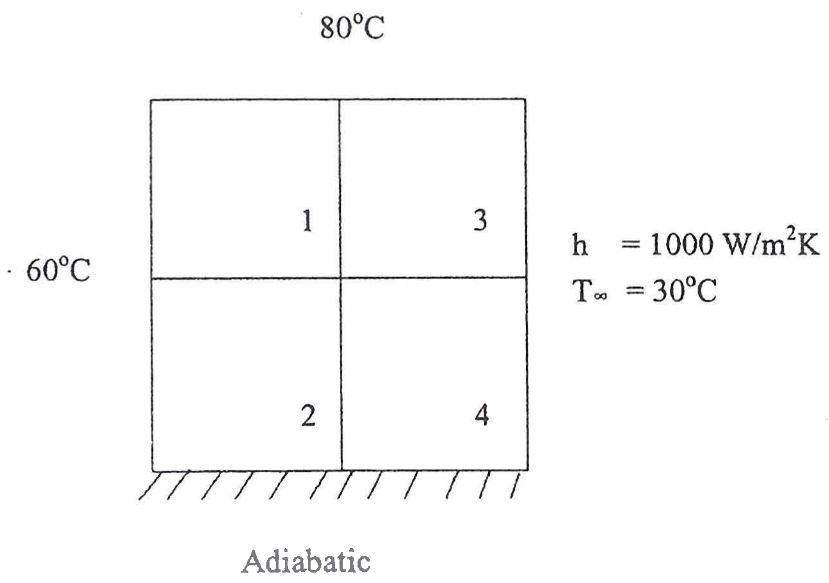
國立清華大學命題紙

95學年度 工程與系統科學 系（所） 21 組碩士班入學考試

科目 熱傳學 科目代碼 3404 共 2 頁第 1 頁 *請在【答案卷卡】內作答

1. (a)Derive the three dimensional heat diffusion equation in Cartesian coordinates (14%), and (b)describe the three kinds of boundary conditions generally encountered in heat transfer problems. (6 %)
2. Consider a long cylinder with radius R_i and uniform volumetric heat generation rate g. The cylinder is surrounded by a cladding with outside radius R_o and is cooled by a coolant at temperature T_f and heat transfer coefficient h. Determine the steady state temperature distribution in the cylinder and the maximum temperature. Assume perfect contact between the cylinder and cladding. Also denote thermal physical properties needed as appropriate. (20%)
3. Consider a slab with thickness of L initially at uniform temperature T_i. For $t > 0$, the surface at $x = L$ is subjected to a coolant at T_0 and heat transfer coefficient h, while the surface at $x = 0$ is kept insulated. Determine the temperature distribution in the slab as a function of time. Denote thermal physical properties needed as appropriate.(20%)
4. Consider two-dimensional, steady-state heat conduction in a square cross section with prescribed boundary conditions as shown, using a finite difference method based on the conservation of energy to determine the temperatures at nodes 1, 2, 3, and 4.(20%)



5. Waste heat of exhaust hot air from a manufacturing process may be recovered by passing water through a thin-walled tube of 1 cm diameter. Assume the temperature of the hot air is 77℃ in cross flow with a velocity of 10 m/s over the tube. The inlet and outlet temperatures of water are 25℃ and 55℃, respectively, and the flow rate is 0.1 kg/s. Please determine the length of the tube required. (20 %)

Hint: (1) For internal convection: $Nu_D = 4.36$, if the flow is laminar; $Nu_D = 0.023 Re_D^{0.8} Pr^{0.4}$ if the flow is turbulent. (2). For external air flow, you may use the Churchill and Bernstein correlation

$$\overline{Nu}_D = 0.3 + \frac{0.62 Re_D^{1/2} Pr^{1/3}}{\left[1+(0.4/Pr)^{2/3}\right]^{1/4}}\left[1+\left(\frac{Re_D}{282000}\right)^{5/8}\right]^{4/5}$$

(3) Look up the table attached for the properties.

Thermophysical Properties of Saturated Water

Temperature, T (K)	Pressure, P (bars)[b]	Specific Volume (m^3/kg) $v_f \cdot 10^3$	Specific Volume (m^3/kg) v_g	Heat of Vaporization, h_{fg} (kJ/kg)	Specific Heat (kJ/kg · K) $c_{p,f}$	Specific Heat (kJ/kg · K) $c_{p,g}$	Viscosity ($N \cdot s/m^2$) $\mu_f \cdot 10^6$	Viscosity ($N \cdot s/m^2$) $\mu_g \cdot 10^6$	Thermal Conductivity (W/m · K) $k_f \cdot 10^3$	Thermal Conductivity (W/m · K) $k_g \cdot 10^3$	Prandtl Number Pr_f	Prandtl Number Pr_g
295	0.02617	1.002	51.94	2449	4.181	1.868	959	8.89	606	19.5	6.62	0.849
300	0.03531	1.003	39.13	2438	4.179	1.872	855	9.09	613	19.6	5.83	0.857
305	0.04712	1.005	29.74	2426	4.178	1.877	769	9.29	620	20.1	5.20	0.865
310	0.06221	1.007	22.93	2414	4.178	1.882	695	9.49	628	20.4	4.62	0.873
315	0.08132	1.009	17.82	2402	4.179	1.888	631	9.69	634	20.7	4.16	0.883

Thermophysical Properties of Gases at Atmospheric Pressure

T (K)	ρ (kg/m^3)	c_p (kJ/kg · K)	$\mu \cdot 10^7$ ($N \cdot s/m^2$)	$\nu \cdot 10^6$ (m^2/s)	$k \cdot 10^3$ (W/m · K)	$\alpha \cdot 10^6$ (m^2/s)	Pr
Air							
100	3.5562	1.032	71.1	2.00	9.34	2.54	0.786
150	2.3364	1.012	103.4	4.426	13.8	5.84	0.758
200	1.7458	1.007	132.5	7.590	18.1	10.3	0.737
250	1.3947	1.006	159.6	11.44	22.3	15.9	0.720
300	1.1614	1.007	184.6	15.89	26.3	22.5	0.707
350	0.9950	1.009	208.2	20.92	30.0	29.9	0.700
400	0.8711	1.014	230.1	26.41	33.8	38.3	0.690
450	0.7740	1.021	250.7	32.39	37.3	47.2	0.686
500	0.6964	1.030	270.1	38.79	40.7	56.7	0.684
550	0.6329	1.040	288.4	45.57	43.9	66.7	0.683