04

TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

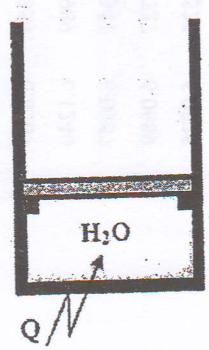
2075 Ashwin

Exam.	Back		
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. Define thermodynamic property. Explain intensive and extensive property with examples. [4]
2. Define polytropic process. Sketch polytropic processes with n = 0, 1, γ 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^{2}K. Determine the total heat loss from the unit length of the pipe. [Take $\sigma = 5.67\times10^{-8}$ w/m^{2}k^4] [6]

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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.K
9.0	43.771	0.001009	16.202	16.203	183.27	2251.0	2434.3	183.27	2396.8	2580.1	0.6223	7.5629	8.1852
9.5	44.817	0.001010	15.398	15.399	187.64	2248.1	2435.7	187.65	2394.4	2582.0	0.6361	7.5301	8.1662
10	45.817	0.001010	14.673	14.674	191.82	2245.2	2437.0	191.83	2392.0	2583.8	0.6493	7.4989	8.1482
15	53.983	0.001014	10.022	10.023	225.97	2221.9	2447.9	225.98	2372.2	2598.2	0.7550	7.2516	8.0066
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
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
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 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
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
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
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

Table 3: Properties of Superheated Steam

P kPa	T ^{0}C	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg.K
400	(143.64)	(0.4625)	(2553.5)	(2738.5)	(6.8961)
	150	0.4708	2564.4	2752.8	6.9300
	200	0.5342	2646.4	2860.1	7.1699
	250	0.5951	2725.6	2963.6	7.3779
	300	0.6548	2804.4	3066.3	7.5654
	350	0.7139	2883.8	3169.4	7.7378
	400	0.7726	2964.3	3273.3	7.8982

P kPa	T ^{0}C	v m^3/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	7.2335

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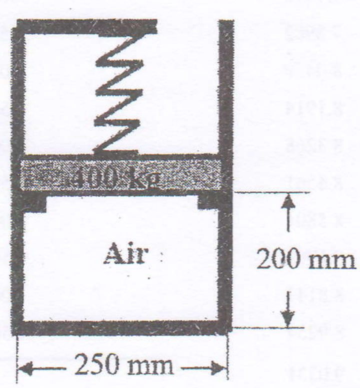
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Chaitra

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

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

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

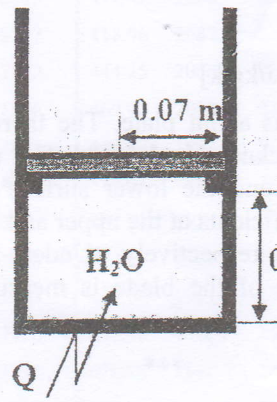
1. State and explain Zeroth law of thermodynamics. Also write down its application. [4]
2. Compare heat and work with suitable examples. Prove that work is a path function. [4]
3. Define pure substance. Explain why quality is necessary to define the state of a two phase mixture. [4]
4. Differentiate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



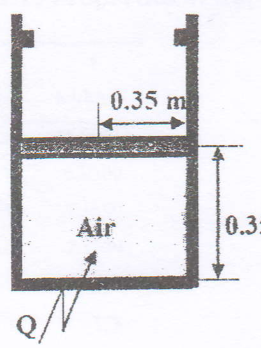
9. A piston cylinder device shown in figure below contains water initially at a pressure of 125 kPa with a quality of 50%. Heat is added to the system until it reaches to a final temperature of 800°C. It takes a pressure of 600 kPa to lift the piston from the stops. Sketch the process on P-V and T-V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

i) The mass of H_2O in the system and

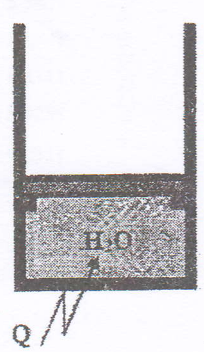
ii) The total work transfer



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



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



P.T.O

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

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

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

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

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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	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
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
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	6.82[illegible]
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	681.42	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

Table 2: Properties of Superheated Steam

P kPa	T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg.K
400	(143.64)	(0.4625)	(2553.5)	(2738.5)	(6.8961)
	150	0.4708	2564.4	2752.8	6.9300
	200	0.5342	2646.4	2860.1	7.1699
	250	0.5951	2725.6	2963.6	7.3779
	300	0.6548	2804.4	3066.3	7.5654
	350	0.7139	2883.8	3169.4	7.7378
	400	0.7726	2964.3	3273.3	7.8982
	450	0.8311	3046.0	3378.5	8.0489
	500	0.8894	3129.3	3485.0	8.1914
	550	0.9475	3214.1	3593.1	8.3268
	600	1.0056	3300.5	3702.7	8.4561
	650	1.0636	3388.6	3814.1	8.5801
	700	1.1215	3478.5	3927.1	8.6993
	750	1.1794	3570.1	4041.8	8.8143
	800	1.2373	3663.4	4158.3	8.9254
	850	1.2951	3758.4	4276.5	9.0331

P kPa	T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg.K
600	(158.86)	(0.3156)	(2567.3)	(2756.7)	(6.7601)
	200	0.3520	2638.5	2849.7	6.9658
	250	0.3938	2720.3	2956.6	7.1806
	300	0.4344	2800.5	3061.2	7.3716
	350	0.4742	2880.9	3165.4	7.5[illegible]
	400	0.5137	2961.9	3270.2	7.7076
	450	0.5529	3044.1	3375.9	7.8591
	500	0.5920	3127.7	3482.9	8.0022
	550	0.6309	3212.7	3591.2	8.1380
	600	0.6697	3299.3	3701.2	8.2676
	650	0.7085	3387.6	3812.7	8.3918
	700	0.7472	3477.6	3925.9	8.5112
	750	0.7859	3569.2	4040.8	8.6264
	800	0.8246	3662.7	4157.4	8.7376
	850	0.8632	3757.8	4275.7	8.8453

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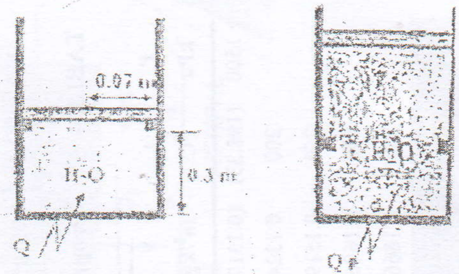
Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE, BME, BGE	Pass Marks	32
Year / Part	I / I	Time	3 hrs.

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

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] [

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, γ = 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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TABLE 3 Properties of SATURATED WATER – Pressure Table [Continued]

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	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
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
1200	188.00	0.001138	0.1622	0.1633	797.31	1791.1	2588.4	798.68	1985.6	2784.3	2.2167	4.3059	6.5226
1300	191.64	0.001144	0.1501	0.1512	813.44	1777.1	2590.5	814.93	1972.1	2787.0	2.2515	4.2430	6.4945
1400	195.08	0.001149	0.1397	0.1408	828.67	1763.6	2592.3	830.28	1959.1	2789.4	2.2842	4.1841	6.4683
1500	198.33	0.001154	0.1305	0.1317	843.12	1750.8	2593.9	844.85	1946.7	2791.5	2.3150	4.1288	6.4438
1600	201.41	0.001159	0.1225	0.1237	856.88	1738.4	2595.3	858.73	1934.6	2793.3	2.3441	4.0766	6.4207
1700	204.35	0.001163	0.1155	0.1167	870.02	1726.6	2596.6	872.00	1923.0	2795.0	2.3717	4.0272	6.3989
1800	207.15	0.001168	0.1092	0.1104	882.61	1715.1	2597.7	884.71	1911.7	2796.4	2.3980	3.9801	6.3781
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

TABLE 2 Properties of SATURATED WATER – Temperature Table

T °C	P kPa	v_l m³/kg	v_{lg} m³/kg	v_g m³/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
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

TABLE 4 Properties of SUPERHEATED STEAM [Continued]

P kPa	T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg.K
1500	(198.33)	(0.1317)	(2593.9)	(2791.5)	(6.4438)
	200	0.1324	2597.5	2796.1	6.4536
	250	0.1519	2694.6	2922.4	6.7077
	300	0.1696	2782.5	3036.9	6.9168
	350	0.1866	2867.2	3147.1	7.1011
	400	0.2030	2951.2	3255.7	7.2687
	450	0.2192	3035.4	3364.2	7.4242
	500	0.2351	3120.4	3473.1	7.5699
	550	0.2510	3206.5	3583.0	7.7076
	600	0.2668	3294.0	3694.2	7.8386
	650	0.2825	3382.9	3806.6	7.9639
	700	0.2981	3473.4	3920.6	8.0841
	750	0.3137	3565.6	4036.1	8.1999
	800	0.3293	3659.3	4153.2	8.3116
	850	0.3448	3754.8	4272.0	8.4198

P kPa	T °C	v m³/kg	u kJ/kg	h kJ/kg	s 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	3357.5	7.2845
	500	0.1757	3116.3	3467.7	7.4318
	550	0.1877	3203.1	3578.4	7.5706
	600	0.1996	3291.0	3690.2	7.7024
	650	0.2114	3380.3	3803.2	7.8283
	700	0.2232	3471.1	3917.6	7.9490
	750	0.2350	3563.5	4033.5	8.0651
	800	0.2467	3657.5	4150.9	8.1771
	850	0.2584	3753.1	4269.9	8.2855

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]

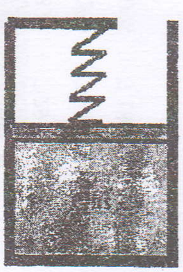


Figure P.8

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

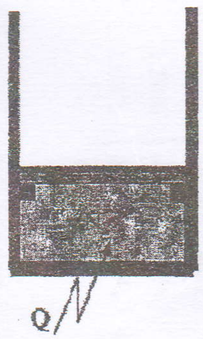


Figure P.10

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]

***

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
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

Table 2: Properties of Superheated Steam

P	T	v	u	h	s
kPa	^{0}C	m^3/kg	kJ/kg	kJ/kg	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	3173.3	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

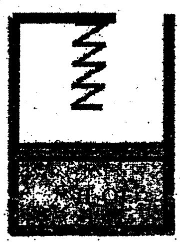
04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Chaitra

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)*

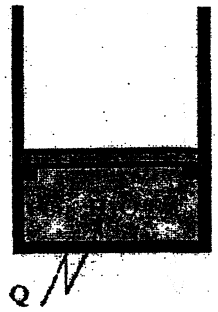
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary tables are attached herewith.*
- ✓ *Assume suitable data if necessary.*

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 Cp = 1005 J/kg.k, $\gamma = 1.4$]

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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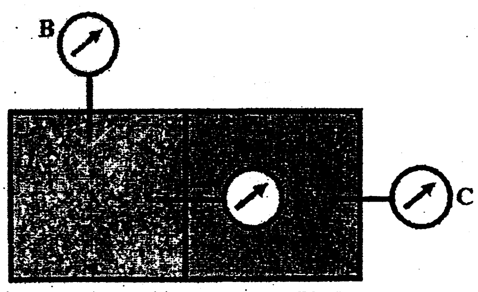
04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Chaitra

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

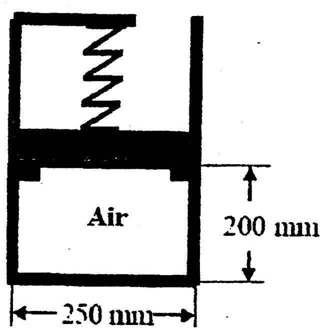
Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE, BME, BGE	Pass Marks	32
Year / Part	I / I	Time	3 hrs.

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

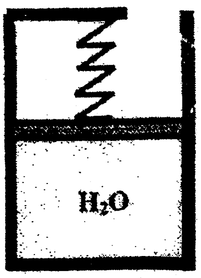
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary figures are attached herewith.***
- ✓ *Assume suitable data if necessary.*

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 $¾^{th}$ 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]

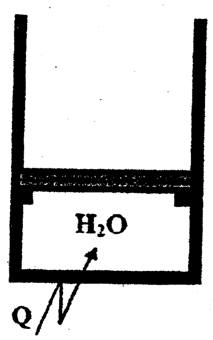

Figure P. 9

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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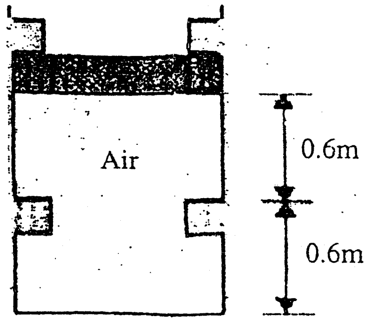
04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Baishakh

Exam.	Regular / Back		
Level	BE	Full Marks	80
Program	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 0.15m^3 and a pressure of 120 kPa to a volume of 0.25m^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 0.05m^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 3. 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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04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 Ashadh

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

Subject: - Fundamental of Thermodynamics & 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.***
- *ssume suitable data if necessary.*

1. Define thermodynamic property and thermodynamic state. List two important features of a thermodynamic property. [4]
2. Define total energy of a system. Also differentiate between stored energy and transient energy with examples. [4]
3. Define pure substance. Derive an expression for specific volume of a two phase mixture in terms of quality. [4]
4. Write down general steady state energy equation. Reduce it for an adiabatic turbine, an adiabatic diffuser and throttling valve. Also mention relevant assumptions for each device. [6]
5. Define heat pump and COP. Explain how performance of reversible and irreversible heat pump can be evaluated by applying first law and second law of thermodynamics. [6]
6. Define air standard analysis. Also list the assumptions of an air standard analysis. [4]
7. Derive an expression for overall heat transfer coefficient for composite plane wall consisting of two layers with convection on both sides. [6]
8. Air (m = 0.1 kg) is contained in piston/cylinder assembly as shown in *Figure P.8*. 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/kg K*] [6]

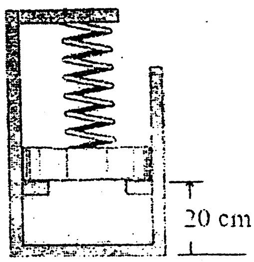


Figure P.8

9. A closed, rigid container of volume 0.5 m^3 is placed on a hot plate. Initially, the container holds two phase mixture of saturated liquid water and saturated water vapor at $T_1 = 100^0C$ with a quality of 0.2. After heating, the temperature in the container is $T_2 = 150^0$ C. Indicate the initial and final states on P-v and T –v diagrams, and determine
   - **(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. [*Refer attached table for the properties of steam*] **[8]**

10. Carbon monoxide (2 kg), contained in the piston-cylinder device as shown in *Figure P.10*, is initially at a pressure of 1.0 MPa and a temperature of 50^0C. Energy is added until the final temperature is 500^0C and the pressure is 2.0 MPa. A pressure of 2.0 MPa is required to lift the frictionless piston from the stops. Show the process on P-V and T-V diagrams and determine the total work transfer and total heat transfer. [Take $R = 297\ J/kg\ K$, $C_V = 743\ J/kg\ K$] **[8]**

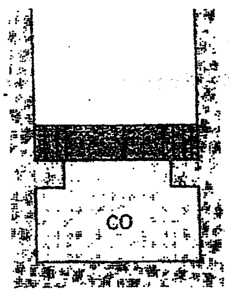


Figure P.10

11. Steam enters the nozzle at 1 MPa, 300^0C, with a velocity of 30 m/s. The pressure of the steam at the nozzle exit is 0.3 MPa. Determine the exit velocity of the steam from the nozzle, assuming a reversible and adiabatic steady flow process. [*Refer attached table for the properties of steam*] **[8]**

12. Calculate the efficiency and specific work output of a simple gas turbine working on the Brayton cycle. The maximum and minimum temperatures of the cycle are 1000 K and 288 K respectively, the pressure ratio is 6. [Take $\gamma = 1.4$, $C_P = 1005\ J/kg\ K$] **[10]**

13. A 2 m long, 0.3 cm diameter electrical wire extends across a room at 15^0C. Heat is generated in the wire as a result of resistance heating, and the surface temperature of the wire is measured to be 152^0C in steady operation. Also, the voltage drop and electric current through the wire are measured to be 60 V and 1.5 A, respectively. Disregarding any heat transfer by radiation, determine the convection heat transfer coefficient for heat transfer between the outer surface of the wire and the air in the room. **[6]**

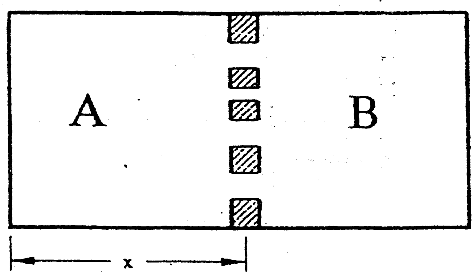
04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 Ashwin

Exam.	New Back (2066 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

✓ 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.*

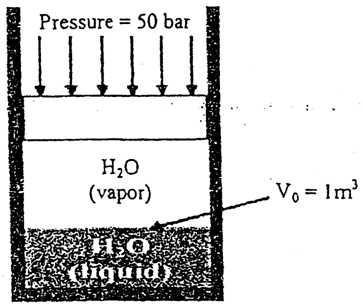
1. Define thermodynamic system. Also differentiate between different types of thermodynamic system with examples. [6]
2. Define work transfer. Derive an expression for work transfer for a polytropic process. [4]
3. Define saturation temperature, saturated vapor, critical point and moisture content. [4]
4. Explain first law of thermodynamics for a control mass with reference to conservation principles. [6]
5. Derive expressions for change in entropy for an ideal gas incompressible substance. [7]
6. Sketch components of Rankine cycle. Also sketch Rankine cycle on P-v and T-s diagram and write an expression for its efficiency. [6]
7. Define convection heat transfer. Differentiate between free and forced convection. [4]
8. The device as shown in figure below has a piston with holes positioned between the two chambers. If the piston is moved so that x is one fourth of the entire length, determine the final mass of air in the chamber A and B. [4]



$V_{tot} = 1\ m^3$

$v_A = v_B = 100\ m^3/kg$

9. A piston cylinder system as shown in figure below with an initial volume of 1 m^3 is surrounded by a constant pressure of 50 bar. Initially there is a liquid vapor mixture of water with quality 0.32 inside the cylinder. This water is cooled to 110°C. Determine work and heat transfer for the process. [8]



10. A gas undergoes a thermodynamic cycle consisting of three processes:

Process 1-2: compression with PV = constant, from P_1 = 100kpa, V_1 =1.6m^3 to V_2 = 0.2m^3
Process 2-3: constant pressure to $V_3 = V_1$
Process 3-1: constant volume $U_1 - U_3 = -3549$ kJ.

There are no significant changes in kinetic and potential energy. Sketch the cycle on P-V and T-V diagrams and determine the work transfer and heat for process 2-3, in kJ. Determine its net work and confirm whether it is a power cycle or a refrigeration cycle? [8]

11. Steam enters an adiabatic turbine at 6MPa, 800°C, and 80m/s and leaves at 100kPa and 140m/s. If the power output of the turbine is 8MW, determine the mass flow rate of the steam flowing through turbine assuming isentropic process. [7]

12. An oil engine works on the ideal constant pressure cycle. The overall compression ratio is 11:1 and constant pressure energy addition ceases at 10% of the stroke. The pressure and temperature at the commencement of compression are 0.96 bar and 18°C, respectively. Determine [8]

a) The thermal efficiency of cycle
b) The work done of cycle

13. A house has 2000m^2 wall area that consists of 1cm of plaster plates (k = 1.2W/mK), 6cm insulation with (k = 0.04W/mK) and outside brick layer 10cm thick, 200m^2 windows with two 2mm thick glass (k= 0.95W/mK) panes separated by 2cm air (k = 0.015W/mK) gap. Assume no inside convective layer but an outside at 35°C. Find the thermal resistance of the walls and the windows both per square meter. Find the total heat transfer rate to inside. [8]

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