Executive Summary

Movement of an Object in Microgravity Environments

Introduction

The problem we were presented with included finding the range of dimensions for the smallest possible asteroid which can be used to land a probe, a method to land a small probe on the asteroid to a target position, and a way to move the probe to a predetermined position using a spring. We were asked to keep the amount of bouncing as small as possible.

Assumptions

To begin, we made a few assumptions that would simplify this problem for us. We assumed that the probe is orbiting the asteroid, the only force acting on the probe is the gravitational force of the asteroid, the asteroid spins on its minor axis, and the asteroid has no atmosphere.

Approach

Next, we examined different physics aspects of the problem. We determined we wanted to model a soft-landing approach, to reduce bouncing, and utilize a mass spring system to allow for surface hopping, which would be the way the probe moved across the surface once landed. Limitations that we considered while attempting to model this were the distance from the asteroid that the force of the microgravity could reach, the escape velocity at the surface of the asteroid, as well as reasonable time for landing.

Our approach is as follows: The probe would be orbiting the asteroid and is dropped and allowed to free fall to the surface, with an initial velocity in the y direction being zero. It would accelerate due to the gravity imparted by the asteroid, which would change as the probe approached the surface. This would also mean that the distance to the surface changes with time. In order to stop our probe from bouncing off of the surface, we wanted to ensure that the impact velocity was lower than the escape velocity.

When starting at rest and accounting for forces, we will have the force of gravity and the normal force which will be at equilibrium. The spring system proposed will produce a force by hitting the surface of the asteroid at a specified angle theta. This will produce a parabolic path as long as the velocity resulting from the produced force is less than the escape velocity. The probe will have a set of 4 springs in order to achieve motion in all directions. There will be no energy losses due to the assumptions made. When it lands, after the initial bounce, dampers attached to the probe will reduce the velocity and allows for control of direction and landing area with each additional bounce.

Proposed Solution

We propose a four spring system with retractable plungers, with an embedded damper system that will allow us to control the magnitude of the bounce and direction the springs will impose on the probe. Each spring and plunger will be able to be changed individually to allow for directional variation. The spring system will also be used to alleviate the force imposed at impact when the probe is first landed, which will thereby reduce the amount of bouncing it will do initially and will allow for a more accurate predetermined landing area.

Summary

To conclude, we propose a spring system that will address only the gravitational force imposed by the asteroid. We modeled this through a system of equations that address surface position, the force of gravity as the probe approaches the asteroid, and the dampening.

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