INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR
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Department of Civil Engineering
Course: CE21003
Submission Deadline:
Total Marks:

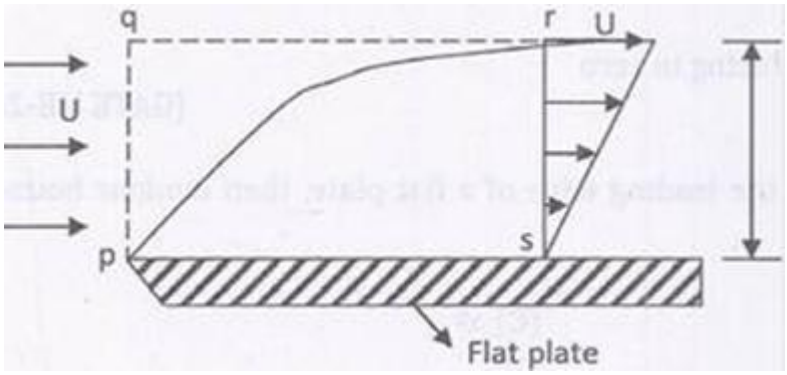
Boundary Layer Analysis

Q1) For air flow over a plate, velocity (U) and boundary layer thickness($\boldsymbol{\delta}$) can be expressed respectively, as

$$\frac{U}{U_\infty} = \frac{3}{2}\frac{y}{\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3 \;\; ; \;\; \delta = \frac{4064x}{\sqrt{Re_x}}$$

If the free steam velocity is 2 m/s, and air has kinematic viscosity of $1.5*10^{-5}$ m^2/s and density of 1.23 kg/m^3 .Then, find the wall shear stress at x=1 m .

Q2) A smooth flat plate with a sharp leading edge is placed along a gas stream flowing at U=10 m/s. The thickness of the boundary layer at section r-s=10 mm, the breadth of the plate is 1m (onto the paper) and the density of the gas $\rho = 1$ kg/m^3 . Assume that the boundary layer is thin, two dimensional, and follows a linear velocity distribution,$u = U(y/\delta)$, at the section r-s, where y is the height from plate. Find the mass flow rate (in kg/s) across the section q-r.



$$\delta = \frac{4.64x}{\sqrt{R_{ex}}}$$

Q3) For the above problem find the integrated drag force (in N) on the plate, between p-s.

Q4) The velocity distribution in a boundary layer is given by ,$\frac{u}{U} = \frac{y}{\delta}$ where u is the velocity at a distance *y* from the plate and $u = U$ at $y = \delta$, where δ is boundary layer thickness. Find the the ratio of displacement thickness to momentum thickness.