#1.

An idealized velocity field is given by the formula

$\mathbf{V} = 4tx\mathbf{i} - 2t^2y\mathbf{j} + 4xz\mathbf{k}$

Is this flow field steady or unsteady? Is it two- or three- dimensional? At the point (x, y, z) = (-1, 1, 0), compute *(a)* The acceleration vector and *(b)* any unit vector normal to the acceleration.

#2.

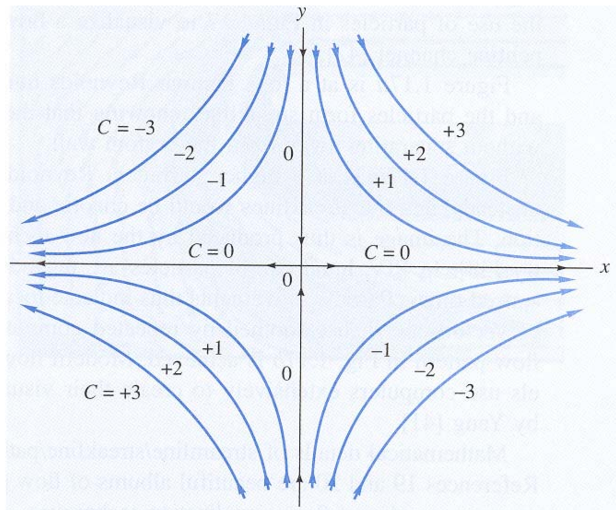
The temperature ***T***, in a long tunnel is known to vary approximately as $T = T_0 - \alpha e^{-x/L} \sin(2\pi t/\tau)$, where $T_0$, $\alpha$, $L$ and $\tau$ are constants, and x is measured from the entrance. A particle moves into the tunnel with a constant speed, U. Obtain an expression for the rate of change of temperature experienced by the particle. What are the dimensions of this expression?

#3.

The velocity field near a stagnation point (see Fig.) may be written in form $u = \dfrac{U_0 x}{L}$ , $v = -\dfrac{U_0 y}{L}$ $U_o$ and $L$ are constants.

(a) Show that the acceleration vector is purely radial.

(b) For the particular case $L$ = 1.5 m, if the acceleration at ($x$, $y$) = (1 m, 1 m) is 25 m/s$^2$, what is the value of $U_0$?

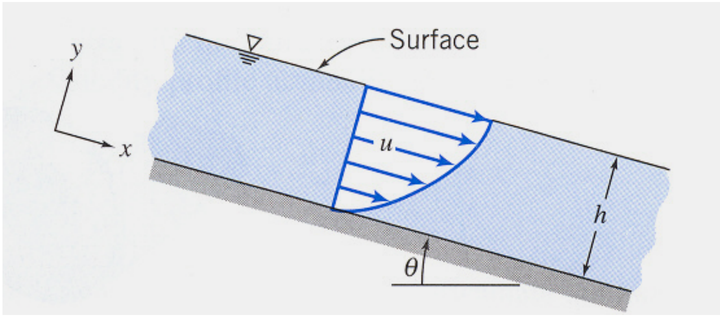


#4.

The velocity field within a laminar boundary layer is approximated by the expression $\vec{V} = \frac{AUy}{x^{1/2}}\hat{i} + \frac{AUy^2}{4x^{3/2}}\hat{j}$. In this expansion, $A$ = 141 $m^{-1/2}$, and $U$ = 0.240 m/s is the free stream velocity. Calculate the acceleration of a fluid particle at point ($x$, $y$) = (0.5 m, 5 mm).

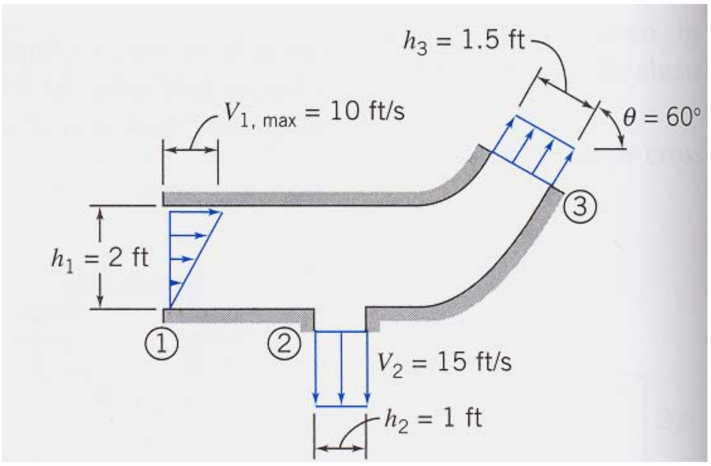
#5.

Oil flows steadily in a thin layer down an inclined plane. The velocity profile is $u = \frac{\rho g \sin\theta}{\mu}\left[hy - \frac{y^2}{2}\right]$. Express the mass flow rate per unit width in terms of $\rho$, $\mu$, $g$, $\theta$ and $h$.



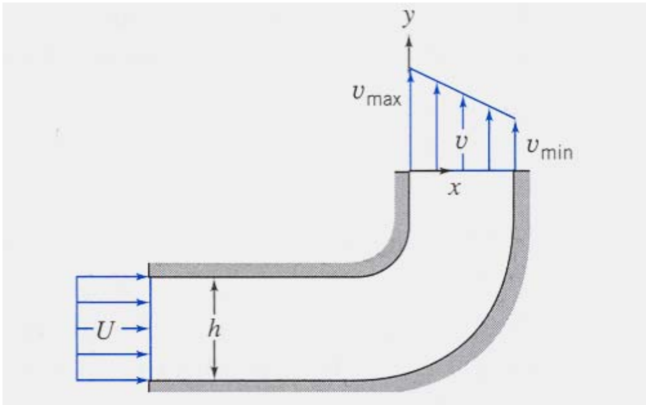
#6.

A two-dimensional reducing bend has a linear velocity profile at section①. The flow is uniform at sections ② and③. The fluid is incompressible and the flow is steady. Find the magnitude and direction of the uniform velocity at section ③.



#7.

Water enters a two-dimensional square channel of constant width, $h$ = 75.5 mm, with uniform velocity, $U$. The channel makes a 90° bend that distorts the flow to produce the linear velocity profile shown at the exit, with $v_{max}$ = 2 $v_{min}$. Evaluate $v_{min}$, if $U$ = 7.5 m/s

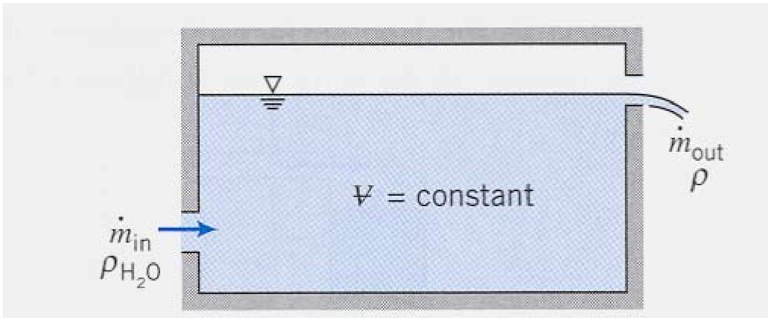


#8.

A laboratory test tank contains sea water of salinity $S$ and density $\rho$. Water enters the tank at conditions ($S_1$, $\rho_1$, $A_1$, $V_1$) and is assumed to mix immediately in the tank. Tank water leaves through an outlet $A_2$ at velocity $V_2$. If salt is a "conservative" property (neither created nor destroyed), use the Reynolds transport theorem to find an expression for the rate of change of salt mass $M_{\text{salt}}$ within the tank.

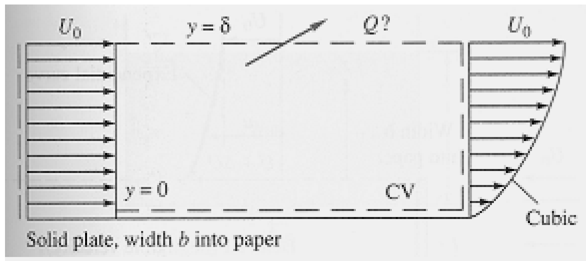
#9.

Tank of fixed volume contains brine with initial density, $\rho_i$ , greater than water. Pure water enters the tank steadily and mixes thoroughly with the brine in the tank. The liquid level in the tank remains constant. Derive expressions for *(a)* the rate of change of density of the liquid mixture in the tank and *(b)* the time required for the density to reach the value $\rho_f$, where $\rho_i > \rho_f > \rho_{H_2O}$.



#10.

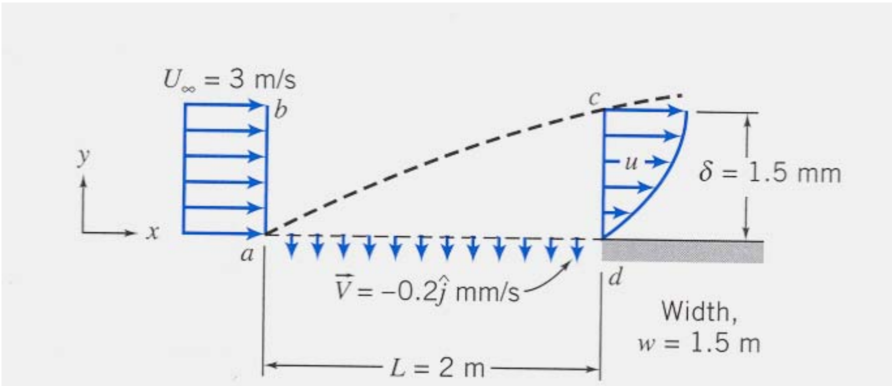
An incompressible fluid flows past an impermeable flat plate as in the figure, with a uniform inlet profile $u = U_0$ and a cubic polynomial exit profile $u \approx U_0\left(\frac{3\eta - \eta^3}{2}\right)$ where $\eta = \frac{y}{\delta}$. Compute the volume flow $Q$ across the top surface of the control volume.



#11.

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*.



#12.

Oil (SG = 0.89) enters at section 1 in the figure at a weight flow of 250 N/h to lubricate a thrust bearing. The steady oil flow exits radially through the narrow clearance between thrust plates. Compute *(a)* the outlet volume flux in mL/s and *(b)* the average outlet velocity in cm/s.