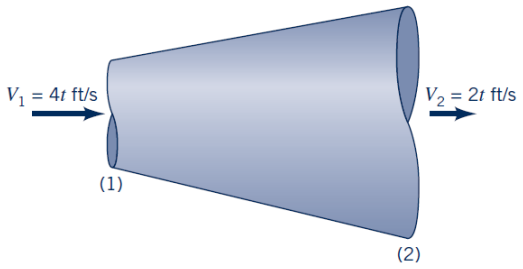
Homework set 4
Due: 2:10 PM – September 28, 2018

Problem 1

The velocity of air in the diverging pipe shown in figure below is given by $V_1 = 4t$ ft/s and $V_2 = 2t$ ft/s, where t is in seconds.
(a) Determine the local acceleration at points (1) and (2). (b) Is the average convective acceleration between these two points negative, zero, or positive? Explain.



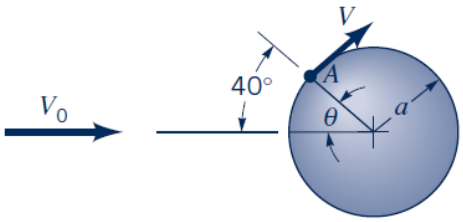
Problem 2

The x and y components of velocity for a two-dimensional flow are $u = 6y$ ft/s and $v = 3$ ft/s, where y is in feet. (a) Determine the equation for the streamlines and sketch representative streamlines in the upper half plane. (b) Plot streamlines using MATLAB or any software that you prefer. MATLAB is recommended!

Note: You are supposed to turn in a final picture and your code. Printed version is fine if you hand in a hard copy.

Problem 3

A fluid flows past a sphere with an upstream velocity of $V_0 = 40$ m/s as shown in figure below. From a more advanced theory it is found that the speed of the fluid along the front part of the sphere is $V = 1.5V_0\ sin\theta$. Determine the stream-wise and normal components of acceleration at point A if the radius of the sphere is $a = 0.20$ m.

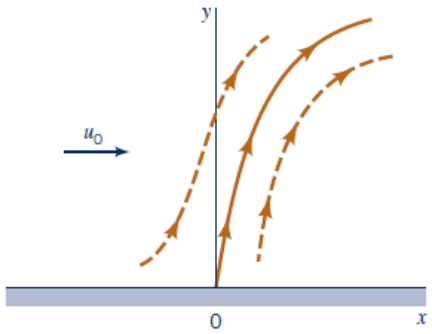


Problem 4

Determine the acceleration field for a three-dimensional flow with velocity components $u = -x$, $v = 4x^2y^2$, and $w = x - y$.

Problem 5

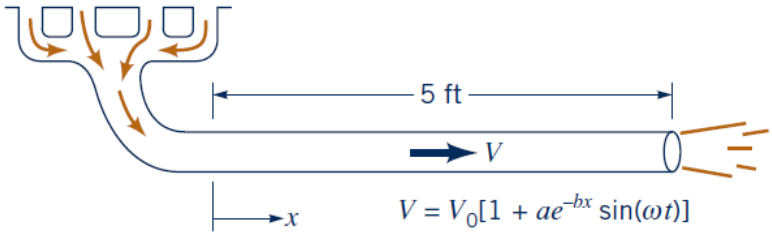
In addition to the customary horizontal velocity components of the air in the atmosphere (the"wind"), there often are vertical air currents (thermals) caused by buoyant effects due to uneven heating of the air as indicated in figure below. Assume that the velocity field in a certain region is approximated by $u = u_0$, $v = v_0(1 - y/h)$ for $0 < y < h$, and $u = u_0$, $v = 0$ for $y > h$. Plot the shape of the streamline that passes through the origin for values of $u_0/v_0 = 0.5$, 1, and 2.



Problem 6

As is indicated in figure below, the speed of exhaust in a cars exhaust pipe varies in time and distance because of the periodic nature of the engines operation and the damping effect with distance from the engine. Assume that the speed is given by $V = V_0\,[1+ae^{-bx}\,sin(\omega t)]$, where $V_0 = 8$ fps, $a = 0.05$, $b = 0.2\ ft^{-1}$, and $\omega = 50$ rad/s. Calculate and plot the fluid acceleration at $x = 0, 1, 2, 3, 4$, and 5 ft for $0 \leq t \leq \pi/25$ s.

Note: You can use MATLAB or any other software to plot the final result. NO code is required for this problem. Only the pen-and-paper calculations, and the final plot.



TEXTBOOK

Munson, B.R., Okiishi, T.H., Huebsch, W.W., and Rothmayer, A.P., "Fundamentals of Fluid Mechanics", 7th Edition, 2013, John Wiley & Sons.