PROBLEM B:
MOVEMENT OF AN OBJECT IN MICROGRAVITY

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Questions to Address

Minimum Asteroid Size

- Not a question of size but gravity
- Minimum asteroid size & mass to produce viable gravitational pull

Landing the Probe

- Land the probe in minimal gravity conditions with minimal bounce as to not damage probe or exit gravitational field

Moving the Probe Around the Asteroids

- How to move around
- No thrust force
- Use a spring

Landing in no atmosphere

Why particularly land on an asteroid?

- Asteroids are the primordial left over. Space rocks with many precious resources
- They contain compounds that help tell what the early solar system was like 4.5 billion years ago.
- ~3/4 of asteroids are carbonaceous (carbon based, organic)
  - May contain amino acids asteroids could have seeded Earth with the organic matter that led to life.
  - Rich in mineral resources
- Ryugu is dark as coal, is carbonaceous.

Calculating Minimum Asteroid Size

Assumptions

- Spheroid Asteroid - with a mostly consistent gravitational pull
- No Atmosphere
- Impact of Weather is negligible
- Stony Type, either C-Class or S-Class

Approach

- Acceleration from gravity depends on Mass and radius of asteroid
- Gravitational Pull between two masses is needed
- Escape velocity

Model Asteroid Dimensions

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.

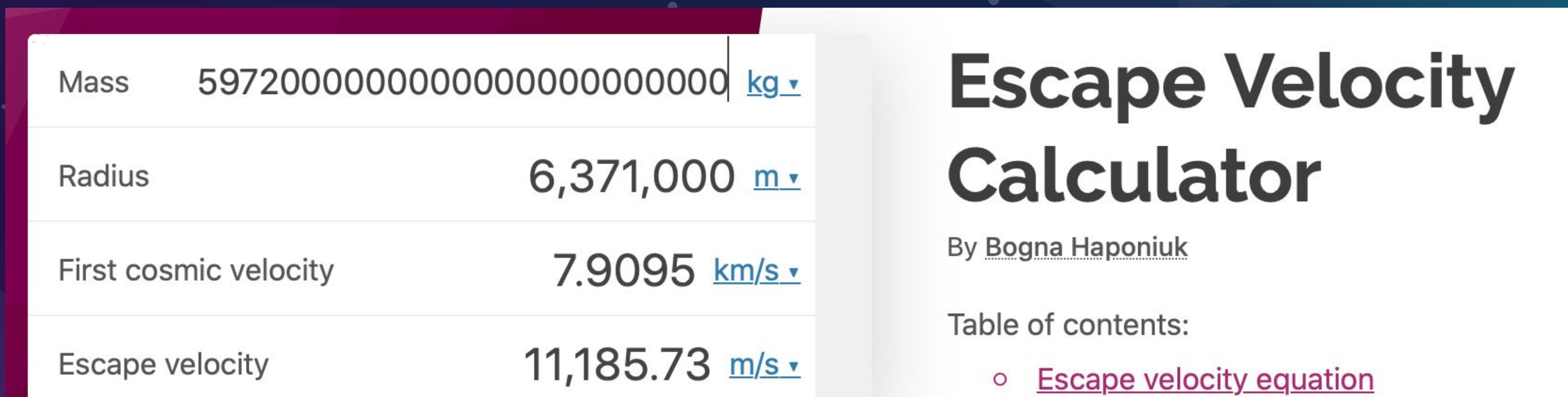
Set Parameters

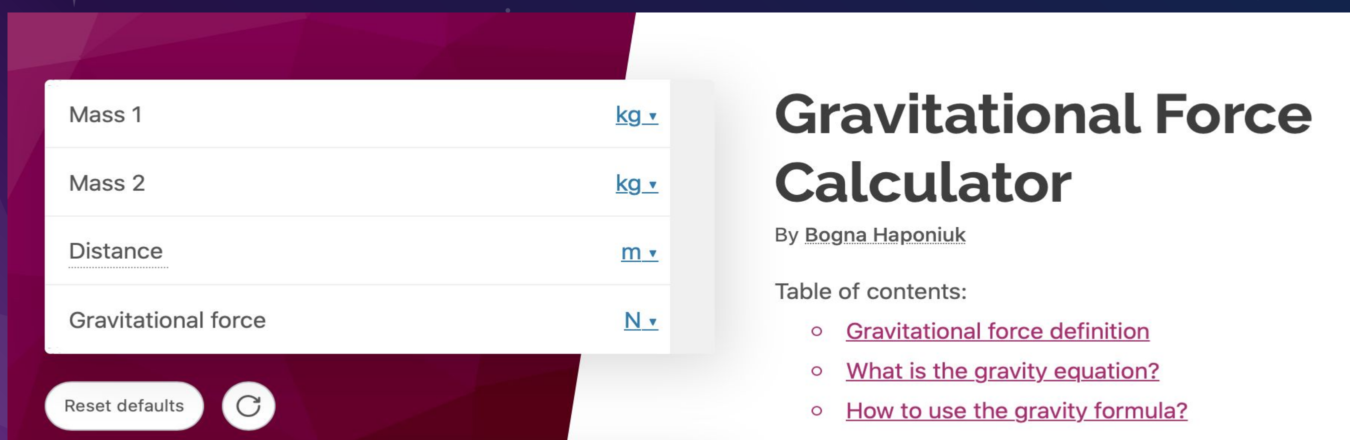
Mass of probe = 200 kg
Desired exit velocity: 3.8 m/s
Distance between probe & asteroid (r) = 12 m
Radius of asteroid = 100 m

Calculated

Mass of Asteroid = 1.08×10^{13} kg
Gravitational Force = 1,002.79 N
Gravitational Acceleration = 0.0721 m/s^2

How we found mass & gravity





Landing a Probe

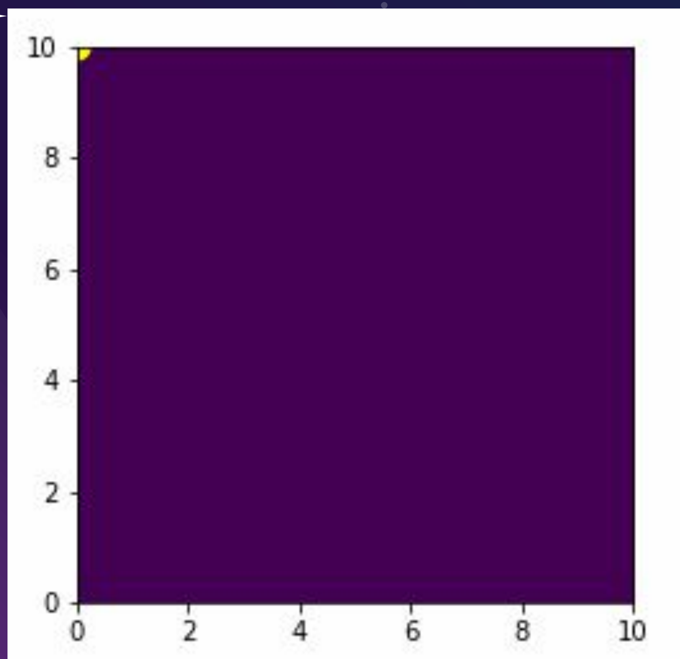
Assumptions

- Flat landing area with no pits or boulders.
- Due to lack of atmosphere, cannot use parachutes, and limited fuel for rockets
- Bounce velocity below exit velocity will not damage probe

Assuming that we need to 'drop' the probe at an area above ground:

- Velocity vector ≥ 75°
- Angle and Initial Velocity affect horizontal distance
- Use physics formulas for downward projectile motion

Probe Bounce Upon landing



We tested a range of initial velocities between 3.8 m/s and 1 m/s.

Velocity determines how far the probe will travel horizontally

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

Vertical Distance Over Time

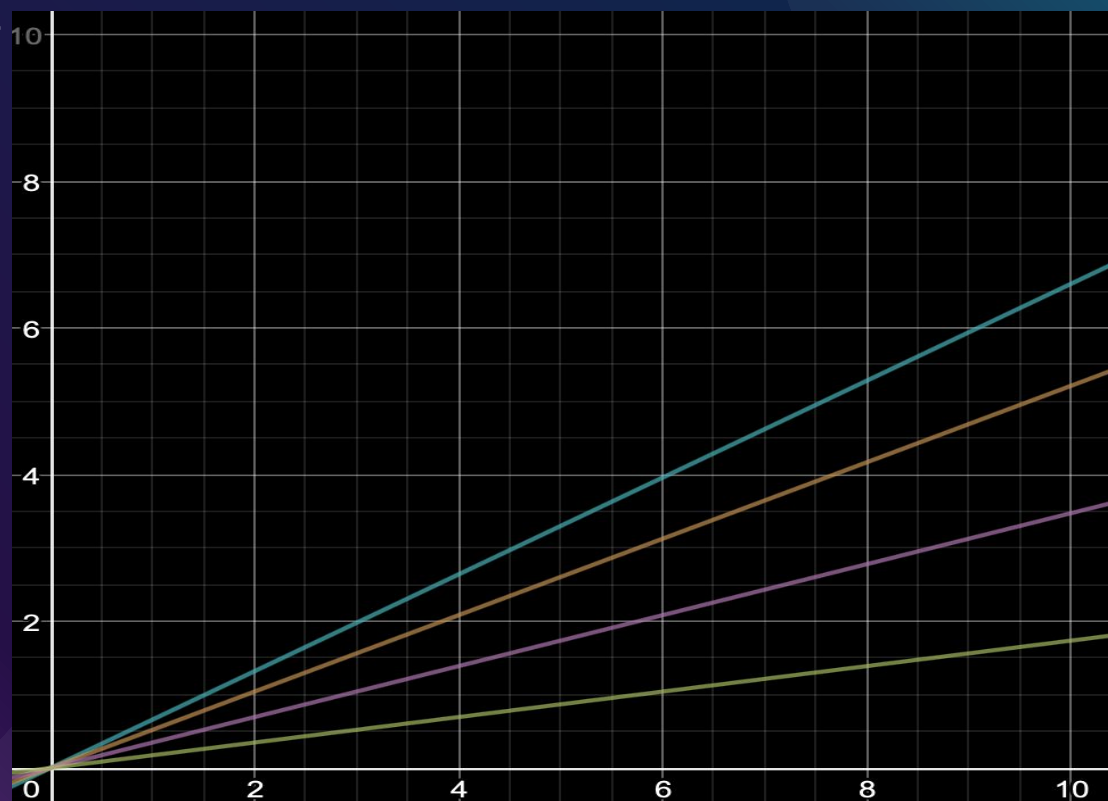
Time in t Seconds to Reach the Asteroid	
t1	1.5565
t2	1.9389
t3	2.7658
t4	4.5648

Legend

V=-3.7423m/s
V=-2.9544m/s
V=-1.9696m/s
V=-0.9848m/s

Horizontal Distance Over Time

Horizontal Distance, x, in Meters Travelled in Time, t			
t1	3.1131	X1	2.0542
t2	3.8780	X2	2.0202
t3	5.5317	X3	1.9211
t4	9.1298	X4	1.5854



Driving around on a Probe

Assumptions

- Rugged, sandy and rocky terrain
- May need to explore craters or hill like ridges

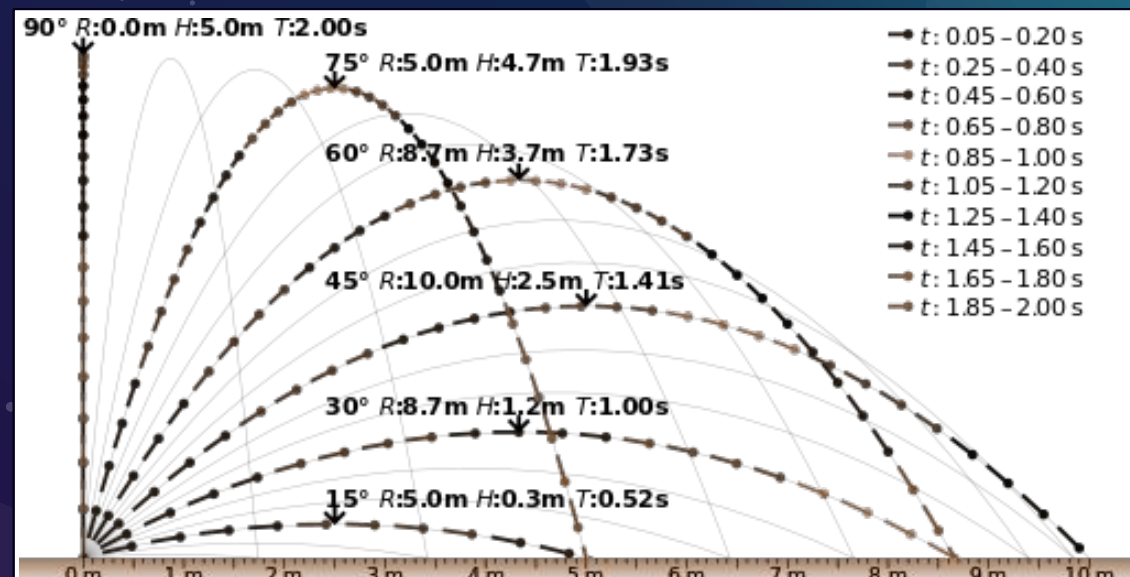
Our Approach

- The suspension on a vehicle is a type of spring.
- Probe can move on flat terrain using wheels, and can explore craters or climb oblique surfaces using a motorized lance system
- Issue: aiming lance as projectile

Limitations of Movement

Vertical Movement Using Spring Based, motorized Lancet :

- ★ Downward movement limited by length of cord
- ★ Upward movement limited by maximum projectile height within exit velocity.
- ★ Max. Height at max velocity of 3.8m/s: **99.9721 meters**
- ★ Max. Horizontal distance at max velocity of 3.8 m/s:200.0055 meters



ADDITONAL QUESTIONS

Problem 1

Adding Rotational Motion:

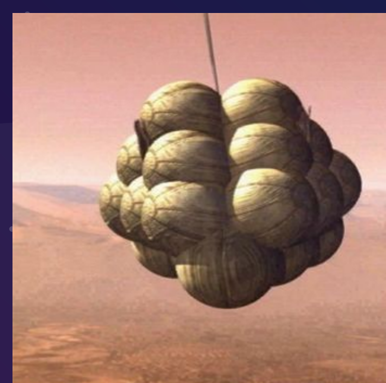
Would change the horizontal distance travelled

Reduce Landing energy

Change by using Inertia and rotational energy formulas. Add air bags

Problem 2

No impact. Solve for gravitational attraction and adjust parameters accordingly



Problem 3

Travel straight, but circumvent any craters with a depth greater than 98 meters.

Unless we install a back-up vertical lance to increase height for climbing.