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 heat equation
   - is the same as the Navier–Stokes equation.
   - cannot be solved.
   - includes h.
   - can be derived from the First Law of Thermodynamics.
   - only holds in a vacuum.
2. For one-dimensional steady-state conduction,
   - the temperature gradient is constant.
   - the temperature is zero.
   - the solution is independent of the boundary conditions.
   - heat generation is always important.
   - the heat flux decays like $1/r$.
3. Fourier's equation
   - is a conservation law.
   - is a constitutive law that relates heat flux to temperature gradient.
   - governs radiative heat transfer.
   - is a reformulation of the First Law of Thermodynamics.
   - always leads to steady-state problems.

2 (7 points) The material "Quadboard" has a thermal conductivity that is not constant, but that behaves as $k = \alpha(T - T_0)^2$. What are the units of α? For a steady one-dimensional problem, what is the heat flux? Write down the governing equation for temperature. Solve it for the case where $T = T_0$ at $x = 0$ and $T = 2T_0$ at $x = L$. Evaluate the heat flux q. What constant value of k gives the same value of q? [Note: the ODE $\theta^2 \mathrm{d}\theta/\mathrm{d}x = C$ can be solved by separating variables.]

3 (10 points) Hot water at 70°C flows along a 2-cm diameter copper pipe. The outside air temperature is 25°C. If the pipe is wrapped in 2 cm of fiberglass ($k = 0.036$ $\mathrm{Wm^{-1}K^{-1}}$), what is the heat flow per unit meter of pipe? How much insulation is required to reduce the heat flow by a factor of two? If there is a 1-mm thick layer of scale (essentially calcium carbonate with $k = 2.5$ $\mathrm{Wm^{-1}K^{-1}}$) on the inside of the pipe, what does the heat flux become? Justify in words why you have ignored the effect of the copper ($k = 400$ $\mathrm{Wm^{-1}K^{-1}}$) pipe.