Prince of Songkla University
Faculty of Engineering

Final Test — Semester 2/2546
17 February 2004 — 13:30 – 16:30
216-231 Principles of Thermodynamics — Room: R201

Name _____ ID _____

Direction:
1. All types of calculators are permitted.
2. There are totally 5 problems, 13 pages, including tables and chart. Solve them all.
3. Two pages of self-written A4 paper are allowed. No photocopy is allowed.
4. Any types of dictionary are allowed.

Perapong Tekasakul
Instructor

Problem No.	**Full score**	**Your mark**
1	20	
2	15	
3	15	
4	20	
5	15	
Total	**85**	

216-231 Priciples of Thermodynamics
Final Test
Semester 2/2546

1. Answer the following questions as clear as possible. (20 points)

(a) Explain how a turbojet engine work. Draw illustration to assist your explanation. (4 points)

(b) What is the main difference between a *Gas Power Cycle* and a *Vapor Power Cycle*. (2 points)

(c) When a fan blows at you, you feel cold. You feel even colder if the fan speed is increased. Why? Explain in the term of heat transfer parameter. (3 points)

(d) Why do we need to know temperature distribution in the boundary layer of a fluid flow when we want to know the convective heat transfer coefficient? (3 points)

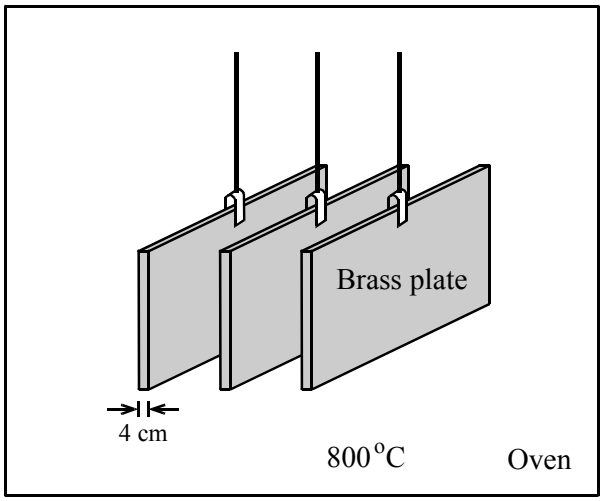
(e) It was suggested by a government official that you need to cook an egg in a boiling water for 15 minutes so that it is safe from Bird Flu disease. Do you know why? (3 points)

(f) What make *Thermal Radiation* different from *Conduction/Convection*? (2 points)

(g) What is a gray body? How does it differ from a blackbody? (3 points)

2. A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 200 and 40 psia. The mass flow rate of the refrigerant is 1.0 lbm/sec. Show the cycle on $T-s$ diagram. Determine (15 points)
   (a) the rate of heat removal from the refrigerated space,
   (b) the power input to the compressor,
   (c) the rate of heat rejection to the environment, and
   (d) the coefficient of performance.

3. In a production facility, 4-cm-thick large brass plates [$k = 110$ W/m.K, $\rho = 8530$ kg/m^3, $c_p = 380$ J/kg.K, and $\alpha = 33.9\text{x}10^{-6}$ m^2/sec] that are initially at a uniform temperature of 30°C are heated by passing them through an oven maintained at 800°C for 15 minutes. Assume $h = 85$ W/m^2.K, determine the surface temperature of the plates when they come out of the oven. (15 points)

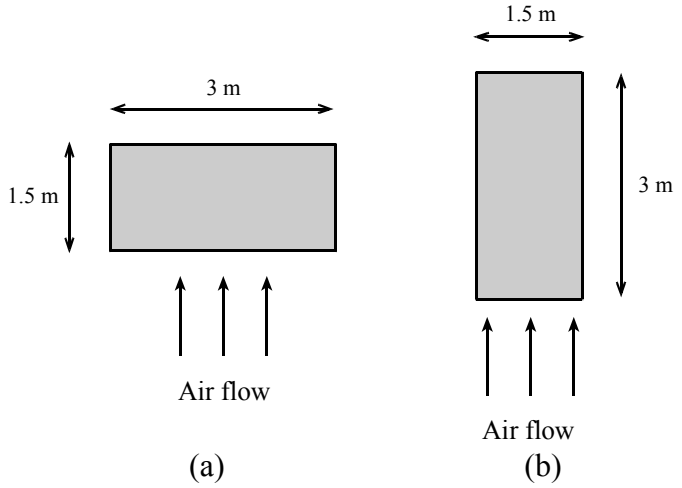


4. A solar collector is a steel sheet painted black to absorb solar radiation so that its surface is hot. Suppose you have a 1.5 m x 3.0 m sheet of the solar collector and on a sunny day it is heated so that its surface temperature is 130°C. If air at temperature of 30 °C blows over its surface at $u_\infty = 5$ m/sec, which configuration can convect heat from its surface better? (a) or (b)? Why? Prove it. (20 Points)

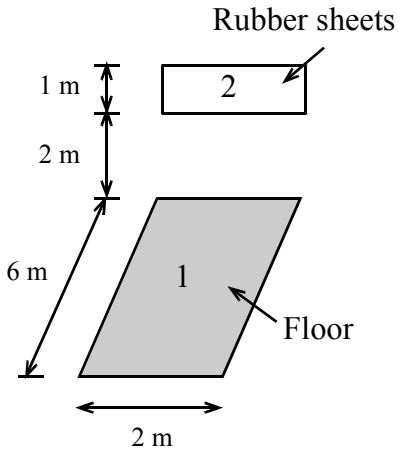
Properties of air at 350 K

$\rho = 0.995$ kg/m^3, $c_p = 1.009$ kJ/(kg K), $\mu = 208.2 \times 10^{-7}$ N sec/m^2

$k = 0.030$ W/(m K), $Pr = 0.700$



5. A floor in the rubber smoking room (1) is heated to the temperature of 100°C. A row of rubber sheets is hung on a bar and has approximate geometry of rectangular shape (2) as shown. Suppose the temperature of the rubber sheets is 50°C, calculate the rate of radiative heat transfer from the floor to the rubber sheets. Assume the following properties. (15 points)



$\varepsilon_1 = 0.7$

$\varepsilon_2 = 0.5$

$\sigma = 5.67 \times 10^{-8}$ W/m^2 K^4

Life Savers

Table 1 Properties of saturated Refrigerant-134a (liquid-vapor).

Press. lbf/in.²	Temp. °F	Specific Volume ft³/lb		Internal Energy Btu/lb		Enthalpy Btu/lb			Entropy Btu/lb · °R		Press. lbf/in.²
		Sat. Liquid v_f	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	
5	−53.48	0.01113	8.3508	−3.74	86.07	−3.73	97.53	93.79	−0.0090	0.2311	5
10	−29.71	0.01143	4.3581	2.89	89.30	2.91	94.45	97.37	0.0068	0.2265	10
15	−14.25	0.01164	2.9747	7.36	91.40	7.40	92.27	99.66	0.0171	0.2242	15
20	−2.48	0.01181	2.2661	10.84	93.00	10.89	90.50	101.39	0.0248	0.2227	20
30	15.38	0.01209	1.5408	16.24	95.40	16.31	87.65	103.96	0.0364	0.2209	30
40	29.04	0.01232	1.1692	20.48	97.23	20.57	85.31	105.88	0.0452	0.2197	40
50	40.27	0.01252	0.9422	24.02	98.71	24.14	83.29	107.43	0.0523	0.2189	50
60	49.89	0.01270	0.7887	27.10	99.96	27.24	81.48	108.72	0.0584	0.2183	60
70	58.35	0.01286	0.6778	29.85	101.05	30.01	79.82	109.83	0.0638	0.2179	70
80	65.93	0.01302	0.5938	32.33	102.02	32.53	78.28	110.81	0.0686	0.2175	80
90	72.83	0.01317	0.5278	34.62	102.89	34.84	76.84	111.68	0.0729	0.2172	90
100	79.17	0.01332	0.4747	36.75	103.68	36.99	75.47	112.46	0.0768	0.2169	100
120	90.54	0.01360	0.3941	40.61	105.06	40.91	72.91	113.82	0.0839	0.2165	120
140	100.56	0.01386	0.3358	44.07	106.25	44.43	70.52	114.95	0.0902	0.2161	140
160	109.56	0.01412	0.2916	47.23	107.28	47.65	68.26	115.91	0.0958	0.2157	160
180	117.74	0.01438	0.2569	50.16	108.18	50.64	66.10	116.74	0.1009	0.2154	180
200	125.28	0.01463	0.2288	52.90	108.98	53.44	64.01	117.44	0.1057	0.2151	200
220	132.27	0.01489	0.2056	55.48	109.68	56.09	61.96	118.05	0.1101	0.2147	220
240	138.79	0.01515	0.1861	57.93	110.30	58.61	59.96	118.56	0.1142	0.2144	240
260	144.92	0.01541	0.1695	60.28	110.84	61.02	57.97	118.99	0.1181	0.2140	260
280	150.70	0.01568	0.1550	62.53	111.31	63.34	56.00	119.35	0.1219	0.2136	280
300	156.17	0.01596	0.1424	64.71	111.72	65.59	54.03	119.62	0.1254	0.2132	300
350	168.72	0.01671	0.1166	69.88	112.45	70.97	49.03	120.00	0.1338	0.2118	350
400	179.95	0.01758	0.0965	74.81	112.77	76.11	43.80	119.91	0.1417	0.2102	400
450	190.12	0.01863	0.0800	79.63	112.60	81.18	38.08	119.26	0.1493	0.2079	450
500	199.38	0.02002	0.0657	84.54	111.76	86.39	31.44	117.83	0.1570	0.2047	500

Table 2 Properties of superheated Refrigerant-134a.

T °F	v ft³/lb	u Btu/lb	h Btu/lb	s Btu/lb · °R	v ft³/lb	u Btu/lb	h Btu/lb	s Btu/lb · °R
	p = 140 lbf/in.² (T_{sat} = 100.56°F)				**p = 160 lbf/in.² (T_{sat} = 109.55°F)**			
Sat.	0.3358	106.25	114.95	0.2161	0.2916	107.28	115.91	0.2157
120	0.3610	110.90	120.25	0.2254	0.3044	109.88	118.89	0.2209
140	0.3846	115.58	125.54	0.2344	0.3269	114.73	124.41	0.2303
160	0.4066	120.21	130.74	0.2429	0.3474	119.49	129.78	0.2391
180	0.4274	124.82	135.89	0.2511	0.3666	124.20	135.06	0.2475
200	0.4474	129.44	141.03	0.2590	0.3849	128.90	140.29	0.2555
220	0.4666	134.09	146.18	0.2667	0.4023	133.61	145.52	0.2633
240	0.4852	138.77	151.34	0.2742	0.4192	138.34	150.75	0.2709
260	0.5034	143.50	156.54	0.2815	0.4356	143.11	156.00	0.2783
280	0.5212	148.28	161.78	0.2887	0.4516	147.92	161.29	0.2856
300	0.5387	153.11	167.06	0.2957	0.4672	152.78	166.61	0.2927
320	0.5559	157.99	172.39	0.3026	0.4826	157.69	171.98	0.2996
340	0.5730	162.93	177.78	0.3094	0.4978	162.65	177.39	0.3065
360	0.5898	167.93	183.21	0.3162	0.5128	167.67	182.85	0.3132
	p = 180 lbf/in.² (T_{sat} = 117.74°F)				**p = 200 lbf/in.² (T_{sat} = 125.28°F)**			
Sat.	0.2569	108.18	116.74	0.2154	0.2288	108.98	117.44	0.2151
120	0.2595	108.77	117.41	0.2166				
140	0.2814	113.83	123.21	0.2264	0.2446	112.87	121.92	0.2226
160	0.3011	118.74	128.77	0.2355	0.2636	117.94	127.70	0.2321
180	0.3191	123.56	134.19	0.2441	0.2809	122.88	133.28	0.2410
200	0.3361	128.34	139.53	0.2524	0.2970	127.76	138.75	0.2494
220	0.3523	133.11	144.84	0.2603	0.3121	132.60	144.15	0.2575
240	0.3678	137.90	150.15	0.2680	0.3266	137.44	149.53	0.2653
260	0.3828	142.71	155.46	0.2755	0.3405	142.30	154.90	0.2728
280	0.3974	147.55	160.79	0.2828	0.3540	147.18	160.28	0.2802
300	0.4116	152.44	166.15	0.2899	0.3671	152.10	165.69	0.2874
320	0.4256	157.38	171.55	0.2969	0.3799	157.07	171.13	0.2945
340	0.4393	162.36	177.00	0.3038	0.3926	162.07	176.60	0.3014
360	0.4529	167.40	182.49	0.3106	0.4050	167.13	182.12	0.3082
	p = 300 lbf/in.² (T_{sat} = 156.17°F)				**p = 400 lbf/in.² (T_{sat} = 179.95°F)**			
Sat.	0.1424	111.72	119.62	0.2132	0.0965	112.77	119.91	0.2102
160	0.1462	112.95	121.07	0.2155				
180	0.1633	118.93	128.00	0.2265	0.0965	112.79	119.93	0.2102
200	0.1777	124.47	134.34	0.2363	0.1143	120.14	128.60	0.2235
220	0.1905	129.79	140.36	0.2453	0.1275	126.35	135.79	0.2343
240	0.2021	134.99	146.21	0.2537	0.1386	132.12	142.38	0.2438
260	0.2130	140.12	151.95	0.2618	0.1484	137.65	148.64	0.2527
280	0.2234	145.23	157.63	0.2696	0.1575	143.06	154.72	0.2610
300	0.2333	150.33	163.28	0.2772	0.1660	148.39	160.67	0.2689
320	0.2428	155.44	168.92	0.2845	0.1740	153.69	166.57	0.2766
340	0.2521	160.57	174.56	0.2916	0.1816	158.97	172.42	0.2840
360	0.2611	165.74	180.23	0.2986	0.1890	164.26	178.26	0.2912
380	0.2699	170.94	185.92	0.3055	0.1962	169.57	184.09	0.2983
400	0.2786	176.18	191.64	0.3122	0.2032	174.90	189.94	0.3051

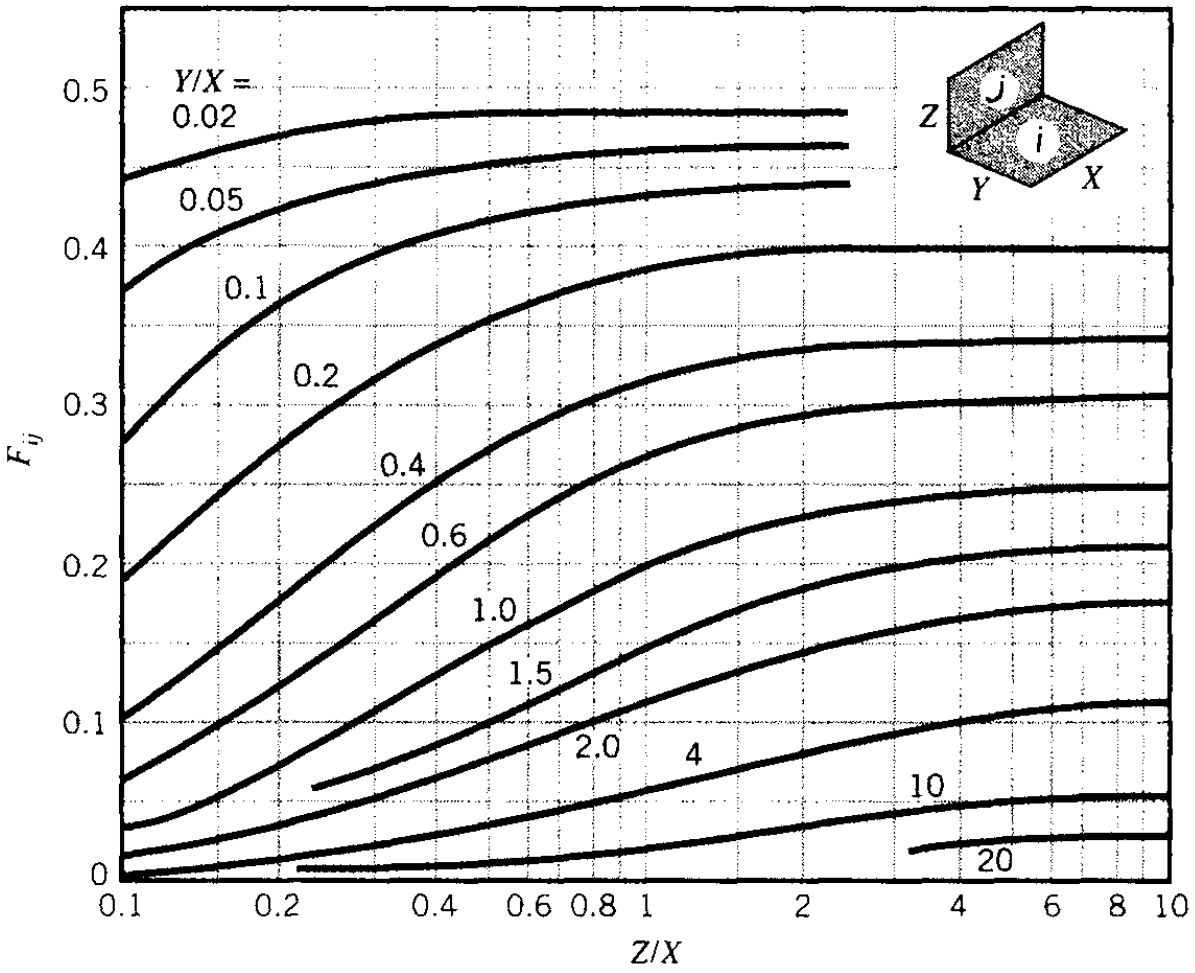


FIGURE 1 View factor for perpendicular rectangles with a common edge.

scratch paper

scratch paper