Name _____ ID _____

Prince of Songkla University
Faculty of Engineering

Final Test
26 Feb 2006
215-231 Thermodynamics II

Semester 2/2549
9:00 – 12:00
Room: R200

Name _____ ID _____

Direction:
1. All types of calculator, and dictionary are permitted.
2. There are totally 5 problems, 12 pages (including tables).
3. One page of hand-written A4 paper is allowed. No photocopy!!

Gumpon Prateepchaikul
Perapong Tekasakul
Instructors

Problem No.	**Full score**	**Your mark**
1	20	
2	15	
3	25	
4	20	
5	20	
Total	**100**	

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215-231 Thermodynamics II

Final Test --- 2/2547

1. A gas-turbine power plant operates on a simple ideal Brayton cycle with air as the working fluid. The air enters the compressor at 95 kPa and 290 K and the turbine at 760 kPa and 1100 K. Heat is transferred to air at a rate of 40,000 kW. Determine the power delivered by this plant assuming variable specific heat of air. (20 points)

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2.Calculate the h_{fg} and s_{fg} of R-134a at -8°C from the Clapeyron equation and find an error by comparing them with the tabulated values. (15 points)

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3. Based on the Psychrometrics you have studied, answer the following questions:

3.1 Tuckzin and Zonti both were eyeglasses. Zonti comes from the hot-weathered horse-riding statue square to the cold prime minister office while Tuckzin goes in the opposite direction. Whose eye glasses are more likely to be fogged? Why? (5 Points)

3.2 Air enters a 25-cm-diameter cooling section at 1 atm, 35°C, and 40% relative humidity at 20 m/s. Heat is removed from the air at the rate of 10 kW. Determine (20 points)

(a) the exit temperature,
(b) the exit relative humidity of the air, and
(c) the exit velocity.

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4. Consider a 300 kJ/min refrigeration system which operates on an ideal vapor compression refrigeration cycle with refrigerant-12 as the working fluid. The refrigerant enters the compressor as saturated vapor at 140 kPa and is compressed to 800 kPa. Show the cycle on a $T-s$ diagram with respect to saturation lines, and determine (20 points)
   (a) the quality of the refrigerant at the end of the throttling process,
   (b) the coefficient of performance, and
   (c) the power input to the compressor.

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5. Butane (C_4H_{10}) is burned with air and a volumetric analysis of the combustion products on a dry basis yields the following composition.

CO_2 7.8% CO 1.1% O_2 8.2% N_2 82.9%

Determine the percent of theoretical air used in this combustion process. (Molecular weight of air is 28.97) (20 points)

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Important tables that would save your day!!

Ideal gas properties -- Air

T K	h kJ/kg	P_r	u kJ/kg	v_r	s° kJ/(kg · K)	T K	h kJ/kg	P_r	u kJ/kg	v_r	s° kJ/(kg · K)
200	199.97	0.3363	142.56	1707.0	1.29559	580	586.04	14.38	419.55	115.7	2.37348
210	209.97	0.3987	149.69	1512.0	1.34444	590	596.52	15.31	427.15	110.6	2.39140
220	219.97	0.4690	156.82	1346.0	1.39105	600	607.02	16.28	434.78	105.8	2.40902
230	230.02	0.5477	164.00	1205.0	1.43557	610	617.53	17.30	442.42	101.2	2.42644
240	240.02	0.6355	171.13	1084.0	1.47824	620	628.07	18.36	450.09	96.92	2.44356
250	250.05	0.7329	178.28	979.0	1.51917	630	683.63	19.84	457.78	92.84	2.46048
260	260.09	0.8405	185.45	887.8	1.55848	640	649.22	20.64	465.50	88.99	2.47716
270	270.11	0.9590	192.60	808.0	1.59634	650	659.84	21.86	473.25	85.34	2.49364
280	280.13	1.0889	199.75	738.0	1.63279	660	670.47	23.13	481.01	81.89	2.50985
285	285.14	1.1584	203.33	706.1	1.65055	670	681.14	24.46	488.81	78.61	2.52589
290	290.16	1.2311	206.91	676.1	1.66802	680	691.82	25.85	496.62	75.50	2.54175
295	295.17	1.3068	210.49	647.9	1.68515	690	702.52	27.29	504.45	72.56	2.55731
300	300.19	1.3860	214.07	621.2	1.70203	700	713.27	28.80	512.33	69.76	2.57277
305	305.22	1.4686	217.67	596.0	1.71865	710	724.04	30.38	520.23	67.07	2.58810
310	310.24	1.5546	221.25	572.3	1.73498	720	734.82	32.02	528.14	64.53	2.60319
315	315.27	1.6442	224.85	549.8	1.75106	730	745.62	33.72	536.07	62.13	2.61803
320	320.29	1.7375	228.42	528.6	1.76690	740	756.44	35.50	544.02	59.82	2.63280
325	325.31	1.8345	232.02	508.4	1.78249	750	767.29	37.35	551.99	57.63	2.64737
330	330.34	1.9352	235.61	489.4	1.79783	760	778.18	39.27	560.01	55.54	2.66176
340	340.42	2.149	242.82	454.1	1.82790	780	800.03	43.35	576.12	51.64	2.69013
350	350.49	2.379	250.02	422.2	1.85708	800	821.95	47.75	592.30	48.08	2.71787
360	360.58	2.626	257.24	393.4	1.88543	820	843.98	52.59	608.59	44.84	2.74504
370	370.67	2.892	264.46	367.2	1.91313	840	866.08	57.60	624.95	41.85	2.77170
380	380.77	3.176	271.69	343.4	1.94001	860	888.27	63.09	641.40	39.12	2.79783
390	390.88	3.481	278.93	321.5	1.96633	880	910.56	68.98	657.95	36.61	2.82344
400	400.98	3.806	286.16	301.6	1.99194	900	932.93	75.29	674.58	34.31	2.84856
410	411.12	4.153	293.43	283.3	2.01699	920	955.38	82.05	691.28	32.18	2.87324
420	421.26	4.522	300.69	266.6	2.04142	940	977.92	89.28	708.08	30.22	2.89748
430	431.43	4.915	307.99	251.1	2.06533	960	1000.55	97.00	725.02	28.40	2.92128
440	441.61	5.332	315.30	236.8	2.08870	980	1023.25	105.2	741.98	26.73	2.94468
450	451.80	5.775	322.62	223.6	2.11161	1000	1046.04	114.0	758.94	25.17	2.96770
460	462.02	6.245	329.97	211.4	2.13407	1020	1068.89	123.4	776.10	23.72	2.99034
470	472.24	6.742	337.32	200.1	2.15604	1040	1091.85	133.3	793.36	23.29	3.01260
480	482.49	7.268	344.70	189.5	2.17760	1060	1114.86	143.9	810.62	21.14	3.03449
490	492.74	7.824	352.08	179.7	2.19876	1080	1137.89	155.2	827.88	19.98	3.05608
500	503.02	8.411	359.49	170.6	2.21952	1100	1161.07	167.1	845.33	18.896	3.07732
510	513.32	9.031	366.92	162.1	2.23993	1120	1184.28	179.7	862.79	17.886	3.09825
520	523.63	9.684	374.36	154.1	2.25997	1140	1207.57	193.1	880.35	16.946	3.11883
530	533.98	10.37	381.84	146.7	2.27967	1160	1230.92	207.2	897.91	16.064	3.13916
540	544.35	11.10	389.34	139.7	2.29906	1180	1254.34	222.2	915.57	15.241	3.15916
550	555.74	11.86	396.86	133.1	2.31809	1200	1277.79	238.0	933.33	14.470	3.17888
560	565.17	12.66	404.42	127.0	2.33685	1220	1301.31	254.7	951.09	13.747	3.19834
570	575.59	13.50	411.97	121.2	2.35531	1240	1324.93	272.3	968.95	13.069	3.21751

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Properties of saturated R-134a (vapor-liquid): Temperature-based

Temp. °C	Press. bars	Specific Volume m^3/kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg · K		Temp. °C
		Sat. Liquid $v_f \times 10^3$	Sat. Vapor v_g	Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Sat. Vapor s_g	
−40	0.5164	0.7055	0.3569	−0.04	204.45	0.00	222.88	222.88	0.0000	0.9560	−40
−36	0.6332	0.7113	0.2947	4.68	206.73	4.73	220.67	225.40	0.0201	0.9506	−36
−32	0.7704	0.7172	0.2451	9.47	209.01	9.52	218.37	227.90	0.0401	0.9456	−32
−28	0.9305	0.7233	0.2052	14.31	211.29	14.37	216.01	230.38	0.0600	0.9411	−28
−26	1.0199	0.7265	0.1882	16.75	212.43	16.82	214.80	231.62	0.0699	0.9390	−26
−24	1.1160	0.7296	0.1728	19.21	213.57	19.29	213.57	232.85	0.0798	0.9370	−24
−22	1.2192	0.7328	0.1590	21.68	214.70	21.77	212.32	234.08	0.0897	0.9351	−22
−20	1.3299	0.7361	0.1464	24.17	215.84	24.26	211.05	235.31	0.0996	0.9332	−20
−18	1.4483	0.7395	0.1350	26.67	216.97	26.77	209.76	236.53	0.1094	0.9315	−18
−16	1.5748	0.7428	0.1247	29.18	218.10	29.30	208.45	237.74	0.1192	0.9298	−16
−12	1.8540	0.7498	0.1068	34.25	220.36	34.39	205.77	240.15	0.1388	0.9267	−12
−8	2.1704	0.7569	0.0919	39.38	222.60	39.54	203.00	242.54	0.1583	0.9239	−8
−4	2.5274	0.7644	0.0794	44.56	224.84	44.75	200.15	244.90	0.1777	0.9213	−4
0	2.9282	0.7721	0.0689	49.79	227.06	50.02	197.21	247.23	0.1970	0.9190	0
4	3.3765	0.7801	0.0600	55.08	229.27	55.35	194.19	249.53	0.2162	0.9169	4
8	3.8756	0.7884	0.0525	60.43	231.46	60.73	191.07	251.80	0.2354	0.9150	8
12	4.4294	0.7971	0.0460	65.83	233.63	66.18	187.85	254.03	0.2545	0.9132	12
16	5.0416	0.8062	0.0405	71.29	235.78	71.69	184.52	256.22	0.2735	0.9116	16
20	5.7160	0.8157	0.0358	76.80	237.91	77.26	181.09	258.36	0.2924	0.9102	20
24	6.4566	0.8257	0.0317	82.37	240.01	82.90	177.55	260.45	0.3113	0.9089	24
26	6.8530	0.8309	0.0298	85.18	241.05	85.75	175.73	261.48	0.3208	0.9082	26
28	7.2675	0.8362	0.0281	88.00	242.08	88.61	173.89	262.50	0.3302	0.9076	28
30	7.7006	0.8417	0.0265	90.84	243.10	91.49	172.00	263.50	0.3396	0.9070	30
32	8.1528	0.8473	0.0250	93.70	244.12	94.39	170.09	264.48	0.3490	0.9064	32
34	8.6247	0.8530	0.0236	96.58	245.12	97.31	168.14	265.45	0.3584	0.9058	34
36	9.1168	0.8590	0.0223	99.47	246.11	100.25	166.15	266.40	0.3678	0.9053	36
38	9.6298	0.8651	0.0210	102.38	247.09	103.21	164.12	267.33	0.3772	0.9047	38
40	10.164	0.8714	0.0199	105.30	248.06	106.19	162.05	268.24	0.3866	0.9041	40
42	10.720	0.8780	0.0188	108.25	249.02	109.19	159.94	269.14	0.3960	0.9035	42
44	11.299	0.8847	0.0177	111.22	249.96	112.22	157.79	270.01	0.4054	0.9030	44
48	12.526	0.8989	0.0159	117.22	251.79	118.35	153.33	271.68	0.4243	0.9017	48
52	13.851	0.9142	0.0142	123.31	253.55	124.58	148.66	273.24	0.4432	0.9004	52
56	15.278	0.9308	0.0127	129.51	255.23	130.93	143.75	274.68	0.4622	0.8990	56
60	16.813	0.9488	0.0114	135.82	256.81	137.42	138.57	275.99	0.4814	0.8973	60
70	21.162	1.0027	0.0086	152.22	260.15	154.34	124.08	278.43	0.5302	0.8918	70
80	26.324	1.0766	0.0064	169.88	262.14	172.71	106.41	279.12	0.5814	0.8827	80
90	32.435	1.1949	0.0046	189.82	261.34	193.69	82.63	276.32	0.6380	0.8655	90
100	39.742	1.5443	0.0027	218.60	248.49	224.74	34.40	259.13	0.7196	0.8117	100

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Properties of saturated R-12 (vapor-liquid): Pressure-based

Press. bars	Temp. °C	Specific Volume m^3/kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg · K		Press. bars
		Sat. Liquid $v_f \times 10^3$	Sat. Vapor v_g	Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Sat. Vapor s_g	
0.6	−41.42	0.6578	0.2575	−1.29	153.49	−1.25	170.19	168.94	−0.0054	0.7290	0.6
1.0	−30.10	0.6719	0.1600	8.71	158.15	8.78	165.37	174.15	0.0368	0.7171	1.0
1.2	−25.74	0.6776	0.1349	12.58	159.95	12.66	163.48	176.14	0.0526	0.7133	1.2
1.4	−21.91	0.6828	0.1168	15.99	161.52	16.09	161.78	177.87	0.0663	0.7102	1.4
1.6	−18.49	0.6876	0.1031	19.07	162.91	19.18	160.23	179.41	0.0784	0.7076	1.6
1.8	−15.38	0.6921	0.09225	21.86	164.19	21.98	158.82	180.80	0.0893	0.7054	1.8
2.0	−12.53	0.6962	0.08354	24.43	165.36	24.57	157.50	182.07	0.0992	0.7035	2.0
2.4	−7.42	0.7040	0.07033	29.06	167.44	29.23	155.09	184.32	0.1168	0.7004	2.4
2.8	−2.93	0.7111	0.06076	33.15	169.26	33.35	152.92	186.27	0.1321	0.6980	2.8
3.2	1.11	0.7177	0.05351	36.85	170.88	37.08	150.92	188.00	0.1457	0.6960	3.2
4.0	8.15	0.7299	0.04321	43.35	173.69	43.64	147.33	190.97	0.1691	0.6928	4.0
5.0	15.60	0.7438	0.03482	50.30	176.61	50.67	143.35	194.02	0.1935	0.6899	5.0
6.0	22.00	0.7566	0.02913	56.35	179.09	56.80	139.77	196.57	0.2142	0.6878	6.0
7.0	27.65	0.7686	0.02501	61.75	181.23	62.29	136.45	198.74	0.2324	0.6860	7.0
8.0	32.74	0.7802	0.02188	66.68	183.13	67.30	133.33	200.63	0.2487	0.6845	8.0
9.0	37.37	0.7914	0.01942	71.22	184.81	71.93	130.36	202.29	0.2634	0.6832	9.0
10.0	41.64	0.8023	0.01744	75.46	186.32	76.26	127.50	203.76	0.2770	0.6820	10.0
12.0	49.31	0.8237	0.01441	83.22	188.95	84.21	122.03	206.24	0.3015	0.6799	12.0
14.0	56.09	0.8448	0.01222	90.28	191.11	91.46	116.76	208.22	0.3232	0.6778	14.0
16.0	62.19	0.8660	0.01054	96.80	192.95	98.19	111.62	209.81	0.3329	0.6758	16.0

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Properties of superheated R-12

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	p = 8.0 bars = 0.80 MPa (T_{sat} = 32.74°C)				**p = 9.0 bars = 0.90 MPa (T_{sat} = 37.37°C)**			
Sat.	0.02188	183.13	200.63	0.6845	0.01942	184.81	202.29	0.6832
40	0.02283	187.81	206.07	0.7021	0.01974	186.55	204.32	0.6897
50	0.02407	194.19	213.45	0.7253	0.02091	193.10	211.92	0.7136
60	0.02525	200.52	220.72	0.7474	0.02201	199.56	219.37	0.7363
80	0.02748	213.13	235.11	0.7894	0.02407	212.37	234.03	0.7790
100	0.02959	225.77	249.44	0.8289	0.02601	225.13	248.54	0.8190
120	0.03162	238.51	263.81	0.8664	0.02785	237.97	263.03	0.8569
140	0.03359	251.39	278.26	0.9022	0.02964	250.90	277.58	0.8930
160	0.03552	264.41	292.83	0.9367	0.03138	263.99	292.23	0.9276
180	0.03742	277.60	307.54	0.9699	0.03309	277.23	307.01	0.9609
	p = 10.0 bars = 1.00 MPa (T_{sat} = 41.64°C)				**p = 12.0 bars = 1.20 MPa (T_{sat} = 49.31°C)**			
Sat.	0.01744	186.32	203.76	0.6820	0.01441	188.95	206.24	0.6799
50	0.01837	191.95	210.32	0.7026	0.01448	189.43	206.81	0.6816
60	0.01941	198.56	217.97	0.7259	0.01546	196.41	214.96	0.7065
80	0.02134	211.57	232.91	0.7695	0.01722	209.91	230.57	0.7520
100	0.02313	224.48	247.61	0.8100	0.01881	223.13	245.70	0.7937
120	0.02484	237.41	262.25	0.8482	0.02030	236.27	260.63	0.8326
140	0.02647	250.43	276.90	0.8845	0.02172	249.45	275.51	0.8696
160	0.02807	263.56	291.63	0.9193	0.02309	263.70	290.41	0.9048
180	0.02963	276.84	306.47	0.9528	0.02443	276.05	305.37	0.9385
200	0.03116	290.26	321.42	0.9851	0.02574	289.55	320.44	0.9711
	p = 14.0 bars = 1.40 MPa (T_{sat} = 56.09°C)				**p = 16.0 bars = 1.60 MPa (T_{sat} = 62.19°C)**			
Sat.	0.01222	191.11	208.22	0.6778	0.01054	192.95	209.81	0.6758
60	0.01258	194.00	211.61	0.6881				
80	0.01425	208.11	228.06	0.7360	0.01198	206.17	225.34	0.7209
100	0.01571	221.70	243.69	0.7791	0.01337	220.19	241.58	0.7656
120	0.01705	235.09	258.96	0.8189	0.01461	233.84	257.22	0.8065
140	0.01832	248.43	274.08	0.8564	0.01577	247.38	272.61	0.8447
160	0.01954	261.80	289.16	0.8921	0.01686	260.90	287.88	0.8808
180	0.02071	275.27	304.26	0.9262	0.01792	274.47	303.14	0.9152
200	0.02186	288.84	319.44	0.9589	0.01895	288.11	318.43	0.9482
220	0.02299	302.51	334.70	0.9905	0.01996	301.84	333.78	0.9800

Name _____ ID _____

ASHRAE Psychrometric Chart No. 1
Normal Temperature
Barometric Pressure: 101.325 kPa

Sea Level