Assignment: Terminal Velocity and Round-Off Error
Due: 9:05 am, Wed Sep. 28

Write a Python program to calculate the terminal velocity of a drop with radius from 1 to 10 µm. Use the equation from the notes and numerical constants given on page 2 of this assignment. Calculate the terminal velocity at 1000 points evenly spaced between a drop radius of 1 and 10 µm. Output the drop radius and terminal velocity to a file. Use Python to create a plot of drop radius versus terminal velocity.

Modify the Python program you wrote from above to calculate the relative error for the following two cases.

Case 1: If you only used one significant figure for all numerical constants.
Case 2: If you use 32-bit floating-point <u>constants and variables</u> for your calculations.
For the "true" values, use the value obtained when using all 64-bit constants and variables (the original code above).
Output your answers to a file with three columns:
<u>Radius</u> <u>Case 1 relative error</u> <u>Case 2 relative error</u>
Also plot the two cases on a single plot (use a legend). Make sure the y-axis is logarithmic.

Concept Question:

Iterative Solutions
Numerical solutions are often iterative, meaning that each step forward in the solution depends on the previous step.
a) Explain why this current solution is <u>not</u> iterative.
b) How might the problem be changed to become iterative?

Round-off Errors
a) Describe at least one <u>specific</u> example of numerical round-off error due to floating point representation in this program. Explain why this error occurs.
b) Does this error have a significant impact on the numerical analysis? Why or why not?

Write a concise summary of the program.
See the class website for the rubric used for grading the report.

Absolute Error - The magnitude of the difference between the approximation ($\tilde{\chi}$) and the true value (χ).

$$\varepsilon_{abs} = |\tilde{\chi} - \chi|$$

Relative Error – The absolute error relative to the true value.

$$\varepsilon_{rel} = \frac{|\tilde{\chi} - \chi|}{|\chi|}$$

Constants:
Using a temperature of 15 C.

ρ_w = 999.102 kg m^{-3}
ρ_a = 1.229 kg m^{-3}
η = 1.812 x 10^{-5} kg m^{-1} s^{-1}
g = 9.810 m s^{-2}

Math check:
For r = 2.5 x 10^{-6} m, v_t = 7.5 x 10^{-4} m s^{-1}

Some Programming Tips
Python:

- The default variables in Python are 64-bit. To make something 32-bit, use the numpy `float32` function.
- To output very small or very large numbers, use exponential format (`%e`) instead of regular float format (`%f`).
- To plot with a logarithmic y-axis, use the matplotlib `semilogy` function.