04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Kartik

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

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

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

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

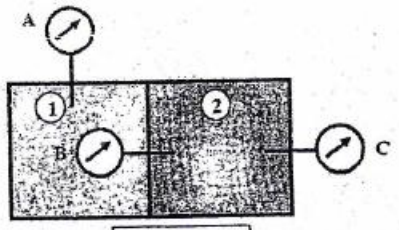

Figure P1

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

[Refer the attached table for properties of water]

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

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

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

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

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

    [Take Cp = 1005 J/kg.K, γ = 1.4]

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

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Properties of SATURATED WATER – Pressure Table

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