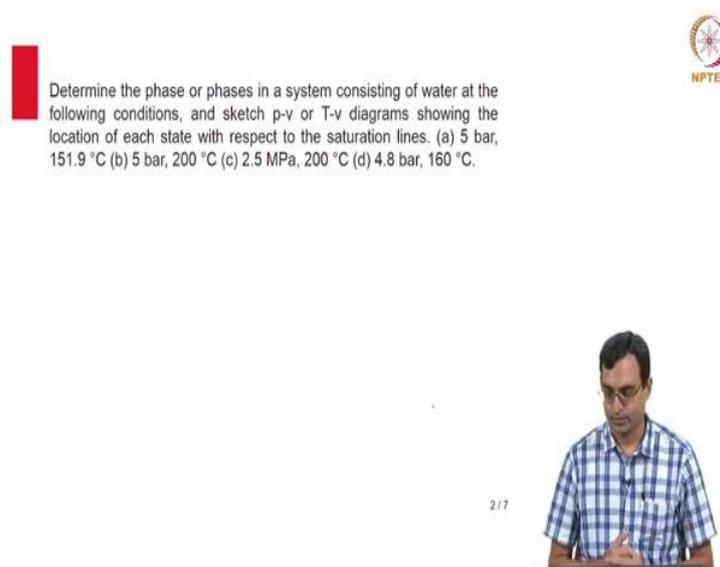


Thermodynamics
Professor. Anand T N C
Department of Mechanical Engineering
Indian Institute of Technology, Madras
Lecture 47
Tutorial Problems (2 numbers)

Let's look at few tutorial problems on steam and water mixtures. It is recommended to have a hardcopy of steam tables.

(Refer Slide Time: 00:41)



Determine the phase or phases in a system consisting of water at the following conditions, and sketch p-v or T-v diagrams showing the location of each state with respect to the saturation lines. (a) 5 bar, 151.9 °C (b) 5 bar, 200 °C (c) 2.5 MPa, 200 °C (d) 4.8 bar, 160 °C.

NPTEL

2/7

The slide contains a problem statement for a thermodynamics tutorial. It asks to determine the phase of water at four different conditions and to sketch p-v or T-v diagrams. A small video inset shows a man in a blue and white checkered shirt speaking. The NPTEL logo is in the top right corner, and the number 2/7 is in the bottom left corner of the slide area.

Figure 1.

Solution of the problem in Fig. 1:

(a) 5 bar, 151.9 °C

Let's go to the steam tables listed by pressure. We don't have a value of 5 bar or 0.5 MPa in the tables. We will find the properties by linear interpolation. The properties at 0.5 MPa are the average of those at 0.4 MPa and 0.6 MPa. After taking average, saturation temperature at 5 bar is 151.2 °C. Since the given temperature, 151.9 °C, is greater than 151.2 °C, the state at 5 bar and 151.9 °C lies in the superheated zone. The intersection of the isotherm $T=151.9$ °C and the isobar $p=5$ bar represents the state asked in the problem on a p-v diagram as well as on the T-v diagram. Figure 2 shows the state (point a) on a p-v and T-v diagram.

(b) 5 bar, 200 °C

At 5 bar, the saturation temperature is $T_{\text{sat}} = 151.2$ °C. The given temperature is greater than T_{sat} . Hence, the state corresponding to 5 bar and 200 °C lies in the superheated zone. Figure 3 shows the state (point b) on a p-v and T-v diagram. The degree of superheat is more in the case b than a. Degree of superheat equals the difference between the saturation temperature and the actual temperature of the superheated vapour.

(c) 2.5 MPa, 200 °C

The pressure 2.5 MPa is not listed in the pressure table. Let's look at a temperature table.

At 200 °C, the saturation pressure is $p_{\text{sat}} = 1.55$ MPa. The given pressure is higher than p_{sat} . Hence, the state lies in the compressed liquid region. Figure 3 shows the state (point c) on a p-v and T-v diagram.

(d) 4.8 bar, 160 °C

Let's look at the table listed by temperature.

At 160 °C, the saturation pressure is $p_{\text{sat}} = 0.6182$ MPa = 6.182 bar. The given pressure, 4.8 bar, is less than p_{sat} . Hence, the point lies in the superheated region. Figure 3 shows the state (point d) on a p-v and T-v diagram.

Within the liquid-vapour dome, the pressure and temperature are not independent. Hence, to locate the state on a p-v or T-v diagram within the liquid-vapor dome, along with pressure or temperature some other property such as internal energy, specific volume, specific enthalpy or specific entropy needs to be given.

x	v	u	h	s	u	h	s	u	h	s
0.0004	12.0	0.000001	72.90	76.2	229.73	76.2	0.000000	229.73	76.2	0.000000
0.0014	14.0	0.000021	82.24	84.8	229.1	84.8	0.000000	229.1	84.8	0.000000
0.0018	15.0	0.000021	84.01	86.5	228.84	86.5	0.000000	228.84	86.5	0.000000
0.0027	17.0	0.000021	86.99	93.4	228.98	93.4	0.000000	228.98	93.4	0.000000
0.0032	18.1	0.000020	88.65	101.0	228.97	101.0	0.000000	228.97	101.0	0.000000
0.004	19.0	0.000020	89.79	107.4	228.88	107.4	0.000000	228.88	107.4	0.000000
0.006	21.0	0.000017	93.73	115.5	228.42	115.5	0.000000	228.42	115.5	0.000000
0.009	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.01	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.012	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.014	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.016	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.018	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.02	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.025	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.03	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.04	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.06	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.08	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.1	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.12	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.14	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.16	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.18	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.2	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.25	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.3	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.4	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.5	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.6	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
0.8	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
1	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
1.2	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
1.4	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
1.6	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
1.8	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
2	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
3	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
4	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
6	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
8	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000
10	23.0	0.000016	98.10	123.8	227.8	123.8	0.000000	227.8	123.8	0.000000



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Determine the phase or phases in a system consisting of water at the following conditions, and sketch p-v or T-v diagrams showing the location of each state with respect to the saturation lines. (a) 5 bar, 151.9 °C (b) 5 bar, 200 °C (c) 2.5 MPa, 200 °C (d) 4.8 bar, 160 °C.

a) $p_w = 5 \text{ bar}$, $T_{sat} = 151.9^\circ\text{C}$, 151.9°C

b) 5 bar, 200 °C

c) 2.5 MPa, 200 °C
at 200 °C $p_{sat} = 15.5 \text{ MPa}$, 15.5 bar, 25 bar

d) 4.8 bar, 160 °C
 $T = 160^\circ\text{C}$, $p_{sat} = 0.182 \text{ MPa}$, 0.182 bar, 0.182 bar

e) $T = 160^\circ\text{C}$, $p = 0.182 \text{ bar}$



Figure 3.

Temp deg C	Pressure MPa	volume (m ³ /kg)		energy (kJ/kg)		enthalpy (kJ/kg)		entropy (kJ/kg.K)			
		vf	vg	uf	ug	hf	hg	sf	sg	sg	
0.01	0.002117	0.001000	205.99	0.01	234.9	0.00	2500.9	0.0000	9.1555	9.1555	
5	0.0026726	0.001000	147.01	21.01	2381.8	21.00	2499.1	2510.1	0.0763	9.9455	9.0242
10	0.00328	0.001000	106.30	42.01	2388.6	42.00	2477.2	2519.2	0.1511	8.7487	8.8991
15	0.00396	0.001001	77.89	63.01	2395.5	62.99	2465.3	2528.3	0.2245	8.5558	8.7803
20	0.00473	0.001002	57.76	83.91	2402.3	83.91	2453.3	2537.4	0.2965	8.3955	8.6660
25	0.00561	0.001003	43.34	104.81	2409.1	104.80	2441.2	2546.5	0.3672	8.1884	8.5561
30	0.00662	0.001004	32.80	125.71	2415.9	125.72	2429.0	2555.5	0.4368	8.0152	8.4520
35	0.00778	0.001006	25.21	146.61	2422.7	146.63	2417.0	2564.5	0.5051	7.8664	8.3517
40	0.00910	0.001008	19.52	167.51	2429.4	167.53	2406.0	2573.5	0.5724	7.8331	8.2555
45	0.00995	0.001010	15.25	188.41	2436.1	188.43	2394.0	2582.4	0.6386	7.8247	8.1633
50	0.01035	0.001012	12.03	209.31	2442.7	209.34	2382.0	2591.3	0.7038	7.8310	8.0748
55	0.01039	0.001015	9.164	230.21	2449.3	230.26	2369.8	2600.1	0.7680	7.2218	7.9899
60	0.01095	0.001017	7.667	251.2	2455.9	251.18	2357.6	2608.8	0.8313	7.0766	7.9081
65	0.01164	0.001020	6.164	272.1	2462.4	272.12	2345.4	2617.5	0.8937	6.9362	7.8296
70	0.01230	0.001023	5.040	293.0	2468.9	292.01	2333.0	2626.1	0.9551	6.7981	7.7540
75	0.01300	0.001026	4.139	314.0	2475.2	314.03	2320.4	2634.6	1.0158	6.6634	7.6812
80	0.01374	0.001029	3.405	335.0	2481.4	335.01	2307.6	2643.0	1.0756	6.5351	7.6111
85	0.01452	0.001032	2.826	356.0	2487.6	356.01	2294.5	2651.3	1.1346	6.4208	7.5424
90	0.01534	0.001036	2.359	377.0	2494.0	377.04	2281.5	2659.5	1.1929	6.2892	7.4781
95	0.01621	0.001040	1.981	398.0	2500.0	398.09	2268.5	2667.6	1.2504	6.1647	7.4151
100	0.01714	0.001044	1.672	419.1	2506.0	419.17	2255.6	2675.6	1.3072	6.0489	7.3541
110	0.01848	0.001052	1.209	481.3	2517.7	481.42	2229.9	2681.7	1.4186	5.8103	7.2281
120	0.01997	0.001060	0.8912	533.6	2528.8	533.61	2202.1	2686.9	1.5276	5.6012	7.1291
130	0.02163	0.001070	0.6660	586.1	2539.5	586.16	2172.2	2691.3	1.6344	5.4118	7.0564
140	0.02347	0.001080	0.5085	638.6	2549.8	638.16	2144.2	2695.4	1.7392	5.1901	6.9293
150	0.02549	0.001091	0.3925	691.7	2559.1	691.17	2117.7	2748.9	1.8418	4.9953	6.8371
160	0.02769	0.001102	0.3048	744.8	2567.8	744.17	2091.9	2747.4	1.9426	4.8065	6.7491
170	0.02997	0.001114	0.2426	798.2	2576.7	798.08	2066.8	2746.1	2.0417	4.6233	6.6650
180	0.03234	0.001127	0.1938	851.9	2585.8	851.05	2042.4	2777.2	2.1392	4.4448	6.5840
190	0.03481	0.001142	0.1564	906.0	2595.0	905.83	1977.9	2783.3	2.2355	4.2794	6.5059
200	0.03740	0.001157	0.1277	960.5	2604.2	962.27	1899.9	2789.0	2.3305	4.0997	6.4200
210	0.04011	0.001173	0.1042	1015.4	2613.3	1017.63	1899.7	2797.3	2.4242	3.9318	6.3363
220	0.04294	0.001190	0.08609	1070.7	2622.2	1073.58	1853.2	2800.9	2.5177	3.7863	6.2640
230	0.04590	0.001209	0.07190	1126.4	2630.9	1127.7	1827.2	2802.9	2.6101	3.6527	6.2128
240	0.04900	0.001230	0.06071	1183.4	2639.3	1183.6	1802.0	2802.0	2.7020	3.4403	6.1423
250	0.05224	0.001252	0.05008	1241.8	2647.5	1241.8	1751.1	2800.9	2.7935	3.2786	6.0721
260	0.05563	0.001276	0.04017	1291.7	2655.7	1291.0	1681.6	2796.6	2.8849	3.1167	6.0016



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4 kg of saturated water-steam mixture is enclosed in a rigid container at an initial pressure of 2 bar. When the mixture is heated, it finally attains the critical state. Find the initial quality of the mixture and the heat transferred to the system during the process.

$m = 4 \text{ kg}$ water + steam
 $p_1 = 2 \text{ bar}$
 $p_2 = \text{critical state}$
 $x_1 = ?$
 $Q = ?$

rigid system - iso chori
 $V = c$

$dV = \delta v - \delta w$
 \downarrow
 0

$v_1 = v_2 = 0.003106 \text{ m}^3/\text{kg}$
 at 2 bar $v_f = 0.001061$ $v_g = 0.8857 \text{ m}^3/\text{kg}$
 at 2 bar $v_1 = v_f + x(v_g - v_f)$
 $x = \frac{v_1 - v_f}{v_g - v_f} = \frac{0.003106 - 0.001061}{0.8857 - 0.001061}$



Figure 4.

Solution of the problem given in Fig. 4:

$m_{mix} = 4 \text{ kg}$, $p_1 = 2 \text{ bar}$, $p_2 = p_c = \text{pressure at the critical point}$

The system is the mixture inside the container.

Since it is a rigid container, the work done $W = 0$.

The first law in the integrated form, $\Delta U = Q$ (there are no changes in kinetic and potential energy).

The process is shown on a T-v diagram in Fig. 4. It is a constant volume process. The initial state is the point of intersection of 2 bar isobar and a vertical line passing through the critical point on a T-v diagram.

Since the mass is fixed and it is a constant volume process, $v_1 = v_2 = v_c =$ specific volume at the critical point $= 0.003106 \text{ m}^3/\text{kg}$.

$$\text{Now, } v_1 = [v_f + x(v_g - v_f)]_{\text{at 2 bar}}$$

Hence, $x = \frac{v_1 - v_f}{v_g - v_f} = \frac{0.003106 - 0.001061}{0.8857 - 0.001061} = 0.0023$ (the values of the specific volumes are obtained from the steam tables)

$$\text{Now, } Q = \Delta U = m\Delta u = m(u_2 - u_1) = m[u_c - \{u_f + x(u_g - u_f)\}]_{2\text{bar}} = 4[2015.7 + 0.0023(2529.1 - 504.5)] = 6026.2 \text{ kJ} \quad (u_2 = u_c = \text{specific internal energy at the critical point})$$

Since Q is positive, the heat is transferred to the system.

373.95	22.064	0.003106	0.003106	2015.7	2015.7	2084.3	0.0	2084.3	4.4070	0.0	4.4070
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(Source of table data: NIST Chemistry WebBook, Accessed Jan 2008)



Properties of Saturated Water - Pressure Table

Pressure MPa	Temp deg C	volume (m ³ /kg)		energy (kJ/kg)		enthalpy (kJ/kg)		entropy (kJ/kgK)			
		vf	vg	uf	ug	hf	hg	df	dg		
0.001	1.0	0.001000	129.7	26.3	2384.5	26.3	2484.4	2513.7	0.1059	8.3690	8.5749
0.0012	1.7	0.001000	108.7	40.6	2388.2	40.6	2478.0	2518.6	0.1460	8.7623	8.9302
0.0014	12.0	0.001001	93.90	50.3	2391.3	50.3	2472.5	2522.8	0.1802	8.8720	8.9321
0.0016	14.0	0.001001	82.74	58.8	2394.1	58.8	2467.7	2526.8	0.2100	8.9393	8.8035
0.0018	15.8	0.001001	74.01	66.5	2396.6	66.5	2463.4	2529.9	0.2364	8.9242	8.7628
0.002	17.5	0.001001	66.99	73.4	2398.9	73.4	2459.5	2532.9	0.2604	8.8620	8.7226
0.003	24.1	0.001003	45.45	101.0	2407.9	101.0	2443.8	2544.8	0.3543	8.2221	8.5784
0.004	29.0	0.001004	34.79	121.4	2414.5	121.4	2432.2	2553.7	0.4224	8.0510	8.4734
0.006	36.2	0.001007	23.71	151.5	2424.2	151.5	2415.1	2566.6	0.5208	7.8082	8.3290
0.008	41.5	0.001009	18.10	173.8	2431.4	173.8	2402.4	2574.2	0.6025	7.5348	8.2275
0.01	43.8	0.001010	14.67	191.8	2437.2	191.8	2392.1	2578.9	0.6402	7.4998	8.1466
0.012	46.4	0.001012	12.36	206.9	2442.0	206.9	2383.4	2582.3	0.6663	7.3884	8.0849
0.014	52.5	0.001015	10.64	220.0	2446.1	220.0	2375.8	2585.8	0.7044	7.2945	8.0311
0.016	55.3	0.001015	9.431	231.6	2449.8	231.6	2369.0	2588.6	0.7228	7.2126	7.9848
0.018	57.8	0.001016	8.443	242.0	2453.0	242.0	2363.0	2590.6	0.7338	7.1402	7.9437
0.02	60.1	0.001017	7.648	251.4	2456.0	251.4	2357.5	2591.9	0.7372	7.0752	7.9072
0.03	69.1	0.001022	5.228	289.2	2467.7	289.2	2332.2	2624.5	0.8411	6.8234	7.7675
0.04	75.9	0.001026	3.993	317.6	2476.3	317.6	2318.5	2636.1	1.0261	6.6429	7.6690
0.06	85.9	0.001035	2.752	358.8	2489.0	358.8	2293.0	2652.9	1.1454	6.3857	7.5311
0.08	93.5	0.001029	2.007	391.8	2494.3	391.9	2275.5	2665.3	1.2202	6.2009	7.4036
0.1	99.4	0.001043	1.684	417.4	2502.6	417.5	2257.4	2674.0	1.3028	6.0500	7.3088
0.12	104.8	0.001047	1.428	439.2	2511.1	439.4	2242.7	2681.3	1.3629	5.9368	7.2377
0.14	109.3	0.001051	1.237	458.3	2518.6	458.4	2231.6	2688.0	1.4110	5.8351	7.1841
0.16	113.3	0.001054	1.091	475.2	2525.4	475.4	2223.6	2694.0	1.4551	5.7403	7.1418
0.18	116.9	0.001058	0.975	490.5	2525.5	490.7	2217.7	2701.4	1.4945	5.6676	7.1021
0.2	120.2	0.001061	0.8857	504.5	2529.1	504.7	2213.4	2706.5	1.5302	5.5987	7.1169
0.3	133.5	0.001073	0.6598	561.1	2543.2	561.4	2183.5	2734.9	1.6717	5.3199	6.9916
0.4	143.4	0.001084	0.5024	604.2	2553.1	604.7	2153.5	2758.1	1.7795	5.1190	6.8905
0.6	158.8	0.001101	0.3136	689.7	2566.8	670.4	2085.7	2785.1	1.9208	4.8264	6.7902
0.8	176.4	0.001118	0.2003	780.0	2576.0	770.9	2041.4	2788.3	2.0453	4.6159	6.6816
1	179.9	0.001121	0.1844	761.4	2582.7	762.5	2034.4	2777.1	2.1381	4.4869	6.5820
1.2	188.0	0.001139	0.1433	797.0	2587.8	798.2	1985.4	2783.7	2.2139	4.3038	6.5217
1.4	194.0	0.001149	0.1408	818.8	2591.8	810.1	1958.4	2788.8	2.2899	4.1843	6.4674



$$x = 2.5 \times 10^{-3}$$



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$$x = 2.5 \times 10^{-3}$$

$$QR = dU = m \Delta u$$

$$Q = m \Delta u$$

$$Q_2 = m(u_2 - u_1)$$

$$102 = 4(2015.7 - 509.2)$$

$$Q_2 = 6024.2 \text{ kJ}$$

$$u_2 = u_m = 2015.7 \text{ kJ/kg}$$

at 2 bar

$$u_1 = (1-x)u_f + x u_g$$

$$u_1 = u_f + x(u_g - u_f)$$

$$u_1 = (-2.5 \times 10^{-3}) \times 504.5 + 2.5 \times 10^{-3} \times 2529.1$$

$$u_1 = 509.15$$

$$u_f = 504.5 \text{ kJ/kg}$$

$$u_g = 2529.1 \text{ kJ/kg}$$



0/7



T (K)	u (kJ/kg)	h (kJ/kg)	s (kJ/kg·K)	u (kJ/kg)	h (kJ/kg)	s (kJ/kg·K)	u (kJ/kg)	h (kJ/kg)	s (kJ/kg·K)		
0.014	32.5	0.001013	10.69	220.0	246.1	220.0	275.8	295.0	0.7364	7.2943	8.0311
0.016	35.3	0.001015	9.431	231.6	249.8	231.6	286.0	298.6	0.7720	7.2126	7.9866
0.018	37.8	0.001016	8.440	242.0	245.0	242.0	293.0	295.0	0.8036	7.1402	7.9437
0.02	40.1	0.001017	7.648	251.4	245.0	251.4	297.5	298.9	0.8320	7.0782	7.9072
0.03	46.1	0.001022	5.228	289.2	246.7	289.2	335.2	294.5	0.9441	6.8234	7.7879
0.04	47.8	0.001026	3.993	317.6	247.3	317.6	351.5	296.1	1.0291	6.6429	7.6690
0.06	47.8	0.001033	2.727	386.8	249.8	386.8	393.0	293.0	1.1444	6.2657	7.5311
0.08	47.8	0.001039	2.087	401.6	298.2	401.6	423.5	294.2	1.2330	6.2009	7.4378
0.1	49.4	0.001043	1.694	417.4	292.5	417.4	427.4	297.4	1.3026	6.1560	7.3588
0.12	104.8	0.001047	1.428	439.2	251.7	439.4	428.7	298.3	1.3629	6.1064	7.2977
0.14	109.3	0.001051	1.237	458.3	251.9	458.4	428.6	298.0	1.4150	6.0531	7.2481
0.16	113.3	0.001054	1.091	475.2	252.4	475.4	422.0	298.0	1.4531	6.0043	7.2014
0.18	116.9	0.001058	0.973	490.5	252.5	490.7	421.0	297.4	1.4845	5.9678	7.1621
0.2	120.2	0.001061	0.8857	504.5	252.9	504.7	420.1	297.3	1.5102	5.9367	7.1289
0.3	133.5	0.001073	0.6258	561.1	253.7	561.4	413.5	294.9	1.6777	5.7199	6.9916
0.4	142.8	0.001084	0.4624	604.2	253.1	604.7	412.5	294.1	1.7765	5.5190	6.8953
0.6	158.8	0.001101	0.2156	669.7	256.8	670.4	408.7	296.1	1.9328	5.2368	6.7502
0.8	170.4	0.001115	0.2403	720.0	257.0	720.9	404.4	298.2	2.0427	4.9159	6.6154
1	179.9	0.001127	0.1944	761.4	257.2	762.3	401.4	297.1	2.1381	4.6469	6.5080
1.2	188.0	0.001139	0.1633	797.0	257.8	798.3	400.4	293.7	2.2159	4.4058	6.5277
1.4	195.0	0.001149	0.1408	828.4	259.1	830.0	400.8	290.8	2.2835	4.1840	6.4675
1.6	201.4	0.001159	0.1237	856.6	259.8	858.5	403.3	292.8	2.3435	4.0764	6.4199
1.8	207.5	0.001168	0.1104	882.4	259.2	884.5	401.4	295.9	2.3975	3.9800	6.3779
2	212.4	0.001177	0.09999	906.1	259.1	908.5	400.8	298.3	2.4488	3.8922	6.3392
3	223.8	0.001217	0.08466	1004.7	262.2	1008.3	400.9	282.2	2.6453	3.5401	6.1826
4	236.4	0.001252	0.06978	1092.3	267.7	1087.9	403.3	280.8	2.7968	3.2728	6.0606
6	275.4	0.001319	0.05243	1266.0	280.9	1213.9	407.7	278.4	3.0278	2.8623	5.8907
8	295.0	0.001385	0.03932	1384.2	287.0	1317.3	401.4	278.7	3.2081	2.5369	5.7400
10	311.8	0.001453	0.02803	1493.5	294.2	1408.1	401.4	275.5	3.3608	2.2554	5.6160
12	324.7	0.001526	0.01926	1573.1	294.3	1491.5	406.9	268.4	3.4967	1.9972	5.4939
14	336.7	0.001610	0.01149	1648.4	297.1	1571.0	406.9	263.0	3.6232	1.7495	5.3727
16	347.4	0.001699	0.006009	1622.3	293.8	1649.7	401.4	260.8	3.7437	1.5006	5.2663
18	357.0	0.001802	0.003702	1699.0	293.8	1732.1	400.8	260.8	3.8718	1.2543	5.1601
20	364.8	0.001920	0.002045	1786.4	295.0	1827.2	401.4	261.2	4.0136	0.9150	5.0514
22.064	373.99	0.002104	0.001196	2015.7	2015.7	2084.3	0.0	2084.3	4.6370	0.0	4.6370



