CHG 3314
Midterm Exam

June 22, 2004

Duration: 90 min
Open book exam
Do any 2 problems; the exam will be marked out of 20
State clearly all assumptions

Good Luck!!!

(10) Problem 1

Water at 50°C is passed through a pipe having thermal conductivity of 0.17 W/m K. The internal and external diameters of the pipe are 5 and 7 cm, respectively. The pipe is located in the environment at 20°C. If the resistances to the internal and external convection are negligible, determine the rate of heat loss per unit length of the pipe.

If water at 70°C were to be passed through a pipe made from the same material and having the same wall thickness as the one described above, what should be its internal diameter for the rate of heat loss per unit length to be the same as the value calculated above?

(10) Problem 2

An electrical current is passed trough a horizontal copper wire 1 mm in diameter and 30 cm long, located in an air stream at 20°C. The ends of the wire are also maintained at 20°C and the convective heat transfer coefficient is estimated to be 30 W/m^2 K. Assuming negligible radiation, determine the maximum current (I) that can be passed through the wire if the midpoint temperature is not to exceed 50°C.

For the copper wire take: k = 386 W/m K and the electrical resistance per unit length, R = 5.467 x 10^{-3} Ω/m. The volumetric rate of heat generation resulting from passing of the electrical current, $\dot{Q}_v/L = I^2 R$, where I is the electrical current in amperes.

(10) Problem 3

A stainless steel ball, which is initially at 10°C, passes through an oven maintained at 300°C. The effective heat transfer coefficient in the oven is 417 W/m^2 K. If after 5 minutes in the oven the average temperature of the ball is 213°C, what is the diameter of the ball? What is the surface temperature of the ball after 5 minutes in the oven?

Use the following properties for the stainless steel: ρ = 8238 kg/m^3, c = 486 J/kg K, k = 13 W/m K.

Appendix

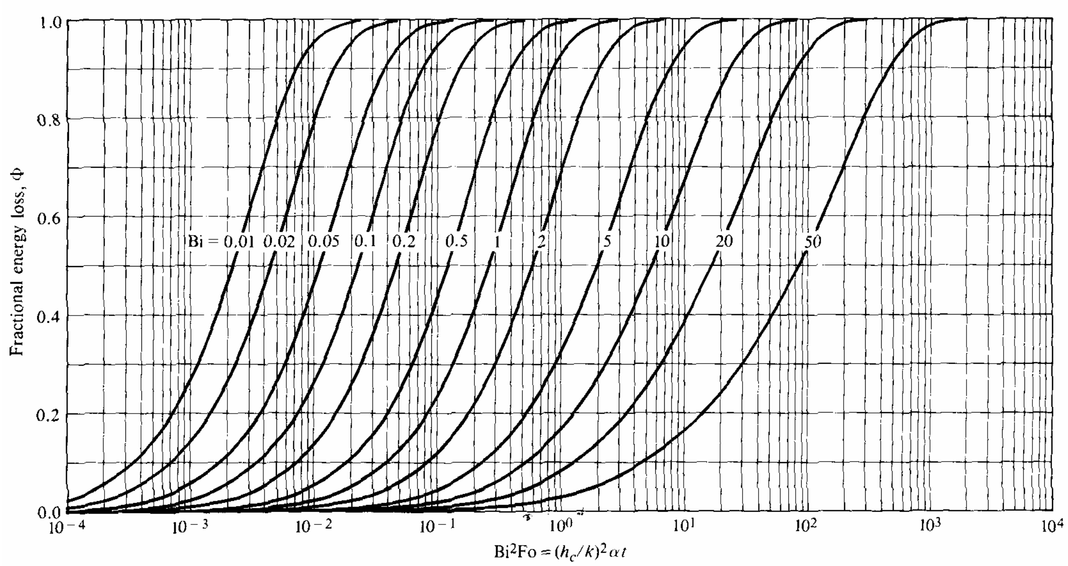

Figure C.2*c* Fractional energy loss for a convectively cooled sphere; $\mathrm{Bi} = h_c R/k$.

Table 3.5 Constants in the one-term approximation for convective cooling of slabs, cylinders, and spheres.

Sphere

Bi	λ_1^2	A_1	B_1	Bi	λ_1^2	A_1	B_1
0.02	0.05978	1.0060	0.9940	2	4.116	1.479	0.6445
0.04	0.1190	1.012	0.9881	4	6.030	1.720	0.5133
0.06	0.1778	1.018	0.9823	6	7.042	1.834	0.4516
0.08	0.2362	1.024	0.9766	8	7.647	1.892	0.4170
0.10	0.2941	1.030	0.9710	10	8.045	1.925	0.3952
0.2	0.5765	1.059	0.9435	20	8.914	1.978	0.3500
0.4	1.108	1.116	0.8935	30	9.225	1.990	0.3346
0.6	1.599	1.171	0.8490	40	9.383	1.994	0.3269
0.8	2.051	1.224	0.8074	50	9.479	1.996	0.3223
1.0	2.467	1.273	0.7740	100	9.673	1.999	0.3131
				∞	9.869	2.000	0.3040

GOOD LUCK!!!