

Problem 2.85

[Difficulty: 1]

2.85 At what minimum speed (in mph) would an automobile have to travel for compressibility effects to be important? Assume the local air temperature is 60°F.

Given: Local temperature

Find: Minimum speed for compressibility effects

Solution:

Basic equation $V = M \cdot c$ and $M = 0.3$ for compressibility effects

$c = \sqrt{k \cdot R \cdot T}$ For air at STP, $k = 1.40$ and $R = 286.9 \text{ J/kg} \cdot \text{K}$ (53.33 ft.lbf/lbm°R).

Hence $V = M \cdot c = M \cdot \sqrt{k \cdot R \cdot T}$

$$V = 0.3 \times \left[1.4 \times 53.33 \cdot \frac{\text{ft} \cdot \text{lbf}}{\text{lbm} \cdot \text{R}} \times \frac{32.2 \cdot \text{lbm} \cdot \text{ft}}{\text{lbf} \cdot \text{s}^2} \times (60 + 460) \cdot \text{R} \right]^{\frac{1}{2}} \cdot \frac{60 \cdot \text{mph}}{88 \cdot \frac{\text{ft}}{\text{s}}} \quad V = 229 \cdot \text{mph}$$