

Exercises for Day 34

Exercise 1. Modify your `Euler1` function from yesterday to create an `EulerDrag` function that solves the ball dropping problem including the air drag term discussed in class. Your new function should receive the ratio k/m as an additional input. (Note that you cannot name the variable ' k/m ' — try `koverm` or `km` or something else.)

Create a main program that does the following:

- Calls the `EulerDrag` function with $dt = 0.001$ s, $y_i = 0$, $V_i = 0$, $y_f = -4$ meters, $g = 9.8$ m/s², and $k/m = 0.1$ sec⁻¹
- Calls the `Exact` function from yesterday to create an exact solution without drag
- Plots the velocity with drag and the exact velocity without drag on Figure 1, with a good x -axis label, y -axis label, title, and legend
- Plots the position with drag and the exact position without drag on Figure 2, with a good x -axis label, y -axis label, title, and legend

Before you turn in your program, check what happens when you set $k/m = 0$. The two plots should lie on top of each other because the exact solution has no drag. If they don't lie on top of each other, find the mistake in your code. If they do lie on top of each other, then set k/m back to 0.1, rerun, and move to the next Exercise. Turn in the main routine, the two functions, and the plot.

Exercise 2. Modify your main program from Exercise 1 to examine the convergence of the solution with drag:

- Run `EulerDrag` four times, with $dt = 0.2, 0.1, 0.05,$ and 0.025 seconds. (Keep all of the other inputs the same as for Exercise 1.)
- Plot the velocity solutions on Figure 1, and the position solutions on Figure 2. Use good labels, etc.
- Do not include the exact solutions without drag on your plots.

You should see that the solution is poor with a large dt , and it gets progressively better as the value of dt becomes smaller. For this Exercise, turn in just the main routine and the plot.

Exercise 3. Write a main routine and function to calculate the trajectory of a projectile with drag, as discussed in class. The function statement should look like the following:

```
function [x,y,t] = TrajectoryDrag(dt,m,k,g,Vlaunch,theta)
```

For the main routine,

- Call the function with $dt = 0.001$ s, $m = 30$ kg, $k = 0.03$ kg/s, $g = 9.8$ m/s², $V_{\text{launch}} = 80$ m/s, and $\theta = 50^\circ$
- Plot the trajectory of the projectile: `plot(x,y)`
- Give the plot good labels and so forth

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ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Department of Mechanical Engineering

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Computer Programming

Next, write a function to calculate the exact trajectory of a projectile *without* air drag (see Day 12 Exercise 4 for the equations). Call this function from your main routine and add the exact no-drag solution to your plot. Add a legend to the plot.

Check that setting k to zero in the call to your `TrajectoryDrag` function gives the same answer as the exact solution. (If it doesn't, fix it.) Then set k back to 0.03 kg/s and run your program. Turn in the main routine, the two functions, and the trajectory plot.