PHYS2502 Mathematical Physics Lab #4 13 Feb 2022

This lab assignment is at 8am, the morning after the date shown, although you should able to complete it easily before the end of the lab period. When you're done, upload your code to the github *repository, and a PDF of your output to the* canvas *page for the course.*

This is a symbolic manipulation exercise that you'll likely want to work in MATHEMATICA.

The differential equation that governs the motion of a mass m falling under linear drag is

$$m\frac{d^2y}{dt^2} = -mg - bv \qquad \text{where} \qquad v = \frac{dy}{dt},$$

g is the acceleration due to gravity near the Earth's surface, and b is a constant called the "drag coefficient." In class we showed how to solve this equation for $v(t)$ as either a separable equation or using the method of integrating factors.

The point of this exercise is to solve this equation for $y(t)$ using the DSolve function in MATHEMATICA (or in whatever symbolic manipulation app you want to use) and show that you get the same answer for $v(t)$ which we derived in class. You will also investigate the motion at very short times, before drag takes hold, in which case it should behalf like a freely falling mass.

Let the initial conditions be that the mass falls from rest from a height h. That is $y(0) = h$ and $v(0) = 0$. If you use MATHEMATICA, you can follow these steps:

1. Set $Assumptions so that m, g, and b are all positive.
2. Define some variable such as diffeq to be the differential equation for the function y[t]. Note that the "equals" sign in a logical expression like an equation is ==. Check the documentation for the proper syntax. For example, the velocity v would be written as D[y[t],t].
3. Define two separate equations for the two initial conditions.
4. Use DSolve to find the solution y[t] in terms of t of the differential equation with the initial conditions. I recommend storing this solution (which is a replacement statement for y[t]) in some variable, and then using this variable to replace y[t] into some expression y. You'll probably want to Simplify the result to gather terms and make the result more recognizable.
5. Use D[y,t] to confirm that the resulting expression for v is the same as we derived in class.
6. Use Series to expand the result for small times. Show that the first terms are what you expect for a freely falling body, and find the first term that depends on the drag coefficient.