Drag and Vectors

Find your name on the list of today's studio groups, find your partner(s), seat yourselves comfortably, and please read through the rest of this document.

Today's Agenda

Today we'll discuss drag forces, briefly review the baseball example from Chapter 22, and build on yesterday's model of the Earth falling into the Sun to make the Earth go *around* the Sun instead.

Drag

Write notes here related to our discussion of drag forces.

Orbital Mechanics

Starting with either your code from last time or our solution, create a file named `orbit_homework.ipynb` and make sure it works. The follow these steps to develop a model of Earth orbiting the Sun.

1. Modify the initial state so it has variables `x`, `y`, `vx` and `vy`. For now, keep the initial velocity at 0. You can leave the `System` object alone for now, although you may need to define it again in order to pick up the new initial state.

2. Modify `universal_gravitation` so it works with the new `State` object and returns a `Vector`. Test it with the initial state and double-check that the return value is a `Vector`.

3. Modify the slope function to work with the new `state` object. Use vector operations as much as possible. Test the slope function with the initial state.

4. You can leave the event function alone for now. Go ahead and run the simulation without it. Check `details` to make sure there were no problems.

5. Plot `x` and `y` as a function of time. You might want to express time in days and distances in millions of km. Do the results make sense?

6. Modify the initial condition so the Earth has some initial velocity in the negative-y direction. Run again and see if the results make sense.

7. Plot `y` versus `x` as a trajectory (see Section 22.4). Does the shape look right?

8. Simulate one revolution of the Earth around the Sun. You can get `UNITS.year` from Pint. The orbital velocity of Earth at perihelion is 30,330 m/s. At the end of one simulated year, is the Earth back at the starting position?

9. Read the documentation of the SciPy function `solve_ivp` and experiment with parameters to try to improve the quality of the solution. In particular, you might want to try `method='RK23'`. For some reason, this solver does better than most for this problem.

10. Optional: Write a function that takes a `State` and `System` object and computes the gravitational potential energy of Earth based on its position. What is the change of potential energy between the initial and final positions?

11. Optional: Write another function that computes the kinetic energy of Earth based on its velocity. What is the change of kinetic energy between the initial and final velocities? Does the solution conserve energy?

Reflection Question

What problems did you encounter during the orbital mechanics activity? How did you overcome them? What strategies do you want to remember for Project 3?

Next Steps

Before class on Thursday, please do the following things:

- ☐ Write your name here: ____
- ☐ Write your partner's name here: ___________________________
- ☐ Before leaving class: complete Project 3 partner preferences form and give to your instructor.
- ☐ By tonight: Scan this worksheet and submit it on Canvas.
- ☐ By Wednesday night: Read Chapter 23. Complete the Reading Quiz. Run the Chapter 23 notebook.
- ☐ Meet in the studios again on Thursday.