#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 $T = T_0 - \alpha e^{x/L} \sin \left(\frac{2\pi t}{\tau}\right)$, 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 $u = \frac{U_0 x}{L}$, $v = -\frac{U_0 y}{L}$, $U_0$ 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 
\[ \vec{V} = \frac{AU_y}{\sqrt{x}} \hat{i} + \frac{AU_y^2}{4x^{3/2}} \hat{j} \]. In this expansion, \( A = 141 \, \text{m}^{-1/2} \), and \( U = 0.240 \, \text{m/s} \) is the free stream velocity. Calculate the acceleration of a fluid particle at point \((x, y) = (0.5 \, \text{m}, 5 \, \text{mm})\).
#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 \( h \).
A two-dimensional reducing bend has a linear velocity profile at section 1. The flow is uniform at sections 2 and 3. 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, \( h = 75.5 \text{ mm} \), 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 \( v_{\text{max}} = 2 \ v_{\text{min}} \). Evaluate \( v_{\text{min}} \), if \( U = 7.5 \text{ m/s} \).
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.
Problem 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
\[
\left( \frac{3\eta - \eta^3}{2} \right)
\]
where \( \eta = \frac{y}{\delta} \). Compute the volume flow \( Q \) across the top surface of the control volume.
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 $bc$.  

![Diagram of water flow past a porous flat plate with velocity profile and specified dimensions.](image-url)
#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.