ECE 309 M.M. Yovanovich

Week 4

Lecture 1

Victoria Day. No Lecture.

Lecture 2

• Lumped Capacitance Model (LCM) $\boxed{Bi = hD/(2k) < 0.2)}$ for transient conduction in a long wire of diameter D with ohmic heating and convection cooling. See ECE 309 Web site for details.

• Temperature excess:
• For heating $\theta = T_f - T(t)$
• For cooling $\theta = T(t) - T_f$
• Both cases are represented by a single *cooling* curve.

• Three components:
• $\dot{E}_{\text{gen}} = J^2 \rho_e$
• $\dot{Q}_{\text{loss}} = hA_{\text{s}} \left[T(t) - T_f \right]$
• $\dot{E}_{\text{storage}} = \rho C_{\text{P}} V d \left[T(t) - T_f \right] / dt$
• Temperature excess: $\theta(t) = T(t) - T_f$
• Derivation of nonhomogeneous ordinary differential equation:

$$\frac{d\theta}{dt} + m\,\theta = n, \qquad t > 0$$

• Definitions of parameters m and n

$$m = \frac{hP}{\rho C_P A_c} \qquad \text{and} \qquad n = \frac{J^2 \rho_e}{\rho C_P}$$

• Intitial condition: $\theta(0) = \theta_0 = T_0 - T_f$
• Definition of characteristic time constant

$$t_c = \frac{1}{m} = \frac{\rho C_P A_c}{hP}$$

• General solution of ODE

$$\theta(t) = \frac{n}{m} + \left(\theta_0 - \frac{n}{m}\right) e^{-mt}, \qquad t > 0$$

• Steady-state solution occurs when $mt \to \infty$
• Then $\dot{E}_{\rm gen} = \dot{Q}_{\rm loss}$
•

$$\theta_{ss} = \frac{n}{m} = \frac{J^2 \rho_{\rm e} A_{\rm c}}{hP}$$

Lecture 3

• Hand in Project 1, Part 1.
• 15 minutes to do Project 1, Part 2.
• Show how to use the resistance concept to obtain the solution to the problem of Project 1, Part 1.
