1. Please derive the three-dimensional heat diffusion equation in solid.　For the solid the thermal conductivity is k, density is ρ, specific heat is C_p, and volumetric heat generation rate is g. (20%)

2. For a composite wall as shown, determine the heat flow rate from the hot fluid to the cold fluid. (20%)
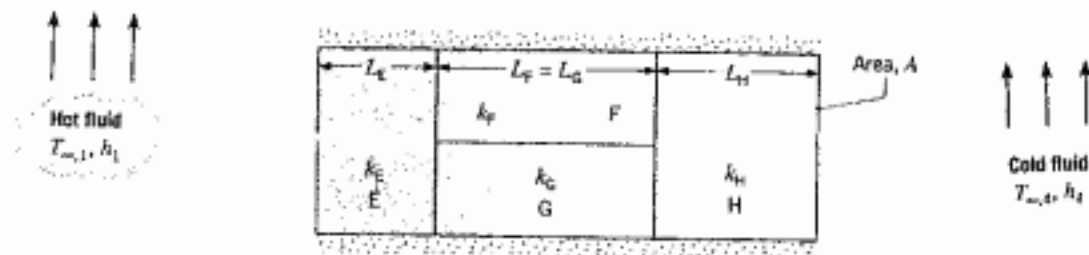
3. A plane wall, with the surface at x = 0 insulated, is initially at T_i.　Determine the transient temperature distribution in the wall if the other surface, i.e., at x = L, is subject to a fluid at a temperature of T_∞ and convective heat transfer coefficient of h for t > 0. The thermal diffusivity of the wall is α. (20%)

4. A fluid at T_i enters a circular channel of diameter D with a mass flow rate of W. The channel wall is held at a uniform temperature of T_s.　Determine the length required to elevate the fluid temperature to T_o.　Assume there is no phase change in the channel.　Also assume fully developed conditions in the channel and the convective heat transfer coefficient from the wall is h.　The specific heat for the fluid is C. (20%)

5. For a counter flow heat exchanger, show that the heat transfer rate may be evaluated by the following equation:

$$Q = U A \, \Delta T_{lm}$$

Where U is the overall heat transfer coefficient, A is the heat transfer area, ΔT_{lm} is a log mean temperature difference defined as

$$\Delta T_{lm} = (\Delta T_1 - \Delta T_2)/\ln(\Delta T_1/\Delta T_2)$$
$$\Delta T_1 = T_{h,i} - T_{c,o}; \quad \Delta T_2 = T_{h,o} - T_{c,i} \qquad (20\%)$$