UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING; MECHANICAL*
SUBJECT	:	**THERMODYNAMICS II**
CODE	:	**IMT 2111**
DATE	:	SUMMER SUPLEMENTARY EXAMINATION 4 DECEMBER 2014
DURATION	:	SESSION 1 (08:00 – 11:00)
WEIGHT	:	40 : 60
TOTAL MARKS	:	100

EXAMINER	:	Ms. C. POPA
MODERATOR	:	Mr. E. BAKAYA-KYAHURWA 2192
NUMBER OF PAGES	:	3 PAGES AND 7 ANNEXURES

INSTRUCTIONS:

1) ANSWER ALL QUESTIONS AND SHOW ALL CALCULATIONS AND UNITS.
2) QUESTIONS MAY BE DONE IN ANY ORDER,
3) UNDERLINE AFTER EVERY COMPLETED QUESTION

2/…

QUESTION 1

A steam plant working at a pressure of 3 MPa that consists of an economizer, evaporator and superheater is generating superheated steam at a temperature of 300 °C. The steam leaves the evaporator 94.5% dry while the water supply to the steam plant enters the economizer at 32 °C and experiences in the economizer a 128.1 °C temperature increase from its original temperature. If the plant is capable of generating 7835 kJ/h of superheated steam and has a thermal efficiency of 75% determine:

1.1. What is the temperature of water leaving the economizer and the heat added in the economizer per kg of water; (5)

1.2. The heat added per kilogram of water in the boiler and superheater respectively; (7)

1.3. Determine the quantity of coal required per hour to drive the plant if the lower calorific value of the coal available to the plant is 38.5 MJ/kg, (3)

1.4. Calculate the equivalent evaporative capacity from and at 100 °C; (2)

1.5. Reproduce and complete the heat balance for the boiler plant shown below.

kJ/kg of coal burnt		
IN	OUT	%
coal	economiser evaporator superheater unaccounted heat losses	

(8)

[25]

QUESTION 2

Steam at a pressure of 0.8 MPa is throttled to a pressure of 0.1 MPa and 100 °C.

2.1. Calculate the initial dryness fraction of the steam. Use Mollier diagram to check your answer and make a sketch showing how the values were obtained. (5)

2.2. Calculate the change in specific internal energy for the above process (10)

[15]

QUESTION 3

3.1. A six cylinder petrol engine has a capacity of 4.2 liters.
Calculate the clearance volume per cylinder in cm^3 if the compression ratio is 20:1. (3)

3.2. 1.8 m^3 of gas at a pressure of 100 kPa and a temperature of 94 °C is compressed according to the law $pV^{1.25} = c$, to a pressure of 900 kPa. The gas is then heated at constant volume to a pressure of 2900 kPa.
Take R= 0.29 kJ/kgK and c_p = 1.005 kJ/kgK and calculate the following:

3.2.1. The mass of the gas; (2)

3.2.2. The volume and temperature at the end of compression process, and at the end of constant volume heating process; (5)

3.2.3. The work done during compression; (2)

QUESTION 3 (continuing)

3.2.4. The change of internal energy for both processes, and state whether it is a gain or a loss; (6)
3.2.5. Draw the pressure-volume diagram for the processes, indicating all values. (5)
[23]

QUESTION 4

4.1. During a test on a surface condenser the following readings were obtained:
vacuum gauge pressure ..... 688.725 mm Hg
barometer reading .....760 mm Hg
condensate temperature .....37.7 °C
condensate mass flow .....4000 kg/h
cooling water inlet temperature .....13 °C
cooling water outlet temperature .....28 °C
cooling water mass flow .....2190 kg/min
specific heat capacity of water .....4.2 kJ/kgK

4.1.1. Determine the condenser pressure in kPa. (2)
4.1.2. Calculate the degree of undercooling using the steam tables (2)
4.1.3. Calculate the dryness fraction of the steam entering the condenser (6)

4.2. Name two reasons for using a condenser in a steam installation (5)
[15]

QUESTION 5

A combined separating and throttling calorimeter is used to determine the dryness fraction of steam from the main pipe. Wet steam at 800 kPa enters the separator at a rate of 112 kg/h. While passing through the separator it loses 4.85 kg/h of moisture. Thereafter it is throttle to a pressure of 300 kPa while the temperature after throttling is 150 °C.
Take c_p for superheated steam, 2.24 kJ/kgK
Determine the dryness fraction of the steam in the main. **[10]**

QUESTION 6

The analysis by volume of a sample of gaseous fuel reveals the following percentage:

CO	H2	CH4	O2	CO2	N2
3	40	40	5	2	10

Determine the minimum volume of air required for the complete combustion of this fuel and the percentage excess air if the air supplied is 5.62 m^3 per m^3 of fuel
(Hint: for combustion of methane $CH_4 + 2\ O_2 = CO_2 + 2H_2O$)

[12]

Useful formulas

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$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{n-1} \qquad \frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}$$

$$\Delta S = mc_v \ln\frac{T_2}{T_1} + mR\ln\frac{V_2}{V_1}$$

$Q = mc\Delta t$ $\qquad$ $W = p\Delta V$

$\Delta U = mc_v\Delta t$ $\qquad$ $W_{1\text{-}2} = pV\ ln\frac{V_2}{V_1} = mRT\ ln\frac{V_2}{V_1}$

$$W_{1\text{-}2} = \frac{p_1V_1 - p_2V_2}{n-1} = \frac{mR\ (T_1 - T_2)}{n-1}$$

$$\eta_{CARNOT} = \frac{T_m - T_a}{T_m}$$

$$\eta_{Boiler} = \frac{m_s\ x\ \Delta h}{m_f\ x\ LCV}^{\circ} \qquad EEC = \frac{m_s\ x\ \Delta h}{m_f\ x\ 2257}$$

$$\eta_{Rankine} = \frac{h_b - h_c - w_p}{h_b - h_f - w_p} \qquad w_p = (p_b\text{-}p_c)\ x\ v_w$$

Specific volumes

$v_x = x\ x\ v_g$ $\qquad$ $v_{sup} = \frac{0.233(h_{sup} - 1943)}{p}$

Specific internal energies

$U_x = h_x - pv_x$ $\qquad$ $u_g = h_g - pv_g$ $\qquad$ $u_{sup} = h_{sup} - pv_{sup}$

Properties of Water and Saturated Steam

p	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g
kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K
1,0	7,0	129,20	29	2 485	2 514	0,106	8,977
1,5	13,0	87,98	55	2 471	2 526	0,196	8,829
2,0	17,5	67,01	74	2 460	2 534	0,261	8,725
2,5	21,1	54,26	89	2 452	2 541	0,312	8,644
3,0	24,1	45,67	101	2 445	2 546	0,354	8,579
3,5	26,7	39,48	112	2 439	2 551	0,391	8,523
4,0	29,0	34,80	121	2 433	2 554	0,423	8,476
4,5	31,0	31,14	130	2 428	2 558	0,451	8,434
5,0	32,9	28,19	138	2 424	2 562	0,476	8,396
5,5	34,6	25,77	145	2 420	2 565	0,500	8,362
6,0	36,2	23,74	152	2 416	2 568	0,521	8,331
6,5	37,7	22,02	158	2 413	2 571	0,541	8,303
7,0	39,0	20,53	163	2 410	2 573	0,559	8,277
7,5	40,3	19,24	169	2 406	2 575	0,576	8,252
8,0	41,6	18,10	174	2 403	2 577	0,593	8,230
8,5	42,7	17,10	179	2 401	2 580	0,608	8,208
9,0	43,8	16,20	183	2 398	2 581	0,622	8,188
9,5	44,8	15,40	188	2 395	2 583	0,636	8,169
10	45,8	14,67	192	2 393	2 585	0,649	8,151
11	47,7	13,42	200	2 388	2 588	0,674	8,118
12	49,5	12,36	207	2 384	2 591	0,696	8,087
13	51,1	11,47	214	2 380	2 594	0,717	8,059
14	52,6	10,69	220	2 377	2 597	0,737	8,033
15	54,0	10,02	226	2 373	2 599	0,755	8,009
16	55,3	9,433	232	2 370	2 602	0,772	7,987
17	56,6	8,911	237	2 367	2 604	0,788	7,966
18	57,8	8,445	242	2 364	2 606	0,804	7,946
19	59,0	8,027	247	2 361	2 608	0,818	7,927
20	60,1	7,650	252	2 358	2 610	0,832	7,909
21	61,1	7,307	256	2 356	2 612	0,845	7,893
22	62,2	6,995	260	2 353	2 613	0,858	7,876
23	63,1	6,709	264	2 351	2 615	0,870	7,861
24	64,1	6,447	268	2 349	2 617	0,882	7,846
25	65,0	6,204	272	2 346	2 618	0,893	7,832
26	65,9	5,980	276	2 344	2 620	0,904	7,819
27	66,7	5,772	279	2 342	2 621	0,915	7,806
28	67,6	5,579	283	2 340	2 623	0,925	7,793
29	68,3	5,398	286	2 338	2 624	0,935	7,781
30	69,1	5,229	289	2 336	2 625	0,944	7,770

p	t_s	v_g	h_f	h_{fg}	h_g	s_f	
kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K
32	70,8	4,922	296	2 332	2 628	0,962	7,747
34	72,0	4,650	302	2 329	2 631	0,980	7,727
36	73,4	4,408	307	2 326	2 633	0,996	7,707
38	74,7	4,190	313	2 322	2 635	1,011	7,688
40	75,9	3,993	318	2 319	2 637	1,026	7,671
45	78,7	3,576	330	2 312	2 642	1,060	7,631
50	81,4	3,240	341	2 305	2 646	1,091	7,595
55	83,7	2,964	351	2 299	2 650	1,119	7,562
60	86,0	2,732	360	2 294	2 654	1,145	7,533
65	88,0	2,535	369	2 288	2 657	1,170	7,506
70	90,0	2,365	377	2 283	2 660	1,192	7,480
75	91,8	2,217	385	2 279	2 664	1,213	7,457
80	93,5	2,087	392	2 274	2 666	1,233	7,435
85	95,2	1,972	399	2 270	2 669	1,252	7,415
90	96,7	1,869	405	2 266	2 671	1,270	7,395
95	98,2	1,777	412	2 262	2 674	1,287	7,377
100	99,6	1,694	418	2 258	2 676	1,303	7,360
110	102,3	1,549	429	2 251	2 680	1,333	7,328
120	104,8	1,428	439	2 244	2 683	1,361	7,300
130	107,1	1,325	449	2 238	2 687	1,387	7,272
140	109,3	1,236	458	2 232	2 690	1,411	7,247
150	111,4	1,159	467	2 226	2 693	1,434	7,223
160	113,3	1,091	475	2 221	2 696	1,455	7,202
170	115,2	1,031	483	2 216	2 699	1,475	7,181
180	116,9	0,977 2	491	2 211	2 702	1,494	7,162
190	118,6	0,929 0	498	2 206	2 704	1,513	7,144
200	120,2	0,885 4	505	2 202	2 707	1,530	7,127
210	121,8	0,845 9	511	2 197	2 708	1,547	7,111
220	123,3	0,809 8	518	2 193	2 711	1,563	7,095
230	124,7	0,776 8	524	2 189	2 713	1,578	7,080
240	126,1	0,746 5	530	2 185	2 715	1,593	7,066
250	127,4	0,718 4	535	2 181	2 716	1,607	7,052
260	128,7	0,692 5	541	2 177	2 718	1,621	7,039
270	130,0	0,668 4	546	2 174	2 720	1,634	7,026
280	131,2	0,646 0	551	2 170	2 721	1,647	7,014
290	132,4	0,625 1	557	2 167	2 724	1,660	7,002
300	133,5	0,605 6	561	2 163	2 724	1,672	6,991
310	134,7	0,587 2	566	2 160	2 726	1,683	6,980
320	135,8	0,570 0	571	2 157	2 728	1,695	6,969
330	136,8	0,553 8	576	2 154	2 730	1,706	6,959
340	137,9	0,538 5	580	2 150	2 730	1,717	6,949
350	138,9	0,524 0	584	2 147	2 731	1,727	6,939
360	139,9	0,510 3	589	2 144	2 733	1,738	6,930
370	140,8	0,497 4	593	2 141	2 734	1,748	6,921

p	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g
kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K
380	141,8	0,485 1	597	2 139	2 736	1,757	6,912
390	142,7	0,473 4	601	2 136	2 737	1,767	6,903
400	143,6	0,462 2	605	2 133	2 738	1,776	6,894
410	144,5	0,451 6	609	2 130	2 739	1,786	6,886
420	145,4	0,441 5	612	2 128	2 740	1,795	6,878
430	146,3	0,431 8	616	2 125	2 741	1,803	6,870
440	147,1	0,422 6	620	2 122	2 742	1,812	6,862
450	147,9	0,413 8	624	2 120	2 744	1,820	6,855
460	148,7	0,405 3	627	2 117	2 744	1,829	6,847
470	149,5	0,397 2	630	2 115	2 745	1,837	6,840
480	150,3	0,389 4	634	2 112	2 746	1,845	6,833
490	151,1	0,381 9	637	2 110	2 747	1,853	6,826
500	151,8	0,374 7	640	2 107	2 747	1,860	6,819
520	153,3	0,361 1	647	2 103	2 750	1,875	6,806
540	154,8	0,348 5	653	2 098	2 751	1,890	6,793
560	156,2	0,336 7	659	2 094	2 753	1,904	6,781
580	157,5	0,325 7	665	2 089	2 754	1,918	6,769
600	158,8	0,315 5	670	2 085	2 755	1,931	6,758
620	160,1	0,305 9	676	2 081	2 757	1,944	6,746
640	161,4	0,296 8	682	2 077	2 759	1,956	6,736
660	162,6	0,288 3	687	2 073	2 760	1,968	6,725
680	163,8	0,280 3	692	2 069	2 761	1,980	6,715
700	165,0	0,272 7	697	2 065	2 762	1,992	6,705
720	166,1	0,265 5	702	2 061	2 763	2,003	6,696
740	167,2	0,258 7	707	2 057	2 764	2,014	6,686
760	168,3	0,252 2	712	2 054	2 766	2,025	6,677
780	169,4	0,246 1	717	2 050	2 767	2,035	6,668
800	170,4	0,240 3	721	2 047	2 768	2,046	6,660
820	171,4	0,234 7	725	2 043	2 768	2,056	6,651
840	172,5	0,229 4	730	2 040	2 770	2,066	6,643
860	173,4	0,224 3	734	2 036	2 770	2,075	6,635
880	174,4	0,219 5	739	2 033	2 772	2,085	6,627
900	175,4	0,214 8	743	2 030	2 773	2,094	6,619
920	176,3	0,210 4	747	2 026	2 773	2,103	6,612
940	177,2	0,206 1	751	2 023	2 774	2,112	6,604
960	178,1	0,202 0	755	2 020	2 775	2,121	6,597
980	179,0	0,198 1	759	2 017	2 776	2,130	6,590
1 000	179,9	0,194 3	763	2 014	2 777	2,138	6,583
1 050	182,0	0,185 5	772	2 006	2 778	2,159	6,566
1 100	184,1	0,177 4	781	1 999	2 780	2,179	6,550
1 150	186,1	0,170 0	790	1 991	2 781	2,198	6,534
1 200	188,0	0,163 2	798	1 984	2 782	2,216	6,519
1 250	189,8	0,156 9	807	1 977	2 784	2,234	6,505
1 300	191,6	0,151 1	815	1 971	2 786	2,251	6,491

p	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g
kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K
1 350	193,4	0,145 7	823	1 964	2 787	2,268	6,478
1 400	195,0	0,140 7	830	1 958	2 788	2,284	6,465
1 450	196,7	0,136 0	838	1 951	2 789	2,299	6,453
1 500	198,3	0,131 7	845	1 945	2 790	2,315	6,441
1 550	199,9	0,127 5	852	1 939	2 791	2,330	6,429
1 600	201,4	0,123 7	859	1 933	2 792	2,344	6,418
1 650	202,9	0,120 1	865	1 927	2 792	2,358	6,407
1 700	204,3	0,116 6	872	1 922	2 794	2,371	6,396
1 750	205,7	0,113 4	878	1 916	2 794	2,385	6,385
1 800	207,1	0,110 3	885	1 910	2 795	2,398	6,375
1 850	208,5	0,107 4	891	1 905	2 796	2,410	6,365
1 900	209,8	0,104 7	897	1 899	2 796	2,423	6,355
1 950	211,1	0,102 0	903	1 894	2 797	2,435	6,346
2 000	212,4	0,099 54	908	1 889	2 797	2,447	6,337
2 050	213,6	0,097 16	914	1 883	2 797	2,459	6,328
2 100	214,9	0,094 89	920	1 878	2 798	2,470	6,319
2 150	216,1	0,092 72	926	1 873	2 799	2,481	6,310
2 200	217,2	0,090 65	931	1 868	2 799	2,492	6,302
2 250	218,4	0,088 67	936	1 863	2 799	2,503	6,293
2 300	219,6	0,086 77	942	1 858	2 800	2,514	6,285
2 350	220,7	0,084 95	947	1 853	2 800	2,524	6,277
2 400	221,8	0,083 20	952	1 849	2 801	2,534	6,269
2 450	222,9	0,081 52	957	1 844	2 801	2,544	6,261
2 500	223,9	0,079 91	962	1 839	2 801	2,554	6,254
2 550	225,0	0,078 35	967	1 834	2 801	2,564	6,246
2 600	226,0	0,076 86	972	1 830	2 802	2,574	6,239
2 650	227,1	0,075 41	977	1 825	2 802	2,583	6,232
2 700	228,1	0,074 02	981	1 821	2 802	2,592	6,224
2 750	229,1	0,072 68	986	1 816	2 802	2,602	6,217
2 800	230,1	0,071 39	991	1 811	2 802	2,611	6,210
2 850	231,0	0,070 14	995	1 807	2 802	2,620	6,204
2 900	232,0	0,068 93	1 000	1 802	2 802	2,628	6,197
2 950	232,9	0,067 76	1 004	1 798	2 802	2,637	6,190
3 000	233,8	0,066 63	1 008	1 794	2 802	2,646	6,184
3 100	235,7	0,064 47	1 017	1 785	2 802	2,662	6,171
3 200	237,5	0,062 44	1 025	1 777	2 802	2,679	6,159
3 300	239,2	0,060 53	1 034	1 768	2 802	2,695	6,146
3 400	240,9	0,058 73	1 042	1 760	2 802	2,710	6,134
3 500	242,5	0,057 03	1 050	1 752	2 802	2,725	6,123
3 600	244,2	0,055 41	1 058	1 744	2 802	2,740	6,112
3 700	245,8	0,053 89	1 065	1 736	2 801	2,755	6,100
3 800	247,3	0,052 44	1 073	1 728	2 801	2,769	6,090
3 900	248,8	0,051 06	1 080	1 721	2 801	2,783	6,079
4 000	250,3	0,049 75	1 087	1 713	2 800	2,797	6,069

p	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g
kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K
4 100	251,8	0,048 50	1 095	1 705	2 800	2,810	6,058
4 200	253,2	0,047 31	1 102	1 698	2 800	2,823	6,048
4 300	254,7	0,046 17	1 109	1 690	2 799	2,836	6,038
4 400	256,1	0,045 08	1 115	1 683	2 798	2,849	6,029
4 500	257,4	0,044 04	1 122	1 676	2 798	2,861	6,019
4 600	258,8	0,043 04	1 129	1 668	2 797	2,874	6,010
4 700	260,1	0,042 08	1 135	1 661	2 796	2,886	6,000
4 800	261,4	0,041 16	1 142	1 654	2 796	2,897	5,991
4 900	262,7	0,040 28	1 148	1 647	2 795	2,909	5,982
5 000	263,9	0,039 43	1 155	1 640	2 795	2,921	5,974
5 100	265,2	0,038 61	1 161	1 633	2 794	2,932	5,965
5 200	266,4	0,037 82	1 167	1 626	2 793	2,943	5,956
5 300	267,6	0,037 07	1 173	1 619	2 792	2,954	5,948
5 400	268,8	0,036 33	1 179	1 612	2 791	2,965	5,939
5 500	269,9	0,035 63	1 185	1 605	2 790	2,976	5,931
5 600	271,1	0,034 95	1 191	1 598	2 789	2,986	5,923
5 700	272,2	0,034 29	1 197	1 591	2 788	2,997	5,915
5 800	273,4	0,033 65	1 202	1 585	2 787	3,007	5,907
5 900	274,5	0,033 03	1 208	1 578	2 786	3,017	5,899
6 000	275,6	0,032 44	1 214	1 571	2 785	3,027	5,891
6 200	277,7	0,031 30	1 225	1 558	2 783	3,047	5,875
6 400	279,8	0,030 23	1 236	1 545	2 781	3,066	5,860
6 600	281,8	0,029 22	1 247	1 532	2 779	3,085	5,845
6 800	283,8	0,028 27	1 257	1 519	2 776	3,104	5,831
7 000	285,8	0,027 37	1 267	1 506	2 773	3,122	5,816
7 200	287,7	0,026 52	1 278	1 493	2 771	3,140	5,802
7 400	289,6	0,025 72	1 288	1 481	2 769	3,157	5,788
7 600	291,4	0,024 95	1 298	1 468	2 766	3,174	5,774
7 800	293,2	0,024 22	1 307	1 455	2 762	3,191	5,761
8 000	295,0	0,023 53	1 317	1 443	2 760	3,208	5,747
8 200	296,7	0,022 86	1 327	1 430	2 757	3,224	5,734
8 400	298,4	0,022 23	1 336	1 418	2 754	3,240	5,721
8 600	300,1	0,021 63	1 345	1 406	2 751	3,256	5,708
8 800	301,7	0,021 05	1 355	1 393	2 748	3,271	5,695
9 000	303,3	0,020 50	1 364	1 381	2 745	3,287	5,682
9 200	304,9	0,019 96	1 373	1 369	2 742	3,302	5,669
9 400	306,4	0,019 45	1 382	1 356	2 738	3,317	5,657
9 600	308,0	0,018 97	1 391	1 344	2 735	3,332	5,644
9 800	309,5	0,018 49	1 399	1 332	2 731	3,346	5,632
10 000	311,0	0,018 04	1 408	1 320	2 728	3,361	5,620
10 400	313,4	0,017 18	1 425	1 295	2 720	3,389	5,596
10 800	316,7	0,016 39	1 442	1 271	2 713	3,417	5,572
11 200	319,4	0,015 64	1 459	1 247	2 706	3,444	5,548
11 600	322,1	0,014 94	1 475	1 222	2 697	3,471	5,524

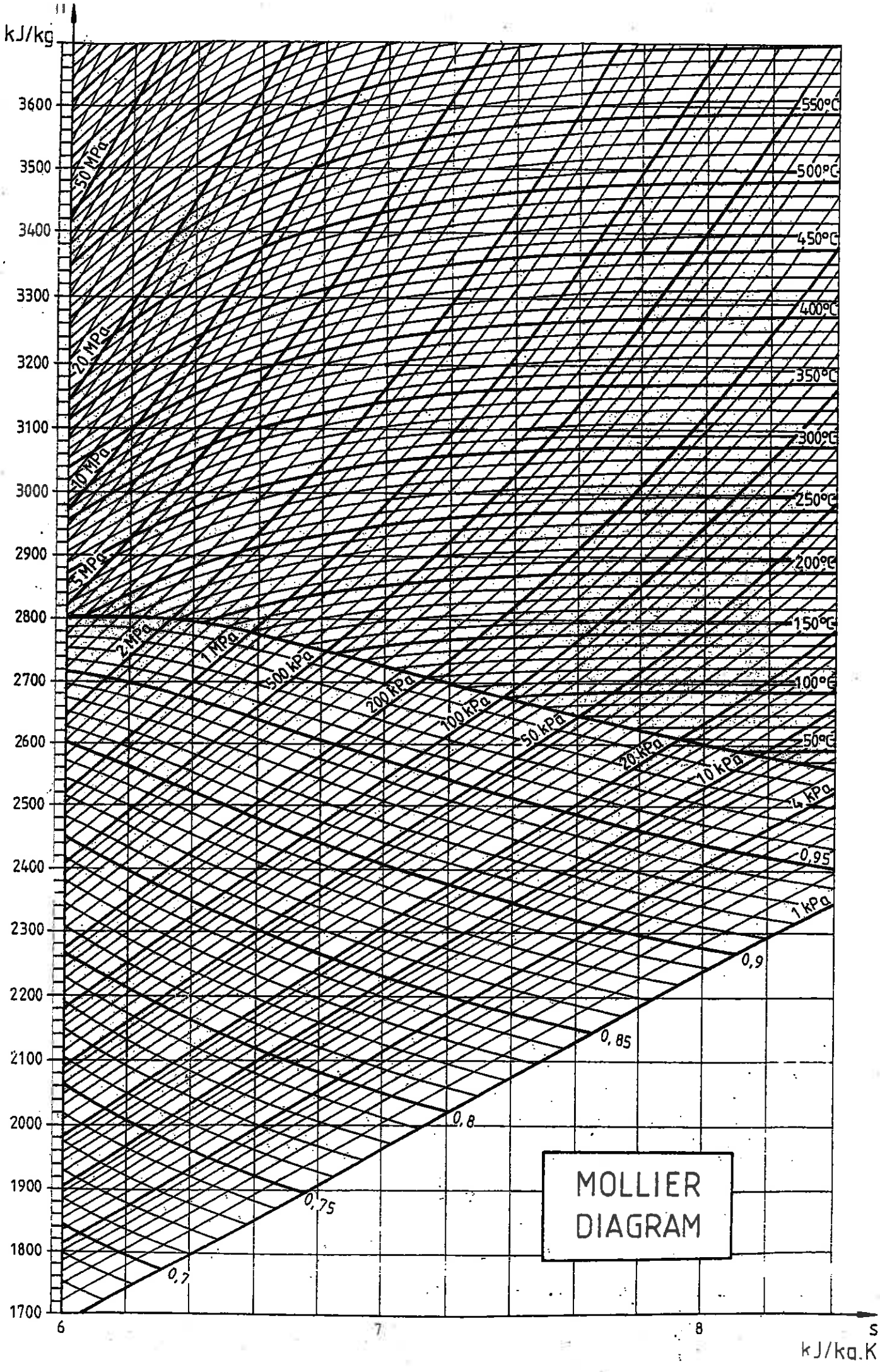
p	t_s	v_g	h_f	h_{fg}	h_g	s_f	
kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K
12 000	324,7	0,014 28	1 492	1 197	2 689	3,497	5,500
12 400	327,2	0,013 66	1 508	1 173	2 681	3,523	5,477
12 800	329,6	0,013 08	1 524	1 148	2 672	3,549	5,453
13 200	332,0	0,012 52	1 540	1 122	2 662	3,574	5,429
13 600	334,4	0,012 00	1 556	1 097	2 653	3,599	5,405
14 000	336,6	0,011 50	1 572	1 071	2 643	3,624	5,380
14 400	338,9	0,011 02	1 587	1 044	2 631	3,649	5,356
14 800	341,1	0,010 56	1 603	1 018	2 621	3,674	5,331
15 200	343,2	0,010 12	1 619	990	2 609	3,698	5,305
15 600	345,3	0,009 707	1 635	963	2 598	3,723	5,279
16 000	347,3	0,009 308	1 651	934	2 585	3,747	5,253
16 400	349,3	0,008 925	1 667	906	2 573	3,772	5,227
16 800	351,3	0,008 553	1 683	876	2 559	3,797	5,199
17 200	353,2	0,008 191	1 700	844	2 544	3,824	5,171
17 600	355,1	0,007 839	1 718	812	2 530	3,850	5,143
18 000	357,0	0,007 498	1 735	779	2 514	3,877	5,113
18 400	358,8	0,007 165	1 752	745	2 497	3,903	5,082
18 800	360,6	0,006 839	1 770	710	2 480	3,929	5,050
19 200	362,3	0,006 517	1 788	673	2 461	3,957	5,016
19 600	364,0	0,006 198	1 807	634	2 441	3,985	4,980
20 000	365,7	0,005 877	1 827	592	2 419	4,015	4,941

Properties of Superheated Steam

p	t_{sup}								
kPa		50°	100°	150°	200°	250°	300°	400°	500°
1	v_{sup}	149,1	172,2	195,3	218,4	241,4	264,5	310,7	356,8
	h_{sup}	2 595	2 689	2 784	2 880	2 978	3 077	3 280	3 489
	s_{sup}	9,241	9,512	9,751	9,966	10,163	10,344	10,670	10,960
5	v_{sup}	29,78	34,42	39,04	43,66	48,28	52,90	62,13	71,36
	h_{sup}	2 594	2 688	2 784	2 880	2 978	3 077	3 280	3 489
	s_{sup}	8,496	8,768	9,008	9,223	9,420	9,601	9,927	10,217
10	v_{sup}	14,87	17,20	19,51	21,83	24,14	26,45	31,06	35,68
	h_{sup}	2 592	2 688	2 783	2 880	2 977	3 077	3 280	3 489
	s_{sup}	8,173	8,447	8,688	8,903	9,100	9,281	9,607	9,897
50	v_{sup}		3,420	3,890	4,356	4,821	5,284	6,209	7,134
	h_{sup}		2 683	2 780	2 878	2 976	3 076	3 279	3 489
	s_{sup}		7,694	7,940	8,158	8,355	8,537	8,864	9,154
75	v_{sup}		2,271	2,588	2,901	3,211	3,521	4,138	4,755
	h_{sup}		2 680	2 779	2 877	2 975	3 075	3 279	3 489
	s_{sup}		7,500	7,750	7,969	8,167	8,349	8,676	8,967
100	v_{sup}		1,696	1,937	2,173	2,406	2,639	3,103	3,565
	h_{sup}		2 676	2 777	2 876	2 975	3 075	3 278	3 488
	s_{sup}		7,36	7,614	7,834	8,033	8,215	8,543	8,834
150	v_{sup}			1,286	1,445	1,601	1,757	2,067	2,376
	h_{sup}			2 773	2 873	2 973	3 073	3 277	3 488
	s_{sup}			7,420	7,643	7,843	8,027	8,355	8,646
200	v_{sup}			0,960 2	1,081	1,199	1,318	1,549	1,781
	h_{sup}			2 770	2 871	2 971	3 072	3 277	3 487
	s_{sup}			7,280	7,507	7,708	7,892	8,221	8,513
300	v_{sup}			0,634 2	0,716 6	0,796 5	0,875 4	1,031	1,187
	h_{sup}			2 762	2 866	2 968	3 070	3 275	3 486
	s_{sup}			7,078	7,312	7,517	7,702	8,032	8,324
400	v_{sup}			0,471	0,534 5	0,595 3	0,654 9	0,772 5	0,889 3
	h_{sup}			2 753	2 862	2 965	3 067	3 274	3 485
	s_{sup}			6,929	7,172	7,379	7,566	7,898	8,191

p kPa		t_{sup}							
		200°	250°	300°	350°	400°	450°	500°	600°
500	v_{sup}	0,425 2	0,474 5	0,522 6	0,570 1	0,617 2	0,664 1	0,710 8	0,804
	h_{sup}	2 857	2 962	3 065	3 168	3 272	3 377	3 484	3 702
	s_{sup}	7,060	7,271	7,460	7,633	7,793	7,944	8,087	8,351
600	v_{sup}	0,352 2	0,394	0,434 4	0,474 3	0,513 6	0,552 8	0,591 9	0,669 7
	h_{sup}	2 851	2 958	3 062	3 166	3 270	3 376	3 483	3 701
	s_{sup}	6,968	7,182	7,373	7,546	7,707	7,858	8,001	8,267
700	v_{sup}	0,300 1	0,336 4	0,371 4	0,405 8	0,439 7	0,473 4	0,506 9	0,573 7
	h_{sup}	2 846	2 955	3 060	3 164	3 269	3 374	3 482	3 700
	s_{sup}	6,888	7,106	7,298	7,473	7,634	7,786	7,929	8,195
800	v_{sup}	0,261	0,293 3	0,324 2	0,354 4	0,384 2	0,413 8	0,443 2	0,501 8
	h_{sup}	2 840	2 951	3 057	3 162	3 267	3 373	3 481	3 699
	s_{sup}	6,817	7,040	7,233	7,409	7,571	7,723	7,866	8,132
900	v_{sup}	0,230 5	0,259 7	0,287 4	0,314 4	0,341	0,367 4	0,393 7	0,445 8
	h_{sup}	2 835	2 948	3 055	3 160	3 266	3 372	3 480	3 699
	s_{sup}	6,753	6,980	7,176	7,352	7,515	7,667	7,811	8,077
1 000	v_{sup}	0,206 1	0,232 8	0,258	0,282 5	0,306 5	0,330 3	0,354	0,401
	h_{sup}	2 829	2 944	3 052	3 158	3 264	3 370	3 478	3 698
	s_{sup}	6,695	6,926	7,124	7,301	7,464	7,617	7,761	8,028
1 500	v_{sup}	0,132 4	0,152	0,169 7	0,186 5	0,202 9	0,219 1	0,235 1	0,266 7
	h_{sup}	2 796	2 925	3 039	3 148	3 256	3 364	3 473	3 694
	s_{sup}	6,452	6,711	6,919	7,102	7,268	7,423	7,569	7,838
2 000	v_{sup}		0,111 5	0,125 5	0,138 6	0,151 1	0,163 4	0,175 6	0,199 5
	h_{sup}		2 904	3 025	3 138	3 248	3 357	3 467	3 690
	s_{sup}		6,547	6,768	6,957	7,126	7,283	7,431	7,701
3 000	v_{sup}		0,070 6	0,081 2	0,090 5	0,099 3	0,107 8	0,116 1	0,132 4
	h_{sup}		2 858	2 995	3 117	3 231	3 343	3 456	3 682
	s_{sup}		6,289	6,541	6,744	6,921	7,082	7,233	7,507
4 000	v_{sup}			0,058 8	0,066 4	0,077 3	0,080	0,086 4	0,098 8
	h_{sup}			2 963	3 094	3 214	3 330	3 445	3 674
	s_{sup}			6,364	6,584	6,769	6,935	7,089	7,368
5 000	v_{sup}			0,045 3	0,051 9	0,057 8	0,063 2	0,068 5	0,078 6
	h_{sup}			2 927	3 070	3 196	3 316	3 433	3 666
	s_{sup}			6,212	6,451	6,646	6,818	6,975	7,258
6 000	v_{sup}			0,036 2	0,042 2	0,047 3	0,052 1	0,056 6	0,065 2
	h_{sup}			2 887	3 045	3 177	3 301	3 421	3 657
	s_{sup}			6,071	6,336	6,541	6,719	6,879	7,166
7 000	v_{sup}			0,029 5	0,035 2	0,039 9	0,044 1	0,048 1	0,055 6
	h_{sup}			2 841	3 018	3 158	3 287	3 410	3 649
	s_{sup}			5,934	6,231	6,448	6,632	6,796	7,088

p kPa		t_{sup}							
		350°	375°	400°	425°	450°	500°	600°	700°
8 000	v_{sup}	0,029 94	0,032 2	0,034 28	0,036 25	0,038 12	0,041 7	0,048 39	0,054 76
	h_{sup}	2 990	3 067	3 139	3 207	3 272	3 398	3 641	3 881
	s_{sup}	6,133	6,255	6,364	6,463	6,555	6,723	7,109	7,279
9 000	v_{sup}	0,025 78	0,027 94	0,029 91	0,031 73	0,033 46	0,036 73	0,042 79	0,048 52
	h_{sup}	2 959	3 042	3 118	3 189	3 256	3 385	3 633	3 874
	s_{sup}	6,039	6,171	6,286	6,390	6,484	6,657	6,958	7,220
10 000	v_{sup}	0,022 41	0,024 53	0,026 39	0,028 12	0,029 72	0,032 75	0,038 31	0,043 53
	h_{sup}	2 926	3 017	3 097	3 172	3 241	3 373	3 624	3 868
	s_{sup}	5,947	6,091	6,213	6,321	6,419	6,596	6,902	7,166
11 000	v_{sup}	0,019 6	0,021 69	0,023 5	0,025 14	0,026 66	0,029 49	0,034 65	0,039 45
	h_{sup}	2 889	2 989	3 075	3 153	3 225	3 360	3 616	3 862
	s_{sup}	5,856	6,014	6,143	6,257	6,358	6,539	6,850	7,117
12 000	v_{sup}	0,017 19	0,019 31	0,021 07	0,022 65	0,024 1	0,026 77	0,031 59	0,036 05
	h_{sup}	2 849	2 960	3 052	3 134	3 209	3 348	3 607	3 856
	s_{sup}	5,762	5,937	6,076	6,195	6,301	6,487	6,802	7,072
13 000	v_{sup}	0,015 09	0,017 26	0,019 01	0,020 53	0,021 93	0,024 47	0,029 01	0,033 18
	h_{sup}	2 804	2 929	3 028	3 114	3 192	3 335	3 599	3 850
	s_{sup}	5,664	5,862	6,011	6,136	6,246	6,437	6,758	7,030
14 000	v_{sup}	0,013 21	0,015 48	0,017 22	0,018 72	0,020 06	0,022 5	0,026 79	0,030 71
	h_{sup}	2 753	2 896	3 003	3 093	3 175	3 322	3 590	3 843
	s_{sup}	5,559	5,784	5,946	6,079	6,193	6,390	6,716	6,991
15 000	v_{sup}	0,011 46	0,013 91	0,015 66	0,017 14	0,018 44	0,020 78	0,024 87	0,028 57
	h_{sup}	2 693	2 861	2 977	3 073	3 157	3 309	3 581	3 837
	s_{sup}	5,443	5,707	5,883	6,023	6,142	6,345	6,677	6,954
16 000	v_{sup}	0,009 76	0,012 48	0,014 27	0,015 73	0,017 02	0,019 28	0,023 19	0,026 7
	h_{sup}	2 617	2 821	2 949	3 051	3 139	3 295	3 573	3 831
	s_{sup}	5,304	5,626	5,820	5,968	6,093	6,301	6,639	6,919
17 000	v_{sup}		0,011 17	0,013 03	0,014 49	0,015 76	0,017 96	0,021 71	0,025 06
	h_{sup}		2 778	2 920	3 028	3 121	3 281	3 564	3 825
	s_{sup}		5,541	5,756	5,914	6,044	6,260	6,603	6,886
18 000	v_{sup}		0,009 97	0,011 91	0,013 38	0,014 63	0,016 78	0,020 39	0,023 59
	h_{sup}		2 729	2 888	3 004	3 102	3 268	3 555	3 818
	s_{sup}		5,449	5,691	5,861	5,997	6,219	6,569	6,855
19 000	v_{sup}		0,008 82	0,010 89	0,012 38	0,013 62	0,015 72	0,019 21	0,022 28
	h_{sup}		2 674	2 855	2 980	3 082	3 254	3 546	3 812
	s_{sup}		5,348	5,625	5,807	5,950	6,180	6,536	6,825
20 000	v_{sup}		0,007 68	0,009 95	0,011 47	0,012 7	0,014 77	0,018 15	0,021 1
	h_{sup}		2 605	2 819	2 955	3 062	3 239	3 537	3 806
	s_{sup}		5,228	5,556	5,753	5,904	6,142	6,505	6,796


h
kJ/kg
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
50 MPa
20 MPa
10 MPa
5 MPa
2 MPa
1 MPa
500 kPa
200 kPa
100 kPa
50 kPa
20 kPa
10 kPa
4 kPa
1 kPa
550°C
500°C
450°C
400°C
350°C
300°C
250°C
200°C
150°C
100°C
50°C
0,95
0,9
0,85
0,8
0,75
0,7
MOLLIER
DIAGRAM
6
7
8
s
kJ/kg.K