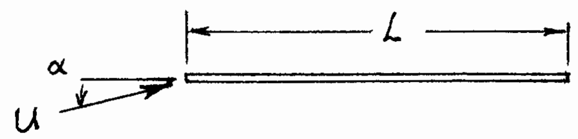
**Qualifying Examination**
**Fluid Mechanics**
(one hour, close book/notes)
January 2004

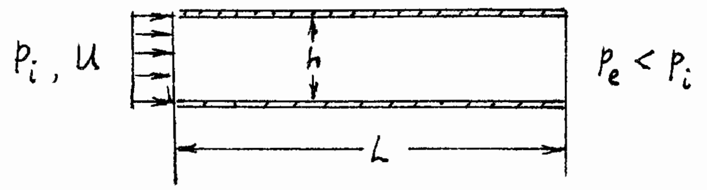
1. A flat plate airfoil of length **L** is placed in a uniform flow **U** at a small angle of attack $\alpha$ as shown.

   (a) Find the force (lift and drag) acting on the airfoil if the flow is incompressible and inviscid. Sketch the streamlines around the airfoil.
   (b) In (a),what effect will have on the force if the airfoil has a finite thickness and/or camber? Explain your results using Bernoulli's equation.
   (c) What are the effects of compressibility and viscosity of the fluid on the force? When these effects should be taken into account?




2. An incompressible viscous flow of uniform velocity **U** enters a parallel-plate channel of length **L** and width **h** as shown. The flow is driven by the pressure difference between the entrance and the exit of the channel.

   (a) Write down the governing equations (2D) which determine the velocity and pressure of the flow in the channel. State the boundary conditions.
   (b) If the channel length is much greater than the entrance length of the flow, determine the velocity profile in the fully developed region.
   (c) In the entrance region, the flow is developing from the uniform flow at the channel entrance to the fully developed velocity profile found in (b). Consider that the fully developed flow starts at the location where the two boundary layers (one over the upper plate and one over the lower plate) merge. Show from the order of magnitude analysis that the entrance length Le is proportional to the product of h and Re where Re = $\rho$ Uh/$\mu$ is the Reynolds number, in which $\rho$ is the fluid density and $\mu$ is the viscosity.



ASSIGNED NUMBER: ______________

Phd.Qualifying Exam – Jan. 2004
*HEAT TRANSFER*
(1 hour – closed book)

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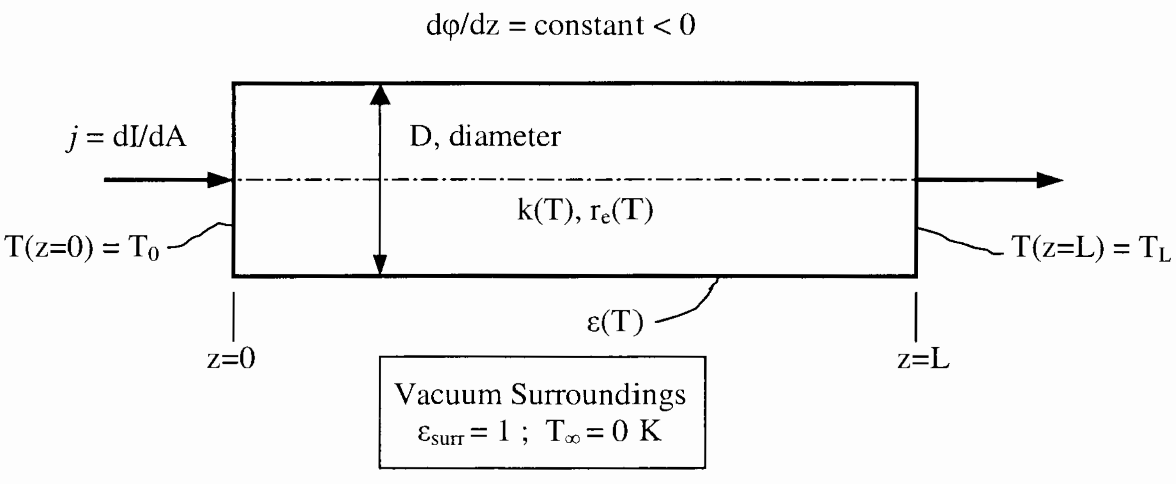
For semiconducting materials, as the temperatue increases:
- the electrical resistivity, $r_e$, decreases
- the thermal conductivity, k, increases
- the emissivity, $\varepsilon$, decreases

Let: $r_e(T) / r_{e0} = (T / T_0)^{-p}$

$k(T) / k_0 = (T / T_0)^{q}$ Note: $q < p$

$\varepsilon(T) / \varepsilon_0 = (T / T_0)^{-s}$

The electrical current flux, $j = dI/dA$, is uniform on the cross section, and the voltage gradient $(d\varphi/dz)$ is constant and negative so that $j$ is positive as shown. The diameter of the rod is D and its length is L. It is exposed to outer space – modelled as a black, zero-degree Kelvin vacuum.




(a) State the condition which allows the *thermally thin fin* approximation to be made.

(b) For *controlled voltage* operation (in which $(d\varphi/dz) \equiv \Phi_o$ is held constant), derive the differential equation governing the temperature variation T(z).

(c) Determine the temperature distribution, T(z), for the case where:

$p = 7/2$
$q = 5/2$
$s = 1/2$