TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

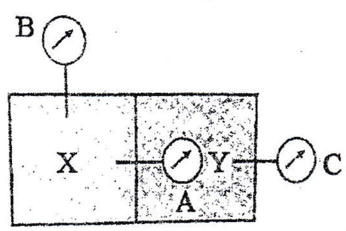
2078 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT, BAM, BIE, BAG, BAS	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental of Thermodynamics and Heat Transfer *(ME 452)*

- ✓ 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.*
- ✓ **[For air take $\gamma = 1.4$, $C_p = 1005$ J/kg.k and $C_v = 718$ J/kg.k]**

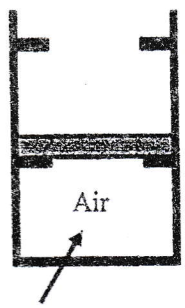
1. Define thermodynamic system, surroundings and boundary with examples. [4]
2. What do you mean by work transfer? Derive the expression for heat and work for adiabatic process. [4]
3. Why quality is necessary to define the state of a two phase mixture? Derive an expression for specific volume of a two phase mixture in terms of quality. [4]
4. Explain first law of thermodynamics for a control mass undergoing a cyclic process. Also state statements for a power cycle and refrigeration cycle. [6]
5. Derive isentropic relations for an ideal gas. Explain second law of thermodynamics for an isolated system. [3+3]
6. Explain the working principle of Rankine Cycle with corresponding processes on P-v and T-s diagram. [6]
7. Derive an expression for overall heat transfer coefficient for a plane wall subjected to convection medium on both sides. [6]
8. A large chamber is separated into two compartments which are maintained at different pressure as shown in figure below. Pressure gauge A reads 200 kPa and pressure gauge B reads 420 kPa. If the barometric pressure is 100 kPa, determine the absolute pressure existing in the compartments and the reading of gauge C. [6]



9. A closed, rigid container of volume 0.5 m^3 is placed on a hot plate. Initially, the container holds mixture of saturated liquid water and saturated water vapor at $T_1 = 100°C$ with a quality of 0.2. After heating, the temperature in the container is $T_2 = 150°C$. Indicate the initial and final states on P-v and T-v diagrams and determine [8]
   a) The pressure at each state.
   b) The mass of the vapor present at each state, in kg
   c) If the heating continued, determine the temperature when the container holds only saturated vapor.

10. A piston cylinder device shown in figure below contains 2 kg of air initially at a pressure of 200 kPa and a temperature of 50°. It takes a pressure of 500 kPa to lift the piston from the bottom stops. The total volume is 2 m^3 when the piston reaches at the upper stops. Heat is added to the system until the final temperature reaches 950°C. Sketch the process on P-V and T-V diagrams and determine [8]

a) the final pressure
b) the total work transfer and
c) the total heat transfer



11. A refrigerator having a COP of 4 maintains the freezer compartment at – 3°C by removing heat at a rate of 11000 kJ/h and rejects heat to the surroundings at 30°C. Determine the power input to the refrigerator and compare it with minimum theoretical power input. If the electricity cost is Rs. 10/kWh, determine the actual and minimum theoretical cost per day for effective operation of 16 h/day. [8]

12. A four stroke engine of swept volume 0.1 m^3 work on Otto cycle. The compression ratio is 9. The initial conditions are pressure 1 bar and temperature 90°C. The heat addition at constant volume is 100 kJ/cycle. Find [8]

- Ideal efficiency
- Mean effective Pressure
- Pressure and temperature at key points of the cycle

13. A cast iron pipe (k = 25 W/mK) with inner and outer diameters of 60 mm and 80 mm respectively is covered by an insulator (k = 0.05 W/mK). Under steady state condition, temperature between the pipe and insulator interface is found to be 250°C. The allowable heat loss from the unit length of the pipe is 500 W/m and outer surface temperature of the insulator should not exceed 50°C. Determine [6]

a) the minimum thickness of the insulation required, and
b) the temperature at the inner surface of the pipe.

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2077 Chaitra

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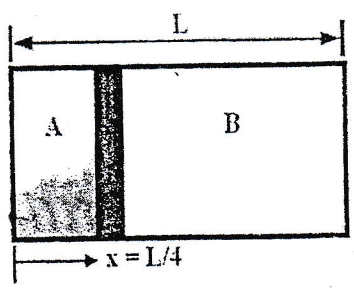
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental of Thermodynamics and Heat Transfer *(ME 452)*

- ✓ 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.***
- ✓ *Assume suitable data if necessary.*

1. Differentiate between the microscopic and macroscopic approach in thermodynamics with examples. [4]
2. Define work transfer. Derive the mathematical expression for work transfer for isothermal process. [4]
3. Define the following terms: Saturation temperature, Saturated liquid, Critical point and Moisture content. [4]
4. Explain first law of thermodynamics for an isolated control mass and a control mass undergoing a cyclic process. [6]
5. Define entropy and derive entropy relations for an ideal gas and an incompressible substance. [6]
6. Sketch an ideal Diesel cycle on P-v and T-s diagrams. Also derive an expression for its efficiency in terms of compression ratio and cut-off ratio. [6]
7. Define thermal resistance. Derive the expression for heat transfer rate through a hollow cylinder with convection on both sides. [6]
8. A cylinder with a total volume of $2m^3$ has a movable piston as shown in figure below. When the piston is at one fourth of the length, both sides have same specific volume of $8\ m^3/kg$. Determine the specific volumes of both sides when the piston is at middle of the cylinder. [6]



9. A rigid tank containing steam initially at 0.3 MPa and 150°C is cooled until the steam temperature becomes 80°C. Draw the P-v and T-v diagrams of the cooling process and determine [8]
   a) the temperature at which the steam becomes saturated vapor.
   b) the quality at final state.
   c) the change in internal energy per kg of steam in the cooling process.

   [Refer the attached table for properties of water]

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 of inlet and exhaust pipes. [Take R = 287 J/kgK and c_p = 1005 J/kgK] [8]

11. An air conditioning unit having COP 50% of the theoretical maximum maintains a house at a temperature of 20°C by cooling it against 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 of air during the cycle is 2000 kJ/kg. Determine:
    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 c_p = 1005 J/kgK, c_v = 718 J/kgK, R = 287 J/kgK, γ = 1.4] [8]

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 temperatures of the composite insulation are fixed, calculate by what percentage the heat transfer will be reduced when the better insulating material is next to the pipe than it is away from the pipe. [6]

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Properties of Saturated Water - Temperature Table

T	P	v_f	v_{fg}	v_g	u_f	u_{fg}	u_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g
°C	kPa	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
80	47.373	0.001029	3.4078	3.4088	334.88	2146.7	2481.6	334.93	2308.2	2643.1	1.0753	6.5359	7.6112
85	57.815	0.001032	2.8279	2.8289	355.86	2132.0	2487.9	355.92	2295.5	2651.4	1.1343	6.4093	7.5436
90	70.117	0.001036	2.3607	2.3617	376.86	2117.1	2494.0	376.93	2282.7	2659.6	1.1925	6.2859	7.4784
95	84.529	0.001040	1.9818	1.9828	397.89	2102.2	2500.1	397.98	2269.7	2667.7	1.2501	6.1653	7.4154
100	101.32	0.001043	1.6726	1.6736	418.96	2087.1	2506.1	419.06	2256.6	2675.7	1.3069	6.0476	7.3545
105	120.79	0.001047	1.4190	1.4200	440.05	2072.1	2512.1	440.18	2243.4	2683.6	1.3630	5.9326	7.2956
110	143.24	0.001052	1.2095	1.2106	461.19	2056.7	2517.9	461.34	2230.0	2691.3	1.4186	5.8200	7.2386
115	169.02	0.001056	1.0359	1.0370	482.36	2041.1	2523.5	482.54	2216.3	2698.8	1.4735	5.7098	7.1833
120	198.48	0.001060	0.8911	0.8922	503.57	2025.5	2529.1	503.78	2202.4	2706.2	1.5278	5.6019	7.1297
125	232.01	0.001065	0.7698	0.7709	524.82	2009.7	2534.5	525.07	2188.3	2713.4	1.5815	5.4962	7.0777
130	270.02	0.001070	0.6676	0.6687	546.12	1993.7	2539.8	546.41	2174.0	2720.4	1.6346	5.3926	7.0272
135	312.93	0.001075	0.5813	0.5824	567.46	1977.5	2545.0	567.80	2159.4	2727.2	1.6873	5.2907	6.9780
140	361.19	0.001080	0.5079	0.5090	588.85	1961.2	2550.0	589.24	2144.6	2733.8	1.7394	5.1908	6.9302

Properties of Superheated Steam

P	T	v	u	h	s
kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg.K
300	(133.56)	(0.6059)	(2543.5)	(2725.3)	(6.9921)
	150	0.6339	2570.7	2760.9	7.0779
	200	0.7163	2650.2	2865.1	7.3108
	250	0.7963	2728.2	2967.1	7.5157
	300	0.8753	2806.3	3068.9	7.7015

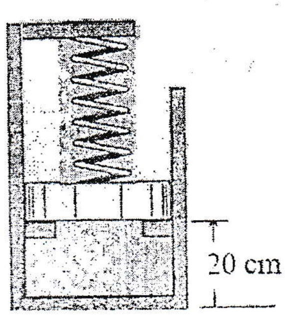
TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Bhadra

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT, BAM, BIE, BAG, BAS	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental of Thermodynamic and Heat Transfer *(ME 452)*

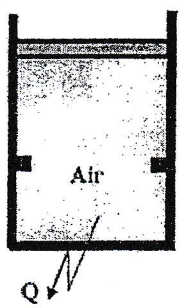
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. Define state function with example and mention main characteristic of a thermodynamic property in relation to a cyclic process. [4]
2. Define a polytropic process. Sketch polytropic process with n=0; n=1; n=1.4; n=∞ on a common P-V diagram. [4]
3. Define enthalpy. Derive an expression for specific heat at constant volume for an ideal gas. [4]
4. Define steady state flow application. Write down general energy equation for a nozzle and diffuser and reduce it for an adiabatic nozzle and diffuser. [6]
5. Write down the Gibb's equation use it to derive an expression for change in entropy for an incompressible substance. Also derive isentropic relation for an incompressible substance. [6]
6. Sketch the ideal diesel cycle on P-V and T-S diagrams and derive an expression for its efficiency in terms of compression ratio and cut-off ratio. [6]
7. Differentiate between black body and gray body. Derive an expression for the rate of heat flow through a composite steel pipe with a layer of insulation on the outside using electrical analogy approach. [6]
8. Air (m=0.1 kg) is contained in piston/cylinder assembly as shown in figure below. Initially, the piston rests on the stops and is in contact with the spring, which is in its unstretched position. The spring constant is 100 kN/m. The piston weighs 30 kN and atmospheric pressure is 101 kPa. The air is initially at 300 K and 200 kPa. Heat transfer occurs until the air temperature reaches the surrounding temperature, 700 K. Find the final pressure and volume. [Take R=287 J/KgK] [6]



9. 5 kg of water is contained in a closed rigid tank at initial pressure of 2000 kPa and a quality of 50%. Heat is transferred from the surrounding until the tank contains only saturated vapor. Sketch the heating process on a P-V diagram an determine
   i) the volume of tank
   ii) the initial temperature of water
   iii) the final pressure of vapor
   [Refer the attached table for properties of steam] [8]

10. Air (0.4 kg) is contained in a piston cylinder device shown in Figure below initially at a pressure of 1500 kPa and 800 K. The cylinder has stops such that the minimum volume of the system is 0.04 m^3. The air in the cylinder is cooled to 300 K. Sketch the process on P-V and T-V diagrams and determine
    a) the final volume and pressure of the air, and
    b) the total work and heat transfer in the process. [Take R= 287 J/KgK and C_v=718 J/KgK]. [8]



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

12. At the beginning of a compression stroke of an air standard diesel cycle having a compression ratio of 16, the temperature is 300 K and the pressure is 100 KPa. If the cut off ratio for the cycle is 2, determine i) the pressure and temperature at the end of each process of the cycle ii) the thermal efficiency. [Take C_v=718 J/kgK, γ=1.4] [8]

13. A 16 cm diameter pipe carrying saturated steam is covered by a layer of insulation of thickness 40 mm (K=0.8 W/mK). Later, an extra layer of insulation of 10mm thick (K=1.2 W/mK) is added. If the surrounding temperature remains constant and heat transfer coefficient (outside) for both insulation materials is 10 W/m^2K, determine the percentage change in the rate of heat loss due to extra insulation layer. [6]

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INSTITUTE OF ENGINEERING

Examination Control Division

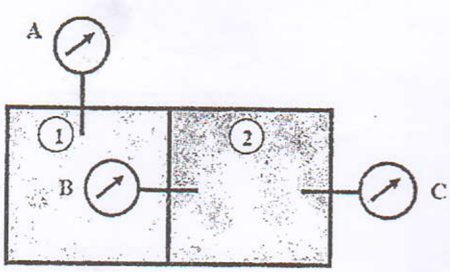
2075 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT, BAME, BIE, BAG	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental of Thermodynamic and Heat Transfer *(ME452)*

- ✓ 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. Differentiate between: (a) control mass and control volume; (b) gauge pressure and absolute pressure. [4]
2. Differentiate between the stored energy and transient energy with examples. Sketch polytropic processes on a common P-V diagram for different values of n. [4]
3. Sketch the following processes on P - v and T - v diagrams. Show both initial and final states properly relative to saturation curves.
   a) A saturated vapor in a rigid tank is heated.
   b) A superheated vapor is condensed isobarically to the saturated liquid state.
   c) A compressed liquid is heated isobarically to the saturated vapor.
   d) A two-phase mixture in a rigid tank is heated such that it passes through a critical point. [4]
4. Write down the general mass and energy conservation equations for a control volume under steady state. Reduce them for heat exchanger and adiabatic pump. [6]
5. Define reversible heat transfer reservoir. Also derive expressions for the change in entropy due to reversible heat transfer process and interpret the result. [6]
6. Differentiate between Power cycle and Refrigeration cycle with the appropriate examples. Sketch the components of a steam power plant and corresponding processes on P-v and T-s diagrams. [6]
7. Using thermal resistance approach derive an expression for outside overall heat transfer coefficients for two layers of 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 below figure. If the local barometer reads 750 mm of Hg and pressure gauges A and B read 300 kPa and 200 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]



9. Water (4 kg) is contained in a piston cylinder device shown in below figure initially at a pressure of 100 kPa with a quality of 10%. The piston has a mass of 100 kg and a cross sectional area of 24.525 cm^2. Heat is now added until H_2O reaches a saturated vapor state. Sketch the process on P - v and T - v diagrams and determine

a) the initial volume
b) the final pressure, and
c) the total work transfer. [Take P_{atm} = 100 kPa, g = 9.81 m/s^2]. [Refer attached table for the properties of steam] [8]

10. Air enters an adiabatic nozzle steadily at 300 kPa, 150°C and with a velocity of 20 m/s and leaves at 100 kPa and with a velocity of 200 m/s. The inlet area of the nozzle is 0.01 m^2. Determine

a) the mass flow rate of air through the nozzle,
b) the exit temperature of the sir, and
c) the exit area of the nozzle.
[Take R = 287 J/kgK and C_p = 1005 J/kgK] [8]

11. A heat pump having a coefficient of performance 50% of the theoretical maximum maintains a house at a temperature of 20°C. The heat leakage from the house occurs at a rate of 0.8 kW per degree temperature difference. For a maximum power input of 1.5 kW, determine the minimum surroundings temperature for which the heat pump will be sufficient? [8]

12. The pressure and temperature at the beginning of the compression stroke of an air standard Diesel cycle are 100 kPa and 300 K. The peak pressure and temperature during the cycle are 8000 kPa and 3000 K respectively. Determine the compression ratio, the cycle efficiency and the mean effective pressure. [Take γ = 1.4, C_p = 1005 J/kgK] [8]

13. A lake surface is covered by a 8 cm thick layer of ice (k = 2.23 W/mK) when the ambient air temperature is -12.5°C. A thermocouple embedded on the upper surface of the layer indicates a temperature of -5°C. Assuming steady state conduction in ice and no liquid subcooling at the bottom surface of the ice layer. Find the heat transfer coefficient at the upper surface. Also work out the heat loss per unit area. [6]

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34 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2075 Baishakh

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT, BIE, BAG, BAM	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental of Thermodynamic and Heat Transfer *(ME452)*

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- ✓ *Attempt __All__ questions.*
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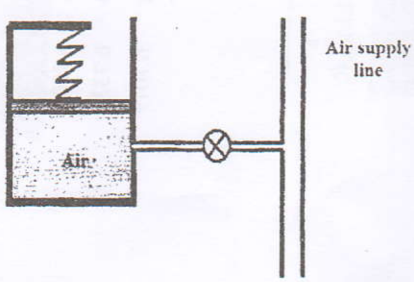
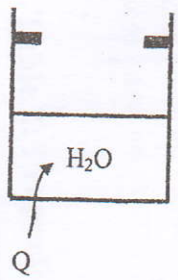
- ✓ ***__Necessary tables are attached herewith.__***
- ✓ *Assume suitable data if necessary.*

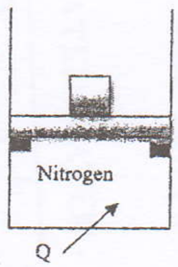
1. Define thermodynamic equilibrium and thermodynamic state. Also explain conditions required for a thermodynamic equilibrium. [4]
2. Derive the mathematical expression of displacement work and simplify it for polytrophic process. [4]
3. Define the term moisture content, superheated vapor, saturation pressure and saturated liquid. [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, heat pump and refrigerator. Also define factors used to measure their performance. [6]
6. Sketch the Rankine cycle on p-v and T-s plots when the state of stream at the boiler outlet is saturated and superheated vapor respectively. Derive an expression for the efficiency of Rankine cycle. [6]
7. Define thermal resistance. Derive the expressions for the rate of heat transfer and overall heat transfer coefficient for composite wall consisting of two layers and convection on both sides. [6]
8. A 5 kg piston in a cylinder with diameter of 100 mm is loaded with a linear spring and the outside atmospheric pressure of 100 kPa. The spring exerts no force on the piston when it is at the bottom of the cylinder and for the state shown in figure below, the pressure is 400 kPa with volume of 0.4 L. The valve is opened to let some air, casing the piston to rise 2 cm. Find the new pressure. [6]



9. A piston cylinder arrangement shown in figure below contains 2 kg of water initially at a pressure of 200 kPa and a temperature of 50°C. Heat is added until the piston reaches the upper stops where the total volume is 1.5 m^3. It takes a pressure of 600 kPa to lift the piston. Sketch the process on P-v and T-v diagrams and determine the final temperature and the total work transfer. [8]



10. Nitrogen (5 kg) is contained in a piston cylinder derive shown in figure below initially at a pressure of 800 kPa and a temperature of 127°C. There is a heat transfer to the system until the temperature reaches to 527°C. 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/Kg.K and C_V = 743 J/kg.K] [8]



11. An air conditioning 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. In an ideal Brayton cycle, air enters the compressor at 100 kPa and 300 K and the turbine at 1000 kPa and 1200 K. Determine the network per kg of air and the cycle efficiency. [Take γ = 1.4 and cp = 1.005 KJ/kg.k] [8]

13. A furance is made of fireclay brick of thickness 0.3 m and thermal conductivity of 1.2 W/m.k. The outside surface is to be insulated by an insulating material with the thermal conductivity of 0.05 W/mk. Determine the thickness of the insulating layer in order to limit the heat loss per unit area of the furnace wall to1200 W/m^2. When the inside surface of wall is at 900°C and the outside surface is at 25°C. [6]

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34 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division

2074 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT,BIE, BAG, BAM	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental of Thermodynamic and Heat Transfer *(ME452)*

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- ✓ *Attempt **All** questions.*
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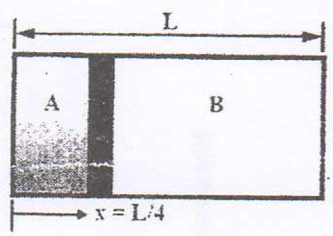
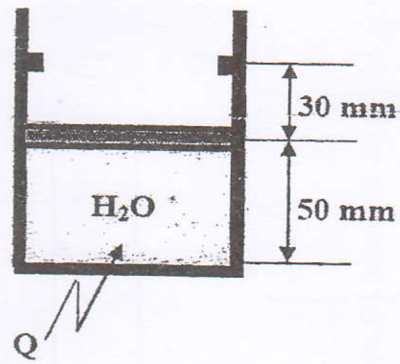
1. Define thermodynamic property. Differentiate between intensive and extensive properties with examples. [4]
2. In what respect the heat and work interactions are (i) similar and (ii) dissimilar? [4]
3. Define quality and moisture content. Derive an expression for specific volume of a two phase mixture in terms of quality. [4]
4. Define a cycle. Explain first law of thermodynamics for control mass undergoing cyclic process. Write down statements of first law for power cycle and refrigeration cycle. [6]
5. Define entropy. Derive and expressions for change in entropy for reversible heat transfer and reversible work transfer process. [6]
6. Explain the working principle of Brayton cycle with corresponding processes on P-v and T-s diagrams. [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 three layers. [6]
8. A cylinder with a total volume of $2m^3$ has a movable piston as shown in figure below, when the piston is at one fourth of the length, both sides have the same specific volume of 8 m3/kg. Determine the specific volumes of both sides when the piston is at middle of the cylinder. [6]



9. The frictionless piston shown in figure below has a mass of 20 kg and a cross sectional area of 78.48 cm^2. Heat is added until the temperature reaches 400°C. If the quality of the H_2O at the initial state is 0.2, determine: [8]

   i) The initial pressure
   ii) The mass of H_2O
   iii) The quality of the system when the piston hits the tops
   iv) The final pressure and
   v) The total work transfer [Take P_{atm} = 100 kPa, g = 9.81 m/s^2]



10. Air enters a compressor operating at steady state at 100 kPa, 300 K and leaves at 1000kPa, 400 K, with a volumetric flow rate of 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 Cp = 1005 J/kgK] [8]

11. A refrigerator having a COP of 4 maintains the freezer compartment at -3° C by removing heat at a rate of 10800 kJ/kg and rejects heat to the surroundings at 27°C. Determine the power input to the refrigerator and compare it with minimum theoretical power input. If the electricity cost 10/kWh, determine the actual an minimum theoretical cost per day for effective operation of 12h/day. [8]

12. At the beginning of a compression stroke of an air standard diesel cycle having a compression ratio of 16, the temperature is 300 K and the pressure is 100 kpa. If the cut off ratio for the cycle is 2, determine (a) the thermal efficiency (b) the mean effective pressure. [Take $\gamma = 1.4$, R = 287J/kg.k]. [8]

13. A thick-walled tube of stainless steel (k=19 W/m° C) with 2 cm inside diameter and 1 cm thickness is covered with a 3 cm layer of asbestos insulation (k=0.2W/m°C). If the inside wall temperature of the pipe is maintained at 600°C and outside wall temperature of the insulation is maintained at 100°C, Calculate the heat loss per unit length. Also calculate the tube insulation interface temperature. [6]

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34 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2073 Magh

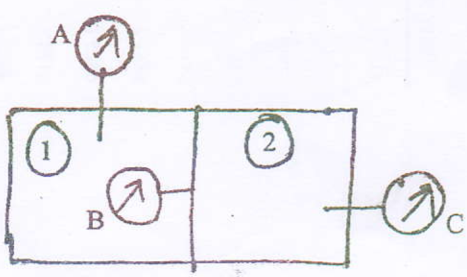
Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT, BIE, B.Agri., BAME	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental of Thermodynamic and Heat Transfer *(ME452)*

- ✓ 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.*

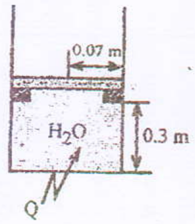
1. Explain how will you find out whether a given variable is a thermodynamic property or not. Also define state function and path function. [4]
2. Explain the differences between stored energy and transient energy with examples. Also define total energy. [4]
3. Define the following terms:

   compressed liquid, degree of superheat, quality, entalpy and specific heat at constant volume. [4]
4. Write down the functions of turbine, compressor, nozzle and heat exchanger. Also write down energy equations for them. [6]
5. Define reversible heat transfer reservoir and reversible work transfer reservoir. Also derive the expressions for change in entropy due to reversible heat transfer and reversible work transfer processes. [6]
6. Explain the working principle of an ideal diesel cycle with P-V and T-S diagrams. [6]
7. Derive an expression for conduction heat transfer through a composite cylinders consisting of three layers of different materials. [6]
8. Three pressure gauges are connected to a container consisting of two compartments as shown in figure below. If the local barometer reads 750 mm of Hg and pressure gauges A and B reads 300 kPa and 200 kPa respectively. Determine the absolute pressure in each compartment and reading of pressure gauge C. [Take $\rho Hg = 13600\ kg/m^3$ 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 600kPa to lift the piston from the stops. Sketch the process on P-v and T-v diagrams and determine:

   a) the mass of H_2O in the system, and
   b) the total work transfer [8]



10. A Gas undergoes a thermodynamic cycle consisting of three process, Process 1-2 constant Pressure, $P = 1.4$ bars, $v_1 = 0.028m^3$, $w_{12} = 10.5$ kJ

    Process 2-3, compression with Pv = constant, $U_3 = U_2$

    Process 3-1, constant volume, U_1-U_3 = -26.4kJ

    There are no significant change in kinetic and potential energy

   a) Sketch the system on a P-v diagram.
   b) Calculate Net work for a cycle, in kJ.
   c) Calculate the heat transfer of Process 1-2 in kJ
   d) Is this a Power cycle or a Refrigerator cycle? [8]

11. 4 kg of water at 25°C is mixed with 1 kg of ice at 0°C in an isolated system. Calculate the change in entropy due to mixing process. [Take latent heat of ice L = 336 kJ/kg and specific heat of water c = 4.18 kJ/kg K] [8]

12. In an Ideal Brayton cycle, air enters the compressor at 100 kPa and 300k and the turbine at 1000 kPa and 1200k. Heat is transferred to the air at a rate of 30Mw. Determine the efficiency and Power output of the plant.[Take Cp = 1005 J/kg K, and γ= 1.4] [8]

13. An exterior wall of a house consists of 0.1m layer of common brick (k = 0.7 W/m°C) followed by a 0.04 m layer of gypsum plaster (k = 0.48 W/m°C). What thickness of loosely packed rock wool insulation (k = 0.065 W/m°C) should be added to reduce the heat loss through the wall by 80 percent? [6]

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34 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2073 Bhadra

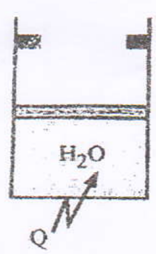
Exam.	**Regular**		
Level	BE	**Full Marks**	80
Programme	BEL, BEX, BCT, BIE, B.Agri., BAME	**Pass Marks**	32
Year / Part	I / II	**Time**	3 hrs.

Subject: - Fundamental of Thermodynamic and Heat Transfer *(ME452)*

- ✓ 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. Differentiate between Microscopic and Macroscopic viewpoint. [4]
2. Define polytropic process. Sketch polytropic processes on a common graph for different values of n. Also derive an expression for work transfer for a polytropic process. [4]
3. Define the following terms: saturation temperature, superheated vapor, moisture content, critical point and specific heat at constant pressure. [4]
4. Write down expression for first law of thermodynamics for a control mass. Reduce it for a cycle process and write down statement of first law of thermodynamics for power and refrigeration cycles. [6]
5. What is the key feature of second law of thermodynamics? State and explain second law of thermodynamics for an isolated system. Also explain entropy generation. [6]
6. Explain the working principle of an Rankine with P-V and T-S diagram. [6]
7. Derive a heat flow equation through a composite plane wall consisting of three layers of different materials. [6]
8. On a new scale N of temperature the freezing point of ice and boiling point of water are 100°N and 400°N respectively. Derive an expression to convert a temperature reading on N scale to °C scale. Also determine the change in N scale when the temperature of a system increases by 50°C. [6]
9. A piston cylinder device shown in figure below 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 $0.4m^3$. Sketch the process on P-v and T-v diagrams and determine: [8]

   a) the final pressure, and
   b) the total work transfer



10. Air expands through an adiabatic turbine from 1000 KPa, 1000 K to 100 KPa, 400K. The inlet velocity is 10 m/s where as exit velocity is 100 m/s. The power output of the turbine is 3600 KW. Determine the mass flow rate of air, the inlet and the exit area. [Take R = 287 J/KgK and Cp = 1005 J/KgK] [8]

11. An air conditioning unit having COP 50% of the theoritical maximum maintains a house at a temperature of 20°C by cooling it against the surrounding temperature. The house gains energy at a rate of 0.8kw per degree temperature difference. For a maximum work input of 1.8KW. Determine the maximum surrounding temperature for which it provides sufficient cooling. [8]

12. An ideal diesel engine has a compression ratio of 20 and uses air as the working fluid. The state of air at the beginning of the compression process is 95kPa and 20°C. If the maximum temperature in the cycle is not to exceed 2200K, determine a) the thermal efficiency and b) the mean effective pressure. [Take Cp = 1005J/kgK, and $\gamma = 1.4$] [8]

13. a) A hollow cylinder with inner and outer diameter of 8 cm and 12 cm respectively has an inner surface temperature of 200°C and outer surface temperature of 50°C. If the thermal conductivity of the cylinder material is 60 w/MK, determine the 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. [4]

    b) The magnitude of heat transfer through an insulating layer of 0.8 m^2 surface area, 5 cm thick and having a thermal conductivity of 0.25 W/mK is found to be 1600 W. Determine the temperature difference existing across the material. [2]

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INSTITUTE OF ENGINEERING

Examination Control Division

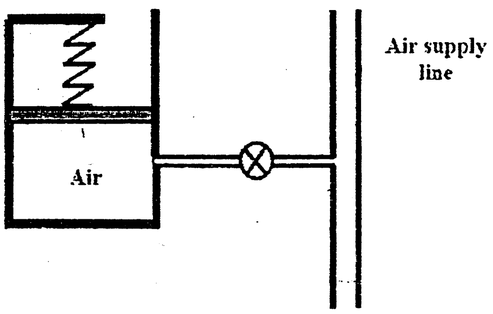
2071 Bhadra

Exam.	Regular / Back		
Level	BE	**Full Marks**	80
Programme	BEL, BEX, BCT, BIE, B.Agri.	**Pass Marks**	32
Year / Part	I / II	**Time**	3 hrs.

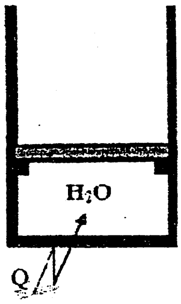
Subject: - Fundamental of Thermodynamics and Heat Transfer *(ME452)*

- ✓ 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 atmospheric pressure, gauge pressure and absolute pressure. Also write down the relationship between them. [4]
2. Differentiate between heat transfer and work transfer. [4]
3. Explain saturation curve of two-phase mixture on T-V diagram. [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 entropy. Derive expressions for changes in entropy for reversible heat transfer and reversible work transfer processes. [6]
6. Sketch an ideal Brayton cycle on P-v and T-s diagrams. Also derive an expression for its efficiency in terms of pressure ratio. [6]
7. Derive for thermal resistance of composite wall using electric analogy. [6]
8. A 15 kg piston in a cylinder with diameter of 0.15 m is loaded with a linear spring and the outside atmospheric pressure of 100 kPa, as shown in figure below. The spring exerts no force on the piston when it is at the lower position of the cylinder and for the state shown, the pressure is 300 kPa with volume of 0.02 m^3. The valve is opened to let some air in, causing the piston to rise 5 cm. Find the new pressure. [Take $g = 9.81\ m/s^2$] [6]



9. A piston cylinder device shown in figure below contains 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. [Refer attached table for the properties of steam] [8]



10. Air expands through an adiabatic turbine from 1000 kPa, 1000 K to 100 kPa, 400 K. The inlet velocity is 10 m/s whereas exit velocity is 100 m/s. The power output of the turbine is 3600 kW. Determine the mass flow rate of air and the inlet and exit diameters. [Take R = 287 J/kgK and C_p = 1005 J/kgK]. [8]

11. An air conditioning unit with a power input of 1.5 kW. It has a COP of 3 while working as a cooling unit in summer and 4 while working as heating unit in winter. It maintains a hall at 22°C year around, which exchanges heat at a rate of 0.8 kW per degree temperature difference with the surroundings. Determine the maximum and the minimum outside temperature for which this unit is sufficient. [8]

12. A Rankine cycle has a boiler working at a pressure of 2 MPa. The maximum and minimum temperatures during the cycle are 400°C and 50°C respectively. Determine the efficiency of the cycle and compare it with that of the Carnot cycle operating between the same temperature limits. [Refer attached table for the properties of steam] [8]

13. A 2.5 cm thick plate (k = 50 W/mK) 50 cm by 75 cm is maintained at 300°C. Heat is lost from the plate surface by convection and radiation to the ambient air at 20°C. If the emissivity of the surface is 0.9 and the convection heat transfer coefficient is 20 W/m^2K, determine the inside plate temperature. [$\sigma = 5.67 \times 10^{-8}$ W/m^2K^4] [6]

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INSTITUTE OF ENGINEERING
Examination Control Division

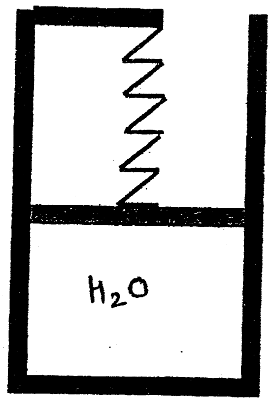
2070 Bhadra

Exam.	Regular		
Level	BE	**Full Marks**	80
Programme	BEL, BEX, BCT, BIE, B.Agri.	**Pass Marks**	32
Year / Part	I /II	**Time**	3 hrs.

Subject: - Fundamental of Thermodynamics & Heat Transfer ***(ME452)***

- ✓ 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. Differentiate between intensive and extensive property. State whether the following properties are intensive or extensive volume, specific volume, temperature and pressure. [4]
2. Differentiate between heat transfer and work transfer. [4]
3. Define pure substance. Explain with illustration. [4]
4. Derive the general energy equation for control volume. [6]
5. Derive the expression for change of entropy for reversible heat reservoirs and reversible work reservoirs. [6]
6. Differentiate between gas and vapor cycles. Also derive an expression for the air standard efficiency of Otto cycle in terms of compression ratio. [6]
7. Derive the expression for combined conduction and convection heat transfer through hollow cylinder covered with two layers of insulation. [6]
8. A gas is contained in a piston cylinder device initially at a pressure of 150 kPa and a volume of 0.04 m^3. Calculate the work done by the gas when it undergoes the following processes to a final volume of 0.1 m^3, (i) Constant-Pressure (ii) Constant temperature (iii) $PV^{1.35}$ = constant. [6]
9. A piston cylinder device with a linear spring initially contains water at a pressure of 4 MPa and 500°C with an initial volume being 0.1m^3, as shown in figure. 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: [8]



a) The mass of water

b) The final temperature and volume and

c) The total work transfer

[Refer the attached tables for properties of steam]

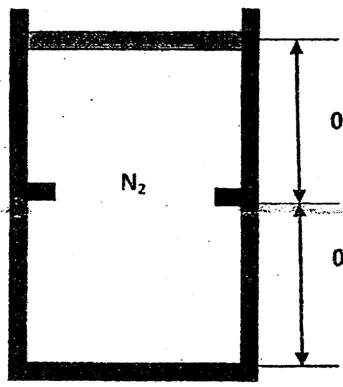
10. Air flows at a rate of 1.5 kg/s through a turbine, entering at 500 kPa, 150° and with a velocity of 120 m/s and leaving at 100 kPa, 25°C and with a velocity of 60 m/s. Power produced by the turbine is 180MW. Determine: [8]

a) Heat loss form the turbine and

b) Diameters of inlet and exhaust pipe

[Take R = 287 J/kgk, C_p = 1005 J/kgk]

11. A piston cylinder device shown in figure below contains 1 kg of Nitrogen initially at a pressure of 250 kPa and a temperature of 500°C. Heat is lost from the system till its temperature reaches 40°C. Sketch the pressure on P-V and T-V diagrams and determine the energy generation. Assume that surrounding is at 20°C. Take P = 297 J/kgk, C_v = 743 J/kgk.



12. In an air standard Brayton cycle the air enters the compressor at 0.18 MPa, 34°C. The pressure leaving the compressor is 2.3 MPa, and the maximum temperature in the cycle is 2350°C. Determine: [8]

a) The pressure and temperature at each point cycle

b) The compressor work, turbine work, and cycle efficiency

[Take Cp = 1005 J/kgk, γ= 1.4]

13. A steam main of 8 cm inside diameter and 9.5 cm outside diameter is lagged with two successive layers of insulation. The layer in contact with pipe is 3.75 cm asbestos with thermal conductivity 0.11 W/m°K and the asbestos layer is covered with 1.5 cm thick magnesia insulation with thermal conductivity of 0.067W/m°K. The inside film heat transfer co-efficient is 290 W/m^{2}K and the outside film heat transfer co-efficient is 7.0 W/m^{2}K. Conductivity of pipe material is 45 W/m°K. Calculate the inside and outside overall heat transfer co-efficient for 50 m length if the steam is passing is at 350°C and the ambient temperature is 30°C. [6]

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INSTITUTE OF ENGINEERING
Examination Control Division
2070 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT, BIE, B.Agri.	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental of Thermodynamic & Heat Transfer *(ME452)*

- ✓ 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 equilibrium. Explain with illustrations. [4]
2. Explain the concept of thermodynamic work and differentiate it with mechanical work. [4]
3. Sketch the saturation curve on P-v and T-v diagram with all important points, lines and regions. [4]
4. Derive and explain first law of thermodynamics for a control mass. Also reduce it for a cylic progress. [6]
5. Define entropy. Derive isentropic relations for an ideal gas and an incompressible. [6]
6. Explain the working of simple vapor compression refrigeration cycle with corresponding processes in p-h and T-s diagrams. [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. 4 kg of air contained in a piston cylinder arrangement at an initial pressure of 2500 kpa and initial volume of 0.25 m^3 is allowed to expand according to pressure volume relation of PV^3= constant until its volume equals to 0.65 m^3. The air is then cooled at constant pressure until the piston comes to its initial position. Then heat is supplied to the air as the piston is locked with a screw until the pressure rises to its initial pressure. Determine the total work transfer. [6]
9. A vessel contains 2 kg of saturated liquid water and saturated water vapor mixture at a temperature of 150°C. One third of the volume is saturated liquid and two third is saturated vapor. Determine the pressure, quality volume internal energy and enthalpy of the mixture. [8]
10. Steam at 4 Mpa, 450°C enters a nozzle operating at steady state with a velocity of 50 m/s. Steam leaves the nozzle at 2 Mpa and 300°C. The inlet area of the nozzle is 80 cm^2 and heat loss from the nozzle surface occurs at the rate of 100 KW. Determine: [8]
    i) The mass flow rate of steam
    ii) The exit velocity of the steam and
    iii) The exit area of the nozzle
    [Refer the attached table for the properties of steam]
11. A control mass system consists of ice and water 12 kg of water, at 37°C is mixed with 8 kg of ice at -27°C. Assuming the process of mixing is adiabatic, find the change of entropy. Latent heat of ice = 336kJ/kg, C_p for water = 4.2 kJ/kg k. [8]
12. A 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]
    a) The pressure and temperature at the end of each process of the cycle.
    b) The thermal efficiency. [Take C_v=718 J/kg.k, Υ=1.4]
13. An exterior wall of a residential building of 25 cm thick brick [k=0.7 W/m.°C] followed by layers of 2cm thick cement plaster [k=0.48 W/m.°C] on both sides. What thickness of extruded polystyrene insulation [k=0.035 W/m.°C] should be added to reduce the heat loss (or gain) through the wall by 55 percent? [6]

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TABLE 1 **Properties of SATURATED WATER – Temperature Table**

T	P	v_l	v_{lg}	v_g	u_l	u_{lg}	u_g	h_l	h_{lg}	h_g	s_l	s_{lg}	s_g
^{0}C	kPa	m^3/kg	m^3/kg	m^3/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K	kJ/kg.K
145	415.29	0.001085	0.4453	0.4464	610.30	1944.5	2554.8	610.75	2129.4	2740.2	1.7910	5.0926	6.8836
150	475.72	0.001090	0.3918	0.3929	631.80	1927.7	2559.5	632.32	2114.1	2746.4	1.8421	4.9960	6.8381
155	542.99	0.001096	0.3457	0.3468	653.35	1910.7	2564.0	653.95	2098.4	2752.3	1.8927	4.9010	6.7937
160	617.66	0.001102	0.3060	0.3071	674.97	1893.3	2568.3	675.65	2082.3	2758.0	1.9429	4.8074	6.7503

TABLE 2 **Properties of SATURATED WATER – Pressure Table**

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	^{0}C	m^3/kg	m^3/kg	m^3/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K	kJ/kg.K
1900	209.84	0.001172	0.1035	0.1047	894.70	1704.0	2598.7	896.92	1900.7	2797.6	2.4231	3.9353	6.3584
2000	212.42	0.001177	0.09841	0.09959	906.33	1693.2	2599.5	908.69	1890.0	2798.7	2.4471	3.8925	6.3396
2250	218.45	0.001187	0.08753	0.08872	933.70	1667.5	2601.2	936.37	1864.4	2800.8	2.5032	3.7926	6.2958
3250	238.37	0.001226	0.06027	0.06150	1025.5	1577.7	2603.2	1029.5	1773.6	2803.1	2.6865	3.4673	6.1538
3500	242.60	0.001235	0.05582	0.05705	1045.3	1557.6	2602.9	1049.6	1753.0	2802.6	2.7251	3.3989	6.1240
3750	246.59	0.001244	0.05194	0.05318	1064.2	1538.1	2602.3	1068.8	1732.9	2801.7	2.7616	3.3341	6.0957
4000	250.39	0.001252	0.04852	0.04977	1082.2	1519.3	2601.5	1087.2	1713.4	2800.6	2.7962	3.2727	6.0689
5000	263.98	0.001286	0.03815	0.03944	1147.8	1448.7	2596.5	1154.2	1639.5	2793.7	2.9201	3.0524	5.9725

TABLE 3 **Properties of SUPERHEATED STEAM**

P	T	v	u	h	s
kPa	^{0}C	m^3/kg	kJ/kg	kJ/kg	kJ/kg.K
2000	(212.42)	(0.09959)	(2599.5)	(2798.7)	(6.3396)
	250	0.1114	2678.8	2901.6	6.5438
	300	0.1254	2771.8	3022.7	6.7651
	350	0.1386	2859.4	3136.6	6.9556
	400	0.1512	2945.1	3247.5	7.1269
	450	0.1635	3030.5	3357.6	7.2845

P	T	v	u	h	s
kPa	^{0}C	m^3/kg	kJ/kg	kJ/kg	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	7.2335

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INSTITUTE OF ENGINEERING

Examination Control Division

2069 Bhadra

Exam.	**Regular (2066 & Later Batch)**		
Level	BE	**Full Marks**	80
Programme	BEL, BEX, BCT, BIE, B. Agri.	**Pass Marks**	32
Year / Part	I / II	**Time**	3 hrs.

Subject: - Fundamentals of Thermodynamics and Heat Transfer ***(ME 452)***

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

. Differentiate between closed system and open system with suitable examples. [5]

2. Define total energy of a system. And differentiate between the stored energy and transient energy with examples. [4]

3. Sketch saturation curve of water in T-v with the help of isobar lines. Show all important points, lines and region. Also define saturation temperature and quality. [6]

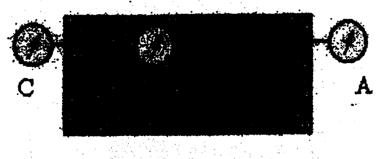
4. Write down general expressions for mass and energy conversion for a control volume. Reduce these equations for an adiabatic nozzle and condenser. [6]

5. Derive expression of entropy generation for a control mass. [6]

6. Write the assumptions of an air standard analysis. Sketch an ideal diesel cycle on P-v and T-s diagrams. Also compare Otto and diesel cycle. [6]

7. Derive an expression for steady state radial heat conduction through a hollow cylinder. Also derive expression for its thermal resistance. [4]

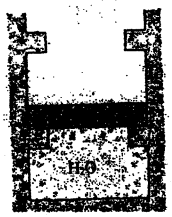
8. A vessel shown has two compartments as shown in figure below at different pressures. The pressure gauge A reads 4 bar and B reads 2 bar. The barometer reads 760mm of Hg. Calculate the reading of gauge C. [Take $\rho = 13600 kg/m^3$ and $g = 9.81 m/s^2$] [5]



9. A one liter closed vessel contains water at its critical conditions. This vessel is cooled until its pressure drops to 1 MPa. Calculate the mass of water in the vessel, the final dryness fraction and final temperature. Also show the process on P-v at T-v diagrams. [6]

10. Consider the piston/cylinder arrangement as shown figure below. When the piston rests on the lower stops, the enclosed volume is 400L. When the piston reaches the upper stops, the volume is 600L. the cylinder initially contains water at 100kPa, 20% quality. It is heated until the water eventually exists as saturated vapor. It takes a pressure of 300kPa to lift the piston. Sketch P-v and T-v diagrams and determine the work transfer and heat transfer for the overall process. [8]

7



11. The conditions of steam at entrance and exit of a turbine are: h_1 = 3456.5kJ/kg, S_1=7.2338kJ/kgK, V_1 = 150m/s; and h_2 = 2792.8kJ/kg, S_2 = 7.4665 kJ/kgK, V_2 = 100m/s respectively. The work output per kg of steam flow is 600kJ. Heat transfer between of 500K. Determine the entropy generation per kg steam flow. [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. [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 = 0.5W/mK). What thickness of rock wool insulation (k = 0.065W/mK) should be added to reduce the heat transfer through the wall by 50%? [8]

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24 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division

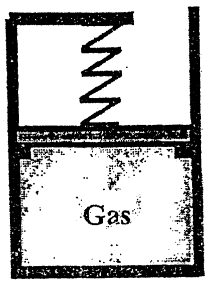
2068 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT, BIE, B.Agri.	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental 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.*

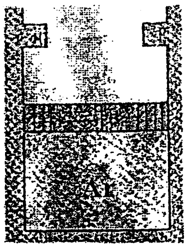
1. Differentiate between microscopic and macroscopic view point of thermodynamics. [4]
2. Write down the similarities and differences between heat transfer and work transfer. [4]
3. Define pure substance. State and explain 'State Postulate'. [4]
4. Write down general mass conservation and energy conservation equations for a control volume. Also derive mass and energy conservation equations for a gas filling process in a gas station. [6]
5. Write down classical statements of second law of thermodynamics. Derive the equivalence between Kelvin Plank's and Clausius's statement of 2^{nd} law of thermodynamics. [6]
6. What is air standard cycle? Differentiate between diesel cycle and otto cycle. [6]
7. Derive the heat transfer for composite plane wall. State the electrical analogy for thermal resistance. [6]
8. A piston cylinder device loaded with a linear spring with a spring constant of k = 100kN/m contains a gas initially at a pressure of P_{atm} = 100 kPa and a volume of $0.05 m^3$, as shown in figure below. The mass and cross sectional area of the piston are 50 kg and $0.01 m^2$ respectively. Heat is supplied to the system until its volume doubles, determine the final pressure. [Take $g = 9.81 m/s^2$] [6]



9. A rigid vessel having a volume of $0.02 m^3$, initially contains water at its critical state. The vessel is cooled until its pressure drops to 2000kPa. Sketch the process on P-V and T-V diagrams and determine: [6]
   a) The mass of H_2O present in the vessel
   b) The quality at final state
   c) The mass of saturated liquid water and saturated water vapour at the final state. [Refer attached table for the properties of steam].

10. Argon (100g) is in the piston-cylinder device shown in the figure below. The initial pressure is 6.0 MPa and temperature is 200C. There is a heat transfer to the argon, causing the piston to rise until it hits the stops. There is an additional heat transfer until the final pressure is 8.0 MPa and temperature is 800°C. [8]

a) Draw the process on P-V and T-V diagrams
b) Find the total work done in the process [Take = 208J/kgK].



11. A heat pump having a coefficient of 50% of the theoretical maximum maintains a house at a temperature of 20°C. The heat leakage from the house occurs at a rate of 0.8kW per degree temperature difference. For a maximum power input of 1.5kW, determine the minimum surroundings temperature for which the heat pump will be sufficient? [8]

12. A steam power plant operates on a simple Rankine cycle between the pressure limits of 2 MPa and 20 kPa. The temperature of the steam at the turbine inlet is 400°C, and the mass flow rate of steam is 50kg/s. Determine: [8]

a) The thermal efficiency of the cycle
b) The net power output of the plant [Refer attached table for the properties of steam]

13. The inside surface of an insulating layer is at 300°C and the outside surface is dissipating heat by convection into air at 25°C. The insulating layer has a thickness of 5cm and thermal conductivity of 0.8W/mK. What is the minimum heat transfer coefficient at the outside surface if the outside surface temperature should not exceed 100°C? [8]

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24 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

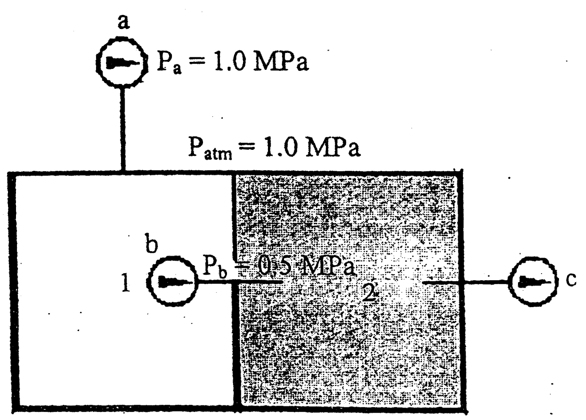
2067 Mangsir

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT, BIE, B.Agri.	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental 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 charts are attached herewith.__*
- ✓ *Assume suitable data if necessary.*

1. Define thermodynamic process. Sketch P-v, T-v and P-T diagram for an ideal gas undergoing isothermal expansion. [5]
2. Define work transfer and heat transfer. Also mention their sign conventions used in the analysis of thermodynamic problems. [4]
3. Define: saturation temperature, saturated vapor, quality, subcooled liquid and critical point. [5]
4. Define steady and unsteady state system. Derive the expression of conservation of mass and conservation of energy for control volume having steady and unsteady flow. [6]
5. Define reversible heat transfer reservoir and reversible work transfer reservoir. Derive expressions for change in entropy for reversible heat transfer reservoir and reversible work transfer reservoir. [8]
6. Differentiate between power cycle and refrigeration cycle. Sketch components, P-v and T-s diagrams for Rankine cycle. [6]
7. Define thermal resistance. Write down expressions of thermal resistance for plane wall, hollow cylinder and convection heat transfer. Derive an expression of heat transfer for a composite plane wall consisting of three layers using thermal resistance, inside and outside wall temperature. [6]
8. Attached to the containers shown in figure below are three pressure gauges. Determine the absolute pressure in compartment 2 and reading of pressure gauge c. [5]



9 A rigid container with a volume of $0.170 m^3$ is initially filled with steam at 200 kPa and 350°C. It is cooled to 90°C. [7]

a) At what temperature does a phase change starts 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 steam]

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 $100 mm^2$. At the exit, the area is $860 mm^2$, and the exit velocity is 20m/s. Determine the exit temperature and pressure of the air. [Take C_P = 1005 J/kg K, R =287J/kg K]. [8]

11. Steam at 700kPa with a quality of 0.96, is throttled down to 350kpa. Calculate the change of entropy per unit mass of steam. [Refer the attached table for properties of steam.] [6]

12. Air enters the compressor of an ideal air standard Brayton cycle at 100kpa, 300k, with a volumetric flow rate of $5 m^3/s$. The compressor pressure ratio is 10. The turbine inlet temperature is 1400k. Determine: [8]

a) The thermal efficiency of the cycle
b) The net power developed, in kW. [Take R = 287J/kg K, cp = 1005J/kg K, Y = 1.4]

13. The inside surface of an insulating layer is at 270°C, and the outside surface is dissipating heat by convention in to air at 20°C. The insulation layer is 4 cm thick and has thermal conductivity of 1.2W/m.K. What is the minimum value of the heat transfer coefficient at the outside surface if the outside temperature is not to exceed 70°C? [6]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 Shrawan

Exam.		Back	
Level	BE	Full Marks	80
Programme	BEX, BCT	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - 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. Define quality of a two-phase mixture. Water at atmospheric condition is heated to superheated vapor state under constant pressure condition. Sketch the heating process on P-v, T-v and T-s diagrams. [5]
2. Prove that "*There exists a property of a closed system such that a change in its value is equal to the difference between the heat supplied and the work done during any change of state.*" [6]
3. Write down classical statements of second law of thermodynamics. [3]
4. Sketch P-V and T-S diagrams for air standard Otto and air standard Diesel cycle. List the differences between Otto and Diesel cycle. [5]
5. ~~Define thermal resistance. Write down expressions for thermal resistances for plane wall,~~ hollow cylinder and convection heat transfer. Derive an expression for a composite plane wall consisting of three layers using thermal resistance. [6]
6. Define viscosity. Explain the effect of temperature and pressure on viscosity. [4]
7. Differentiate between Laminar and turbulent flow. Also define Reynolds Number. [5]
8. Define turbine. How turbines are classified according to head? [4]
9. Air (2 kg) is contained in a vertical frictionless piston-cylinder device shown in *Figure P.9*. The mass of the piston is such that the air has a pressure and temperature of 10.0 MPa and 75.5^{0}C. There is a heat transfer to the cylinder until the piston reaches some stops, at which point the total volume is 0.04 m^3. There is an additional heat transfer to the air until the pressure is 15.0 MPa. Determine the total heat transfer and the total work, and show the process on P-v and T-v diagrams. [$R = 287$ *J/kg.K*, $c_v = 718$ *J/kg.K*] [10]

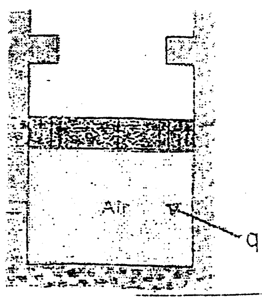


Figure P.9

10. Steam at 800 kPa and 300^{0}C is flowing with a velocity of 45 m/s reversibly and adiabatically through a nozzle and leaves the nozzle at 100 kPa. Determine the exit velocity of the steam in m/s. [*Refer the attached table for properties of steam*] [8]

11. An air-standard Diesel cycle has a compression ratio of 18, and the heat transferred to the working fluid per cycle is 1800 kJ/kg. At the beginning of the compression process the pressure is 0.1 MPa and the temperature is 15^0C. Determine:
   (a) The pressure and temperature at each point in the cycle.
   (b) The thermal efficiency.
   (c) The mean effective pressure.
   [*Take* $c_p = 1.005$ *kJ/kg and* $c_v = 0.718$ *kJ/kg*]. [10]

12. An insulated steam pipe passes through a room in which the air and walls are at 25^0C. The outside diameter of the pipe is 70 mm, and its surface temperature and emissivity are 200^0C and 0.8 respectively. If the coefficient associated with free convection heat transfer from the surface to the air is 15 W/m^2K, what is the rate of heal loss from the surface per unit length of the pipe? [$\sigma = 5.67 \times 10^{-8}\ W/m^2K^4$] [7]

13. Water is flowing at the rate of 40 liters/s through a tapering pipe. The diameters at the bottom and upper ends are 300 mm and 200 mm respectively. If the pressure at the bottom and upper ends are 250 kPa and 100 kPa respectively determine the difference in datum head. [$\rho = 1000\ kg/m^3$, $g = 9.81\ m/s^2$] [7]

TABLE 1 **Properties of SATURATED WATER – Pressure Table**

P kPa	T ^{0}C	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
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	7.39
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	7.358
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	7.354
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	6.707
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	6.684
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	6.662
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	6.64

TABLE 2 **Properties of SUPERHEATED STEAM**

P kPa	T ^{0}C	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg.K
800	(170.44)	(0.2404)	(2576.6)	(2768.9)	(6.6625)
	200	0.2607	2630.2	2838.8	6.8151
	250	0.2931	2714.8	2949.3	7.0373
	300	0.3241	2796.6	3055.9	7.2319
	350	0.3544	2877.9	3161.4	7.4084
	400	0.3843	2959.6	3267.0	7.5713
	450	0.4139	3042.2	3373.3	7.7237
	500	0.4433	3126.1	3480.7	7.8673
	550	0.4726	3211.3	3589.4	8.0036

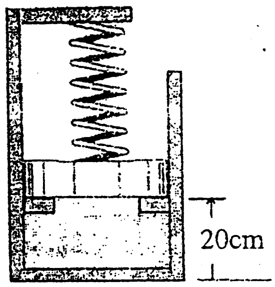
34 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2066 Magh

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

Subject: - 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. Sketch the following process on P-v, T-v and T-s diagrams: [5]
   a) Water at compressed liquid state is heated to super heated vapor state in a cylinder with a freely moving cylinder.
   b) Water at two phase mixture (saturated liquid and saturated vapor) state is heated to super heated vapor state in a rigid vessel.
2. Define total energy of a system. Also differentiate between the stored energy and transient energy. [5]
3. Define steady state work applications. Write down the steady state energy equation and reduce it for an adiabatic turbine. Explain which properties are significant for a gas turbine. [5]
4. Define a polytropic process. Sketch polytropic processes with n = 0, 1, 1.4 and ∞ on a common P-v diagram. Derive an expression for work transfer for an isothermal process. [5]
5. Air (m = 0.1 kg) is contained in piston/cylinder assembly as shown in figure. Initially, the piston rests on the stops and is in contact with the spring, which is in its unstretched position. The spring constant is 100 kN/m. The piston weighs 30 kN and atmospheric pressure is 101 kPa. The air is initially at 300K and 200 kPa. Heat transfer occurs until the air temperature reaches the surrounding temperature, 700K. [10]
   a) Find the final pressure and volume
   b) Find the process work
   c) Find the heat transfer
   d) Draw the P-V diagram of the process. [Take R = 287 J/kgK, C_V = 718 J/kg K]



6. Steam enters a nozzle at 400°C and 800 kPa with a velocity of 10 m/s, and leaves at 300°C and 200 kPa while losing heat at a rate of 25 kW. For an inlet area of 800cm^2, determine the velocity and the volume flow rate of the steam at the nozzle exit. [Refer the attached table for properties of steam] [8]

7. State Clausius Inequality. Explain it for reversible and irreversible refrigerators. [5]

8. The pressure and temperature at the beginning of compression of an air-standard diesel cycle are 95 kPa and 300K, respectively. At the end of the heat addition, the pressure is 7.2 MPa and the temperature is 2150K. Determine: [10]

   a) the compression ratio
   b) the cutoff ratio
   c) the thermal efficiency of the cycle. [$R = 287$ J/kg, $C_V = 718$ J/kg K]

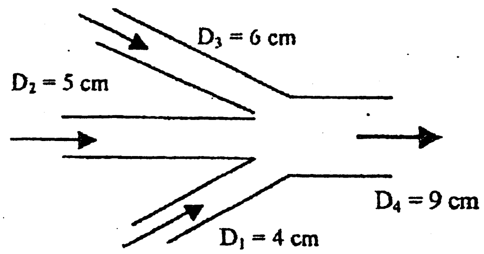
9. Derive an expression for an overall heat transfer coefficient for a composite cylinder consisting of three cylindrical layers subjected to convection on both sides. [5]

10. The roof of an electrically heated home is 8m long, 6m wide, and 0.25m thick, and is made of a flat layer of concrete whose thermal conductivity is $k = 0.8$ W/m.K. The temperatures of the inner and the outer surfaces of the roof on night are measured to be 15°C and 4°C, respectively, for a period of 10 hours. Determine: [6]

    a) the rate of heat loss through the roof for that night, and
    b) the cost of that heat loss to the home owner if the cost of electricity is Rs. 10/kWh.

11. Define: Cohesive force, Pressure head, Stream line and Coefficient of Lift. [5]

12. Three pipes steadily deliver water to a large exit pipe shown in figure. For velocity $V_2 = 5$ m/s, and the exit flow rate $Q_4 = 120$ m^3/h, find (a) V_1; (b) V_3; and (c) V_4 if it is known that increasing Q_3 by 20% would increase Q_4 by 10%. [6]



13. Define turbomachine and hydraulic machine. Differentiate between turbine and pump. [5]

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34 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2065 Kartik

Exam.		Back	
Level	BE	Full Marks	80
Programme	BEX, BCT	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - 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**.*
- ✓ *Assume suitable data if necessary.*

1. Explain the laws of thermodynamics. Define the entropy as a function of state. [5]

2. a) Write down the general steady flow energy equation. Derive the simplified forms when used for the centrifugal pump and table fan. [5]

   b) Water is in a piston/cylinder maintaining constant pressure at 700 KPa, quality 90% with a volume of $0.1m^3$. A heater is turned on, heating the water with 2.5 KW. How long does it take to vaporize all the liquid? [8]

3. a) Define heat engine, refrigerator and heat pump. Explain why the performance of heat engine is measured in terms of efficiency but that of refrigerator and heat pump is in terms of COP? Why does the expression for COP differ for refrigerator and heat pump? [5]

   b) A Carnot engine operates between two reservoirs at temperature T_L and T_H. The work output of the engine is 0.6 times the heat rejected. The difference in temperatures between the source and the sink is 200°c. Calculate the thermal efficiency, the source temperature and the sink temperature. [6]

4. a) Using T-S and P-V diagram, prove that, for the same quantity of heat added, increase of compression ratio increases the thermal efficiency of an Otto-Cycle. [8]

   b) Consider a steam power plant operating on the simple ideal Rankine Cycle. The steam enters the turbine at 3 Mpa and 350°c and is condensed in the condenser at a pressure 80 Kpa. Determine the thermal efficiency of the cycle. [8]

5. a) Derive an expression for the heat loss and overall heat transfer coefficient through a composite wall of layers considering the convective heat transfer coefficient. [8]

   b) Air at 27°c and 1 atm flows over a flat plate at a temperature of 60°c with a speed of 2 m/s. Calculate the heat transferred in the first 20cm of the plate and 40cm of the plate. (Properties at the film temperature 43.5°c are $\upsilon = 17.36\times10^{-6} m^2/s$, K = 0.02749 w/m°c, Pr = 0.7, Cp = 1.006 Kj/Kgk) [8]

6. a) Explain the characteristics of laminar and turbulent boundary layer. [5]

   b) The diameter of a pipe changes from 200mm at a section of 5m above datum to 50mm at a section 3m above datum. The pressure of water at first section is 500 Kpa. If the velocity of flow at the first section is 1m/s, determine the pressure at the second section. [8]

7. Describe the working principles of impulse and reaction turbine. [6]

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9

31 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Ashwin

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT, BIE, B. Agri.	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental of Thermodynamics and Heat Transfer *(ME452)*

- ✓ 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. Differentiate between Microscopic and Macroscopic viewpoint with examples. [4]
2. Derive expressions for displacement work transfer for the following process: [4]
   a) Constant- Pressure Process
   b) Constant temperature process and
   c) Polytrophic process
3. Explain how saturation curve is formed on T-v diagram. [4]
4. State first law of thermodynamics for a control mass undergoing cyclic process. Write the mass and energy equations for a control volume and reduce them for steady state process. [6]
5. Define isentropic process. Derive isentropic relations for an ideal gas and incompressible substances. [6]
6. Sketch an ideal Brayton cycle on P-v and T-s diagrams; also derive an expression for its efficiency. [6]
7. Derive an expression for conduction heat transfer through a composite cylinder. [6]
8. A mercury manometer is used to measure the pressure in stream pipe. The level of the mercury in the manometer is 97.5 mm. Find the absolute pressure of stream inside the pipe. If the reading of the manometer drops to 80 mm, what is the new pressure of steam? [6]

   [Take sp.gr. of Hg = 13.6, P_{atm} = 760 mm of Hg and g = 9.81 m/s^2]
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. (Steam tables are attached here with) [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?
10. A gas turbine develops 60 MW of power output, Mass flow rate of gas is found to be 80 kg/s. Properties of gas at inlet and exit of the turbine are as follows: [8]

Properties	Inlet	Outlet
Pressure	8 MPa	0.1 MPa
Temperature	500°C	50°C
Velocity	50 m/s	150 m/s
Elevation above the reference level	10 m	5 m

   a) Determine the rate at which heat is lost from the turbine surface.
   b) Determine the inlet and outlet areas. [Take R = 287 J/kg.k C_p = 1005 J/kgk)

Table A 2.2: Properties of SATURATED WATER – Temperature Table

T ^{0}C	P kPa	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
5	0.8726	0.001000	147.02	147.02	21.020	2360.4	2381.4	21.021	2488.7	2509.7	0.07626	8.9473	9.0236
10	1.2281	0.001000	106.32	106.32	41.986	2346.3	2388.3	41.988	2476.9	2518.9	0.1510	8.7476	8.8986
15	1.7056	0.001001	77.896	77.897	62.915	2332.3	2395.2	62.917	2465.1	2528.0	0.2242	8.5550	8.7792
20	2.3388	0.001002	57.777	57.778	83.833	2318.2	2402.0	83.835	2453.4	2537.2	0.2962	8.3689	8.6651
25	3.1690	0.001003	43.356	43.357	104.75	2304.1	2408.9	104.75	2441.6	2546.3	0.3670	8.1888	8.5558
30	4.2455	0.001004	32.895	32.896	125.67	2290.0	2415.7	125.67	2429.6	2555.3	0.4365	8.0148	8.4513
35	5.6267	0.001006	25.219	25.220	146.58	2275.9	2422.5	146.59	2417.8	2564.4	0.5050	7.8461	8.3511
40	7.3814	0.001008	19.527	19.528	167.50	2261.7	2429.2	167.50	2405.9	2573.4	0.5723	7.6827	8.2550
45	9.5898	0.001010	15.262	15.263	188.41	2247.5	2435.9	188.42	2393.9	2582.3	0.6385	7.5244	8.1629
50	12.344	0.001012	12.036	12.037	209.31	[illegible]	2442.6	209.33	2381.9	2591.2	0.7037	7.3708	8.0745
55	15.752	0.001015	9.5716	9.5726	230.22	2219.0	2449.2	230.24	2369.8	2600.0	0.7679	7.2217	7.9896
60	19.932	0.001017	7.6733	7.6743	251.13	2204.7	2455.8	251.15	2357.7	2608.8	0.8312	7.0768	7.9080
65	25.022	0.001020	6.1986	6.1996	272.05	2190.3	2462.4	272.08	2345.4	2617.5	0.8935	6.9360	7.8295
70	31.176	0.001023	5.0437	5.0447	292.98	2175.8	2468.8	293.01	2333.1	2626.1	0.9549	6.7991	7.7540
75	38.563	0.001026	4.1323	4.1333	313.92	2161.3	2475.2	313.96	2320.6	2634.6	1.0155	6.6658	7.6813
80	47.373	0.001029	3.4078	3.4088	334.88	2146.7	2481.6	334.93	2308.2	2643.1	1.0753	6.5359	7.6112
85	57.815	0.001032	2.8279	2.8289	355.86	2132.0	2487.9	355.92	2295.5	2651.4	1.1343	6.4093	7.5436
90	70.117	0.001036	2.3607	2.3617	376.86	2117.1	2494.0	376.93	2282.7	2659.6	1.1925	6.2859	7.4784
95	84.529	0.001040	1.9818	1.9828	397.89	2102.2	2500.1	397.98	2269.7	2667.7	1.2501	6.1653	7.4154
100	101.32	0.001043	1.6726	1.6736	418.96	2087.1	2506.1	419.06	2256.6	2675.7	1.3069	6.0476	7.3545
105	120.79	0.001047	1.4190	1.4200	440.05	2072.1	2512.1	440.18	2243.4	2683.6	1.3630	5.9326	7.2956
110	143.24	0.001052	1.2095	1.2106	461.19	2056.7	2517.9	461.34	2230.0	2691.3	1.4186	5.8200	7.2386
115	169.02	0.001056	1.0359	1.0370	482.36	2041.1	2523.5	482.54	2216.3	2698.8	1.4735	5.7098	7.1833
120	198.48	0.001060	0.8911	0.8922	503.57	2025.5	2529.1	503.78	2202.4	2706.2	1.5278	5.6019	7.1297
125	232.01	0.001065	0.7698	0.7709	524.82	2009.7	2534.5	525.07	2188.3	2713.4	1.5815	5.4962	7.0777

10

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

12. An engine working on a diesel cycle has a compression ratio of 16 and the cut off takes place at 8% of the stroke. Determine its air standard efficiency. What will be new efficiency if compression ratio is increased to 20? [Take $\gamma = 1.4$]. [8]

13. A 150 mm steam pipe (k = 42 W/mK) has inside diameter of 120 mm and outside diameter of 160 mm. It is insulated at the outside with asbestos (k = 0.8 W/mK). The steam temperature is 150°C and the air temperature is 20°C. The heat transfer co-efficient for inner and outer surfaces are 100 W/m^2K and 30 W/m^2K. How thick should the asbestos to be provided in order to limit the hat loss to 2.1 kW/m^2? [6]

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P kPa	T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg.K
200	(120.24)	(0.8859)	(2529.4)	(2706.5)	(7.1272)
	150	0.9597	2576.7	2768.6	7.2793
	200	1.0803	2653.9	2870.0	7.5059
	250	1.1988	2730.8	2970.5	7.7078
	300	1.3162	2808.2	3071.4	7.8920
	350	1.4329	2886.7	3173.[illegible]	8.0624
	400	1.5493	2966.6	3276.4	8.2216
	450	1.6655	3047.9	3381.0	8.3714
	500	1.7814	3130.8	3487.1	8.5133
	550	1.8973	3215.4	3594.9	8.6483
	600	2.0130	3301.7	3704.3	8.7773
	650	2.1287	3389.7	3815.4	8.9011
	700	2.2443	3479.4	3928.3	9.0201
	750	2.3599	3570.9	4042.9	9.1350
	800	2.4755	3664.1	4159.2	9.2460
	850	2.5910	3759.1	4277.3	9.3536

P kPa	T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg.K
300	(133.56)	(0.6059)	(2543.5)	(2725.3)	(6.9921)
	150	0.6339	2570.7	2760.9	7.0779
	200	0.7163	2650.2	2865.1	7.3108
	250	0.7963	2728.2	2967.1	7.5157
	300	0.8753	2806.3	3068.9	7.7015
	350	0.9536	2885.3	3171.3	7.8729
	400	1.0315	2965.4	3274.9	8.0[illegible]27
	450	1.1092	3047.0	3379.7	8.1830
	500	1.1867	3130.1	3486.1	8.3252
	550	1.2641	3214.7	3594.0	8.4604
	600	1.3414	3301.1	3703.5	8.5895
	650	1.4186	3389.1	3814.7	8.7134
	700	1.4958	3478.9	3927.7	8.8325
	750	1.5729	3570.5	4042.3	8.9475
	800	1.6500	3663.8	4158.8	9.0585
	850	1.7271	3758.8	4276.9	9.1661

11. a) Name the following complexes by IUPAC system [2+3]

 i) $[Cr(H_2O)_5Cl]Cl_2$

 ii) $[Co(en)_3]Br_3$

 iii) $K_2[NiCl_4]$

 iv) $[Cr(C_6H_6)_2]$

 b) How does Werner's theory explain the structures of complex compounds?

12. What are primary and low explosives? Give the preparation and uses of glycerol trinitrate. [2+3]

13. a) What is paint? Give the requisites of a good paint. [3+2]

 b) What are lubricating oils? Indicate their importance in engineering fiels.

14. a) What isomerism is shown by butenedioic acid and why? [3+2]

 b) Differentiate between racemic mixture and meso compound.

15. What are elimination reactions? Write the mechanism of E^2 reaction taking an example. Show your acquaintance to Saytzeff's rule. [1+2+2]

16. What do you mean by SN reactions? Explain reaction mechanism for the hydrolysis of 3° alky halide by aqueous sodium hydroxide. [1+4]

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22

49 (Minimum)

14 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Baishakh

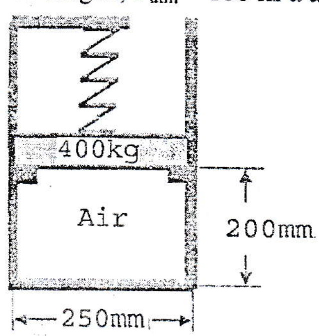
Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT, BAM, BIE, BAG	Pass Marks	32
Year / Part	I / II	Time	3 hrs.

Subject: - Fundamental of Thermodynamic and Heat Transfer *(ME 452)*

- ✓ 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.*

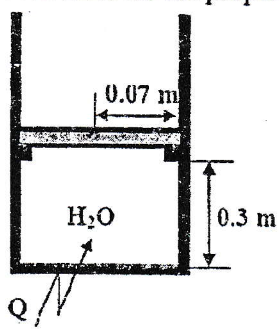
1. Differentiate between: (a) intensive property and extensive property; (b) state function and path function. [4]
2. Define internal energy and total energy of a system. Derive work transfer for an ideal gas undergoing an isothermal process. [4]
3. Sketch the saturation curve of water with the help of isobaric lines and isothermal lines. [4]
4. Derive an expression for mass flow rate through a uniform section of any control volume. Differentiate between steady and unsteady state control volume with examples. [6]
5. Define reversible work transfer reservoir. Also derive expressions for the change in entropy due to reversible work transfer process and interpret the result. [6]
6. Differentiate between Gas cycle and Vapor cycle with the appropriate examples. Sketch the components of a gas turbine power plant and corresponding processes on P-v and T-s diagrams. [6]
7. Using thermal resistance approach derive an expression for inside overall heat transfer coefficients for two layers of hollow cylinder subjected to convection medium 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 force on it. Heat is added to the system until the piston is displaced upward by 80 mm. Determine

   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] [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:

   a) the mass of H_2O in the system, and
   b) the total work transfer. [Refer attached table for the properties of steam] [8]



10. Air flows steadily through an adiabatic compressor entering at 150 kPa. 150°C and with a velocity of 200 m/s and leaving at 100 kPa, 500°C and with a velocity of 100 m/s. The exit area of the compressor is 100 cm^2. Determine

   a) the mass flow rate of air through the compressor, and
   b) the power required to drive the compressor.
   [Take R = 287 J/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 net entropy change due to the process. [Take C_v = 10.183 kJ/kgK] [8]

12. The compression ratio of an ideal Otto cycle is 8.5.At the beginning of the compression stroke, air is at 100 kPa and 27°C. The pressure is doubled during the constant volume heat addition process. Determine: [8]

   a) the heat added per kg of air
   b) the net work output per kg of air,
   c) the thermal efficiency, and
   d) the mean effective pressure
   [Take C_v = 718 J/Kg.k, γ = 1.4]

13. A hot plate of length 80 cm, width 50 cm and thickness 4 cm is placed in air stream at 20°C. It is estimated that a total of 300 W is lost from the plate surface by radiation when it has a outer surface temperature of 250°C at steady state. If the convective heat transfer coefficient is 25 W/m^2K and the thermal conductivity of the plate is 50 W/mK, determine the inside surface temperature of the plate. [6]

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