Hailstone Terminal Velocity

$r := \frac{.005}{2}$ $g := 9.8$ $d := 2 \cdot r$ $\nu := .0000133$

$\gamma_{hail} := 6000$ $p := 96000$ $T := 273$ (SI units)

$\rho_{air} := \frac{p}{287 \cdot T}$ $\rho_{air} = 1.2253$

Use correlation from Frank White's book.

$$p(x) := \sqrt{8 \cdot \gamma_{hail} \cdot \frac{r}{3 \cdot \rho_{air} \cdot \left(12 \cdot \frac{\nu}{r \cdot x} + \frac{6}{1 + \sqrt{2 \cdot r \cdot \frac{x}{\nu}}} + 0.4\right)}} - x$$

$x := 10$ x is the "guess" for the root solver

$V := \text{root}(p(x), x)$ V is the terminal velocity in meters/second

$V = 7.9559$ $Re := d \cdot \frac{V}{\nu}$ $Re = 2.991 \times 10^3$

$C_D := \frac{24}{Re} + \frac{6}{1 + \sqrt{Re}} + 0.4$ $C_D = 0.5158$

Now a program is written to calculate the terminal velocity over a range of hailstone diameter ranging from .1cm to 15 cm.

$$w(x, r1) := \sqrt{8 \cdot \gamma_{hail} \cdot \frac{r1}{3 \cdot \rho_{air} \cdot \left(12 \cdot \frac{\nu}{r1 \cdot x} + \frac{6}{1 + \sqrt{2 \cdot r1 \cdot \frac{x}{\nu}}} + 0.4\right)}} - x$$

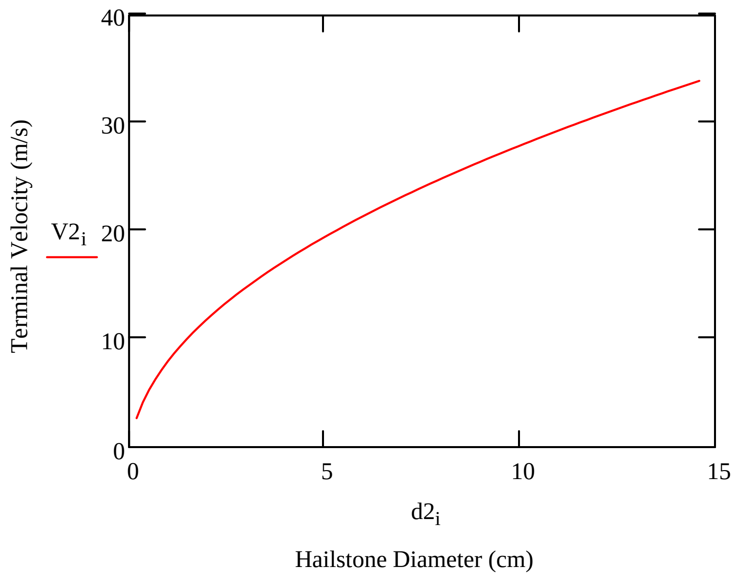
$V1(x, r1) := \text{root}(w(x, r1), x)$ V1 is a function - where x is the guess and r1 is the hailstone diameter.

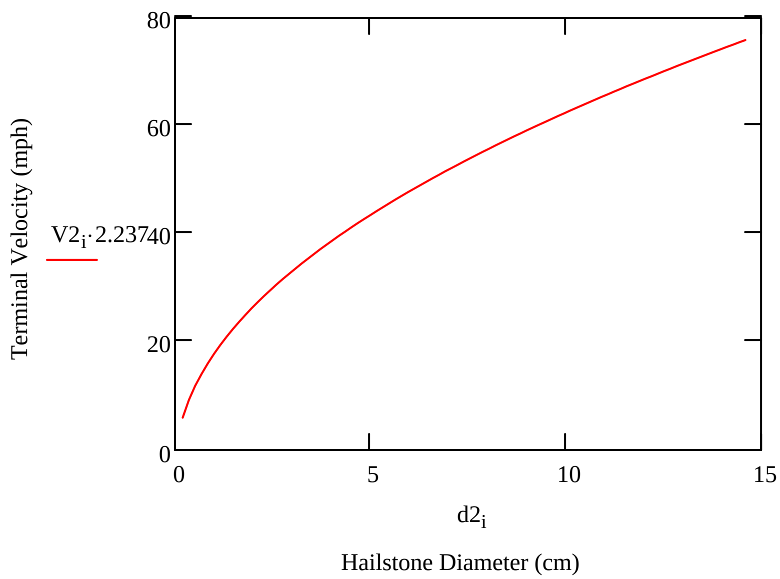
$$V2 := \left| \begin{array}{l} \text{for } k \in 0..90 \\ \quad \left| \begin{array}{l} r2 \leftarrow \dfrac{.001 + k \cdot .0008}{2} \\ V2_k \leftarrow V1(5, r2) \end{array} \right. \\ V2 \end{array} \right.$$

A for loop is used to calculate velocity for 90 hailstone diameters. The guess for each call of function V1 is 5.

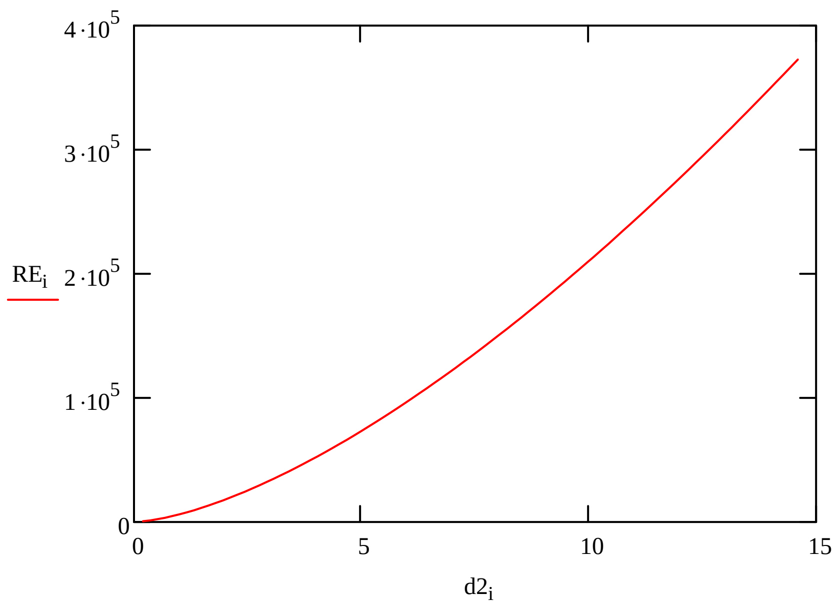
$i := 0..90$ $\quad d2_i := (0.001 + i \cdot .0008) \cdot 200$ $\quad$ Diameters in centimeters.

Now graph the terminal velocity and Reynolds number





$$RE_i := d2_i \cdot .01 \cdot \frac{V2_i}{\nu}$$



$$C_{D_i} := \frac{24}{RE_i} + \frac{6}{1 + \sqrt{RE_i}} + 0.4$$