Jumping Lunar Robot with Camera

When Perseverance landed on Mars, it brought with it the double-bladed helicopter robot Ingenuity to fly above the rover and help JPL plan out its mission by spotting locations of interest and taking pictures of the surrounding area for more detail. Since there isn't any air on the moon, NASA can not send a helicopter to fly on the moon and help with robotic missions, but they might be able to send a jumping robot to take overhead pictures.

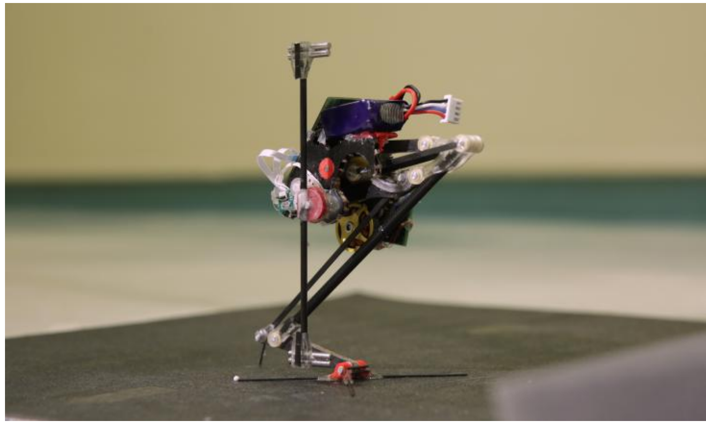
- Design, build and test a jumping robot that can take pictures of the surrounding area on the way up and on the way down for use on the moon. This might be done with replaceable solid rocket motors but that would require having a rocket motor for every set of pictures taken. Jumping would allow many more uses.
- https://www.youtube.com/watch?v=daaDuC1kbds&t=172s
- These robots are terrific jumpers. We need a camera that can take pictures of the ground while it is high above.
- How high does it jump—maximum 10 ft on Earth
- When does it take good pictures?
- Can it keep the same orientation the whole time so the camera

stays pointed correctly?

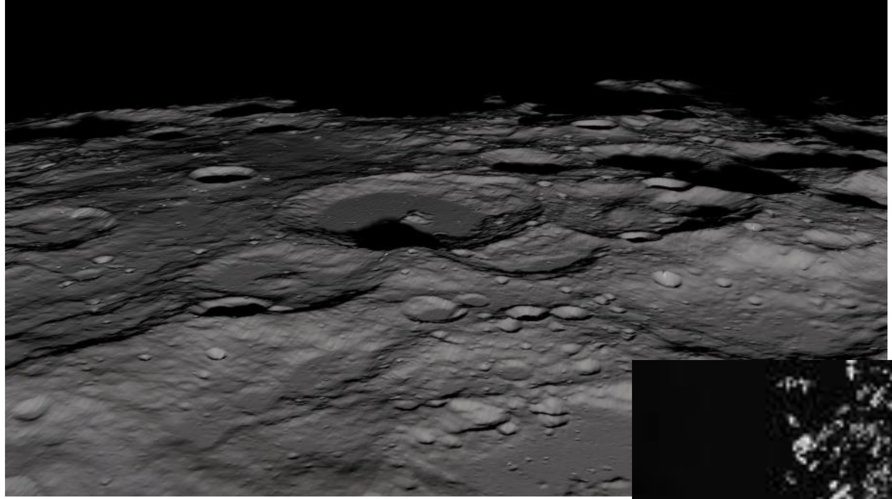
- How does it survive the fall?
- Can it reset without assistance?
- How long does it take to reset for another jump?
- How many times can it jump before it may be damaged?
- What materials would be used for the moon?
- Lighter weight is better.
- Your robot can look completely different from these sample robots

<u>Suggested Teams</u>

1. Robot body
2. Storing potential energy
3. Controls
4. Power--Solar panel(s), batteries



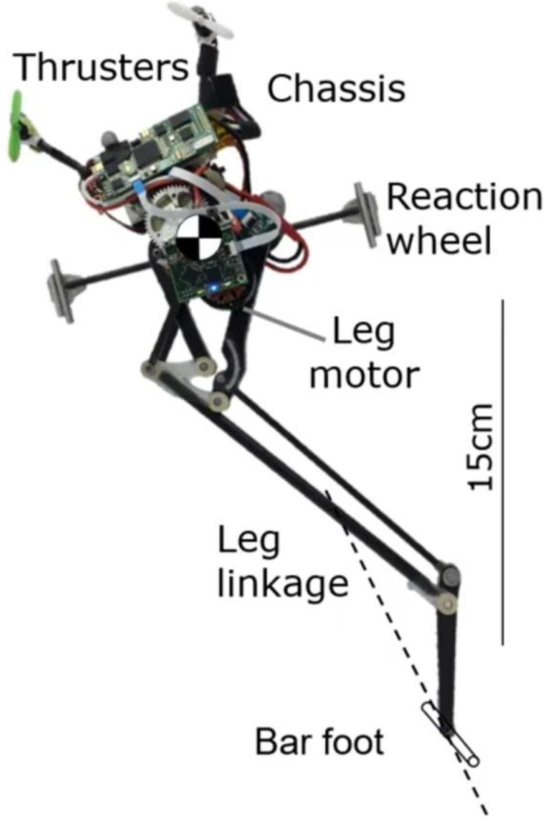
- The intended work location for this robot to work is on the South Pole of the moon where the sun will always be on the horizon with long shadows on the ground. The ground will be hilly if not mountainous with baseball and soccer ball sized rocks strewn about.
- For the jumping, it would be wise to test in a grass field because it is safer for your robot for the fall
- For testing your camera, there may be value to testing near your football stadium because of shadows and contrast you might see in the later afternoon.
- Visible spectrum cameras are the easiest and cheapest for demonstration but there may be other cameras that could be of value.
- Keep it simple to keep the robot small

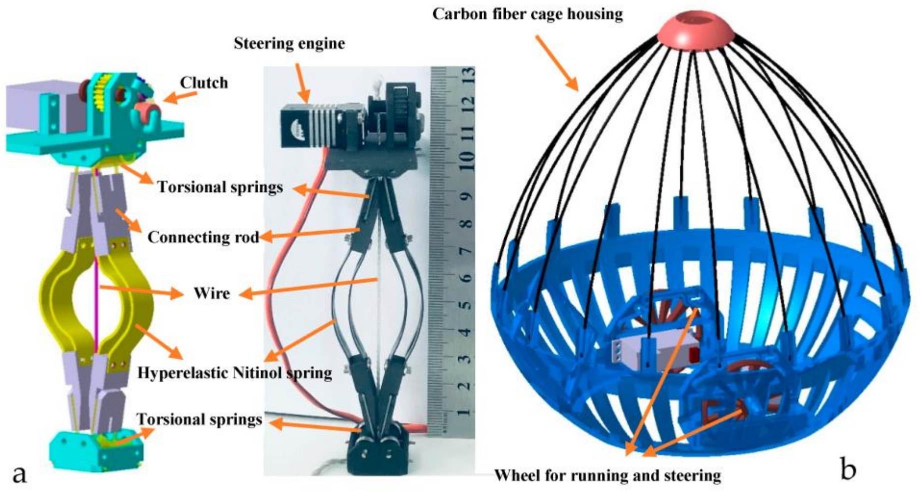


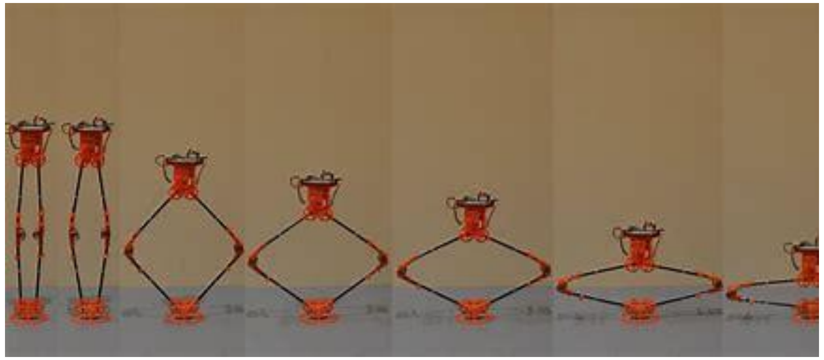
Jumping Robot Requirements
we expect to see all these systems

The lower the mass of your robot, the higher it will be able to jump but it is important to get good pictures.

1. Robot body (suggest 2 people min.)
    1. Survives repeated launches and falling
    2. Setting itself upright for next launch
    3. Camera with orientation
    4. Method for finding it after a jump
2. Energy Storage for Launching (suggest 2 people min.)
    a. Must be good for temperature range of the moon
        a. Springs—compression, tension, torsion,… , other flexible materials
    b. Releasing mechanism
        a. Must be repeatable, Won't release before time
3. Controls (suggest 2 people min.)
    a. Arduino, raspberry pi, other,… (small)
    b. Runs the motor for storing potential energy
    c. Runs the release mechanism
    d. Runs camera(s)
    e. Camera/robot orientation
    f. Transmits pictures from camera to a person's phone
        a. blue tooth suggested—there's no wi-fi on the moon
4. Power Systems—solar panels and batteries (suggest 2 people min.)
    1. Solar panels (?) charges battery that runs controls
    2. Size of battery
    3. Time for recharge can be slow
    4. Orientation—when the robot lands, it needs to be positioned that will allow for solar panels to recharge batteries
    5. Solar panels are not damaged when falling back to the ground (positioning on the robot?)







Making your robot competitive

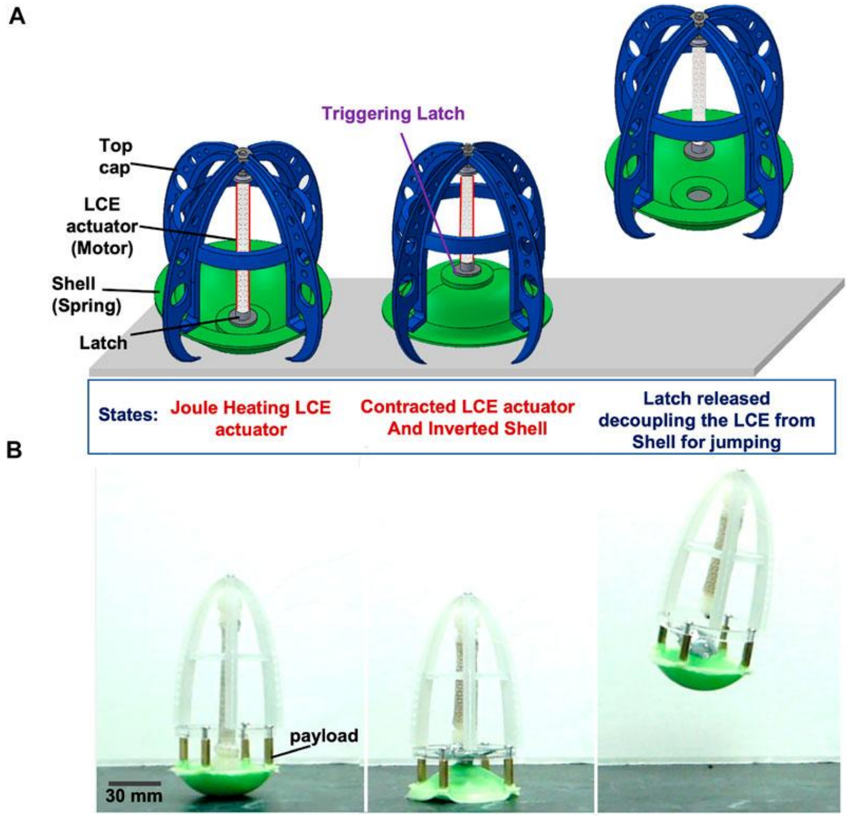
1. Jump height Maximum of 10 ft.
2. Reset without assistance
3. Time between jumps (try to keep it low)
4. Number of jumps without breaking (keep track of your jump number and repairs)
5. Picture quality, pointing in the right direction
6. Connection to phone / computer for pictures
   (should be independent of outside wi-fi—may be far from the rover)

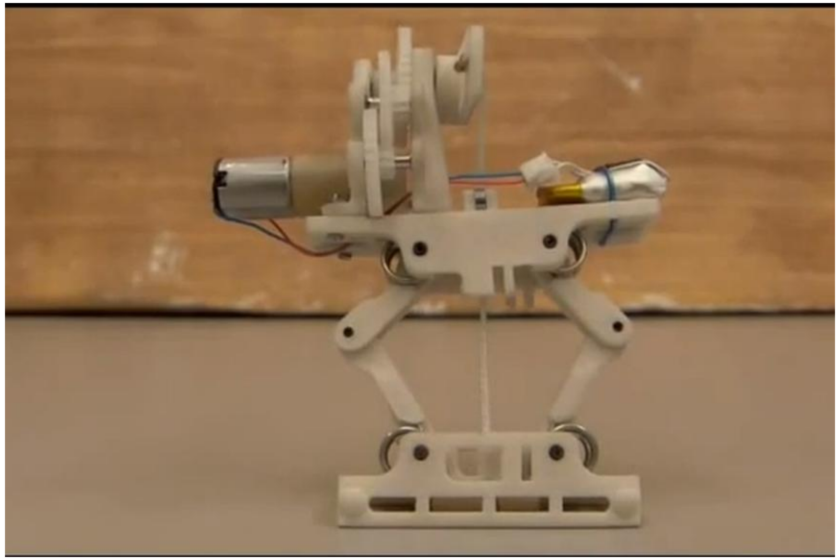
There may be a value to cutting back on the jump height to save it from breaking and to get more jumps before it breaks.
One camera is better for mass but there may be a good reason to have 2 cameras for better pictures.

Unfortunately, we are testing this on Earth with air resistance so not everything will work the same as on the moon. Fins and parachutes will help the robot here on Earth, but they won't work on the moon so don't use them. However, you may need a nose cone because of wind drag.

Some types of Springs

Compression
Extension
Disc
Linear wave
Rotor
Strip
Torsion
Garter





Thinking bigger

- If your robot can jump 10 ft on earth it will jump around 60 ft on the moon (that's around 6 stories high). It is more important to get many pictures from 60ft height and survive than to get one picture at 300 ft and the robot is broken from the fall.
- since there won't be Wi-Fi available every where on the moon, the astronauts or a robot may need to follow the jumping robot around to collect the photos by wi-fi or Bluetooth and also to help find the robot after many jumps. This means the robot should store the photos for a short time and then drop them as a batch when it has a connection. It may also be helpful to have a flashing light so it can be found easier.
- Translation across the moon's surface? If it jumps up and down in the same place, we will get the same pictures over and over. If it lands on a slope, the next jump will be in a different direction and it will land in a new location. Is there a way to direct the jump for going in a particular direction?
- Can you have a robot that drives around and throws the camera up and retrieves it and then drives to another spot. A driving robot can't go as many places as a jumping robot. It's called a jumping robot not a camera shooting robot—make the robot jump—leaves the ground.
- Does the camera need to be on the top? It can see the ground better if it doesn't have the lower part of the robot in its view.
- Does all the weight have to be on top? It may be valuable to have the larger mass up top but there could be ways to have some mass down low.
- Could you have more than one stored energy source or if it could be multiple (like a couple of springs or a couple of inverted half-tennis balls). You are not limited to one spring or other energy source. All of the pictures in the presentation use multiple springs or flexible rods or bands. Is it possible to arrange them to have variable jumping heights?
- I would rather see your robot jump 3 or 4ft off the ground instead of see it jump 12 or 13 ft—stored energy and safety.

How the robot will be used

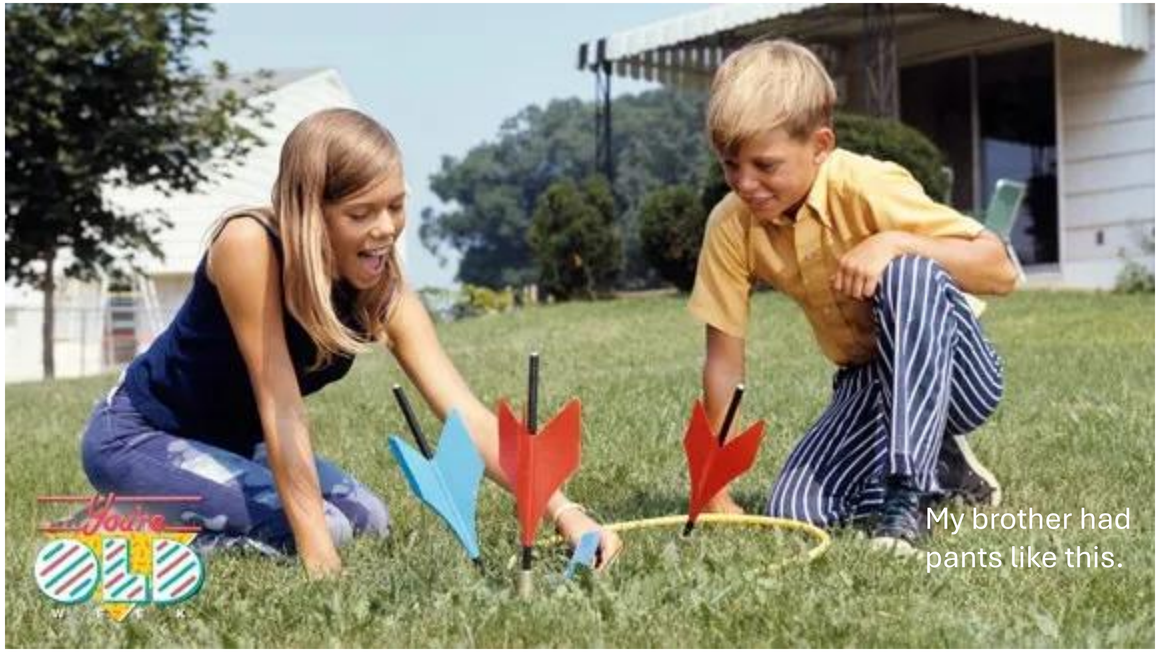
1. Astronaut (1 person) carries the robot to a location
2. Sets it down and has time to walk away (10 to 20 sec delay)
3. Jumps minimum of 3 feet /maximum of 10 feet high
4. Takes a picture or video of the surrounding lunar surface
5. Lands and resets itself
6. Jumps again (similar height) to take picture of a different segment of the surrounding lunar surface
7. Transmits pictures (or video) to a team member’s phone (Bluetooth or wifi)

The over-all function is the biggest objective—not height. 10 ft jump is the maximum. Robots should be able to jump 3 foot but a higher jump will demonstrate more time for a picture to be taken and keep orientation. Keeping the robot weight down is probably the biggest factor in getting the height.

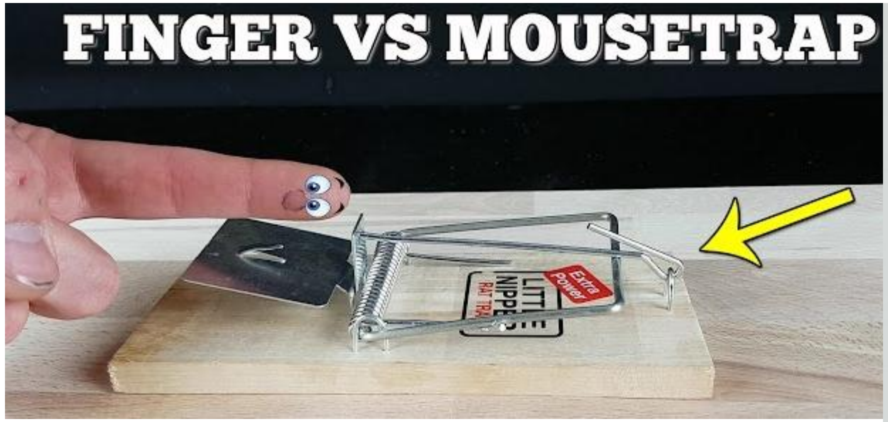
Safety

In order to prevent some hazards, we have to have some limitations.

- Your robot should not go higher than 10 ft (equals 60 ft on the moon)
- This will limit the amount of stored energy in your spring, bungee cord or what ever (bungees won't last on the moon because of temperatures)
- Cannot have sharp parts on your robot



When I was a kid, somebody invented the game of Lawn Darts. The ideas was to try to get the lawn dart to land in the circle—kind of like cornhole but with something more pointy. It was fun until someone got a dart in their foot or hit in the head---DANGEROUS. By limiting the height of the jumps we should be able to keep this robot safe. Many schools do Estes rockets. With simple safety from your teacher, you should be able to do this.



Mouse traps hurt when your fingers get snapped, rat traps really hurt. Be careful with stored energy

Tips

- Start by shaping your idea using recycled products—cardboard, drink bottles, soda cans, soup cans, paper, tape
- Stuff from the garage—nuts, bolts, coffee can, paint can, spring from the old gate,
- draw on paper then draw in CAD—faster.
- Find parts at hardware store, McMaster-Carr
- Plan for multiple iterations of your idea.

Testing

- Rather than testing on sand or concrete with some rocks on top, which is similar to the surface of the moon but are really messy and can change from state to state, this year we will use a moving blanket. I'm not pretending that this is a great example of the lunar surface but it will give everyone around the country a simple testing surface both for taking off, landing and resetting for the next jump. I found this moving blanket on sale at Harbor Freight for $5. You don't have to test with this brand of blanket if you already have one, this is just what I found for cheap.
- For the **Preliminary Design Review** teams should demonstrate as many of the functions as they can to receive pointers and tips from reviewers but it may be wise to catch the robot instead of letting it hit the ground repeatedly. Your robot may not be completely assembled but you should be able to show some functionality.
- For the **Critical Design Review**, teams will get 5 min. to

1. Set the robot down on the moving blanket (wherever the team chooses)
2. Start their robot (should be a pause before it takes off to allow the astronaut to get away from it)
3. The robot jumps and takes a picture (or continuous video)
4. The robot resets itself
5. The robot jumps again and takes another picture (or continuous video)
6. Team shows the pictures taken by their robot on a phone or computer.
7. Robot should include representations of solar panels and how the team wants them arranged on the robot. (I do not expect them to be functional)
8. The Team should also have video evidence that your robot has completed multiple test jumps
9. It is best for the robot if the robot falls back down on the blanket.