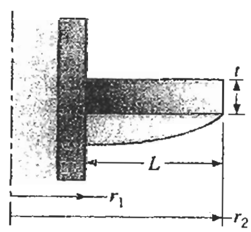
1. A plane wall is a composite of two materials, A and B, with imperfect contact. The wall of material A has volumetric heat generation distribution of $q = q_0 \cos[\pi x/(2L_A)]$ and thermal conductivity of k_A = 5 W/mK and thickness L_A = 5mm. Where $q_0 = 1.0\times10^8$ W/m^3, is a constant. The wall material B has no heat generation with k_B = 20 W/mK and thickness L_B =1mm. The thermal contact resistance between material A and material B for a unit area is 1×10^{-4} m^{2}K/W. The inner surface of material A, i.e., x =0, is well insulated, while the outer surface of material B is cooled by a water stream with T_f = 285 C and heat transfer coefficient of 10,000 W/m^{2}K. Determine the maximum temperature of material A. Show your derivation clearly. (20 %)

2. Consider an annular fin as shown, assume temperature at the fin base is Tb and fin tip is adiabatic, please determine the fin heat transfer rate, fin effectiveness and fin efficiency if the fluid temperature is T_∞ and heat transfer coefficient is h. Show your derivation clearly. (20%)



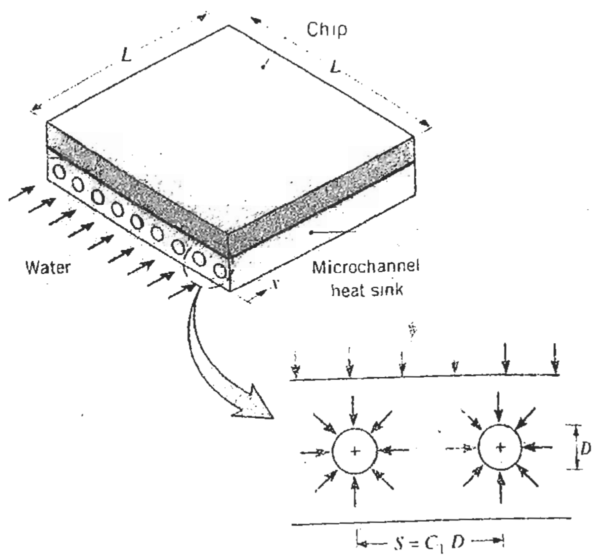
3. A semi-infinite solid wall is initially with uniform temperature T_i. The surface at x = 0 is suddenly changed to T_s, a constant, for t ≧ 0. Determine the transient temperature distribution in the solid wall and heat flux at x =0. Assume the thermal conductivity and thermal diffusivity of the wall material are k and α, respectively. Show your derivation clearly. (20%)

4. A microchannel heat sink with water as the working fluid has been proposed for cooling high performance computer chip as shown. For L=10 mm, D= 1mm, C1=2 and chip power dissipated to the microchannels is 20 W. Assume water temperature at channel inlet is 300 K and the total water flow rate is 0.0010 kg/s, determine the water temperature at outlet and maximum channel wall temperature. The following water properties are given: density (ρ) = 990 kg/m^3; specific heat (C_p) = 4.18 kJ/kgK; viscosity (μ) = 5.80×10^{-4} kg/ms, thermal conductivity (k) = 0.640 W/mK.

Hint：Nu_D=4.36 if the flow is laminar;

$Nu_D = 0.023 Re_D^{0.8} Pr^{0.4}$ if the flow is turbulent.

Show your derivation clearly. (20%)



5. Coolant inside a tube is heated by hot outer flow as shown; please determine the coolant temperature at outlet and total heat transfer rate from the outer fluid to the coolant. The inside and outside radii of the tube are r_i and r_o, respectively. The thermal conductivity for the tube wall material is k. Show your derivation clearly. (20%)