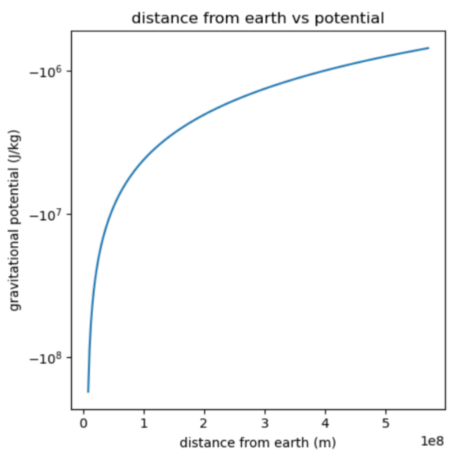
Apollo Program Congressional Report

Introduction

Thank you all for taking the time to read this report. The Apollo Program's goal is to put humans on the moon, and bring them back safely. Such a mission, in broad strokes, requires launching a rocket from Earth with enough acceleration and fuel to escape the Earth's gravity, sending an attached spacecraft to the moon, landing it on the moon, and bringing it and the people on board back to Earth.

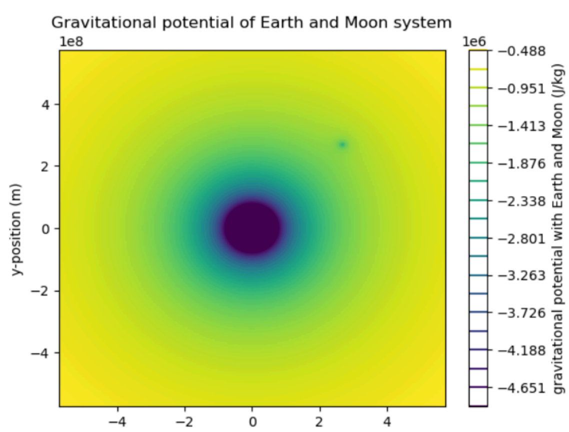
Gravitational Potential of the Earth-Moon System

Gravity is what keeps people and everything else from flying off into space. It is powerful, but not insurmountable. A quantity called the "gravitational potential" measures the amount of energy (measured in Joules) held by a one kilogram (about 2.2 pound) object a certain distance from a gravitational body. By subtracting the gravitational potential at two different locations, then multiplying by the mass of an object, you can calculate the amount of energy needed to move an object between those 2 locations. A graph of the gravitational potential around Earth is shown below. This was calculated by using Python, a programming language, as well as NumPy, which is a Python library (essentially an add-on) to assist with calculations in Python. Matplotlib, another library, was then used to generate this plot. This is the case for all the calculations and figures shown in this report.



It is important to note the logarithmic y-axis of this graph. This, along with the graph's downward curvature, indicates that it costs a lot of energy to get a rocket off of the earth, but once you move further away, a comparably small amount of energy is needed to continue to propel the rocket.

A plot of gravitational potential in 2-Dimensions of the combined Earth and Moon system can also be generated, and is shown below.



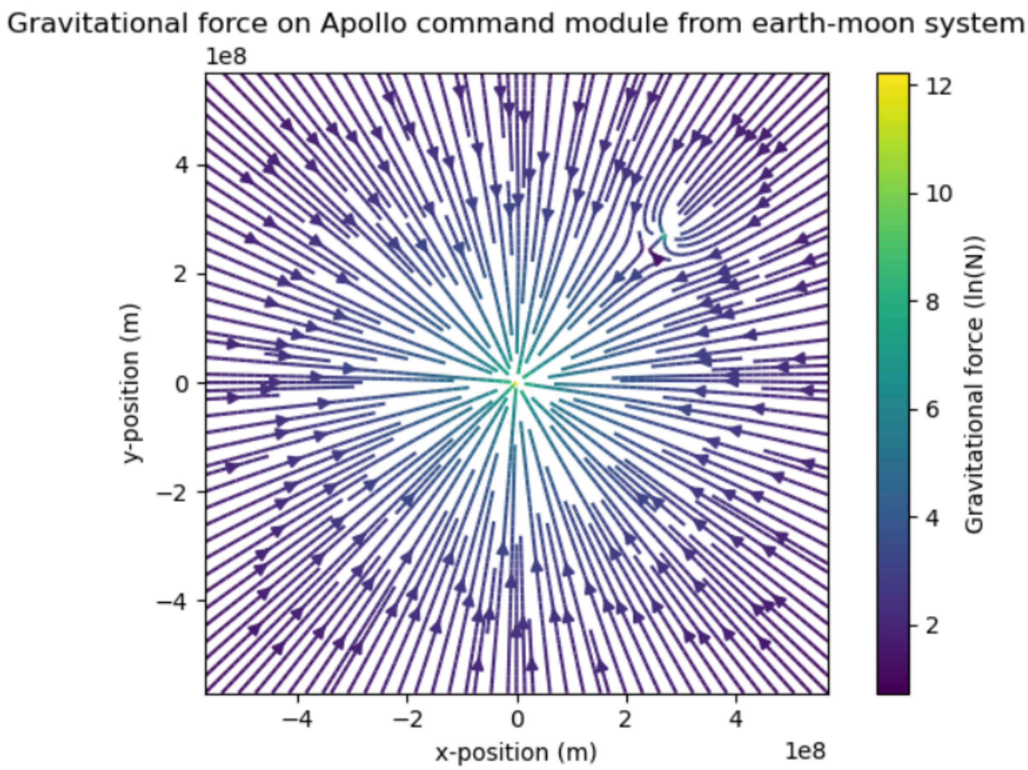
The Earth is at the center of this plot, while the moon is placed up and to the right of the Earth, where the slightly darker dot appears.

The darker the color, the more energy is required to escape from that point. The moon's small size and lighter color in this figure relative to the Earth shows that it is much easier to escape from the Moon than the Earth, so we would not need to bring the same level of rocket equipment to the moon.

Gravitational Force of the Earth-Moon System

The gravitational force is another element that must be considered when attempting to escape Earth, or any gravitational body. In order to escape, we must generate a sustained upward force which is greater than the force of gravity felt on the surface of the object. The sum of forces on an object divided by the object's mass is equal to the acceleration experienced by the object, meaning that an object experiencing a greater net force (forces acting in opposite directions will cancel) will also experience a greater acceleration.

The following plot shows the gravitational force felt by a 5500 kg (roughly 12000 lb) proposed command module.



Once again, the Earth sits at the center of this plot, while the moon sits up and to the right of the Earth.

In this plot, the lighter colors represent a stronger gravitational force, and the colors are logarithmic, meaning that the green and especially the yellow represent much stronger forces than the blue and violet. This means that during the trip, the gravitational force will be relatively small, except when close to the earth or the moon.

Projected Performance of the Saturn V Stage 1 Rocket

The Saturn V rocket is a prototype rocket which would propel the Apollo spacecraft away from earth before detaching from the spacecraft. This detachment saves fuel and money because we have to propel less mass away from the Earth, which thereby saves energy.

Our preliminary calculations indicate that the Saturn V rocket would burn fuel for about 157 seconds, and propel the spacecraft about 74 Kilometers (about 46 miles) into the air before running out of fuel and detaching.

In addition to the previously mentioned functions, the “Quad” module from SciPy (another Library) was used to compute an integral to find the altitude of the rocket after the fuel was expended.

Discussion and Future Work

We have recently received the test results from the first prototype Saturn V rocket. This prototype had a fuel burn time of 160 seconds, and climbed 70 km (about 43 Miles) into the atmosphere. While there is a slight discrepancy from our calculations, and we will need a greater level of accuracy before attempting a moon landing, it still demonstrates that we are capable of creating a rocket very similar to the theoretical parameters outlined above. This discrepancy was likely caused by some slightly inaccurate assumptions we made in calculating the height and burn time of the rocket which simplified the calculations. An example of an assumption we made was that we ignored the effects of air resistance on the rocket. This assumption meant that we should expect our calculated altitude to be higher than the measured altitude, and that is exactly what we saw.

To make future calculations more accurate, we would need to account for air resistance, we would need to obtain more accurate measurements of parameters of the rocket, such as the rate of fuel consumption, and we would need a better understanding of how the rocket behaves in the atmosphere, likely through more test launches. Once again, thank you all for reading this report on the Apollo Program. For anyone interested, there is a document with blown-up versions of all these figures as well as an additional figure which did not make it into this report attached.