Department of Mathematics
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MAG6134: Fluid Dynamics
Assignment-3

Q.1 Consider the steady fully developed 2D flow of a viscous incompressible fluid within a parallel plate channel. The fluid flow is induced due to an external pressure gradient along the axis of the channel. Let T_0, T_1 ($T_0 < T_1$) be the constant temperatures of the lower and upper plates, respectively. Obtain the temperature distribution in the channel when

(i) $T_0 \neq T_1$

(ii) $T_0 = T_1$

(iii) The lower plate is insulated.

Also, obtain the Nusselt number at both the plates.

Q.2 Repeat problem in Q.1 considering a generalized Couette flow when the lower plate moves with velocity U_0.

Q.3 Obtain the temperature distribution for the steady 2D fully developed flow within a pipe when the flow is induced due to an external pressure gradient. Represent the temperature distribution and rate of heat transfer coefficient in non-dimensional form. Assume that the surface of the pipe is kept at a constant temperature.

Q.4 Let a viscous incompressible fluid be filled in the annulus region created by two co-axial cylinders of radii R_1 and R_2 ($R_1 < R_2$). The flow within this region is induced due to angular velocity of the cylinders with velocities ω_1 and ω_2, respectively. Considering that the cylinders are kept at temperatures T_1 and T_2 ($T_1 < T_2$), obtain the temperature distribution within the flow-field. Discuss the cases when

(i) $\omega_1 = 0$, $\omega_2 \neq 0$

(ii) $\omega_1 \neq 0$, $\omega_2 = 0$

Also, obtain the non-dimensional coefficient of heat transfer at the inner and outer cylinders.

Q.5 Let an infinite expanse of fluid is kept over an infinite plate oriented along $x - axis$. Initially, at $t = 0$, the plate is at rest. At $t > 0$, the plate starts moving with velocity $u = U$(constant). If T_w be the temperature of the plate and T_∞ be the free-stream temperature at $t > 0$. Obtain the temperature distribution within the boundary layer region. Also, obtain the Nusselt number at the surface.

Q.6 Extend the problem described in Q.5 considering the plate to be porous.

Q.7 Extend the problems in Q.5 and Q.6 considering $u = Ut$, ($t > 0$).

Q.8 Consider the steady 2D flow of viscous incompressible fluid over an infinite stretching sheet. This fluid flow is induced due to stretching of the sheet in $-ve$ and $+ve$ direction of $x - axis$ with velocity $u_w = u_0 x$, keeping the origin as fixed (as shown in figure). The fluid outside the boundary layer region is at rest. T_w and T_∞ are the temperatures of the sheet and the fluid at infinity.

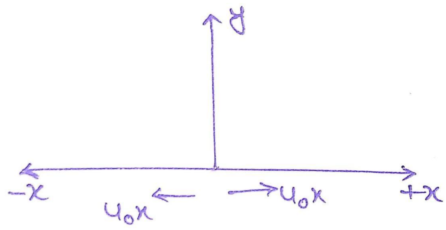

Fig: geometry of the problem.

(i) Model the fluid flow & heat transfer for this problem using suitable PDEs and boundary conditions.

(ii) Assuming the similarity of flows, reduce the problem into a model involving ODEs.

(iii) Can you suggest a method to solve the resulting ODE model? Give a brief outline of the solution method.

Q.9 Explain what is meant by geometric similarity, kinematic similarity and dynamic similarity. What is the importance of dynamic similarity in fluid dynamics?

Q.10 Derive the boundary layer equations for the time dependent 2D flow of a viscous incompressible fluid with constant fluid properties moving with velocity U_∞.

Q.11 What happens with the equations in Q.10 when the plate is replaced by an irregular surface (not a flat plate)?

Q.12 Obtain the momentum integral equation in Q.11 assuming the flow to be steady.

Q.13 (i) Discuss the displacement thickness and momentum thickness.

(ii) What is the meaning of boundary layer separation?

(iii) Discuss the methods of controlling the boundary layer separation.

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