

Program: B. Sc. in Electrical & Electronic Engineering  
Semester: 3<sup>rd</sup>

Date: 9 December, 2023  
Time: 1:30 pm – 4:30 pm

**ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)**  
**ORGANISATION OF ISLAMIC COOPERATION (OIC)**  
**DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING**

Semester Final Examination  
Course Number: MCE 4391  
Course Title: Basic Mechanical Engineering (EEE)

Winter Semester: 2022 - 2023  
Full Marks: 150  
Time: 3 Hours

There are six questions. Answer **all the** questions. The symbols have their usual meanings. Marks of each question are mentioned with the questions and corresponding CO and PO and the total marks are written on the right side. Assume reasonable value of missing data.

1. a) A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 0.2 MPa and 0.5 MPa. The mass flow rate of the refrigerant is 0.08 kg/s. 25  
(CO2)  
(PO2)
- (i) **Illustrate** the system diagram along with P-h diagram. (3 marks)
  - (ii) **Briefly explain** the function of the components of the system. (5 marks)
- Determine the followings:**
- (iii) **Enthalpy** at all points. (4 marks)
  - (iv) The **rate of heat removal** from the refrigerated space. (2 marks)
  - (v) The **power input** to the compressor. (2 marks)
  - (vi) The **rate of heat rejection** to the environment. (2 marks)
  - (vii) The **COP** of the refrigerator. (2 marks)
- b) **Derive** mathematical relation between COP of refrigeration and heat pump system (5 marks)
2. a) 25  
(CO4)  
(PO1)
- (i) **Describe** how steam is formed and illustrate the effect of increasing and decreasing pressure on the process using P-v diagram. Identify different lines and points from the P-v diagram. (5 marks)
  - (ii) **Find the properties** of steam mentioned below, under the following conditions using the steam table:
    - a. Saturation temperature at 160 kPa. (2 mark)
    - b. Saturation pressure at 150°C. (1 mark)
    - c. At saturated condition,  $T=120^{\circ}\text{C}$  and  $h = 2500$  kJ/Kg find the dryness fraction. (2 marks)
    - d. At superheated condition,  $P=16$  MPa and  $T=600^{\circ}\text{C}$  find the enthalpy. (2 mark)

- b) (i) **Discuss the working principle** of boiler through the illustration of simple diagram. (5 marks)
- (ii) Write a **short note** on boiler mountings and accessories. (4 marks)
- (iii) Explain **any two** of the following terms briefly: (4 marks)
- Superheater.
  - Water level indicator.
  - Manhole.
  - Economizer
3. a) (i) **Define vapor pressure and cavitation.** (4 marks)
- (ii) **Classify** different types of fluid flow. (5 marks)
- (iii) **Differentiate** between **Newtonian fluid** and **non-Newtonian fluid.** (3 marks)
- (iv) **Explain** the reason why viscosity of liquids decreases, and the viscosity of gases increases with temperature. (3 marks)
- b) A piezometer and a Pitot tube are tapped into a 40-mm diameter horizontal water pipe, and the height of the water columns are measured to be 0.26 m in the piezometer and 350 mm in the Pitot tube (both measured from the top surface of the pipe).
- Draw** the setup described above. (2 marks)
  - Determine** the velocity at the center of the pipe. (3 marks)
- c) The pressure difference between an oil pipe and waterpipe is measured by a double-fluid manometer, as shown in Fig.1. For the given fluid heights and specific gravities, calculate the pressure difference  $\Delta P = P_B - P_A$ . (5 marks)

25  
(CO5)  
(PO1)  
(PO2)

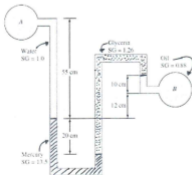


Fig.1

- 4 a) **Illustrate** the construction details of an IC engine. (4 marks) 25 (CO3)
- b) **Illustrate** the engine terminologies in a single diagram and explain them briefly. (8 marks) (PO1)
- c) (i) **Illustrate and explain** the working principle of a two-stroke engine. (7 marks)
- (ii) **Illustrate and explain** briefly, any three from the following terms: (6 marks)
- Cylinder block and Cylinder liner
  - Piston and Crankcase
  - Connecting Rod and Crankshaft
  - Intake and exhaust valve, Cylinder Head
- 5 a) (i) **Define priming** and its necessity in centrifugal pump. (3 marks) 25
- (ii) **Differentiate** between **pump, fan, blower,** and **compressor** in a tabular format. (4 marks) (CO5) (PO1)
- b) **Illustrate** the components of a **hydroelectric powerplant** and explain briefly. (6 marks)
- c) (i) **State** a side-by-side comparison between **impulse** and **reaction turbine**. (4 marks)
- (ii) **Illustrate** a **Pelton wheel, Francis** and **Kaplan** turbine with proper labelling and explain them briefly. (8 marks)
- 6 a) In a piston cylinder arrangement, a gas of with volume  $0.192 \text{ m}^3$  is compressed with compression ratio of 13.5 using the law  $p v^{1.37} = C$ . At the beginning of the compression, the state of working fluid is 1 bar and 316 K. [R=289 J/kg.K,  $C_p = 0.996 \text{ kJ/kg.K}$ ] 25 (CO2) (PO2)
- Identify and illustrate** the process through P-v diagram. (1 marks)
  - Determine** the mass of the working fluid. (1 marks)
  - Determine** temperature, pressure, and volume at the end of the compression. (3 marks)
- b) **State and elaborate** the Clausius and Kelvin-Planck statements and discuss the perpetual motion machine of second kind based on those statements. (5 marks)
- c) An ideal otto cycle has a compression ratio of 8 using 1 kg of air. At the beginning of the compression process, air is at 100 kPa and  $17^\circ\text{C}$ . 800 kJ/kg heat is transferred to air during the constant-volume heat addition process. (Take  $R=0.287 \text{ kJ/kg.K}$ ,  $C_p = 1.001 \text{ kJ/kg.K}$  and  $C_v = 0.707 \text{ kJ/kg.K}$ )
- Illustrate** the P-v and T-s diagram of the above-mentioned cycle and identify the processes. (4 marks)
  - Find** T, P and V at each state. (8 marks)
  - Calculate** the  $W_{in}$ . (2 marks)
  - Calculate** the thermal efficiency of the system. (1 marks)

## Saturated Water-Pressure Table

**TABLE A-3**

Saturated water—Pressure table

Press., P, kPa	Sat. temp., T <sub>sat</sub> , °C	Specific volume, m <sup>3</sup> /kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg·K		
		Sat. liquid, v <sub>f</sub>	Sat. vapor, v <sub>g</sub>	Sat. liquid, u <sub>f</sub>	Evap., u <sub>fg</sub>	Sat. vapor, u <sub>g</sub>	Sat. liquid, h <sub>f</sub>	Evap., h <sub>fg</sub>	Sat. vapor, h <sub>g</sub>	Sat. liquid, s <sub>f</sub>	Evap., s <sub>fg</sub>	Sat. vapor, s <sub>g</sub>
20	60.06	0.001017	7.6481	251.40	2204.6	2456.0	251.42	2357.5	2608.9	0.8320	7.0752	7.9073
25	64.06	0.001020	6.2034	271.93	2190.4	2462.4	271.96	2345.5	2617.5	0.8932	6.9370	7.8302
30	69.09	0.001022	5.2287	289.24	2178.5	2467.7	289.27	2335.3	2624.6	0.9441	6.8234	7.7675
40	75.86	0.001026	3.9933	317.58	2158.8	2476.3	317.62	2318.4	2636.1	1.0261	6.6430	7.6691
50	81.32	0.001030	3.2403	340.49	2142.7	2483.2	340.54	2304.7	2645.2	1.0912	6.5019	7.5931
75	91.76	0.001037	2.2172	384.36	2111.8	2496.1	384.44	2278.0	2662.4	1.2132	6.2426	7.4558
100	99.61	0.001043	1.6941	417.40	2088.2	2505.6	417.51	2257.5	2675.0	1.3028	6.0562	7.3580
101.325	99.97	0.001043	1.6734	418.95	2087.0	2506.0	419.06	2256.5	2675.6	1.3069	6.0476	7.3545
125	105.97	0.001048	1.3750	444.23	2068.8	2513.0	444.36	2240.6	2684.9	1.3741	5.9100	7.2841
150	111.35	0.001053	1.1594	466.97	2052.3	2519.2	467.13	2226.0	2693.1	1.4337	5.7894	7.2231
175	116.04	0.001057	1.0037	486.82	2037.7	2524.5	487.01	2213.1	2700.2	1.4850	5.6865	7.1716
200	120.21	0.001061	0.88578	504.50	2024.6	2529.1	504.71	2201.6	2706.3	1.5302	5.5968	7.1270
225	123.97	0.001064	0.79329	520.47	2012.7	2533.2	520.71	2191.0	2711.7	1.5706	5.5171	7.0877
250	127.41	0.001067	0.71873	535.08	2001.8	2536.8	535.35	2181.2	2716.5	1.6072	5.4453	7.0525
275	130.58	0.001070	0.65732	548.57	1991.6	2540.1	548.86	2172.0	2720.9	1.6408	5.3800	7.0207

## Saturated Water-Temperature Table

**TABLE A-4**

Saturated water—Temperature table

Temp., T, °C	Sat. press., P <sub>sat</sub> , kPa	Specific volume, m <sup>3</sup> /kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg·K		
		Sat. liquid, v <sub>f</sub>	Sat. vapor, v <sub>g</sub>	Sat. liquid, u <sub>f</sub>	Evap., u <sub>fg</sub>	Sat. vapor, u <sub>g</sub>	Sat. liquid, h <sub>f</sub>	Evap., h <sub>fg</sub>	Sat. vapor, h <sub>g</sub>	Sat. liquid, s <sub>f</sub>	Evap., s <sub>fg</sub>	Sat. vapor, s <sub>g</sub>
100	101.42	0.001043	1.6720	419.06	2087.0	2506.0	419.17	2256.4	2675.6	1.3072	6.0470	7.3542
105	120.90	0.001047	1.4186	440.15	2071.8	2511.9	440.28	2243.1	2683.4	1.3634	5.9319	7.2952
110	143.38	0.001052	1.2094	461.27	2056.4	2517.7	461.42	2229.7	2691.1	1.4188	5.8193	7.2382
115	169.18	0.001056	1.0360	482.42	2040.9	2523.3	482.59	2216.0	2698.6	1.4737	5.7092	7.1829
120	198.67	0.001060	0.89133	503.60	2025.3	2528.9	503.81	2202.1	2706.0	1.5279	5.6013	7.1292
125	232.23	0.001065	0.77012	524.83	2009.5	2534.3	525.07	2188.1	2713.1	1.5816	5.4996	7.0771
130	270.26	0.001070	0.66808	546.10	1993.4	2539.5	546.38	2173.7	2720.1	1.6346	5.3919	7.0265
135	313.22	0.001075	0.58179	567.41	1977.3	2544.7	567.75	2159.1	2726.9	1.6872	5.2901	6.9773
140	361.53	0.001080	0.50850	588.77	1960.9	2549.6	589.16	2144.3	2733.5	1.7392	5.1901	6.9294
145	415.68	0.001085	0.44600	610.19	1944.2	2554.4	610.64	2129.2	2739.8	1.7908	5.0919	6.8827
150	476.16	0.001091	0.39248	631.66	1927.4	2559.1	632.18	2113.8	2745.9	1.8418	4.9953	6.8371
155	543.49	0.001096	0.34648	653.19	1910.3	2563.5	653.79	2098.0	2751.8	1.8924	4.9002	6.7927
160	618.23	0.001102	0.30680	674.79	1893.0	2567.8	675.47	2082.0	2757.5	1.9426	4.8066	6.7492
165	700.93	0.001108	0.27244	696.46	1875.4	2571.9	697.24	2065.6	2762.8	1.9923	4.7143	6.7067
170	792.18	0.001114	0.24260	718.20	1857.5	2575.7	719.08	2048.8	2767.9	2.0417	4.6233	6.6650

## Superheated Water

**TABLE A-6**

Superheated water (Continued)

T °C	v m <sup>3</sup> /kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m <sup>3</sup> /kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m <sup>3</sup> /kg	u kJ/kg	h kJ/kg	s kJ/kg·K
P = 15.0 MPa (342.16°C)												
Sat.	0.010341	2455.7	2610.8	5.3108	0.007932	2390.7	2529.5	5.1435	0.005862	2294.8	2412.1	4.9310
350	0.011481	2520.9	2693.1	5.4438					0.009950	2617.9	2816.9	5.5526
400	0.015671	2740.6	2975.7	5.8819	0.012463	2684.3	2902.4	5.7211	0.012721	2807.3	3061.7	5.9043
450	0.018477	2880.8	3157.9	6.1434	0.015204	2845.4	3111.4	6.0212	0.014793	2945.3	3241.2	6.1446
500	0.020828	2998.4	3310.8	6.3480	0.017385	2972.4	3276.7	6.2424	0.016571	3064.7	3396.2	6.3390
550	0.022945	3106.7	3450.4	6.5290	0.019305	3085.8	3423.6	6.4266	0.018185	3175.3	3539.0	6.5075
600	0.024921	3209.3	3583.1	6.6796	0.021073	3192.5	3561.3	6.5890	0.019695	3281.4	3675.3	6.6593
650	0.026804	3310.1	3712.1	6.8033	0.022742	3295.8	3693.8	6.7366	0.021134	3385.1	3807.8	6.7991
700	0.028521	3409.8	3839.1	6.9573	0.024342	3397.5	3823.5	6.8735	0.0223870	3490.1	4067.5	7.0531
800	0.032123	3609.3	4091.1	7.2037	0.027405	3599.7	4079.3	7.1237	0.025484	3795.7	4325.4	7.2829
900	0.035503	3811.2	4343.7	7.4288	0.030348	3803.5	4334.6	7.3511	0.029020	4004.3	4584.7	7.4950
1000	0.038808	4017.1	4599.2	7.6378	0.033215	4010.7	4592.0	7.5616	0.031504	4216.9	4847.0	7.6933
1100	0.042062	4227.7	4858.6	7.8339	0.036029	4222.3	4852.8	7.7588	0.033952	4433.8	5112.9	7.8802
1200	0.045279	4443.1	5122.3	8.0192	0.038806	4438.5	5117.6	7.9449	0.036371	4655.2	5382.7	8.0574
1300	0.048469	4663.3	5390.3	8.1952	0.041556	4659.2	5386.5	8.1215				
P = 25.0 MPa												
P = 30.0 MPa												
P = 35.0 MPa												
375	0.001978	1799.9	1849.4	4.0345	0.001792	1738.1	1791.9	3.9313	0.001701	1707.8	1762.4	3.8724
400	0.006005	2428.5	2578.7	5.1400	0.002798	2058.9	2152.8	4.4758	0.002105	1914.9	1988.6	4.2144
425	0.009176	2607.8	2805.0	5.4708	0.005299	2452.9	2611.8	5.1473	0.003434	2253.3	2373.5	4.7751
450	0.009176	2721.2	2950.6	5.6759	0.006737	2618.9	2821.0	5.4422	0.004957	2497.5	2671.0	5.1946
500	0.011143	2887.3	3165.9	5.9643	0.008691	2824.0	3084.8	5.7956	0.006933	2755.3	2997.9	5.6331
550	0.012736	3020.8	3339.2	6.1816	0.010175	2974.5	3279.7	6.0403	0.008348	2925.8	3218.0	5.9093
600	0.014140	3140.0	3493.5	6.3637	0.011445	3103.4	3446.8	6.2373	0.009523	3065.6	3399.0	6.1229
650	0.015430	3251.9	3637.7	6.5243	0.012590	3221.7	3599.4	6.4074	0.010565	3190.9	3560.7	6.3030
700	0.016643	3359.9	3776.0	6.6702	0.013654	3334.3	3743.9	6.5699	0.011523	3308.3	3711.6	6.4623
800	0.018922	3570.7	4043.8	6.9322	0.015628	3551.2	4020.0	6.8301	0.013278	3531.6	3996.3	6.7409
900	0.021075	3780.2	4307.1	7.1668	0.017473	3764.6	4288.8	7.0699	0.014904	3749.0	4270.6	6.9853