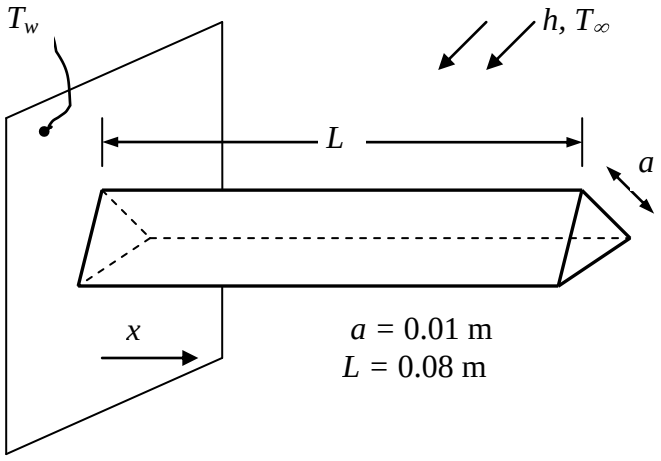
Problem Set # 4

Given: Wed., Oct. 10 **Recommended Completion Date:** Wednesday, Oct. 17
Do not submit for grading

Problem 1: A straight metal rod [k_{rod} = 138.56 W/m-K] of equilateral triangular cross-section is welded (excellent thermal contact) to a wall that is maintained at a constant temperature of T_w = 118°C. The length of the rod L = 0.08 m, and the side of its equilateral cross-section is 0.01 m, as shown in the figure below. The rod is exposed to a forced convection environment: h = 20 W/m^2-K and T_∞ = 18°C. Steady-state conditions prevail, and radiation heat transfer may be assumed to be negligible.
(hint: use compensated length approach)

a) Estimate the tip temperature

b) Calculate the fin efficiency



Ans.: (a) $T_{tip} = 92.05$°C; *(b)* $\eta_{fin} = 82.5\%$

Problem 2: One end of a copper rod [k_{rod} = 395 W/m-°C] of 30 cm long and 12.5 mm diameter, is firmly connected (excellent thermal contact) to a wall that is maintained at 200°C. The other end of the rod is firmly connected (again, excellent thermal contact) to a wall that is maintained at 93°C. Air is blown across the rod: T_∞ = 38 °C; and h = 17 W/m^2-°C. (i)What is the total rate of convective heat loss from the rod to the air? (ii) Redo part *i* but assume thermal contact resistances at both ends of the rod are characterized by $h_{contact}$ = 1000 W/m^2-°C.

Ans.: (i) 19.73 W; *(ii)* 11.3 W

Problem 3: A very long insulated electrical cable is buried in earth at a depth of z = 0.3 m. The diameter of the cable is D_i = 0.02 m, and the outer diameter of the insulation D_o = 0.03 m. The electrical resistance of the cable is 5×10^{-4} Ω/m. The thermal contact resistances are negligible. The earth surface temperature is essentially constant at 10°C. Other data are given below:

$k_{cable} = 200$ W/m-°C

$k_{insulation} = 5$ W/m-°C

$k_{earth} = 0.5$ W/m-°C

Design conditions dictate that the maximum temperature in insulation should not exceed 80°C.

a) What is the maximum electrical current that the cable can safely carry under steady-state conditions?

b) Under the operating conditions of Part (a) what is the maximum temperature inside the cable?

Ans.: (a) $I_{max} = 343.4\ A$; *(b)* $T_{max} = 80.023$°C

Please do the following problems from the Textbook

Incropera et al. 2007: **4.9, 4.15, 4.20**

Or

Incropera et al. 2011: **4.9, 4.17, 4.26**