

The Open University of Sri Lanka
 Faculty of Engineering Technology
 Department of Mechanical Engineering



Study Programme : Bachelor of Science Honours in Engineering
 Name of the Examination : Final Examination
Course Code and Title : DMX3401 - Fluid Mechanics and Thermodynamics
 Academic Year : 2024/2025
 Date : 12th February 2026
 Time : 0930hrs -1230hrs
 Duration : **3 hours**

General instructions

1. Read all instructions carefully before answering the questions.
2. Answer all **five (05)** questions. All questions carry equal marks.
3. This is a Closed Book Test (CBT).
4. Answers should be in clear hand writing.
5. Do not use Red colour pen.
6. Take the specific gas constant (R) for air as 0.287 kJ/kg K.
7. Density of water is 1000 kg/m³.
8. For air $C_v = 0.718$ kJ/kgK and $C_p = 1.005$ kJ/kg K
9. Take acceleration due to gravity as 9.81 ms⁻².

Q1. (a) Draw the Temperature (T) – Entropy (S) diagram for the Rankine Cycle of a simple steam power plant and explain all the processes.

(8 marks)

(b) In a steam power plant, steam is supplied, dry saturated at 60 bar to a turbine and the condenser pressure is 0.055 bar. If the plant operates on the Rankine cycle, calculate, per kg of steam:

- (i) the work output neglecting the feed pump work.
- (ii) the work required for the feed pump.
- (iii) the heat transferred to the condenser cooling water.
- (iv) the heat supplied to the boiler.
- (v) the Rankine efficiency, and
- (vi) the specific steam consumption (SSC).

(12 marks)

You may use the thermodynamic properties of steam provided at the end of the question paper.

- Q2. (a) Write down the steady flow energy equation and continuity equation explaining all the terms in those equations.

(8 marks)

- (b) In a steam power station, steam flows steadily through a 0.2 m diameter pipeline from the boiler to turbine. At the boiler end, the steam conditions are found to be: pressure(p) = 4MPa, temperature(t) = 400°C, enthalpy(h) = 3213.6 kJ/kg, and specific volume(v) = 0.073 m³/kg. At the turbine end the conditions are found to be: p = 3.5 MPa, t = 392°C, h = 3202.6 kJ/kg and v = 0.084 m³/kg. There is a heat loss of 8.5 kJ/kg from the pipeline. Calculate the steam flow rate.

(12 marks)

- Q3. (a) Write down the relationship between vacuum pressure, absolute pressure and gauge pressure defining each term.

(8 marks)

- (b) A cylindrical bucket(empty) 450 mm in diameter and 750 mm long is forced with its open end first into water until its lower edge is 6 m below the water surface. Determine the force required to maintain this position, if the trapped air remains at constant temperature during the whole operation. Atmospheric pressure = 1.01 bar. The wall thickness and weight of the bucket may be considered negligible.

(12 marks)

- Q4. (a) Define the terms “Total pressure (Total force)” and “Centre of pressure” in hydrostatics.

(6 marks)

- (b) Fig.Q4 shows a circular opening in the sloping wall of a reservoir closed by a disc valve 0.9 m diameter. The disc is hinged at H and a balance weight W is just sufficient to hold the valve closed when the reservoir is empty.

Determine the additional weight that must be placed on the arm at a point 1.2 m from the hinge, so that the valve will remain closed until the water level rises to 0.72 m above the centre of the valve.

(14 marks)

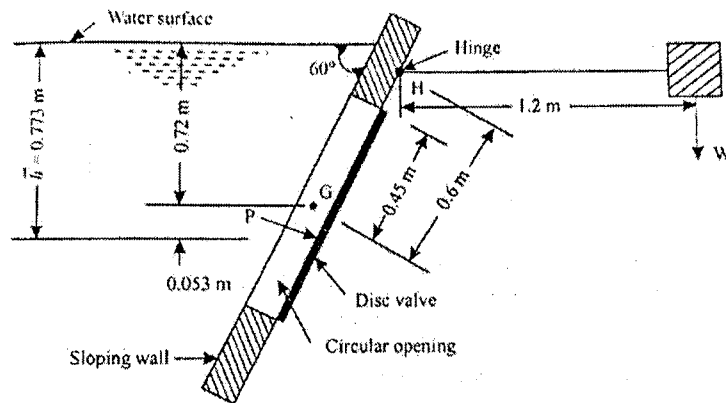


Fig.Q4.

- Q5. (a) Write down the Bernoulli's Equation and continuity equation in fluid dynamics and explain each term in those equations. (6 marks)
- (b) A 6 m long pipe is inclined at an angle of 20° with the horizontal. The smaller section of the pipe which is at lower level is of 100 mm diameter and the larger section of the pipe is 300 mm diameter as shown in Fig.Q5. If the pipe is uniformly tapering and the velocity of water at the smaller section is 1.8 m/s, determine the difference of pressures between the two sections.

(14 marks)

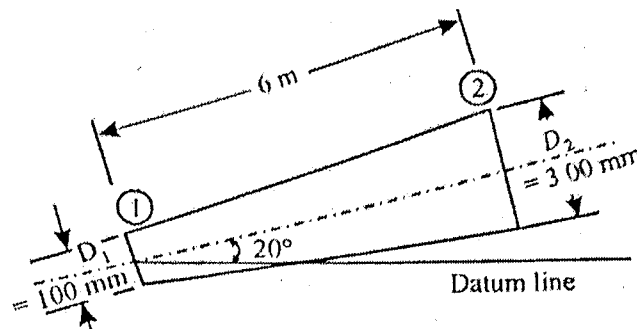


Fig.Q5.

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Saturated steam and Water

p [bar]	T_s [°C]	v_g [m ³ /kg]	u_f [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]
0.006112	0.01	206.1	0†	2375	0*	2501	2501	0†	9.155	9.155
0.010	7.0	129.2	29	2385	29	2485	2514	0.106	8.868	8.974
0.015	13.0	87.98	55	2393	55	2470	2525	0.196	8.631	8.827
0.020	17.5	67.01	73	2399	73	2460	2533	0.261	8.462	8.723
0.025	21.1	54.26	88	2403	88	2451	2539	0.312	8.330	8.642
0.030	24.1	45.67	101	2408	101	2444	2545	0.354	8.222	8.576
0.035	26.7	39.48	112	2412	112	2438	2550	0.391	8.130	8.521
0.040	29.0	34.80	121	2415	121	2433	2554	0.422	8.051	8.473
0.045	31.0	31.14	130	2418	130	2428	2558	0.451	7.980	8.431
0.050	32.9	28.20	138	2420	138	2423	2561	0.476	7.918	8.394
0.055	34.6	25.77	145	2422	145	2419	2564	0.500	7.860	8.360
0.060	36.2	23.74	152	2425	152	2415	2567	0.521	7.808	8.329
0.065	37.7	22.02	158	2427	158	2412	2570	0.541	7.760	8.301
0.070	39.0	20.53	163	2428	163	2409	2572	0.559	7.715	8.274
0.075	40.3	19.24	169	2430	169	2405	2574	0.576	7.674	8.250
0.080	41.5	18.10	174	2432	174	2402	2576	0.593	7.634	8.227
0.085	42.7	17.10	179	2434	179	2400	2579	0.608	7.598	8.206
0.090	43.8	16.20	183	2435	183	2397	2580	0.622	7.564	8.186
0.095	44.8	15.40	188	2436	188	2394	2582	0.636	7.531	8.167
0.100	45.8	14.67	192	2437	192	2392	2584	0.649	7.500	8.149
0.12	49.4	12.36	207	2442	207	2383	2590	0.696	7.389	8.085
0.14	52.6	10.69	220	2446	220	2376	2596	0.737	7.294	8.031
0.16	55.3	9.432	232	2450	232	2369	2601	0.772	7.213	7.985
0.18	57.8	8.444	242	2453	242	2363	2605	0.804	7.140	7.944
0.20	60.1	7.648	251	2456	251	2358	2609	0.832	7.075	7.907
0.22	62.2	6.994	260	2459	260	2353	2613	0.858	7.016	7.874
0.24	64.1	6.445	268	2461	268	2348	2616	0.882	6.962	7.844
0.26	65.9	5.979	276	2464	276	2343	2619	0.904	6.913	7.817
0.28	67.5	5.578	283	2466	283	2339	2622	0.925	6.866	7.791
0.30	69.1	5.228	289	2468	289	2336	2625	0.944	6.823	7.767
0.32	70.6	4.921	295	2470	295	2332	2627	0.962	6.783	7.745
0.34	72.0	4.649	302	2472	302	2328	2630	0.980	6.745	7.725
0.36	73.4	4.407	307	2473	307	2325	2632	0.996	6.709	7.705
0.38	74.7	4.189	312	2475	312	2322	2634	1.011	6.675	7.686
0.40	75.9	3.992	318	2476	318	2318	2636	1.026	6.643	7.669
0.42	77.1	3.814	323	2478	323	2315	2638	1.040	6.612	7.652
0.44	78.2	3.651	327	2479	327	2313	2640	1.054	6.582	7.636
0.46	79.3	3.502	332	2481	332	2310	2642	1.067	6.554	7.621
0.48	80.3	3.366	336	2482	336	2308	2644	1.079	6.528	7.607
0.50	81.3	3.239	340	2483	340	2305	2645	1.091	6.502	7.593
0.55	83.7	2.964	351	2486	351	2298	2649	1.119	6.442	7.561
0.60	86.0	2.731	360	2489	360	2293	2653	1.145	6.386	7.531
0.65	88.0	2.535	369	2492	369	2288	2657	1.169	6.335	7.504
0.70	90.0	2.364	377	2494	377	2283	2660	1.192	6.286	7.478
0.75	91.8	2.217	384	2496	384	2278	2662	1.213	6.243	7.456
0.80	93.5	2.087	392	2498	392	2273	2665	1.233	6.201	7.434
0.85	95.2	1.972	399	2500	399	2269	2668	1.252	6.162	7.414
0.90	96.7	1.869	405	2502	405	2266	2671	1.270	6.124	7.394
0.95	98.2	1.777	411	2504	411	2262	2673	1.287	6.089	7.376
1.00	99.6	1.694	417	2506	417	2258	2675	1.303	6.056	7.359

$$\begin{aligned}
 * \quad \frac{h_f}{[\text{kJ/kg}]} &= \frac{p v_f}{[\text{kJ/kg}]} = \frac{p}{[\text{bar}]} \times \frac{10^5 [\text{N}]}{[\text{m}^2]} \times \frac{v_f}{[\text{m}^3/\text{kg}]} \times \left[\frac{\text{m}^3}{\text{kg}} \right] \times \frac{[\text{kJ}]}{10^3 [\text{N m}]} \times \frac{1}{[\text{kJ/kg}]} \\
 &= \frac{p}{[\text{bar}]} \times \frac{v_f}{[\text{m}^3/\text{kg}]} \times 10^2 = 0.006112 \times 0.0010002 \times 10^2 = 0.0006112
 \end{aligned}$$

Saturated steam and Water

p [bar]	T_s [°C]	v_g [m ³ /kg]	u_f [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]
40	250.3	0.04977	1082	2602	1087	1714	2801	2.797	3.273	6.070
42	253.2	0.04732	1097	2601	1102	1698	2800	2.823	3.226	6.049
44	256.0	0.04509	1109	2600	1115	1683	2798	2.849	3.180	6.029
46	258.8	0.04305	1123	2599	1129	1668	2797	2.874	3.136	6.010
48	261.4	0.04117	1136	2598	1142	1654	2796	2.897	3.094	5.991
50	263.9	0.03944	1149	2597	1155	1639	2794	2.921	3.052	5.973
55	269.9	0.03563	1178	2594	1185	1605	2790	2.976	2.955	5.931
60	275.6	0.03244	1206	2590	1214	1570	2784	3.027	2.863	5.890
65	280.8	0.02972	1232	2586	1241	1538	2779	3.076	2.775	5.851
70	285.8	0.02737	1258	2581	1267	1505	2772	3.122	2.692	5.814
75	290.5	0.02532	1283	2576	1293	1473	2766	3.166	2.613	5.779
80	295.0	0.02352	1306	2570	1317	1441	2758	3.207	2.537	5.744
85	299.2	0.02192	1329	2565	1341	1410	2751	3.248	2.463	5.711
90	303.3	0.02048	1351	2559	1364	1379	2743	3.286	2.393	5.679
95	307.2	0.01919	1372	2552	1386	1348	2734	3.324	2.323	5.647
100	311.0	0.01802	1393	2545	1408	1317	2725	3.360	2.255	5.615
105	314.6	0.01696	1414	2537	1429	1286	2715	3.395	2.189	5.584
110	318.0	0.01598	1434	2529	1450	1255	2705	3.430	2.123	5.553
115	321.4	0.01508	1454	2522	1471	1224	2695	3.463	2.060	5.523
120	324.6	0.01426	1473	2514	1491	1194	2685	3.496	1.997	5.493
125	327.8	0.01349	1492	2505	1511	1163	2674	3.529	1.934	5.463
130	330.8	0.01278	1511	2496	1531	1131	2662	3.561	1.872	5.433
135	333.8	0.01211	1530	2487	1551	1099	2650	3.592	1.811	5.403
140	336.6	0.01149	1548	2477	1571	1067	2638	3.623	1.750	5.373
145	339.4	0.01090	1567	2467	1591	1034	2625	3.654	1.689	5.343
150	342.1	0.01035	1585	2456	1610	1001	2611	3.685	1.627	5.312
155	344.8	0.00982	1604	2445	1630	967	2597	3.715	1.565	5.280
160	347.3	0.00932	1623	2433	1650	932	2582	3.746	1.502	5.248
165	349.8	0.00884	1641	2420	1670	895	2565	3.777	1.437	5.214
170	352.3	0.00838	1660	2406	1690	858	2548	3.808	1.373	5.181
175	354.6	0.00794	1679	2391	1711	819	2530	3.839	1.305	5.144
180	357.0	0.00751	1699	2375	1732	778	2510	3.872	1.236	5.108
185	359.2	0.00709	1719	2358	1754	735	2489	3.905	1.163	5.068
190	361.4	0.00668	1740	2339	1777	689	2466	3.941	1.086	5.027
195	363.6	0.00627	1762	2318	1801	639	2440	3.977	1.004	4.981
200	365.7	0.00585	1786	2294	1827	584	2411	4.014	0.914	4.928
202	366.5	0.00569	1796	2283	1838	560	2398	4.031	0.875	4.906
204	367.4	0.00552	1806	2271	1849	535	2384	4.049	0.835	4.884
206	368.2	0.00534	1817	2259	1861	508	2369	4.067	0.792	4.859
208	369.0	0.00517	1829	2245	1874	479	2353	4.087	0.745	4.832
210	369.8	0.00498	1842	2231	1889	447	2336	4.108	0.695	4.803
212	370.6	0.00479	1856	2214	1904	412	2316	4.131	0.640	4.771
214	371.4	0.00458	1871	2196	1921	373	2294	4.157	0.579	4.736
216	372.1	0.00436	1888	2174	1940	328	2268	4.186	0.508	4.694
218	372.9	0.00409	1911	2146	1965	270	2235	4.224	0.417	4.641
220	373.7	0.00368	1949	2097	2008	170	2178	4.289	0.263	4.552
221.2	374.15	0.00317	2014	2014	2084	0	2084	4.406	0.000	4.406

Further Properties of Water and Steam

T [°C]	p_s [bar]	v_f $10^{-2}[\text{m}^3/\text{kg}]$	c_{pf} c_{pg} [kJ/kg K]	μ_f μ_g $10^{-6}[\text{kg}/\text{m s}]$	k_f k_g $10^{-6}[\text{kW}/\text{m K}]$	$(Pr)_f$	$(Pr)_g$
0.01	0.006112	0.10002	4.210 1.86	1752 8.49	569 16.3	12.96	0.97
5	0.008719	0.10001	4.204 1.86	1501 8.66	578 16.7	10.92	0.96
10	0.01227	0.10003	4.193 1.86	1300 8.83	587 17.1	9.29	0.96
15	0.01704	0.10010	4.186 1.87	1136 9.00	595 17.5	7.99	0.96
20	0.02337	0.10018	4.183 1.87	1002 9.18	603 17.9	6.95	0.96
25	0.03166	0.10030	4.181 1.88	890 9.35	611 18.3	6.09	0.96
30	0.04242	0.10044	4.179 1.88	797 9.52	618 18.7	5.39	0.96
35	0.05622	0.10060	4.178 1.88	718 9.70	625 19.1	4.80	0.96
40	0.07375	0.10079	4.179 1.89	651 9.87	632 19.5	4.30	0.96
45	0.09582	0.10099	4.181 1.89	594 10.0	638 19.9	3.89	0.95
50	0.1233	0.1012	4.182 1.90	544 10.2	643 20.4	3.54	0.95
55	0.1574	0.1015	4.183 1.90	501 10.4	648 20.8	3.23	0.95
60	0.1992	0.1017	4.185 1.91	463 10.6	653 21.2	2.97	0.95
65	0.2501	0.1020	4.188 1.92	430 10.7	658 21.6	2.74	0.95
70	0.3116	0.1023	4.191 1.93	400 10.9	662 22.0	2.53	0.96
75	0.3855	0.1026	4.194 1.94	374 11.1	666 22.5	2.36	0.96
80	0.4736	0.1029	4.198 1.95	351 11.3	670 22.9	2.20	0.96
85	0.5780	0.1032	4.203 1.96	330 11.4	673 23.3	2.06	0.96
90	0.7011	0.1036	4.208 1.97	311 11.6	676 23.8	1.94	0.96
95	0.8453	0.1040	4.213 1.99	294 11.8	678 24.3	1.83	0.97
100	1.01325	0.1044	4.219 2.01	279 12.0	681 24.8	1.73	0.97
105	1.208	0.1048	4.226 2.03	265 12.2	683 25.3	1.64	0.98
110	1.433	0.1052	4.233 2.05	252 12.4	684 25.8	1.56	0.99
115	1.691	0.1056	4.240 2.07	241 12.6	686 26.3	1.49	0.99
120	1.985	0.1060	4.248 2.09	230 12.8	687 26.8	1.42	1.00
125	2.321	0.1065	4.26 2.12	220 13.0	687 27.3	1.36	1.01
130	2.701	0.1070	4.27 2.15	211 13.2	688 27.8	1.31	1.02
135	3.131	0.1075	4.28 2.18	203 13.4	688 28.3	1.26	1.03
140	3.614	0.1080	4.29 2.21	195 13.5	688 28.8	1.22	1.04
145	4.155	0.1085	4.30 2.25	188 13.7	687 29.4	1.18	1.05
150	4.760	0.1091	4.32 2.29	181 13.9	687 30.0	1.14	1.07
160	6.181	0.1102	4.35 2.38	169 14.2	684 31.3	1.07	1.09
170	7.920	0.1114	4.38 2.49	159 14.6	681 32.6	1.02	1.12
180	10.03	0.1128	4.42 2.62	149 15.0	676 34.1	0.97	1.15
190	12.55	0.1142	4.46 2.76	141 15.3	671 35.7	0.94	1.18
200	15.55	0.1157	4.51 2.91	134 15.7	665 37.5	0.91	1.22
210	19.08	0.1173	4.56 3.07	127 16.0	657 39.4	0.88	1.25
220	23.20	0.1190	4.63 3.25	121 16.3	648 41.5	0.86	1.28
230	27.98	0.1209	4.70 3.45	116 16.7	639 43.9	0.85	1.31
240	33.48	0.1229	4.78 3.68	111 17.1	628 46.5	0.84	1.35
250	39.78	0.1251	4.87 3.94	107 17.5	616 49.5	0.85	1.39
260	46.94	0.1276	4.98 4.22	103 17.9	603 52.8	0.85	1.43
270	55.05	0.1302	5.10 4.55	99 18.3	589 56.6	0.86	1.47
280	64.19	0.1332	5.24 4.98	96 18.8	574 61.0	0.88	1.53
290	74.45	0.1366	5.42 5.46	93 19.3	558 66.0	0.90	1.60
300	85.92	0.1404	5.65 6.18	90 19.8	541 72.0	0.94	1.70
320	112.9	0.1499					
340	146.1	0.1639					
360	186.7	0.1894					
370	210.5	0.2225					
374.15	221.2	0.317					

The values for saturated water can be used with good accuracy above saturation pressure. The values for saturated steam can be used with only moderate accuracy below saturation pressure at temperatures greater than 200 °C.