**1.13*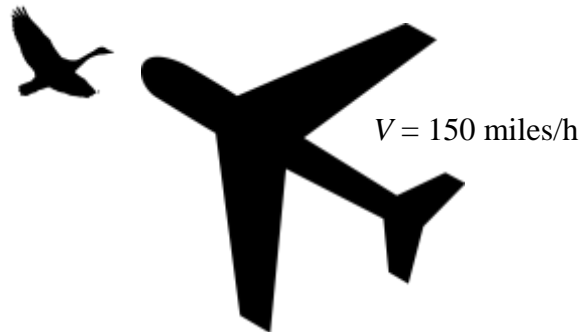* Estimate the magnitude of the force, in lbf, exerted on a 12-lb goose in a collision of duration 10^{-3} s with an airplane taking off at 150 miles/h.

KNOWN: A goose of known mass collides with known duration with an airplane with known velocity.

FIND: Determine the magnitude of the force exerted on the goose.

SCHEMATIC AND GIVEN DATA:

$m = 12$ lb
$\Delta t = 10^{-3}$ s

$V = 150$ miles/h

ENGINEERING MODEL:
1. Initial goose velocity is negligible compared to aircraft velocity.

ANALYSIS: The actual forces developed when birds and aircraft collide are difficult to determine precisely, but estimates can be calculated using average values of acceleration and force magnitudes as follows:

The goose is accelerated from a very low velocity to 150 miles/h in 10^{-3} s. Thus, the average acceleration magnitude is

$$|a| = \left(\frac{150\,\text{miles/h} - 0}{10^{-3}\,\text{s}}\right)\left|\frac{1\,\text{h}}{3600\,\text{s}}\right|\left|\frac{5280\,\text{ft}}{1\,\text{mile}}\right| = 2.2 \times 10^5\,\text{ft/s}^2$$

The magnitude of the average force applied is

$$|F| = m|a| = (12\,\text{lb})\left(2.2 \times 10^5\,\frac{\text{ft}}{\text{s}^2}\right)\left|\frac{1\,\text{lbf}}{32.2\,\frac{\text{lb}\cdot\text{ft}}{\text{s}^2}}\right| = \underline{\textbf{82,000 lbf}}$$

rounded