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	1 / 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 °C	v_f m^3/kg	v_{fg} m^3/kg	v_g m^3/kg	u_f kJ/kg	u_{fg} kJ/kg	u_g kJ/kg	h_f kJ/kg	h_{fg} kJ/kg	h_g kJ/kg	s_f kJ/kg.K	s_{fg} kJ/kg.K	s_g kJ/kg.K
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	0.4352	0.4363	613.91	1941.7	2555.6	614.37	2126.9	2741.3	1.7996	5.0162	6.8158
450	147.94	0.001088	0.4129	0.4140	622.93	1934.7	2557.6	623.42	2120.5	2743.9	1.8214	5.0056	6.8507
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	151.82	0.001093	0.3738	0.3749	639.84	1921.2	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