Closed Book

QUALIFYING EXAM - FLUID MECHANICS

May 2009

1. The velocity field of a two dimensional steady incompressible flow is given by

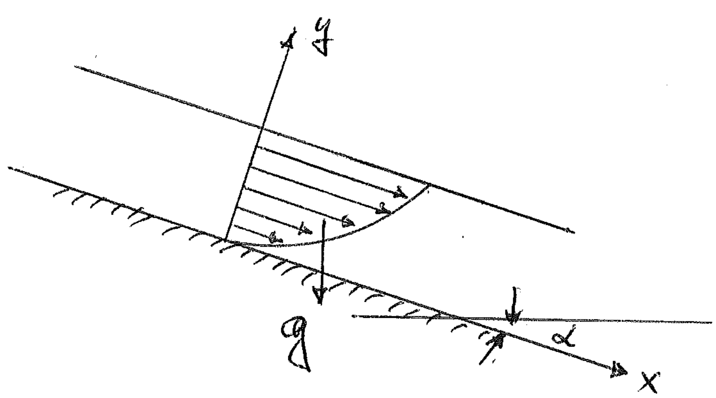
$$u(x,y) = 2\cos(x + 2y) - x\sin(xy)$$

$$v(x,y) = -\cos(x + 2y) + y\sin(xy)$$

Calculate the streamfunction $\psi(x, y)$ the vorticity $\omega(x, y)$ and the location of stagnation points if any

2. A thin film of incompressible liquid flows down a plane which is inclined at an angle α with the direction of gravity. The flow is due to the gravitational force only. Assume the flow is steady and the volume flow rate is Q .In terms of the given volume flow rate Q calculate the the thickness of the liquid film h and the avereage speed V at which the region of transition from one thickness to another advances down the plane.

3. Find an expression for the speed of sound in a perfect gas with the equation of state $p = \rho RT$, where p is the pressure ρ the density T the temperature and R the universal gas constant



Prob. #2.

Phd.Qualifying Exam – May 2009

HEAT TRANSFER

(90 min., Closed Book)

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1. Thermal Properties

   (a) What microscopic physical mechanisms underlie the macroscopic *specific heat* at constant volume, c_v, in the following materials:

   (i) carbon dioxide as an *ideal gas*

   (ii) super critical carbon dioxide as a *dense gas*

   (iii) aluminum oxide (a dielectric *solid*)

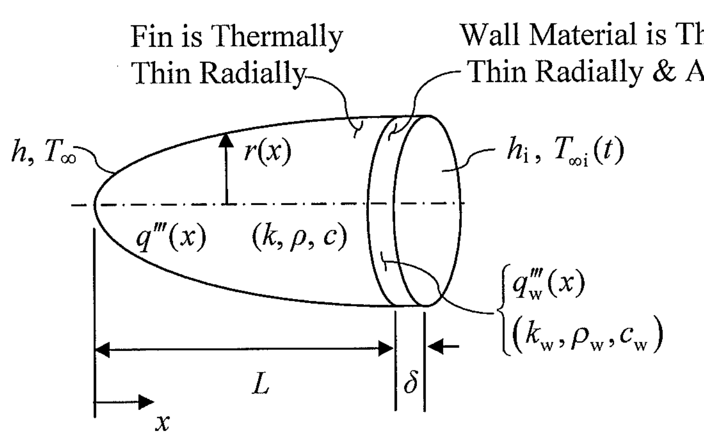
   (b) What microscopic physical mechanisms underlie the *thermal conductivity* in *metals*?

   (c) For *very thin dielectric films*, the *thermal conductivity* is observed to be substantially larger than for the same material in bulk.

   (i) Why?

   (ii) What *dimensionless group* defines when the film is thin enough for this to be seen? Should this dimensionless group be large or small to see this increased thermal conductivity?

2.



At time $t = 0$, the fin and wall are isothermal: $T(x,0) = T_w(x, 0) = T_0$.

Note: q''' = energy generation/vol

At time $t = 0^+$: the fin is exposed to an ambient fluid at T_∞ with a heat transfer coefficient h; the base (wall) is exposed to a fluid at $T_{\infty i}$ with a heat transfer coefficient h_i.

Derive the differential equations and boundary conditions which, if solved, would give the *transient* temperature distributions in the fin, $T(x,t)$, and in the wall, $T_w(x,t)$.
