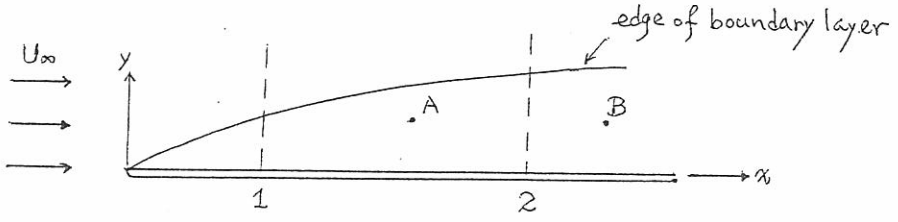
1. (25%) Consider a 2-D uniform-pressure, laminar boundary layer on a flat plate with constant properties. A and B are two points at the same height above the plate.
   (a) Is the edge of boundary layer a streamline? (5%)
   (b) Does the streamline which passes through point A pass above or through or below point B? Why? (5%)
   (c) Sketch qualitatively the velocity profile of x-component along y-direction at stations 1 and 2. (5%)
   (d) Assume the velocity can be approximated by
   $$u/U_\infty = a(\delta/y) + b(y/\delta) + c(y/\delta)^2 ,$$
   where δ is the boundary layer thickness, U_∞ is the free stream velocity, a, b and c are constants. Please list appropriate boundary conditions and solve the values a, b and c. (10%)

2. (25%)
   (a) What is the definition of fluid? What is the Newtonian fluid? (6%)
   (b) Start with the Navier-Stokes (N-S) equations for a steady, incompressible fluid flow, explain the physical meaning of each term. (5%) Please derive the dimensionless form of the N-S equations by choosing proper physical scales, and answer why the viscous terms can be neglected when the Reynolds number is very high. (10%)
   (c) Explain the physical meaning of the Reynolds number. (4%)

3. (30%) Consider a steady entrance flow of a circular pipe of radius R. The fluid with constant density ρ and viscosity μ develops its velocity profile from uniform velocity U at the entrance with pressure P_1 to the laminar paraboloid downstream with pressure P_2 over an entrance length L.
   (a) Sketch velocity profiles at sections $x = 0$, $L/3$, $L/2$, L, *overlaid on the same u-r axes*. (5%)
   (b) Sketch the pressure drop along the axial axis of the pipe from $x = 0$ to $2L$. Explain your reasons. (5%)
   (c) Find the wall drag F_D in the entrance region, i.e., $x = 0$ to L as a function of proper variables by the integral formulation. (10%)
   (d) Derive the pressure gradient dP/dx in the fully developed region by the integral formulation. (5%)
   (e) Does the laminar flow in the pipe transit to turbulent flow downstream (e.g., $5L$) the fully developed region? Explain your reasons. (5%)

4. (20%) A two-dimensional velocity field of a fluid flow is given as $u = 2xt$ and $v = -2yt$.
   (a) Find the acceleration components a_x and a_y for this flow. (6%)
   (b) Find the stream function for this flow. (5%)
   (c) Derive the pathline of a particle whose position is (1,1) at a time $t = 0$. (9%)



試題隨卷繳回