ME 323 Midterm Exam. 11/07/02, 58pts total Name_____

True/False. Circle the correct answer. (1pt each, 7pts total)

1. k, h and s are functions of temperature. T F

2. In general, k is a function of temperature and position. T F

3. The electrical resistor analogy for heat transfer is exact for steady 1-D heat problems with constant properties involving conduction, convection, and radiation. T F

4. The heat transfer coefficient h is a constant for heat transfer problems involving convection. T F

5. Convection is the most important heat transfer mode affecting the Earth's surface temperature. T F

6. Conduction is the dominant heat transfer mechanism at low temperatures. T F

7. Radiation is the dominant heat transfer mechanism at high temperature. T F

Assortment of problems of increasing value and effort….

8. (3pts) What are the respective units of k, h, and s?

9. (3pts) Describe the process of convection heat transfer at fluid-solid interface.

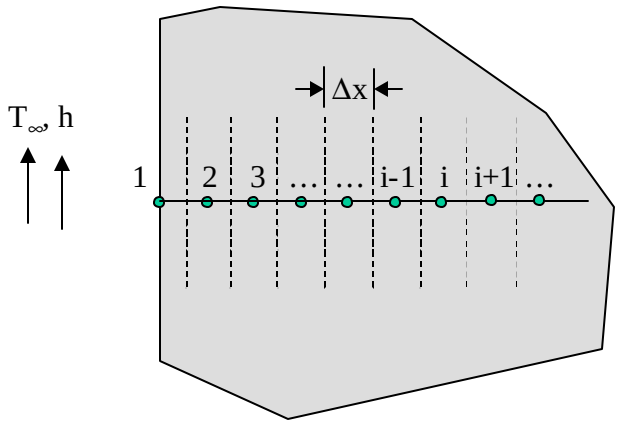
10. (6pts) A curtain over a window provides a thermal solution. With your knowledge of the three heat transfer mechanisms describe how a curtain accomplishes its objectives.

11. (6pts) The heat flux on a surface of width w is given by $q''(y) = (k\ T_o/L)(1+(y/L)^2)$. What is the total heat transfer per unit width w for $0 < y < L$.

12. (6 pts) A 1-D transient conduction problem in a wall, where the conductivity k is a function of position x is governed by the equation

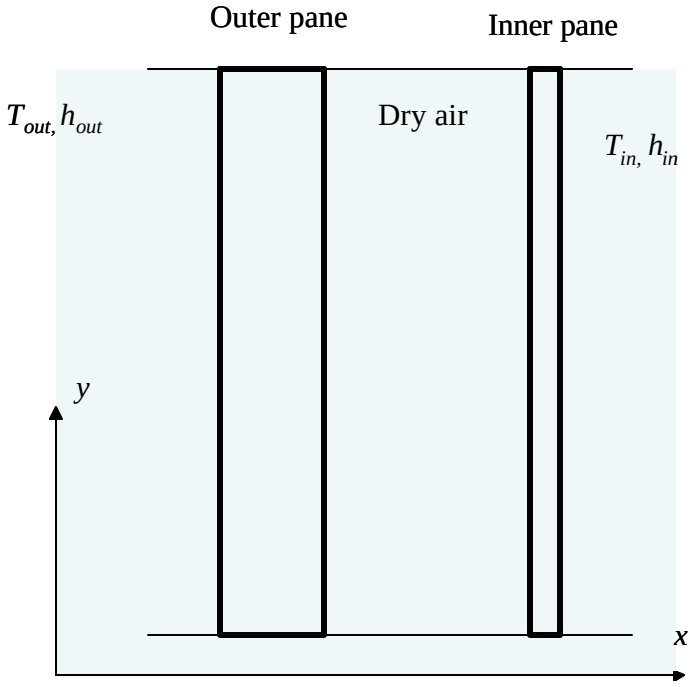
$$\rho c_p \frac{dT}{dt} = \frac{d}{dx}\left(k \frac{dT}{dx}\right)$$

The above equation needs be discretized using the finite difference method for numerical solution. Discretize the conduction term in the above equation at node *i*.

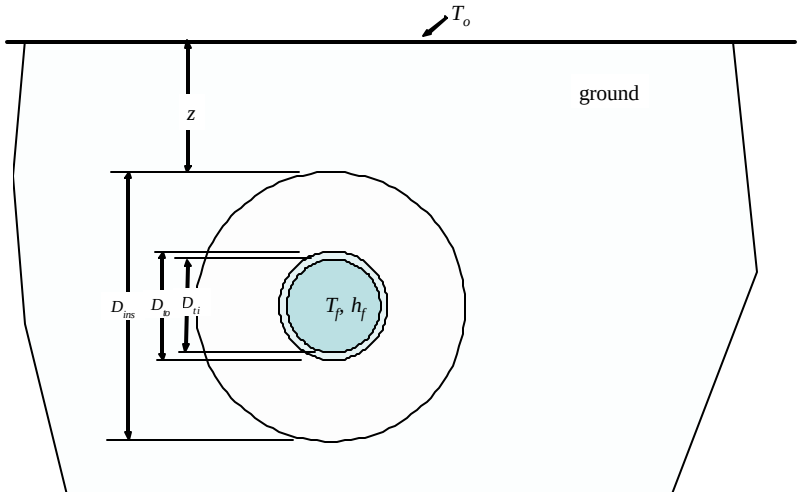


13. (7pts) 'Enough' hair can serve as insulation, but an isolated hair acts like a fin performing the opposite function. Identify the steps, boundary conditions, assumptions, etc. you would use to compute the heat loss from a single hair. Use the 'fin solutions' table attached and sound argument to justify any necessary assumptions.

14. (8pts) A 'safety' double pane window consists of a significantly thicker outer pane than the inner pane. Assuming the external heat transfer coefficient is much larger than the interior heat transfer coefficient, using the grid overlaid on the sketch draw a fairly quantitative temperature profile you might expect on the schematic (to scale) provided below assuming the inside temperature is 100 F and the outside temperature is 0 F.



15. (12 pts) A long insulated pipe of length L is buried in the ground a distance z from the surface. The pipe carries a heated fluid of temperature T_f flowing at a rate yielding heat transfer coefficient h_f. The temperature of the outside air/ground interface is given by T_o. A schematic of this situation (not necessarily to scale) is sketched in the figure below with some important dimensions given.



A. Draw the resistance model for this thermal problem. DO NOT SOLVE.

B. Write, label, identify the important thermal resistances (make table if necessary) Use values from the figure where appropriate in your labels.

C. For a metal pipe conveying a liquid with h = 10, what is the controlling thermal resistance if k_{ins} = 0.1, D_{ins} = 0.10, D_{to} = 0.033, D_{ti} = 0.027, k_t = 20, k_{ground} = 3, and z = 0.25? (SI units used)

Cheat sheet

Photocopy of shape factor page,

Table of fin solutions

Cylindrical and spherical thermal resistance.