convective layer of fluid. [6]
8. The device shown in figure below has a free moving piston between the two chambers. The initial total volumes of A and B are equal with $vA = 100\ m^3/kg$ and $vB = 50\ m^3/kg$. If the piston is moved so that x is one-fourth of the entire length, determine the final specific volumes of chambers A and B. [6]



9. A piston cyclinder arrangement shown in figure below contains 1 kg of water initially at a pressure of 1 MPa and a temperature of 500°C. The water is cooled until it is completely converted into saturated liquid. It requires a pressure of 400 kPa to support the piston. Sketch the process on P-v and T-v diagrams and determine the total work transfer. (Refer the attached table for the properties of water) [8]

10. Steam at 0.4 MPa and 200°C enters into an adiabatic nozzle with a velocity of 50 m/s and leaves the nozzle at 0.1 MPa and with a velocity of 75 m/s. Determine [8]

a) The exit temperature of the steam.
b) The ratio of inlet diameter to the exit diameter. (Refer the attached table for the properties of steam)

11. Work output of an ideal engine is 4 times the heat rejected by it. Determine its efficiency. If the sink temperature increases by 300°C, its efficiency reduces to 60%. Determine its source and sink temperatures. [8]

12. An air standard Otto cycle has a compression ratio of 10. At the beginning of the compression stroke, the pressure and temperature are 100 kPa and 20°C respectively. The peak temperature during the cycle is 2000 K. Determine,

a) The pressure and temperature at the end of each process of the cycle
b) The thermal efficiency (Take Cv = 718 J/kgk, $\gamma = 1.4$) [8]

13. A thick walled tube of stainless steel (k = 19 W/m°C) with 2 cm inside diameter and 4 cm outer diameter is covered with a 3 cm layer of asbestos insulation (k = 0.2 W/m°C). If the inside and outside wall temperature of the pipe is maintained at 600°C and 100°C. Calculate the heat loss per meter of length. Also calculate the tube-insulation interface temperature. [6]

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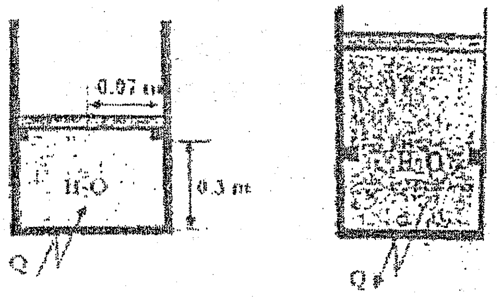
1. Define thermodynamic equilibrium. Explain reversible and irreversible processes with reference nature of intermediate states. [4]
2. Define internal energy, potential energy, kinetic energy and total energy of a thermodynamic system. Also differentiate between microscopic potential energy and macroscopic potential energy. [4]
3. Define saturation pressure, saturation temperature and critical point. Write down the effect of pressure on
   a) Specific volume of a saturated liquid (V_f)
   b) Specific volume of a saturated vapor (V_g)
   c) Change in specific volume due to evaporation (V_{lg}) [4]
4. State and explain conservation of energy for a control volume. [6]
5. Differentiate between thermal and mechanical irreversibilities. Explain why most of the real processes are irreversible. Also explain how they can be assumed to be reversible. [6]
6. Explain with the help of neat diagrams the various processes of any Rankine cycle and derive an expression for its efficiency. [6]
7. Derive an expression with appropriate diagram for conduction heat transfer through a composite cylinder tube consisting of three layers of different materials. [6]
8. A piston cylinder has a diameter of 0.1 m. With an outside atmospheric pressure of 100 kPa, determine the piston mass that will create an inside pressure of 500 kPa. What would be the new pressure if the piston mass is halves. [Take $g = 9.81\ m/s^2$] [6]
9. Steam is contained in a closed rigid container. Initially, the pressure and temperature of the steam are 1500 kPa and 250°C, respectively. The temperature drops as a result of heat transfer to the surroundings. Determine the pressure at which condensation first occurs and the fraction of the total mass that gas been condensed when the temperature reaches 100°C. What percentage of the volume is occupied by saturated liquid at the final state? [8]
10. A piston cylinder devices shown in figure below contains water initially at 105°C with quality 10%. Heat is added to the system until it becomes saturated vapor. It takes pressure of 1000 kPa to lift the piston from the stops. Sketch the P-v, T-v diagram and determine: [8]
    a) The mass of water in system
    b) The total work transfer

c) The total heat transfer *[Refer the attached table for properties of water]*



11. 2 kg water at 100°C is mixed with 4 kg of water at 20°C in an isolated system. Calculate the net change in entropy due to the mixing process. [Take specific heat of water c = 4.18 kJ/K] [8]

12. An ideal Brayton cycle has pressure ratio of 10. The temperature of air at compressor and turbine inlets are 300K and 1200K respectively. Determine its thermal efficiency and mass flow rate of air required to produce net power output of 80MW. [Take Cp = 1005 J/Kg.K, $\gamma = 1.4$] [8]

13. A 200 mm diameter 50 m long pipe carrying steam is covered with 40 mm thick of high temperature insulation (k = 0.1 W/m) and 30 mm thick of low temperature insulation (k = 0.05 W/m). The inner and outer surfaces of the insulating layer are at 400°C and 40°C respectively. Determine:

a) The rate of heat loss from the pipe,
b) The temperature at the interface of two insulating layer. [6]

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04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Shrawan

Exam.	New Back (2066 & Later Batch)		
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. Define thermodynamic property. Differentiate between state function and path function with examples. [4]
2. Define total energy. Differentiate between stored energy and transient energy with examples. [4]
3. Define quality and write why it is necessary. Sketch saturation curve on P-V diagram and also show constant quality lines. [4]
4. Differentiate between steady state work application and unsteady state flow applications. Derive mass conservation and energy conservation equations for a process in which gas contained in a rigid cylinder is being consumed during cooking. [6]
5. Define Entropy. Derive an expression for change in Entropy for reversible heat transfer and reversible work transfer process. [6]
6. Differentiate between gas and vapor cycles. Sketch P-V and T-S diagrams and layout for Brayton and Rankine cycle. [6]
7. Write down expressions for thermal resistance for a plane wall and a convective fluid layer. Use them to derive overall heat transfer coefficient for a plane subjected convection on both sides. [6]
8. An oxygen cylinder having a volume of 10 m^3 initially contains 5 kg of oxygen. Determine the specific volume of oxygen in the cylinder initially. During certain process 3 kg of oxygen is consumed. Determine the final specific volume of oxygen in the cylinder. Also sketch the amount of oxygen that has been consumed versus the specific volume of the remaining in the cylinder. [6]
9. A piston cylinder device shown in **Figure P.9** contains 2 kg of water initially at a pressure of 500 kPa with a quality of 20 %. The water is heated until it becomes a saturated vapor. The volume of the system when the piston is at the upper stops is 0.4 m^3. Sketch the process on P-v and T-v diagrams and determine: [8]
   (a) the final pressure, and
   (b) the total work transfer. [*Refer the attached tables for the properties of steam*]

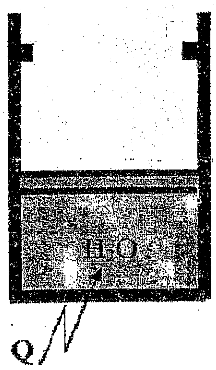

Figure P.9

10. Air enters a nozzle steadily at 300 kPa, 127^0C and with a velocity of 40 m/s and leaves at 100 kPa and with a velocity of 300 m/s. The heat loss from the nozzle surface is 20 kJ/kg of the air. The inlet area of the nozzle is 100 cm^2. Determine: [8]
(a) the exit temperature of the air, and
(b) the exit area of the nozzle. [Take $R = 287\ J/kgK$ and $c_p = 1005\ J/kgK$]

11. A carnot engine operates between two reservoirs at temperature TL and TH. The work output of the engine is 0.6 times the heat rejected. The difference in temperature between the sources and the sink is 200°C. Calculate the thermal efficiency, source temperature and the sink temperature. [8]

12. An ideal gas turbine cycle has a pressure ratio of 10. The minimum and maximum temperatures are 300 K and 1500 K respectively. Determine: [8]

i) The net work per kg of air
ii) The thermal efficiency of the cycle and
iii) Compare both of these for a cycle with ideal compressor and turbine.

[Take $\gamma = 1.4$ and cp = 1005 J/kg.k]

13. A steel pipe having an outside diameter of 2 cm is to be covered with two layers of insulation, each having a thickness of 1 cm. The average conductivity of one material is 5 times that of the other. Assuming that the inner and outer surface temperature of the composite insulation are fixed, calculate by what percentage the heat transfer will be reduced when the better insulating material is nearer to the pipe than it is away from the pipe. [6]

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TABLE 1 Properties of SATURATED WATER – Pressure Table

P kPa	T ^0C	v_l m^3/kg	v_{lg} m^3/kg	v_g m^3/kg	u_l kJ/kg	u_{lg} kJ/kg	u_g kJ/kg	h_l kJ/kg	h_{lg} kJ/kg	h_g kJ/kg	s_l kJ/kg.K	s_{lg} kJ/kg.K	s_g kJ/kg.K
400	143.64	0.001084	0.4614	0.4625	604.47	1949.0	2553.5	604.91	2133.6	2738.5	1.7770	5.1191	6.8961
425	145.84	0.001086	0.4357	0.4368	613.91	1941.7	2555.6	614.37	2126.9	2741.3	1.7996	5.0762	6.8758
450	147.94	0.001088	0.4129	0.4140	622.93	1934.7	2557.6	623.42	2120.5	2743.9	1.8211	5.0356	6.8567
475	149.94	0.001090	0.3923	0.3934	631.56	1927.8	2559.4	632.07	2114.2	2746.3	1.8415	4.9971	6.8386
500	151.87	0.001093	0.3738	0.3749	639.84	1921.4	2561.2	640.38	2108.2	2748.6	1.8610	4.9604	6.8214
550	155.49	0.001097	0.3415	0.3426	655.48	1908.9	2564.4	656.08	2096.8	2752.9	1.8977	4.8917	6.7894
600	158.86	0.001101	0.3145	0.3156	670.05	1897.3	2567.3	670.71	2086.0	2756.7	1.9315	4.8286	6.7601
650	162.02	0.001104	0.2915	0.2926	683.71	1886.2	2569.9	684.42	2075.8	2760.2	1.9631	4.7699	6.7330
700	164.98	0.001108	0.2717	0.2728	696.58	1875.8	2572.4	697.35	2066.0	2763.3	1.9925	4.7154	6.7079
750	167.79	0.001111	0.2544	0.2555	708.76	1865.8	2574.6	709.59	2056.6	2766.2	2.0203	4.6642	6.6845
800	170.44	0.001115	0.2393	0.2404	720.33	1856.3	2576.6	721.23	2047.7	2768.9	2.0464	4.6161	6.6625
850	172.97	0.001118	0.2258	0.2269	731.37	1847.1	2578.5	732.32	2039.1	2771.4	2.0712	4.5706	6.6418
900	175.39	0.001121	0.2138	0.2149	741.92	1838.3	2580.2	742.93	2030.7	2773.6	2.0948	4.5274	6.6222
950	177.70	0.001124	0.2030	0.2041	752.03	1829.8	2581.8	753.10	2022.6	2775.7	2.1173	4.4863	6.6036
1000	179.92	0.001127	0.1933	0.1944	761.75	1821.6	2583.3	762.88	2014.8	2777.7	2.1388	4.4471	6.5859
1100	184.10	0.001133	0.1764	0.1775	780.14	1805.9	2586.0	781.38	1999.8	2781.2	2.1793	4.3736	6.5529

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]

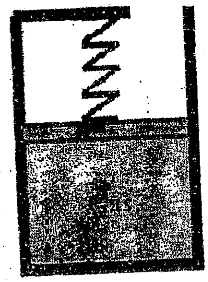

Figure P.8

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]

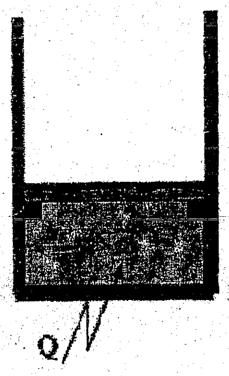

Figure P.10

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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04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Kartik

Exam.	New Back (2066 & Later Batch)		
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. Explain different types of thermodynamic systems with examples. [4]
2. Differentiate between heat transfer and work transfer. Derive the mathematical expression for work transfer for an ideal gas undergoing isothermal process. [4]
3. Define quality and moisture content. Derive an expression for specific volume of a two phase mixture in terms of quality. [4]
4. Differentiate between steady state work applications and steady state flow applications with examples. Also write the functions and governing equations for an adiabatic turbine and adiabatic nozzle. [6]
5. Define heat engine and heat pump. Explain how first law and second law of thermodynamics can be applied to analyze the performance of a heat pump. [6]
6. Sketch an ideal otto cycle on P-v and T-s diagram. Derive the expression for compression ratio interms of cylinder dimension. [6]
7. Derive an expression for overall heat transfer coefficient for a hollow cylinder subjected to convection medium on both sides. [6]
8. Three pressure gauges are connected to a container consisting of two compartments as shown in figure below. If the local barometer reads 760 mm of Hg and pressure gauges A and B read 250 kPa and 150 kPa respectively. Determine the absolute pressure in each compartment and reading of pressure gauge C. [Take ρ_{Hg} = 13600 kg/m^3 and g = 9.81 m/s^2] [6]

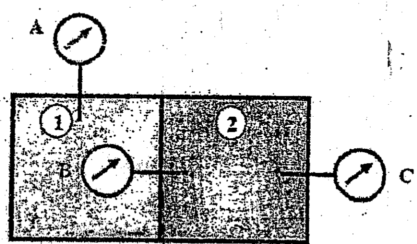

Figure P1

9. A rigid vessel having a volume of 0.4 m^3 contains 2.0 kg of liquid water and water vapor mixture in equilibrium at a pressure of 250 kPa. Calculate: [8]
   i) The volume and mass of liquid
   ii) The volume and mass of vapour
   iii) Temperature
   iv) Enthalpy
   v) If it is heated until its pressure reached to 350 kPa, what will be its quality?

[Refer the attached table for properties of water]

10. Air enters a compressor operating at steady state at 100 kPa, 300 K and leaves at 1000 kPa, 400 K. The volumetric flow rate of air at the exit is 1.5 m^3/min. The work consumed by the compressor is 250 kJ per kg of air. Neglecting the effects of potential and kinetic energy, determine the heat transfer rate, in kW. [Take R = 287 J/kgK and C_p = 1005 J/kgK] [8]

11. A heat pump heats a house in the winter and then reverses to cool it in the summer. The room temperature should be 22°C in the winter and 26°C in the summer. Heat transfer through the walls and ceilings is estimated to be 3000 kJ/h per degree temperature difference between the inside and outside. [8]

    i) Determine the power required to run it in the winter which when the outside temperature decrease to 0°C.
    ii) If the unit is run by the same power as calculate in (i) throughout the year, determine the maximum outside summer temperature for which the house can be maintained at 26°C

12. Air enters the compressor of an ideal Brayton cycle at 100 kPa, 290 K with a volumetric flow rate of 4 m^3/s. The pressure ratio for cycle is 10 and the maximum temperature during the cycle is 1500 K. Determine: [8]

    i) The thermal efficiency of the cycle
    ii) The fraction of work output that is consumed by the compressor and
    iii) The net power output

    [Take Cp = 1005 J/kg.K, γ = 1.4]

13. A 2 m long steel plate (k = 50 W/mK) is well insulated on its sides, while its left section is maintained at 120°C and the right section is exposed to ambient air at 40°C. Under steady state conditions, a thermocouple inserted at the middle of the plate gives a temperature of 100°C. Determine the value of convection heat transfer coefficient for convection heat transfer between the right section of the plate and air. [6]

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Properties of SATURATED WATER – Pressure Table

P* kPa	T °C	v_f m^3/kg	v_{fg} m^3/kg	v_g m^3/kg	u_f kJ/kg	u_{fg} kJ/kg	u_g kJ/kg	h_f kJ/kg	h_{fg} kJ/kg	h_g kJ/kg	s_f kJ/kg.K	s_{fg} kJ/kg.K	s_g kJ/kg.K
25	64.980	0.001020	6.2038	6.2048	271.97	2190.3	2462.3	271.99	2345.4	2617.4	0.8933	6.9365	7.8298
30	69.114	0.001022	5.2288	5.2298	289.27	2178.4	2467.7	289.30	2335.3	2624.6	0.9441	6.8231	7.7672
35	72.700	0.001024	4.5252	4.5262	304.28	2168.0	2472.3	304.32	2326.4	2630.7	0.9878	6.7266	7.7144
40	75.877	0.001026	3.9930	3.9940	317.59	2158.8	2476.4	317.64	2318.5	2636.1	1.0261	6.6427	7.6688
45	78.736	0.001028	3.5759	3.5769	329.58	2150.4	2480.0	329.62	2311.3	2640.9	1.0603	6.5684	7.6287
50	81.339	0.001030	3.2398	3.2408	340.49	2142.8	2483.3	340.54	2304.8	2645.3	1.0912	6.5016	7.5928
60	85.949	0.001033	2.7314	2.7324	359.84	2129.2	2489.0	359.90	2293.1	2653.0	1.1454	6.3856	7.5310
70	89.956	0.001036	2.3644	2.3654	376.68	2117.3	2494.0	376.75	2282.9	2659.6	1.1920	6.2869	7.4789
80	93.511	0.001038	2.0866	2.0876	391.63	2106.7	2498.3	391.71	2273.6	2665.3	1.2330	6.2009	7.4339
90	96.713	0.001041	1.8688	1.8698	405.11	2097.1	2502.2	405.20	2265.3	2670.5	1.2696	6.1247	7.3943
100	99.632	0.001043	1.6933	1.6943	417.41	2088.3	2505.7	417.51	2257.6	2675.1	1.3027	6.0562	7.3589
101.32	100.00	0.001043	1.6727	1.6737	418.96	2087.1	2506.1	419.06	2256.6	2675.7	1.3069	6.0476	7.3545
125	105.99	0.001048	1.3742	1.3752	444.25	2068.9	2513.2	444.38	2240.7	2685.1	1.3741	5.9100	7.2841
150	111.38	0.001053	1.1584	1.1595	467.02	2052.4	2519.4	467.18	2226.2	2693.4	1.4338	5.7894	7.2232
175	116.07	0.001057	1.0027	1.0038	486.89	2037.8	2524.7	487.08	2213.3	2700.4	1.4851	5.6866	7.1717
200	120.24	0.001060	0.8848	0.8859	504.59	2024.8	2529.4	504.80	2201.7	2706.5	1.5304	5.5968	7.1272
225	124.01	0.001064	0.7923	0.7934	520.59	2012.9	2533.5	520.83	2191.2	2712.0	1.5708	5.5172	7.0880
250	127.44	0.001067	0.7177	0.7188	535.22	2001.9	2537.1	535.49	2181.3	2716.8	1.6075	5.4454	7.0529
275	130.61	0.001070	0.6563	0.6574	548.73	1991.8	2540.5	549.02	2172.3	2721.3	1.6411	5.3800	7.0211
300	133.56	0.001073	0.6048	0.6059	561.29	1982.2	2543.5	561.61	2163.7	2725.3	1.6721	5.3200	6.9921
325	136.31	0.001076	0.5609	0.5620	573.04	1973.3	2546.3	573.39	2155.6	2729.0	1.7009	5.2645	6.9654
350	138.89	0.001079	0.5232	0.5243	584.10	1964.8	2548.9	584.48	2147.9	2732.4	1.7278	5.2129	6.9407
375	141.33	0.001081	0.4903	0.4914	594.56	1956.7	2551.3	594.96	2140.6	2735.6	1.7531	5.1646	6.9177

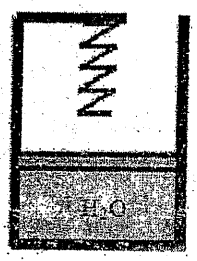
04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Chaitra

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)*

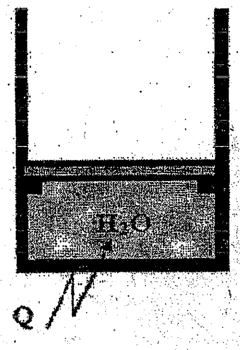
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. State and explain zeroth law of thermodynamics. 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 Rankines cycle on p-v and T-s diagrams and derive an expression for its efficiency. [6]
7. Derive the expression for overall heat transfer coefficient for composite plane wall consisting of two layers and subjected convective medium on both sides. [6]
8. At the inlet and exhaust of a turbine the absolute steam pressure are 6000 kPa and 4.0 cm of Hg, respectively. Barometric pressure is 75 cm of Hg. Calculate the guage pressure for the entering steam and the vacuum gauge pressure for the exhaust steam. (ρ_{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 = 100 kPa, x_1 = 0.8 and V_1 = 0.01 m^3. When the system is heated, it encounters a linear spring (k = 100 kN/m). At this state volume is 0.015 m^3. The heating continues till its pressure is 200 kPa. If the diameter of the piston is 0.15 m, 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 of 200 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. [Take Cp = 1005 J/kg, k and R = 287 J/kg.h] [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. 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 K and 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 = 1005 J/kg.k, γ = 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^{2}K and 10 W/m^{2}K 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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04 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2071 Chaitra

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

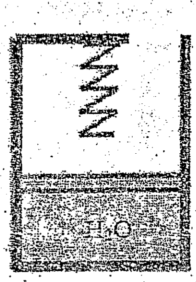
Subject: - Fundamentals of Thermodynamics and Heat Transfer *(ME402)*

- ✓ 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. 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 vopor 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 Rankines cycle on p-v and T-s diagrams and derive an expression for its efficiency. [6]
7. Derive the expression for overall heat transfer coefficient for composite plane wall consisting of two layers and subjected convective medium on both sides. [6]
8. At the inlet and exhaust of a turbine the absolute steam pressure are 6000 kPa and 4.0 cm of Hg, respectively. Barometric pressure is 75 cm of Hg. Calculate the guage pressure for the entering steam and the vacuum gauge pressure for the exhaust steam. (ρ_{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 = 100 kPa, x_1 = 0.8 and V_1 = 0.01 m^3. When the system is heated, it encounters a linear spring (k = 100 kN/m). At this state volume is 0.015 m^3. The heating continues till its pressure is 200 kPa. If the diameter of the piston is 0.15 m, determine: [8]

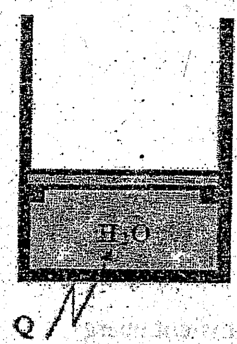
   a) The final temperature and

   b) The total work transfer



10. Air enters into a turbine at 2 MPa, 400°C and with a velocity of 200 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. [Take Cp = 1005 J/kg, k and R = 287 J/kg.h] [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. 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 K and 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 C_p = 1005 J/kg.k, γ = 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^{2}K and 10 W/m^{2}K 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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04 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

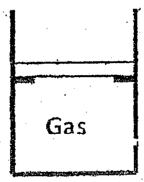
2071 Shawan

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE, BME, BGE	Pass Marks	32
Year / Part	I / I	Time	3 hrs.

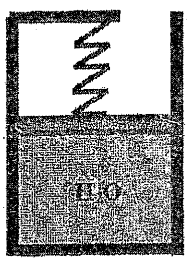
Subject: - Fundamental of Thermodynamics and Heat Transfer *(ME402)*

- ✓ 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 figures are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. Differentiate between the microscopic and macroscopic view point in thermodynamics with example. [4]
2. Define energy and power. Differentiate between stored and transient energy with examples. [4]
3. Define moisture content and critical point. Derive an expression for specific volume of a two phase (liquid and vapor) mixture in terms of quality. [4]
4. Differentiate between steady state work application and steady state flow application. Write down mass and energy conservation equation of steady state process. Reduce them for a nozzle and a condenser. [6]
5. Explain entropy. Derive the relations for entropy for an ideal gas and an incompressible substance. [6]
6. Sketch Rankine cycle on P-v and T-s diagram using dry saturated stream and obtain an expression for the Rankine cycle efficiency. [6]
7. Define thermal resistance. Derive an expression for heat transfer through composite plane wall of three different layers of different materials using electric analogues approach. [6]
8. A piston cylinder arrangement shown in figure below has cross sectional area of 0.01m2 and a piston mass of 80 kg. If the atmospheric pressure is 1 bar, what should be the gas pressure to lift the piston? If 50 kg mass is added above the piston, what would be the new pressure? [6]



9. A piston cylinder device with a linear spring initially contains water at a pressure of 4 MPa and 500°C with the initial volume being 0.1 m3, as shown in figure below. The system now cools until the pressure reaches 1000 kPa. If the piston is at the bottom, the system pressure is 300 kPa. Sketch the process on P-v diagram and determine the mass of H_2O, the final temperature and volume and the total work transfer. [Refer the attached table for properties of steam] [8]



10. A perfect gas flows through a nozzel where it expands in a reversible adiabatic manner. The inlet conditions are 22 bar, 500°C and 38m/s at the exit the pressure is 2 bar. Determine the exit velocity and exit area if the flow rate is 4 kg/s. Take R=190 J/Kg K and $\Upsilon = 1.35$. [8]

11. A house is to be maintained at 25°C in summer as well as winter. For this purpose, it is proposed to use a reversible device as a refrigerator in summer and a heat pump in winter. The ambient temperature is 40°c in summer and 3°c in winter. The energy losses as heat from the roof and the walls are estimated as 5 kw per degree Celsius temperature between the room and the ambient conditions. Calculate the power required to operate the device in summer and winter. [8]

12. At the beginning of a compression stoke of an air standard Diesel cycle having a compression ratio of 16 the temperature is 300 K and the pressure is 1000 kpa, if the cut off ratio for the cycle is 2 Determine: [8]

    a) The pressure and temperature at the end of each process of the cycle.

    b) The thermal efficiency and

    c) The mean effective pressure

    [Take R =287 J/kg.k and $\Upsilon = 1.4$]

13. A gas turbine blade is modeled as a flat plate. the thermal conductivity of the blade material is 15W/mk and its thickness is 1.5 mm. 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 upper and lower surfaces of the blade are 2500 W/m^{2}K and 1500 W/m^{2}K respectively. Under steady state conditions, the temperature at upper surface of the blade is measured as 850°C, determine the temperature of the coolant air. [6]

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TABLE 1 Properties of SATURATED WATER – Pressure Table

P kPa	T °C	v_l m³/kg	v_{lg} m³/kg	v_g m³/kg	u_l kJ/kg	u_{lg} kJ/kg	u_g kJ/kg
90	96.713	0.001041	1.8688	1.8698	405.11	2097.1	2502.2
100	99.632	0.001043	1.6933	1.6943	417.41	2088.3	2505.7
101.32	100.00	0.001043	1.6727	1.6737	418.96	2087.1	2506.1
125	105.99	0.001048	1.3742	1.3752	444.25	2068.9	2513.2
900	175.39	0.001121	0.2138	0.2149	741.92	1838.3	2580.2
950	177.70	0.001124	0.2030	0.2041	752.03	1829.8	2581.8
1000	179.92	0.001127	0.1933	0.1944	761.75	1821.6	2583.3
1100	184.10	0.001133	0.1764	0.1775	780.14	1805.9	2586.0
1200	188.00	0.001138	0.1622	0.1633	797.31	1791.1	2588.4

TABLE 2 Properties of SUPERHEATED STEAM

P kPa	T °C	v m³/kg	u kJ/kg	H kJ/kg	s kJ/kg.K
4000	(250.39)	(0.04977)	(2601.5)	(2800.6)	(6.0689)
	300	0.05882	2724.4	2959.7	6.3598
	350	0.06644	2826.1	3091.8	6.5811
	400	0.07340	2919.8	3213.4	6.7688
	450	0.08002	3010.3	3330.4	6.9364
	500	0.08642	3099.7	3445.4	7.0902
	550	0.09268	3189.0	3559.7	7.2355
	600	0.09884	3278.9	3674.3	7.3687
	650	0.1049	3369.8	3789.5	7.4970

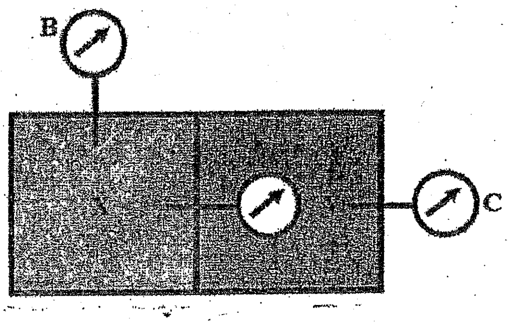
04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Chaitra

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. Explain the difference between path function and point function with example. [4]
2. Define heat transfer and work transfer. Also mention similarities and differences between heat and work. [4]
3. Define pure substance. Explain why property tables and charts are necessary. [4]
4. Differential between steady state and unsteady state analysis. Write down general mass conservation and energy conservation equation for a steady state process and reduce them for an adiabatic turbine. [6]
5. Define isentropic process. Derive isentropic relations for an ideal gas and an incompressible substance. [6]
6. Sketch the 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 expressions for inside and outside overall heat transfer co-efficient for a hollow cylinder subjected to convection medium on both sides. [6]
8. A large chamber is separated into two compartments which are maintained different pressures as shown in figure below. Pressure gauge A reads 200 kPa and pressure gauge B reads 150 kPa. If the atmospheric pressure is 100 kPa, determine the absolute pressure existing in the compartments and the reading of gauge C. [6]



9. A rigid container with a volume of 0.170 m^3 is initially filled with stream at 200 kPa, 300°C. It is cooled to 90°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?
   Also sketch the process on P-v and T-v diagrams. [Refer the attached table for properties of stream]

10. Air flows at a rate of 1.2 kg/s through a compressor, entering at 100 kPa, 25°C, with a velocity of 60 m/s and leaving at 500 kPa, 150°C, with a velocity of 120 m/s. Heat lost by the compressor to the surrounding is estimated to be 20 kJ/kg. Calculate the power required to drive the compressor and diameter of inlet and exhaust pipes. [Take R = 287 J/kgK and c_p = 1005 J/kgK] [8]

11. An air condition unit having COP 50% of the theoretical maximum maintains a house at a temperature of 20°C by cooling it again the surrounding temperature. The house gains Energy at a rate of 0.8 KW per degree temperature difference. For a maximum work input of 1.8 Kw, determine the maximum surrounding temperature for which it provides sufficient cooling. [8]

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 air during the cycle is 2000 kJ/kg. Determine the pressure and temperature at the end of each process of the cycle, the thermal efficiency and the mean effective pressure. [Take R = 287 J/kg.k and Υ = 1.4] [8]

13. A steel pipe having an outside diameter of 2 cm is to be covered with two layers of insulations, each having a thickness of 1 cm. The average conductivity of one material is 5 times that of the other. Assuming that the inner and outer surface temperature of the composite insulation are fixed, calculate by what percentage the heat transfer will be reduced when the better insulating materials is nearer to the pipe than it is away from the pipe. [6]

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04 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2070 Ashad

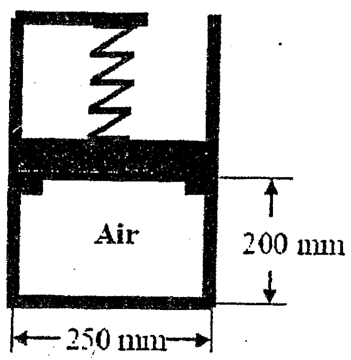
Exam.	**New Back (2066 & Later Batch)**		
Level	BE	**Full Marks**	80
Programme	BCE, BME, BGE	**Pass Marks**	32
Year / Part	I / I	**Time**	3 hrs.

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

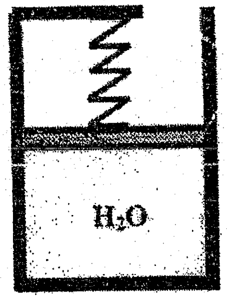
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ *__Necessary figures are attached herewith.__*
- ✓ *Assume suitable data if necessary.*

1. State and explain equality of temperature. Also state zeroth law of thermodynamics. [4]
2. Derive an expression for work transfer for any process on a piston cylinder device. Reduce it to get the expression for work transfer during a polytropic process. [4]
3. Define pure substance. State and explain "state postulate". [4]
4. Differentiate between steady state work applications and steady state flow applications. Write down the functions of a thermal turbine and nozzle. Also derive governing equations for them when they operate under steady state condition. [6]
5. State the entropy change statement for a control volume and derive an expression for its entropy generation. [6]
6. Sketch an ideal Otto cycle on P-v and T-s diagrams. Also derive an expression for its efficiency in terms compression ratio. [6]
7. Derive the expression for overall heat transfer coefficient for a composite plane wall consisting of two layers and subjected to convective modium on both sides. [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 forces on it. Heat is added to the system until the piston is displaced upward by 80 mm. Determine: [6]

    a) The temperature at which piston leaves the stops and
    b) The final pressure. [Take R = 287 J/kg. K, p_{atm} = 100 kPa and g = 9.81 m/s^2]



9. A piston cylinder device with a linear spring initially contains water at a pressure of 4 Mpa and 500°C with the initial volume being 0.1 m^3, as in figure below. The system now cools until the pressure reaches 1000 kpa. If the piston is at the bottom, the system pressure is 300 kpa. Sketch the process on P-v diagram and determine the mass of H_2O, the final temperature and volume and the total work transfer. [Refer the attached table for properties of steam] [8]



10. Air flows at rate of 1.2 kg/s through a compressor, entering at 100 kpa, 25°C, with a velocity of 60 m/s and leaving at 500 kpa, 150°C, with a velocity of 120 m/s. Heat lost by the compressor to the surrounding is estimated to be 20 kJ/kg. Calculate the power required to drive the compressor and diameters of inlet and exhaust pipes. [Take R = 287J/kgK and c_p = 1005 J/kgK]. [8]

11. A rigid vessel consists of 0.4 kg of hydrogen initially at 200 kpa and 27°C. Heat is transferred to the system from a reservoir at 600 K until its temperature reaches 450 K. Determine the heat transfer, the change in entropy of hydrogen and the amount of entropy produced. [Take c_v = 10.183 J/kgK]. [8]

12. An ideal gas turbine cycle produces 15 MW of power output. The properties of air at the compression inlet are 100 kpa and 17°C. The pressure ratio for cycle is 15 and the heat added per kg of air per cycle is 900 KJ/kg. Determine: (a) Efficiency of cycle (b) The maximum temperature during the cycle and (c) Mass flow rate of air. [Take δ = 1.4 and c_p = 1005 J/Kg.k] [8]

13. A furnace wall 300 mm thick is made up of an inner layer of fire brick (k = 1 W/mK) covered with a layer of insulation (k = 0.2 W/mK). The inner surface of the wall is at 1300°C and the outer surface is at 30°C. Under steady state condition, temperature at the interface is measured to be 1100°C. Determine: [6]

    a) Heat loss per unit area of the wall and
    b) The thickness of each layer

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04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 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. Write features of a thermodynamic property. Also differentiate between state function and path function with examples. [4]
2. Differentiate between heat and work. [4]
3. Define compressed liquid, degree of superheat, moisture content and saturated vapor. [4]
4. Define cyclic process State and explain first law of thermodynamics for a control mass undergoing a cyclic process. [6]
5. Explain the directional feature of the natural process with any one example. State the second of thermodynamics for an isolated system. Also explain the entropy generation. [6]
6. Sketch P-v and T-s diagram for a Brayton cycle. Also derive an expression for its efficiency in terms of pressure ratio. [6]
7. Derive expressions for inside overall heat transfer coefficient and outside overall heat transfer coefficient for a hollow tube subjected to convection medium on its both inner and outer surface. [6]
8. The Piston of a vertical Piston cylinder device containing as gas has a Mass of 50 kg and cross sectional area of $0.02m^2$, [6]
   i) Determine the pressure inside the cylinder.
   ii) During some process heat is lost by the gas to the surroundings and it's volume decreases to ¾th of the initial volume, determine it's final pressure. [Take Patm = 100 KPa and g = 9.81 M/s^2]
9. A piston cylinder device shown in figure P.9 contains 0.2 Kg of a mixture of saturated liquid water and saturated water vapor at a temperature of 50°C and a volume of $0.03m^3$. The mass of the piston resting on the stops is 50 Kg and the cross sectional area of the piston is 12.2625 cm^2. The atmospheric pressure is 100 kPa. Heat is transferred until it becomes saturated vapor. Sketch the process on P-v and T-v diagrams and determine: [8]
   i) The final pressure, and
   ii) The total work transfer. [Take g = 9.8 ms^{-2}] [Refer attached table for the properties of steam]

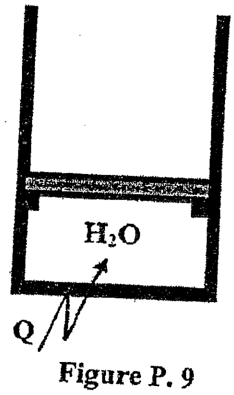

Figure P. 9

10. Air flows at a rate of 1.2 kg/s through a turbine entering at 500 kpa, 150°C; with a velocity of 120 m/s and leaving at 100 kpa, 25°C; with velocity of 60 m/s. Heat lost by the turbine to the surrounding is found to be 20 kJ/kg. Calculate the power developed by the turbine and diameter of inlet and enhast pipes. [Take R = 287 J/kg.k, and Cp = 100 SJ/kg.k] [8]

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

    i) Determine the actual and minimum theoretical cost per day.
    ii) Compare the actual operating cost with the cost of direct electric resistance heating.

12. Steam at 2 MPa, 350°C is expanded in a steam turbine working on a Rankine cycle to 8 kPa. Determine the net work per kg of steam and the cycle efficiency assuming ideal processes. What will be the difference in efficiency if pump work is neglected? [Refer attached table for the properties of steam] [8]

13. A gas turbine blade is modeled as a flat plate. The thermal conductivity of the blade material is 15 W/mk and its thickness is 1.5 mm. 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 2500 W/m^2k and 1500 W/m^2k 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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04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 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.*
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- ✓ *Necessary tables are attached herewith.*
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1. Write features of a thermodynamic property. Also differentiate between state function and path function with examples. [4]
2. Differentiate between heat and work. [4]
3. Define compressed liquid, degree of superheat, moisture content and saturated vapor. [4]
4. Define cyclic process State and explain first law of thermodynamics for a control mass undergoing a cyclic process. [6]
5. Explain the directional feature of the natural process with any one example. State the second of thermodynamics for an isolated system. Also explain the entropy generation. [6]
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9. A piston cylinder device shown in figure P.9 contains 0.2 Kg of a mixture of saturated liquid water and saturated water vapor at a temperature of 50°C and a volume of $0.03m^3$. The mass of the piston resting on the stops is 50 Kg and the cross sectional area of the piston is 12.2625 cm^2. The atmospheric pressure is 100 kPa. Heat is transferred until it becomes saturated vapor. Sketch the process on P-v and T-v diagrams and determine: [8]
   i) The final pressure, and
   ii) The total work transfer. [Take g = 9.8 ms^{-2}] [Refer attached table for the properties of steam]

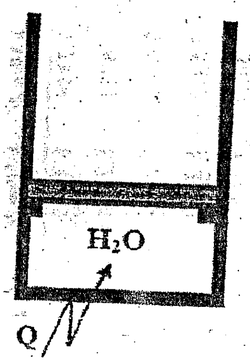

Figure P.9

10. Air flows at a rate of 1.2 kg/s through a turbine entering at 500 kpa, 150°C; with a velocity of 120 m/s and leaving at 100 kpa, 25°C; with velocity of 60 m/s. Heat lost by the turbine to the surrounding is found to be 20 kJ/kg. Calculate the power developed by the turbine and diameter of inlet and enhast pipes. [Take R = 287 J/kg.k, and Cp = 100 SJ/kg.k] [8]

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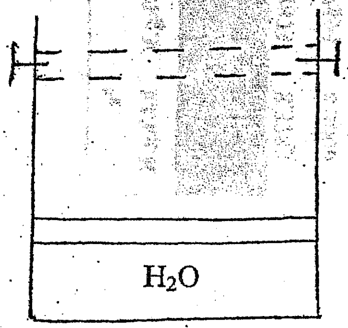
04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Ashad

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE, BME	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 these terms: (a) Quasi-equilibrium process (b) An open system (c) Thermodynamic equilibrium (d) Intensive property. [4]
2. Define stored and transient energies with examples. [2+2]
3. Define the terms saturated vapor, superheated vapor and critical point. Also derive an expression for specific volume of a two phase mixture in terms of quality. [3+3]
4. Derive unsteady state energy equation for an open system. Apply this equation to derive governing equations for the discharge of a gas from a cylinder. [6]
5. State and explain Kelvin-Planck and Clausius statement of second law of thermodynamics. Also prove their equivalence. [8]
6. Sketch the Brayton cycle on P-V and T-s diagrams and derive an expression for its efficiency in terms of pressure ratio. [6]
7. Derive an expression for inside overall heat transfer coefficient for a hollow cylinder subjected to convection on both sides. [6]
8. A cylinder with a frictionless piston contains $0.1m^3$ of gas at 200KPa pressure. The piston is connected to a coil spring, which exerts a force proportional to displacement from its equilibrium position. The gas is heated until the volume is doubled at which pressure is 500KPa. Determine the work done by the gas. Take atmospheric pressure equal to 100KPa. [4]
9. A piston cylinder arrangement shown in figure below contains 0.5kg of water initially at a pressure of 400KPa with a quality of 50%. The system is heated to a position where the piston is locked, and then cooled till it becomes a saturated vapor at a temperature of 60°C. Sketch the process on P-v and T-v diagrams and determine total work transfer. [8]



10. Steam enters a turbine operating at steady state with a mass flow rate of 4600kg/h. The turbine develops a power output of 1000kW. At the inlet, the pressure is 6000kPa, the temperature is 400°C, and the velocity is 10m/s. At the exit, the pressure is 100kPa, the quality is 0.9, and the velocity is 50m/s. Calculate the rate of heat transfer between the turbine and surroundings in kW? (Refer the attached table for properties of steam). [8]

11. A heat engine working on Carnot cycle converts one-fifth of the heat input into work. When the temperature of the sink is reduced by 80°C, the efficiency gets doubled. Make calculations for the temperature of source and sink. [6]

12. Determine the efficiency of an ideal Rankine cycle operating between boiler pressure of 1.6MPa and condenser pressure of 6KPa. Steam leaves the boiler as saturated vapor. [8]

13. An exterior wall of a house may be approximated by a 10cm layer of common brick [k=0.7W/m°C] followed by a layer of a 3.8cm layer of cement plaster [k=0.48W/m°C]. What thickness of loosely packed rock-wool insulation [k=0.065W/m°C] should be added reduce the heat loss (or gain) through the wall by 80 percent? [6]

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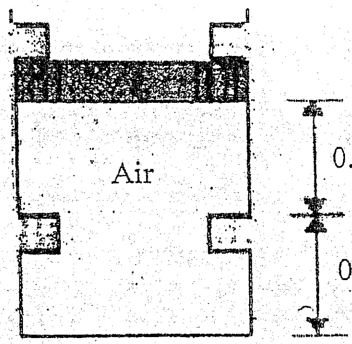
04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Baishakh

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

Subject: - Fundamentals of Thermodynamics and Heat Transfer

- ✓ 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 three types of thermodynamic system. [4]
2. Define thermodynamic process. Derive the expression for work done during polytropic process. [4]
3. Define compressed liquid line, saturation temperature and quality. Derive the relation $v = v_l + xv_{lg}$ for the two phase mixture. [4]
4. Derive the general expression for conservation of energy for control volume. Modify it for turbine and nozzle. [8]
5. Derive the relations for entropy for ideal gases. Also show the equivalence of Clausius and Kelvin's statement. [6]
6. Describe the working principle of Rankine cycle with the help of P-v and T-s diagram. [5]
7. Derive an expression for heat transfer through a mild steel pipe with a layer of insulation on the outside. Take temperature of fluid in the pipe as t_{fluid}, temperature of air as t_{air} and length of the pipe as L. ($t_{fluid} > t_{air}$). [6]
8. In a quasiequilibrium process in a closed system, a gas expands from a volume of $0.15 m^3$ and a pressure of 120 kPa to a volume of $0.25 m^3$ in such a manner that $P(V + 0.030) =$ constant, where V is in m^3. Calculate the work. [6]
9. A $1.8 m^3$ rigid tank contains steam at 220°C. One third of the volume is in the liquid phase and the rest is in the vapor form. Determine: [8]
   a) The pressure of the steam
   b) The quality of the saturated mixture; and
   c) The specific volume
10. Air is contained in a vertical cylinder fitted with a frictionless piston and a set of stops as shown in figure below. The cross sectional area of the piston is $0.05 m^2$. At initial condition, piston is in upper stops with pressure and temperature inside the cylinder as 0.3 MPa and 731°C respectively. Air is cooled as a result of heat transfer to the surroundings. The piston starts to move down at pressure 0.21 MPa. The cooling process continues until the temperature reaches 70°C. [10]
    a) Draw p-v diagram for the process
    b) Find the temperature of the air inside the cylinder when the piston reaches the lower stops.
    c) Calculate the heat transfer during the process. (For air R = 287J/kgK, Cp = 1004J/kgK, C_v = 717 J/kgK).



11. Steam enters an adiabatic turbine at 10MPa and 510°C. Exit condition are 0.06MPa and quality of 96%. Determine the isentropic efficiency and actual work for a mass flow rate of 10Kg/sec. [Refer the attached table for properties of steam.] [8]

12. An exterior wall of a house may be approximated by a 10cm layer of common brick [K = 0.7 W/m°C] followed by a layer of 3.8cm of cement plaster. [K = 0.48 W/m°C]. What thickness of loosely packed rock wool insulation [K = 0.005W/m°C] should be added to reduce the heat loss (or gain) through the wall by 80%. [8]

13. The compression ratio in an air standard Otto cycle is 8. At the beginning of the compression stroke, the pressure is 0.1 MPa and the temperature is 15°C. The heat transfer to the air per cycle in 1800KJ/KG of air. Determine: [7]

a) The pressure and temperature at the end of each process of the cycle
b) The thermal efficiency
c) The mean effective pressure. [R = 287J/KgK, Cv = 718J/kgK]

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