Answer on Question #64729, Physics / Mechanics | Relativity

A sphere of diameter D, moving at speed v in air, experiences a quadratic drag force given approximately by F_D = (0.25 Ns^2/m^4) D^2 v^2, for diameters of few centimetres or more, and speeds of a metre per second or more. Calculate the terminal velocity of a basketball (25 cm diameter, mass 1 kg), and of a grapefruit 10 cm in diameter (assume a density of 1000 kg/m3 for the grapefruit).

Solution:

An object falling through the air will reach a terminal velocity when the drag force is equal to the weight:

$$F_{net} = mg - F_D = 0$$

So,

$$mg = 0.25D^2v^2$$

The terminal velocity from given can be expressed by

$$v_t = \sqrt{\frac{mg}{0.25D^2}} = \frac{2}{D}\sqrt{mg}$$

For a basketball

$$v_t = \frac{2}{0.25\ \text{m}}\sqrt{1\ \text{kg} \times 9.8\ \text{m/s}^2} = 25.0\ \text{m/s}$$

For a grapefruit

$$m = \rho V = \rho\frac{4}{3}\pi r^3 = (1000)\frac{4}{3}\pi(0.05)^3 = 0.524\ \text{kg}$$

$$v_t = \frac{2}{0.10\ \text{m}}\sqrt{0.524\ \text{kg} \times 9.8\ \text{m/s}^2} = 45.8\ \text{m/s}$$

Answer: 25.0 m/s; 45.8 m/s.