Name: ___________________________________

EXAM II
Conductive Heat Transfer

Tuesday September 27, 2005
Closed Book, Closed Notes

Instructions

1. This exam is closed books and closed notes. Test notes are provided.
2. Write on the exam script only. Extra paper can be obtained from the instructor. Write ONLY on the front side of each page. Do not separate pages of the exam; do not remove staples from the exam.
3. On all graphs, be absolutely *neat* and *clear* about distinguishing features, curvature, relative magnitudes and labels.
4. Clearly indicate the part of the problem, i.e. a, b, etc., to which your analyses correspond.
5. Reference any figures, charts or tables from the test notes.
6. Show all work. Show *all* equations in symbolic form, all numerical substitutions, and all calculations.

GOOD LUCK!

Problem	Points	Possible
1		3
2		27
3		20
Total		50

Problem 1

(a) In words (no equations or symbols), explain the meaning or provide the definition of effectiveness for a fin.

(b) In words, list the condition(s) under which lumped capacitance is valid for a solid which is subjected to convective heat transfer. If lumped capacitance is valid, what is the implication for the temperature variation in the solid as compared with the temperature variation in the surrounding liquid?

Problem 2

A constant-area fin having thermal conductivity k, perimeter P, cross-sectional area A_c, and base temperature T_b undergoes one-dimensional steady-state conduction. The fin is exposed to a fluid with average convective heat transfer coefficient h and ambient temperature T_∞.

(a) From a differential control volume, derive the differential equation governing T(x) for a long fin where x is the axial coordinate originating at the base of the fin. Clearly draw and label the control volume with the differential length dx and all heat transfer rates. Perform the energy balance, expand q(x+dx) in a Taylor series about x, substitute the Taylor series into the energy balance, simplify and take the limit as dx approaches zero, substitute Fourier's law and simplify.

(b) Specify boundary conditions needed to solve this differential equation.

(c) Solve for T(x).

Problem 3

A solid having uniform thermal conductivity k undergoes steady-state two-dimensional heat transfer and generates energy $\dot{q}$ uniformly throughout its volume. Its domain has been discretized in Cartesian coordinates with a uniform grid spacing Δx in the x direction and a uniform grid spacing Δy in the y direction, with the nodes numbered as shown. From a finite control volume, derive the expression for T_5 using finite difference methods. Draw the control volume, clearly labelling Δx, Δy, and heat transfer rates.