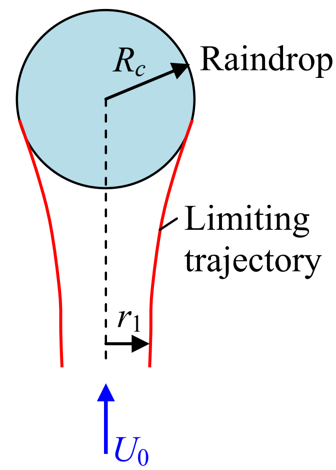
Today, we will:

- Continue to discuss particle cleaning by **raindrops** and **spray chambers**
- Discuss the Calvert and Englund model for **single drop grade removal efficiency**
- Discuss **Brownian motion** and its effect on single drop collection grade efficiency

Last time, we developed an expression for the **single drop grade removal efficiency** $E_d(D_p)$ of a spherical raindrop of diameter D_c (radius R_c) falling down at speed U_0, and encountering dusty air containing particles of diameter D_p. We defined r_1 as the **limiting trajectory radius**, such that all particles of diameter D_p within this radius are collected by the raindrop, and all particles outside of this radius are not collected, but rather miss hitting the raindrop altogether. Based on the geometry, we derived:



$$\boxed{E_d\left(D_p\right)=\left(r_1/R_c\right)^2}$$

Now the problem reduces to generating an expression for r_1.

Example: Single-drop collection grade efficiency for one particle diameter

Given: Raindrops of diameter 200 microns are falling through dusty air at STP (ρ = 1.184 kg/m^3, μ = 1.849 × 10^{-5} kg/(m s)). The uniformly distributed aerosol particles are of unit density (ρ_p = 1000 kg/m^3), and of diameter 5 microns.

To do: Calculate the single-drop collection grade efficiency $E_d(D_p)$ as a percentage to three significant digits for these particles.

Solution:

Example: Single-drop collection grade efficiency as a function of particle diameter

Given: A polydisperse aerosol at STP ($\rho = 1.184$ kg/m^3, $\mu = 1.849 \times 10^{-5}$ kg/(m s)) is cleaned by raindrops of diameter 200 microns. The particles are of unit density ($\rho_p = 1000$ kg/m^3). The raindrop (the "collector" falls at terminal gravitational settling velocity $V_{t,c} =$ 0.700464 m/s. For convenience, I have pre-calculated the terminal gravitational settling velocity $V_{t,p}$ for various particle diameters. Assume that particles are absorbed by the raindrop when they hit the raindrop, and are therefore removed from the air.

To do: For each diameter, calculate the single-drop collection grade efficiency $E_d(D_p)$ as a percentage to three significant digits for each particle diameter D_p in the table below.

Solution: **Table to be filled in during class:**

D_p (μm)	V_t (m/s)	$E_d(D_p)$ (%)
2	0.000127646	
3	0.000279763	
4	0.000490739	
7	0.001476776	
8.5	0.002168354	
10	0.002992228	
15	0.006692553	
20	0.01185533	

D_p (μm)	V_t (m/s)	$E_d(D_p)$ (%)
25	0.018468719	
30	0.026513567	
40	0.046775902	
50	0.072295146	
70	0.13687402	
85	0.194258109	
100	0.25629326	