CENG101B Heat Transfer Fall Quarter 2008
http://maecourses.ucsd.edu/ceng101b

Quiz II

This is a 50 minute closed-book exam; no notes. Please put your name on the top sheet. Answer all three questions. Explain your working and state any assumptions you have made.

1 (3 points) Circle the correct answer.

1. The effectiveness of a finned heat exchanger with no-flux end condition
   - is independent of its width.
   - tends to 0 as the fin becomes longer.
   - can be computed in two ways: by integrating over the base or by integrating over the surface.
   - is the same for all fins of the same shape.
   - was derived in class for short fins.
2. For small Biot numbers,
   - the temperature along the boundary of the solid is equal to the ambient temperature.
   - temperature changes linearly in time inside the solid.
   - the solution one uses is only valid for small X_{Fo}.
   - one can find the solution by solving an ordinary differential equation.
   - the solution is independent of the ambient temperature.
3. The unsteady heat equation has a similarity solution for a semi-infinite solid
   - because there is no natural length scale for the problem.
   - because there is no time dependence
   - for narrow solids.
   - that holds in a narrow layer near the boundary.
   - that is independent of the thermal diffusivity α.

2 (7 points) A 52&7/8-inch long, 2-inch wide and 1/2-inch thick steel blade is put in a fire to obtain an impressive effect for a blockbuster Hollywood trilogy. Given that a bright cherry-red glow is visible at 1000°C and that the fire is at 1600° C, how long does it take for the sword to reach a photogenic temperature? [The properties of steel vary over such a large temperature range; take the values (actually for iron) at 500°C of $k = 61$ W/m·K, $c_p = 532$ J/kg·K and $\rho = 7,870$ kg/m^3 as representative. Assume there is little air flow directly past the blade, so that the heat transfer coefficient has the value of 20 W/m^2·K.]

3 (10 points) A thin rectangular slab of silicon of half-thickness 10-cm (thermal diffusivity $\alpha =$ 0.8 cm^2/s) at 80°C is immersed in a bath of water that is maintained at 4°C. What are the temperatures at the midpoint and surface of the slab after 1 second? After 1 minute? [The similarity solution for transient heat conduction with an imposed temperature at $y = 0$ in the semi-infinite slab $y > 0$ is given by $\Theta = \mathrm{erf}(y/\sqrt{4\alpha t})$. The thermal penetration depth is $\delta_T = 4(\alpha t)^{1/2}$. The temperature in a thin slab for not-too-short times is given by $\Theta_1 = A_1 \exp(-\lambda_1^2 X_{Fo}) \cos \lambda_1 \xi$, where ξ is the non-dimensional coordinate measured from the midpoint of the slab ($\xi = 0$) to its surface ($\xi = 1$). See the graphs on the next page.]

Graphs