The below objective and problem are meant to truly investigate your ability to computationally find forces and determine future motion. As such, the problem is extra credit which will go towards the Video Homework portion of your grade. There is no deadline for this assignment until the last day of normal classes this semester. Fulfilling the task at hand and adequately explaining yourself in the video will grant 2 points. You can gain a 3rd by fulfilling the bonus part of the question.

**Objective:** *I have mastery of determining changing forces acting on a system, translating that system into a computational model, and using that model to determine future motion.*

1. Though we have not returned in some time, the Apollo missions to land on the Moon were a triumph in human engineering and understanding about orbital dynamics. Here your mission is to replicate in a simplified model the necessary rocket burns to land a rocket on the surface of the Moon. On the launch date in question, the Moon is located at 406 662 km in the positive x-direction and is moving with a speed of 970 m/s in the negative z-direction. You can assume that the Earth is stationary for this model and located at the origin. You are launching the rocket from the surface of the Earth in the positive x-direction (so at $\langle R_{Earth}, 0, 0\rangle$). The radius of the Moon is 1737.4 km and the radius of the Earth is 6371 km. The mass of the Moon is $73.46 \times 10^{21}$ kg and the mass of the Earth is $5.7924 \times 10^{24}$ kg.

   You are launching with a Saturn V rocket, which outputs a force of $33 \times 10^6$ N of force and has an average mass of $1 \times 10^5$ kg (in truth it jettisons stages as it goes along, but we'll just work with an average). You have enough fuel on board for 165 seconds of thrust, which can be spaced out however you might like. We'll assume that you can turn or reorient your main thrusters without fuel cost, so you can fire them in whatever direction you like, so long as you don't exceed the total 165 seconds.

(2) (a) Determine the direction and duration of any rocket burns (when you are using fuel to thrust) you need to make in order to hit the Moon. You don't need to worry about landing safely for this, splatting into it will work (though it won't make nearly so great of headlines...). Think of it as commands along the lines of: "Starting at X seconds burn for Y seconds in the Z direction."

(1 (bonus)) (b) Determine the direction and duration of any rocket burns you need to get yourself into a closed orbit around the Moon. *THIS IS REAL TRICKY (but it will make great headlines!)*

- *Your videos can be longer for this, but try to keep them under 6-7 minutes in length.*
- You also need to make sure your code is public and send me the link along with your video. Good luck!
- Hint: The escape velocity of the Moon is under 2.4 km/s, so if you are hoping to get captured by the Moon's gravity you need to ensure you've slowed down well below that speed...
- Hint 2: Thrusting in a direction opposite your motion is a good way to slow down