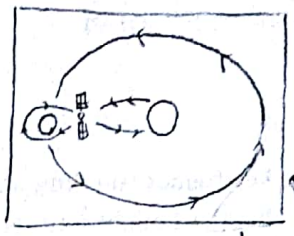
Jinfay Yuan Manu Patil

Project 3 Model Development



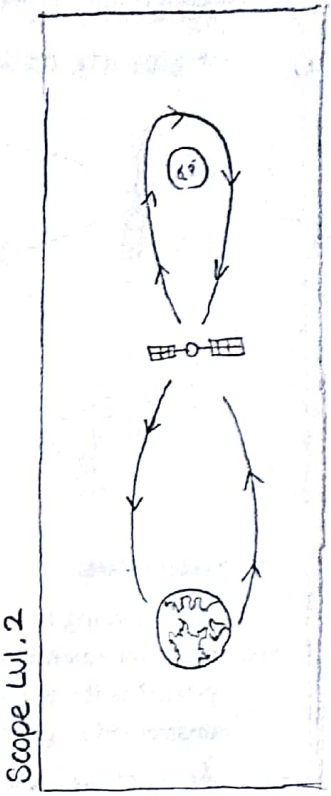
THIS HANDOUT walks you through some key questions of the modeling process. You do not complete these questions once and then move on; you should complete each of these questions thoughtfully now and then return to them throughout your modeling process. Continue to update the responses to these questions as you iterate on your model.

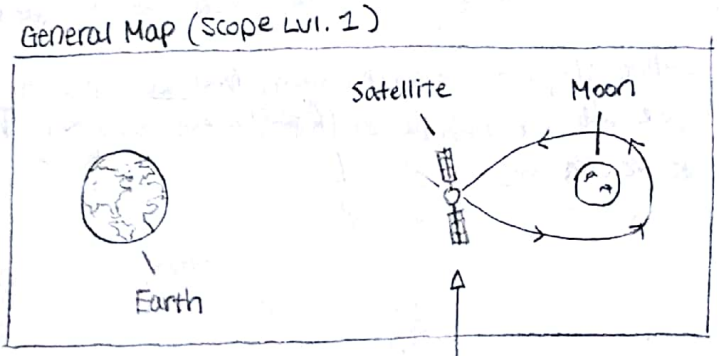
Some of these items might duplicate material already included in your proposal. That's OK - repeat it here with additional detail.

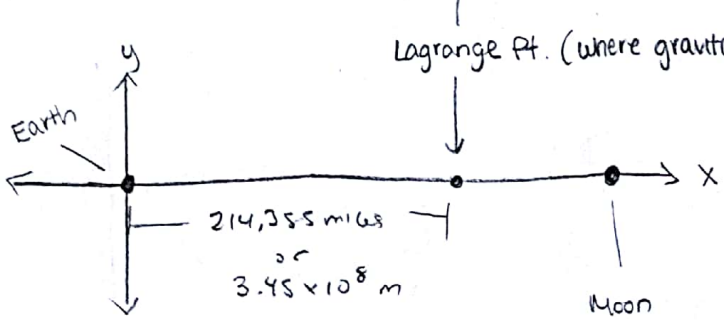
Part I

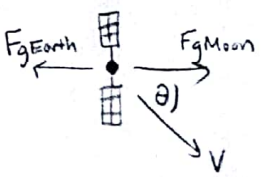
1. **Cartoon**

   Draw a cartoon of your system and its behavior. One good way to do this is to draw a set of "key frames" for the system — a series of snapshots that show the system at different points in time. (Example: If I'm modeling a hopper, I might show a frame with the hopper on the table, a frame with it moving up, a frame with it moving down, and a frame with it landing on the table.) As part of this process, identify key phases of motion and transitions between phases.









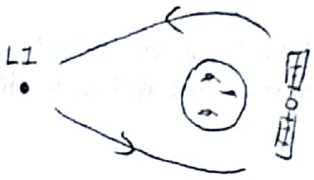
2. **Phases**

Think about the key frames you drew. Are there multiple phases? (Example: For a hopper I might consider a stored-energy phase, a motion phase, and a landing phase.) When will your model "start", and when will it "end"?

Start and End

- Satellite at Lagrange Pt.

Middle



3. **System Parts**

Are you going to model every part of the system, or are you focusing on a particular part? How will you model the parts of your system? Is it one particle? Multiple particles? A rigid body? Is it constrained or free?

At first we will model the satellite slingshotting around the moon. Next, we will add the interaction with the earth. Next, we will have both the earth and the moon orbiting. We will add these parts as we complete the previous ones

4. **Interactions, Forces, Torques**

What are the system interactions? How do the parts of your system interact with each other and the rest of the world? What forces and/or torques are important? Which can be ignored? Make a note of any information you will need to find.

We will need to consider the forces of gravity of the moon, earth and eventually the sun and the satellite. We will consider other terms as we progress.

5. **Schematic Diagram**

Draw a schematic diagram of your system that shows the components of your system and the coordinate system. Label important quantities and relationships (e.g., lengths, angles). Are you using Cartesian coordinates or some other coordinate system? Specify the origin and orientation of the coordinate system by sketching a set of unit vectors. If you find it useful, you might also draw free body diagrams for your system.[1]

Please refer to diagram on page 1.

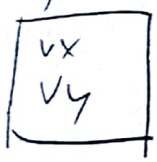
[1] See https://en.wikipedia.org/wiki/Free_body_diagram.

Part II

1. **State Variables and Parameters**

List the variables that describe the state of the system as it varies in time. How many position variables do you need? How many velocity variables? What model parameters will you use to describe the characteristics of your system? (Some or all of these might be shown on your schematic.)

Satellite
x
y
Vx
Vy

Moon
x
y


Stage 2

Earth
X=0
y=0

Mass_ Earth
Mass_ Moon
G
r_0 -> moon starting position
radius_ Earth
radius_ Moon

2. **Mathematical Models of Forces**

What are the force interactions that you will include in your system? What models are you using for those forces, and how will you express those models mathematically? For example, if you are modeling a spring force using Hooke's law, you might write Fspring = -k x, where k is a parameter and x is a state variable. Write out a model for each interaction below, in terms of the state variables and parameters.

We will mainly be using the gravitational force equation. We will have to calculate the force between the satellite and the earth and the satellite and the moon. If we decide to have the moon as well we will have to track the force of attraction between the moon and earth as well

3. Equations of Motion / Slope Function

Combine your mathematical models and your state variables to determine the equations of motion (as a system of first-order differential equations) and/or slope function for your system.

dx/dt = vx
dy/dt = vy
dvx/dt = (forceEarth.x + forceMoon.x) / Mass_Satellite
dvy/dt = (forceEarth.y + forceMoon.y) / Mass_Satellite

If we add lunar movement, we can add the code from the orbit homework.

Part III

Part III is to implement your model. When you start your implementation, and how far you get before you turn in this worksheet, will depend on your project. But you should have at least started writing code and ideally have a working simulation of your first-cut model.

In this space, please write a sentence or two to describe the current state of your implementation and what you've learned so far from implementing.

We have completed the entire implementation of the first

KEEP THIS WORKSHEET HANDY, because some of the content here should appear in your final computational essay. Remember when we talked about making the essay a stand-alone deliverable? It's not necessary to repeat *everything* that's in this worksheet in your essay, but be thoughtful in choosing what content to include so anyone reading it knows everything they need to know about the model.

- ☐ Write your name here: Manu Pahl
- ☐ Write your partner's name here: Justin Yuan
- ☐ Write your studio and your team number here: Studio 1 Team #
- ☐ By Sunday night: Scan this worksheet and submit it on Canvas.