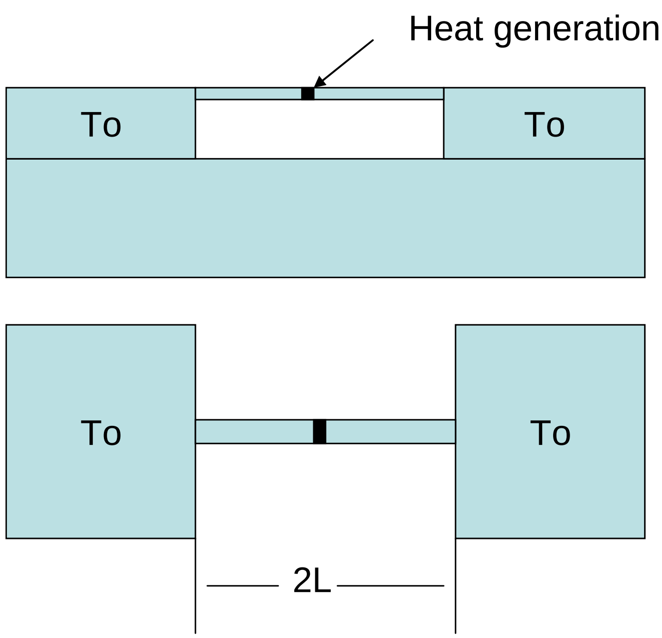
HT Qualifying Exam   Fall 2007

1) A microsensor is made by fabricating a suspended polysilicon beam above a substrate as shown below. Current is passed through the beam which heats only a small region which has a high electrical resistance. The beam has a length of 2L and cross sectional area Ac and the ends of the beam where it meets the substrate are fixed at a temperature To. The beam is also exposed to air at To with a convective heat transfer coefficient h. Assume that the beam has the typical material properties K, ρ, c_p.

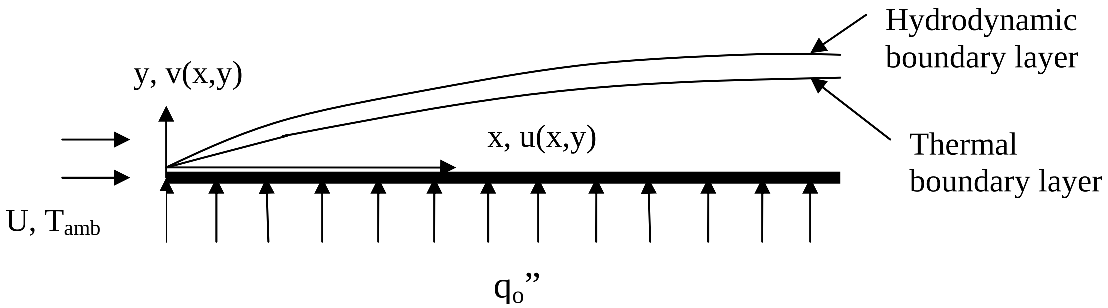
1) Find and expression for the temperature distribution in the beam as a function of the power dissipation P in the small heated region.

2) Assume that the beam is redesign to have uniform volumetric heat dissipation q along its length. The beam is still exposed to convective heat transfer conditions and the ends are still fixed at To. Find the expression for the temperature distribution in the beam.

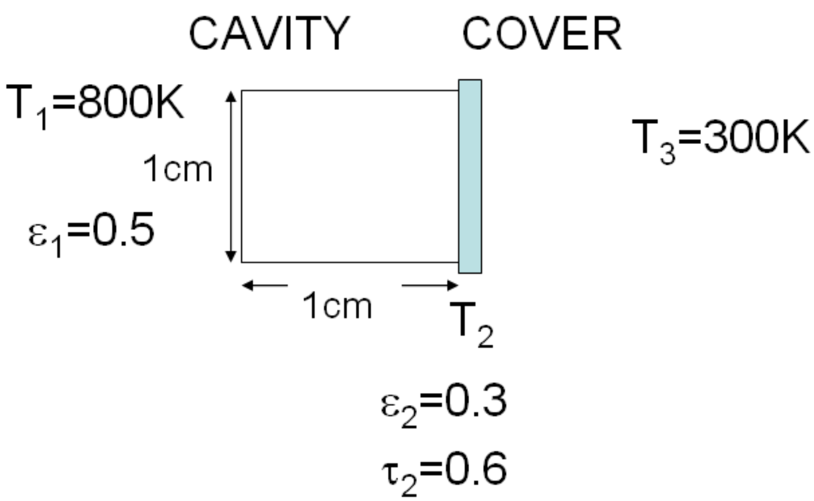
3) Discuss qualitatively how the temperature distribution in part 2 may change if h/k = 1 vs h/k = 10.



2) Consider steady, two-dimensional, low speed, incompressible, constant properties laminar forced convection boundary layer flow over a flat plate at a uniform surface heat flux q_0''.



1. (20%) Write down the governing equations and boundary conditions to determine the two velocity components u(x,y), v(x,y) and the temperature T(x,y).
2. (35%) By assuming $\eta = y\, b(x)$, $\psi = c(x)\, f(\eta)$, where $\psi(x,y)$ is the stream-function, and η is the similarity parameter, determine the functions b(x) and c(x) that result in a similarity solution for the flow. Also determine the governing equation and boundary conditions for $f(\eta)$.
3. (35%) By further assuming that in order for similarity to exist, $T(x,y) - T_{amb} = d(x)\, \phi(\eta)$, where the wall temperature excess $d(x) = T(x,0) - T_{amb} = N x^n$, determine the value of n, and the governing equation and boundary conditions for $\phi(\eta)$.
4. (10%) Determine the net rate of convected energy by the flow at any given x location.



3) Consider the square cavity shown above with a transparent cover.
   (a) Sketch the equivalent network for this problem
   (b) Develop a relationship for the effective emissivity of the cavity
   (c) Calculate the effective emissivity
   (d) Estimate the heat loss from the cavity if the surroundings temperature is 300K.