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# SCUDEM IV 2019

UNIVERSITY OF ST. THOMAS - HOUSTON

## Problem B

## Movement Of An Object In Microgravity Environments

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## Introduction

Asteroids are small rocky objects that orbit the sun. It's estimated that if the masses of all the asteroids in our solar system were combined, the sum would only reach 4% of the mass of Earth's Moon!  So why do we care about tiny space rocks? While asteroids are considered small, it's only in comparison to larger celestial bodies such as the Moon and Earth. Several of the smaller asteroids observed are even bigger than the Statue of Liberty! More importantly, to scientists, asteroids hold key information for unlocking the secrets of our solar system, while any entrepreneur would appreciate the rich, concentrated resources that can be found on asteroids. Thanks to these reasons, there has been a great interest in sending probes to asteroids. Unfortunately, landing a probe on an asteroid presents astronauts with unique challenges, how to select the right asteroid for landing, and how to land and navigate in a microgravity environment with no atmosphere?

## MISSION

The proposed mission consists of determining the minimum range of dimensions an asteroid must have in order for a small probe to land. Next, a method has to be developed to first place a small probe in the asteroid and determine the final position where the probe will be after it lands. Then, develop a way to move the probe to a predetermined position using a spring.

Our prompt provides us with three different missions.

### A. Selecting the Smallest Asteroid

Finding the minimal dimensions for an asteroid such that a probe can still land and ambulate safely on its surface.

### B. Landing the Probe

Calculate the velocity and angle needed in order to land the probe with minimal bouncing and damage in a designated landing area.

### C. Travelling on the Asteroid

Move probe to a predetermined position using a spring to hop in a given direction

Specify limits of the probe's movement.

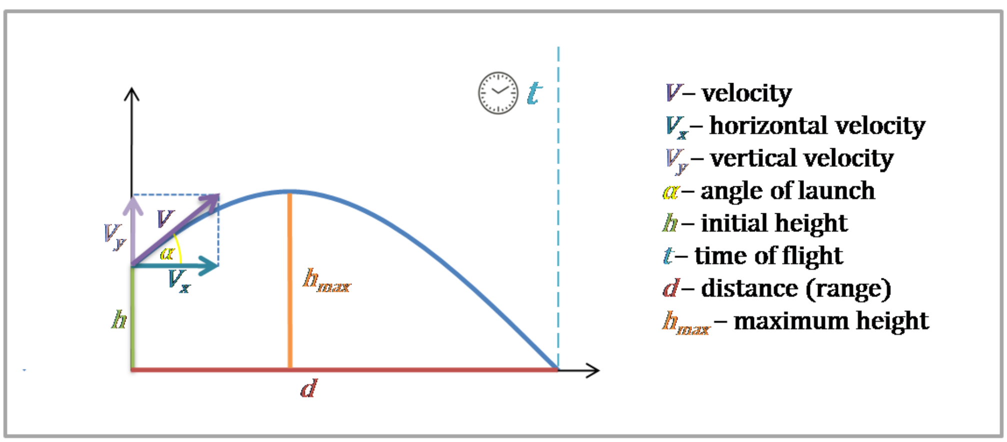
# Assumptions and Approach

## I. Asteroid size

When we first received this prompt, our first thought in regards to asteroid size was that it had to be bigger than our probe. After doing some research on typically asteroid sizes, we quickly realized that most asteroid would have no problem accommodating several probes side by side. Instead, we turned to look at the gravity produced by an asteroid and the distribution of its gravity. We found that the minimum exit velocity required for simple movement is 3.8 m/s which we used to find the other values.

## II. Landing

In order to increase our chances of landing successfully, we need to find the prime landing spot to reduce impact and avoid damage. Furthermore, we need to find a landing velocity that will create minimal bounce at a rate lower than exit velocity. Thus, to calculate our landing, we used projectile motion formulas.




## III. Movement

When considering movement, the probe can move on flat terrains using wheels with a spring-based suspension, and can explore craters or climb oblique surfaces using a motorized lance system. Using these methods, we have to keep in mind the exit velocity, and for the lance the angle at which it should be launched.

## IV. Limitations of movement

Some of the limitations of Vertical Movement Using Spring Based, motorized Lancet include: downward movement limited by length of cord, upward movement limited by maximum and projectile height within exit velocity.

- Maximum Height at max velocity of 3.8m/s: 99.9721 meters
- Maximum Horizontal distance at max velocity of 3.8 m/s:200.0055 meters

## V. The model

The asteroid size parameters and escape velocities considered:

Minimum Asteroid size may vary with the mass of the asteroid and mass of the craft attempting to land on the asteroid. The greater the mass and the closer the masses to each other, the greater the gravitational attraction between them.

In this case we chose some numbers to work with.

**Set Parameters**

- Mass of probe = 200 kg
- Desired exit velocity: 3.8 m/s
- Distance between probe & asteroid (r) = 12 m
- Radius of asteroid = 100 m

**Calculated**

- Mass of Asteroid = 1.08x1013 kg
- Gravitational Force = 1,002.79 N
- Gravitational Acceleration = 0.0721 m/s2

| ESCAPE VELOCITY CALCULATIONS | |
|---|---|
| VE=escape velocity | meters/second |

| | |
|---|---|
| G = gravitational constant | 6.67E-11 |
| M = mass | kilograms |
| r = radius | meters |
| | |
| MINIMUM ESCAPE VELOCITY IN ORDER TO 'WALK' | |
| 3.8 | M/S |

| Mass | Radius m | escape velocity | | |
|---|---|---|---|---|
| 73000000000 | 245 | 0.0127 | Bennu | UNKOWN |
| 35000000000 | 250 | 0.0086 | Itokawa | S |
| 200000000000000 | 2750 | 0.0594 | otawara | UNKOWN |
| 50000000000000 | 950 | 0.0860 | Toutatis | S |
| 4E+18 | 90000 | 0.2567 | Chiron | B |
| 2000000000000 | 800 | 0.0204 | Apollo | S |
| 4000000000000 | 1000 | 0.0231 | Geographos | S |
| 6.69E+15 | 6500 | 0.1454 | Eros | S |
| 1.033E+17 | 33000 | 0.1125 | Mathilde | C |
| 1E+17 | 29000 | 0.1260 | Ida | s |
| 1.5E+18 | 51500 | 0.2748 | siwa | |
| 6.1E+18 | 107500 | 0.2654 | eugenia | |
| 1.7E+18 | 62000 | 0.2430 | lutetia | |
| 2.59E+20 | 284500 | 0.6535 | vesta | |
| 2E+19 | 117000 | 0.4416 | juno | |
| 2.05E+20 | 291000 | 0.5685 | pallas | |
| 9.393E+20 | 482500 | 0.7339 | ceres | |

| | |
|---|---|
| kg in a ton | 907.185 |
| | |
| | |
| calculating M | |
| when r=100 | 1.08E+13 |
| when r=500 | 54,089,852,084,482.10 |
| when r=1000 | 108,179,704,168,964.00 |

Probe Bounce Upon landing

Velocity determines how far the probe will travel horizontally. By testing a range of initial velocities between 3.8 m/s and 1 m/s.

The number of bounces is determined by drop height, lower height = less bounces & shock absorption technology

| | |
|---|---|
| GRAVITY | 3.7216 |
| V1 | 3.8 |
| V2 | 2 |
| V3 | 0.5 |
| | |
| Vx1 | 1.996223558 |
| Vx2 | 1.050643978 |
| Vx3 | 0.2626609944 |
| | |
| Vy1 | 3.233433393 |
| Vy2 | 1.701807049 |

| |
|---|
| differential equation for change in y |
| dy/dt= Vy1-g*t |
| dy/dt= Vy2-g*t |
| dy/dt= Vy3-g*t |

| | | | | |
|---|---|---|---|---|
| DROP HEIGHT | 12 | | | |
| T1 | 3.157894737 | this is time ball reaches the ground the first time | | |
| T2 | 6 | | | |
| T3 | 24 | | | |
| Calculating horizontal distance travelled in the above mentioned time frames | | | | |
| X1 | 6.303863866 | Yo1 | 12 | Yf1 |
| X2 | 6.303863866 | Yo2 | 12 | Yf2 |
| X3 | 6.303863866 | Yo3 | 12 | Yf2 |