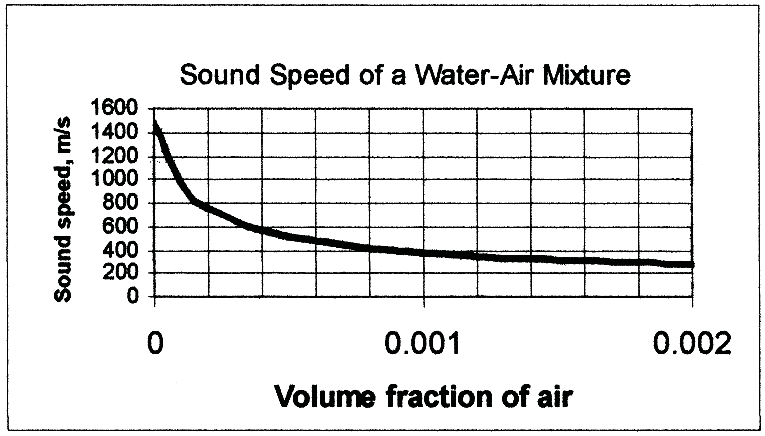
(b) For the given data, a plot of sound speed versus gas volume fraction is as follows:




The difference in air and water compressibility is so great that the speed drop-off is quite sharp.

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**1.80*** A two-dimensional steady velocity field is given by $u = x^2 - y^2$, $v = -2xy$. Find the streamline pattern and sketch a few lines. [*Hint*: The differential equation is exact.]

**Solution:** Equation (1.44) leads to the differential equation:

$$\frac{dx}{u} = \frac{dy}{v} = \frac{dx}{x^2 - y^2} = \frac{dy}{-2xy}, \quad \text{or:} \quad (2xy)dx + (x^2 - y^2)dy = 0$$

As hinted, this equation is *exact*, that is, it has the form $dF = (\partial F/\partial x)dx + (\partial F/\partial y)dy = 0$. We may check this readily by noting that $\partial/\partial y(2xy) = \partial/\partial x(x^2 - y^2) = 2x = \partial^2 F/\partial x\partial y$. Thus we may integrate to give the formula for streamlines:

$$\mathbf{F = x^2 y - y^3/3 + constant} \quad \textit{Ans.}$$

This represents (inviscid) flow in a series of 60° corners, as shown in Fig. E4.7a of the text. [This flow is also discussed at length in Section 4.7.]

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**1.81** Repeat Ex. 1.13 by letting the velocity components increase linearly with time:

$$\mathbf{V} = Kxt\mathbf{i} - Kyt\mathbf{j} + 0\mathbf{k}$$

**Solution:** The flow is unsteady and two-dimensional, and Eq. (1.44) still holds:

$$\text{Streamline:} \quad \frac{dx}{u} = \frac{dy}{v}, \quad \text{or:} \quad \frac{dx}{Kxt} = \frac{dy}{-Kyt}$$