Prince of Songkla University
Faculty of Engineering

Midterm Test
25 December 2007
215-332 Heat Transfer

Semester 2/2550
13:30-16:30
Room: 1300

Name _____ ID _____

Direction:
1. All types of calculator, and dictionary are permitted.
2. There are totally 5 problems.
3. One page of hand-written A4 paper is allowed. No photocopy!!

Perapong Tekasakul
Instructor

Problem No.	Full score	Your mark
1	15	
2	15	
3	10	
4	10	
5	10	
Total	**60**	

215-332 Heat Transfer

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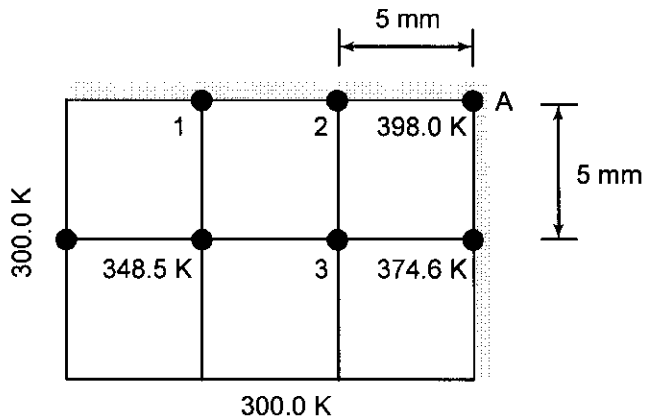
1. The walls of a refrigerator are typically constructed by sandwiching a layer of insulation between sheet metal panels. Consider a wall made from fiberglass insulation of thermal conductivity k_i = 0.046 W/m.K and thickness L_i = 50 mm and steel panels, each of thermal conductivity k_p = 60 W/m.K and thickness L_p = 3 mm. If the wall separates refrigerated air at $T_{\infty,i}$ = 4°C from ambient air at $T_{\infty,o}$ = 25°C, what is the heat gain per unit surface area (flux)? Draw the diagram and show the thermal circuit. Coefficients associated with natural convection at the inner and outer surfaces may be approximated as $h_i = h_o$ = 5 W/m^2.K. (15 points)

2. A cylindrical shell of inner and outer radii, r_i and r_o, respectively, is filled with a heat-generating material that provides a uniform volumetric generation rate (W/m^3) of $\dot{q}$. The inner surface is insulated, while the outer surface of the shell is exposed to a fluid at T_∞ and a convection coefficient h.
   (a) Obtain an expression for the steady-state temperature distribution, $T(r)$, in the shell, expressing your result in terms of r_i, r_o, $\dot{q}$, h, T_∞, and the thermal conductivity k of the shell material.
   (b) Determine an expression for the heat rate, $q'(r_o)$, at the outer radius of the shell in terms of $\dot{q}$ and shell dimensions.

   Hint: Begin with $T(r) = -\frac{\dot{q}}{4k} r^2 + C_1 \ln r + C_2$. (15 points)

3. Steady-state temperature (K) at three nodal points of a long rectangular rod are as shown. The rod experiences a uniform volumetric generation rate of $5\text{x}10^7$ W/m^3 and has a thermal conductivity of 20 W/m.K. Two of its sides are maintained at a constant temperature of 300 K, while the others are insulated. Determine the temperature at nodes 1, 2, and 3. (10 points)

$$T_{m,n+1}+T_{m,n-1}+T_{m+1,n}+T_{m-1,n}+\frac{\dot{q}(\Delta x)^2}{k}-4T_{m,n}=0$$



4. Steel balls 12 mm in diameter are annealed by heating to 1150 K and then slowly cooling to 400 K in an air environment for which $T_\infty = 325$ K and $h = 20$ W/m^2.K. Assuming the properties of the steel to be $k = 40$ W/m.K, $\rho = 7800$ kg/m^3, and $c = 600$ J/kg.K, estimate the time required for the cooling process. (10 points)

5. Consider atmospheric air at 25°C and a velocity of 25 m/s flowing over both surfaces of a 1-m long flat plate that is maintained at 125°C. Determine the rate of heat transfer per unit width from the plate. Use fluid properties: ρ = 1.00 kg/m^3, ν = 20.72x10^{-6} m^2/sec, k = 0.0299 W/m.K, Pr = 0.7. (10 points)