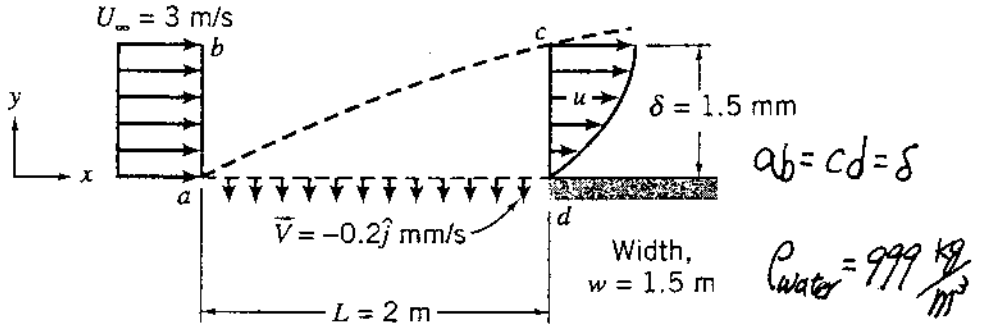
1) 20%

Water flows steadily past a porous flat plate. Constant suction is applied along the porous section. The velocity profile at section *cd* is

$$\frac{u}{U_\infty} = 3\left[\frac{y}{\delta}\right] - 2\left[\frac{y}{\delta}\right]^{1.5}$$

Evaluate the mass flow rate across section *bc*.



$ab = cd = \delta$

$\rho_{water} = 999\ kg/m^3$

2) 20%

Derive the basic equation of fluid statics and apply it to obtain Archimedes' principle for a submerged object. The Archimedes' principle is that the net vertical pressure force, or buoyancy, on the object equals to the force of gravity on the liquid displaced by the object.

3) 20%

Consider the two-dimensional flow field defined by the following velocity components:

$$u = x(1+t), v = y$$

for this flow field, find the equation and draw the line of:

(a) The streamline through the point (1,2) at $t = 0$,

(b) The pathline for a particle released at the point (1,2) at $t = 0$,

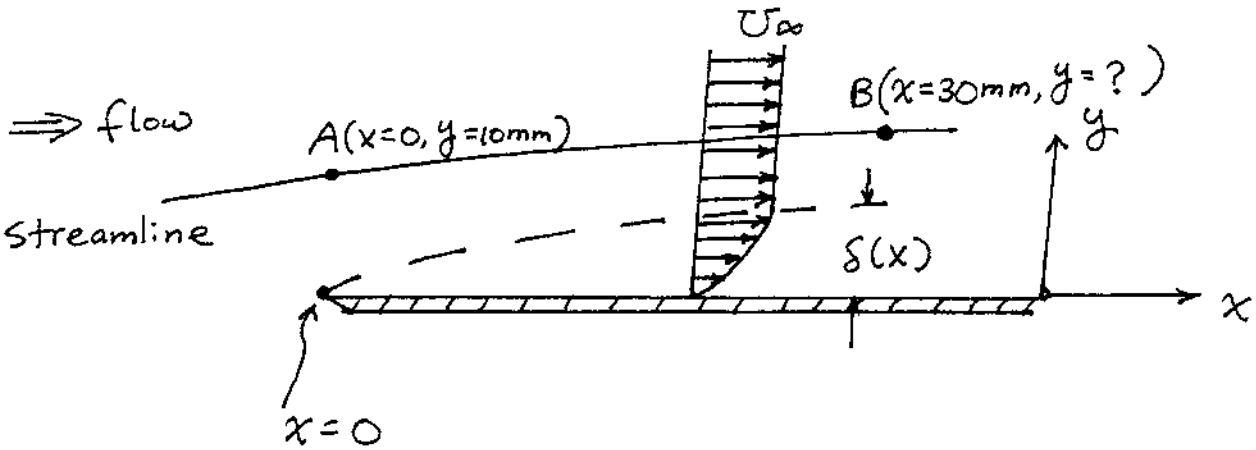
(c) The streakline at $t = 0$ which passes through the point (1,2).

4) 20%

Consider a boundary layer developed from the leading edge of a flat plate. The boundary layer thickness, $\delta(x)$, is described by

$$\delta = 5\left(\frac{\upsilon x}{U_\infty}\right)^{\frac{1}{2}}$$

where x is the streamwise distance from the leading edge; U_∞ is the free stream velocity; υ is the kinemetic viscosity, $\upsilon = 16\times10^{-6} m^2/s$.



In the boundary layer, the velocity profile can be described by

$$\frac{U}{U_\infty} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$$

Note that $U_\infty = 30\, m/s$. We are interested in a streamline passing through the point A at x = 0 and y = 10 mm, shown in the figure. This streamline also passes the point B at x = 30 mm. Find the y coordinate of the Point B.

5) 20%

Consider the schematic diagram shown below.

(a) Use the above model, briefly describe the boundary layer theory.
(b) Write down the continuity and momentum equations of the x- and y- component.
(c) Write down the boundary layer assumption.
(d) Use the momentum equation of item (b) and the order of magnitude, derive the boundary layer equations.