ME 353 M.M. Yovanovich

Week 6

Lecture 1

Project 1 will be returned tomorrow.
Read Chapter 5: Sections 5.1 - 5.8.
Lumped Capacitance Model (Method) LCM; $Bi = h\mathcal{L}/k < 0.2$; $T(\vec{r}, t) = T(t)$; system parameters: $V, S, \rho, c_P, k, \alpha, h, T_i, T_f, T_{\text{surr}}, q_{\text{in}}, \dot{E}_{\text{gen}}, \dot{E}_{\text{storage}}, Q_{\text{conv}}, Q_{\text{rad}}$; energy balance on control volume gives governing equation:

$$Q_{\text{in}} + \dot{E}_{\text{gen}} = \dot{E}_{\text{storage}} + Q_{\text{conv}} + Q_{\text{rad}}$$

$Q_{\text{in}} = q_{\text{in}}S$; $\dot{E}_{\text{gen}} = \mathcal{P}V$; $\dot{E}_{\text{storage}} = \rho V c_P d\theta(t)/dt$ where $\theta(t) = T_f - T(t)$ or $\theta(t) = T(t) - T_f$; $Q_{\text{conv}} = hS\theta$; $Q_{\text{rad}} = \epsilon\sigma S(T^4(t) - T_{\text{surr}}^4)$;
ode:

$$d\theta/dt + (h_0 P)/(\rho c_P V)\theta = q_{\text{in}}S/(\rho c_P V) + \mathcal{P}/(\rho c_P)$$

where $h_0 = h + h_{\text{rad}}$; IC: $\theta(0) = \theta_i$; ode is nonlinear when radiation is present; numerical solutions are required; examine special cases: (a) $q_{\text{in}} = 0$ and $\mathcal{P} = 0$; (b) $q_{\text{in}} = 0$ and $\mathcal{P} > 0$;
case (a): solution: $\theta(t)/\theta_i = exp(-mt)$ where $m = hP/(\rho c_P V) = 1/t_c$ where $t_c = \rho c_P V/(hS)$ is the characteristic time or the time constant;
case (b): solution: $\theta(t) = n/m + (\theta_i - n/m)exp(-mt)$;
steady-state solution: when $d\theta(t)/dt = 0$, then $\theta_{ss} = n/m$; see Website and Maple worksheets; see text for examples and problem set with solutions;

Lecture 2

Return Project 1. Well done in general.
Characteristic body length in Biot number: $Bi = h\mathcal{L}/k$; $\mathcal{L} = V/S$;
discuss LCM with Ohmic (Joulean) heating;
diffusion in halfspace: three types of boundary conditions: (i) Dirichlet, (ii) Neumann, (iii) Robin; see text for solutions; see Website for Maple worksheets.

Lecture 3

See Website for Maple worksheets for solutions of LCM and diffusion in halfspace for Dirichlet, Neumann and Robin conditions; discuss midterm exam:

Friday, October 24, 4:30-6:30 PM in CPH3374/3388;
three questions of equal value; all material up to and including the LCM; close book examine; one letter size crib sheet (both sides); calculator; old midterm exams are on the Website.