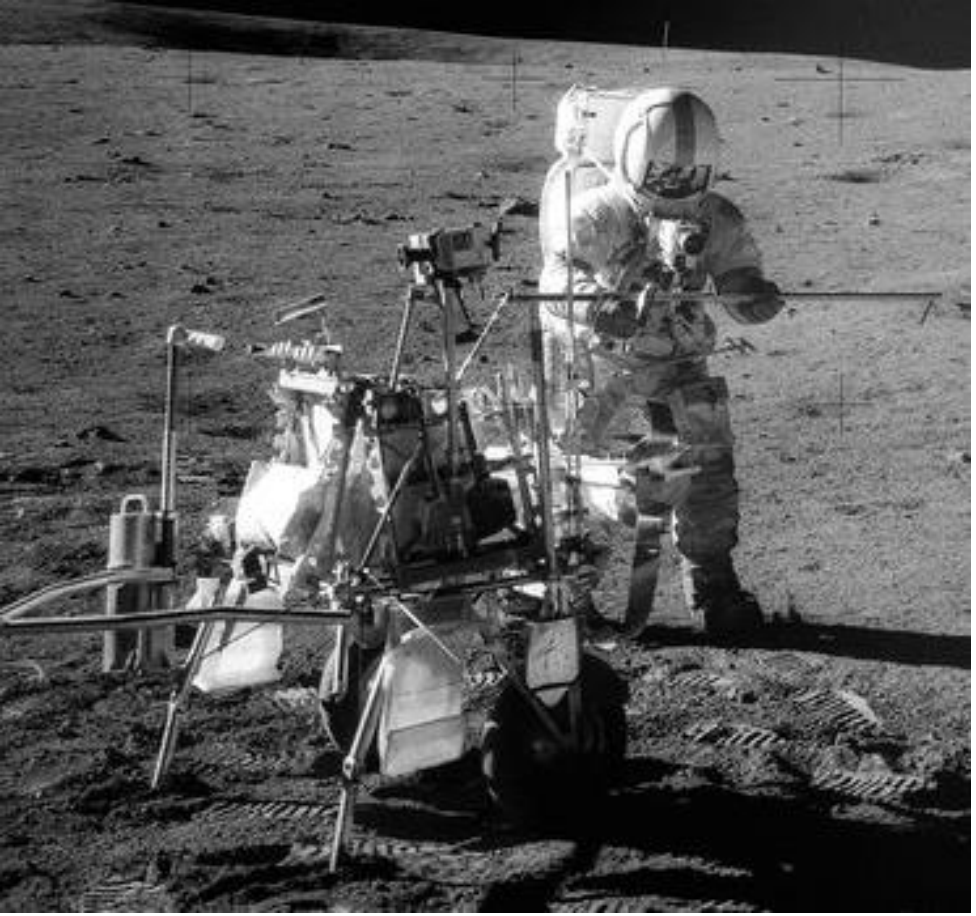
Lunar wheels



Apollo Lunar Tool and sample carrier

When the next astronauts land on the moon, the first couple of missions will probably be short missions and won't take a lot of equipment. The astronauts will need some kind of wagon or wheel barrow to move their tools (shovels, rock hammers, rakes, coring drills…) and rock samples around with them. We don't know what the new tool and sample carrier will look like but you can help determine what the wheels (a very important component) will look like. $1.8 million per kilogram is an estimate for cost of landing equipment on the moon. What ever the tool/sample carrier looks like, it will need some light weight wheels that can handle the high and low temperatures of the moon and the fine, dry, sharp sand as well as large rocks. Although this is a very difficult environment, these wheels may not be in use for more than a week or so of time. Although the tools and rocks that the astronauts use might be around 50 kg here on Earth, while the carrier is being pulled around on the moon, the same mass will be about $1/6^{th}$ the weight because of the moons smaller gravitational pull. The astronauts will be in space suits that will limit their mobility so the carrier needs to be easy to work with.

On the first couple of Apollo missions, the astronauts did not have a lunar rover and had to use a hand cart for pulling around their tools and rock samples. On the first Artemis missions they will also be careful with how much mass they send to the moon and will need a new sample/tool carrier. They will be bringing similar tools as they did for the Apollo missions but they will have different needs Right now we have no idea what that wagon might look like. As you can see in the Apollo photo, the tool carrier is pretty tall because it saves the astronaut from bending down in their space suits. Because the tool/sample carrier could become pretty big and complicated, HUNCH is concentrating on one of the most complicated and important components of the carrier—the wheel.

Problem:

Design light weight wheels for dry, loose sand that will be easy to pull without kicking up lots of dust and follows

- Must be able to handle temperature variations from 250F in the sun to -250F in the shade.
- Light weight but durable
- Good for speeds up to 10 to 12 mph
- Used for a sample/tool holder pulled by the crew for lunar samples
- Diameter of wheel between 6” to 12”
- Width of wheel between 2” to 6”
- All 4 wheels don’t have to be the same.

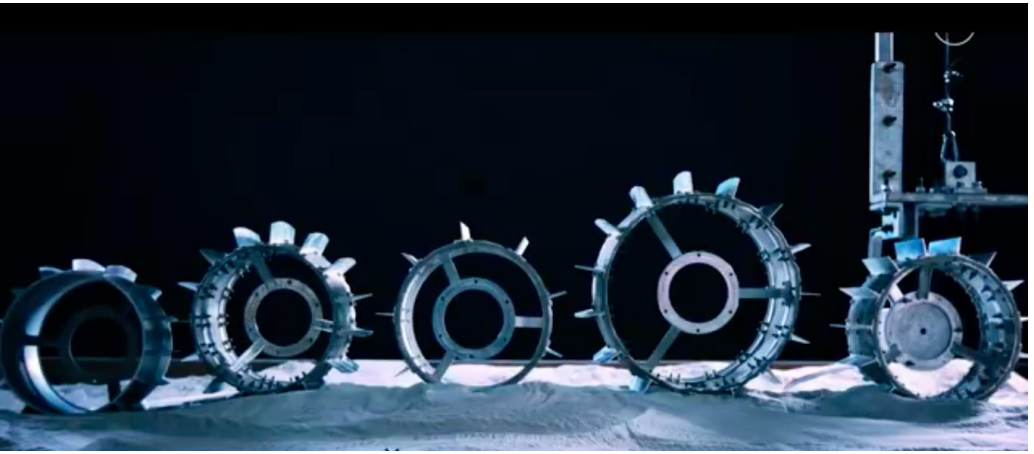
Things to consider:

- Able to follow astronaut traveling diagonally up a hill without sliding down.
- How do you plan to attach the wheel to the axel
- Roller bearing, bushing, no bearing at all? What materials would you suggest?

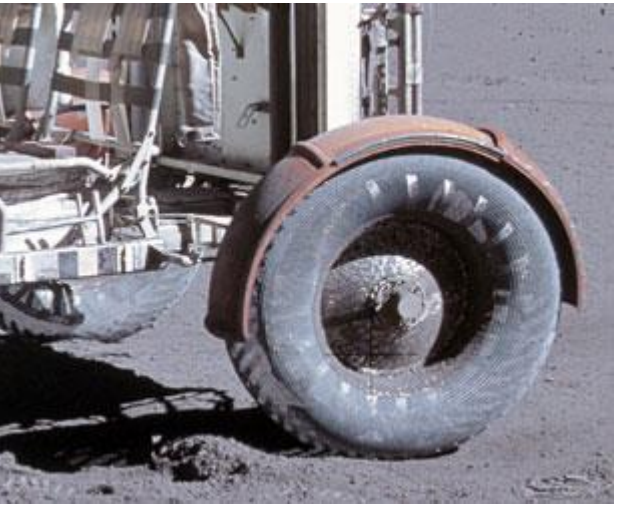
Testing

- Pull it through at least 2” deep of **dry,** play sand and mix in some bigger rocks

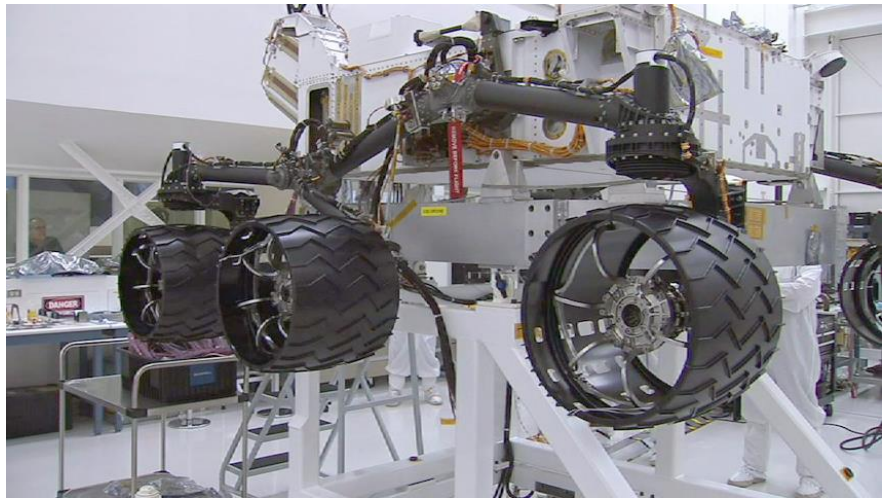
I don’t expect you to make this out of the flight material but be prepared to explain what materials the real one would be made of as well as the mass of your flight wheel.



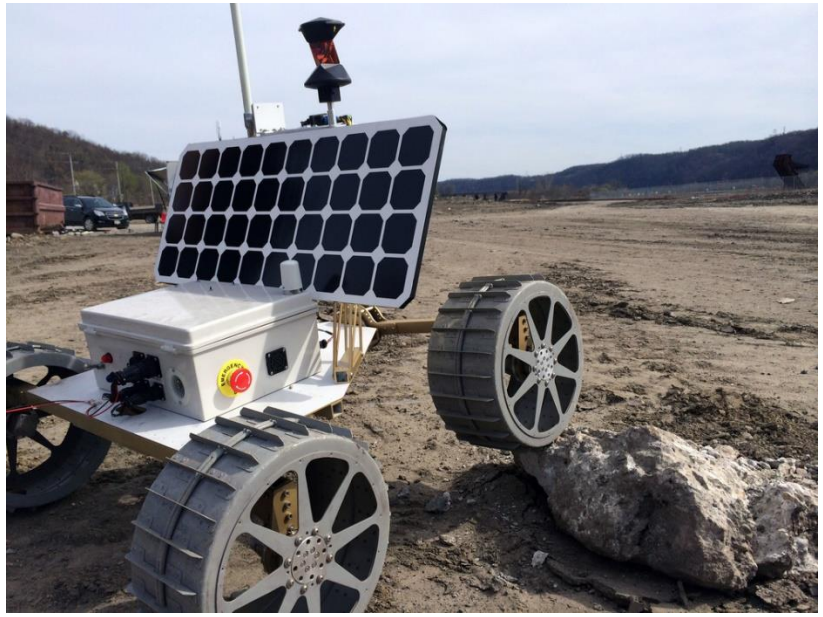
Several variations on a lunar rover wheel



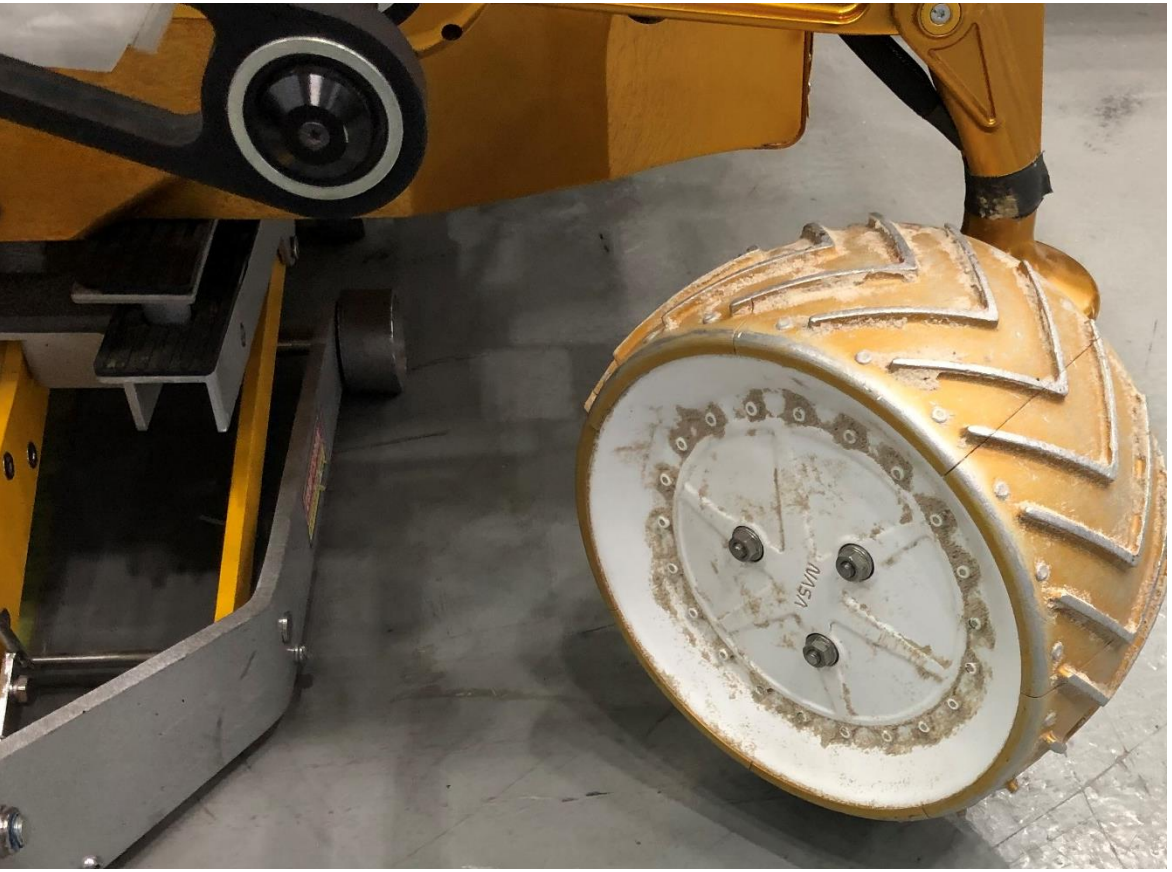
Apollo Lunar Rover



Curiosity rover that is currently on Mars



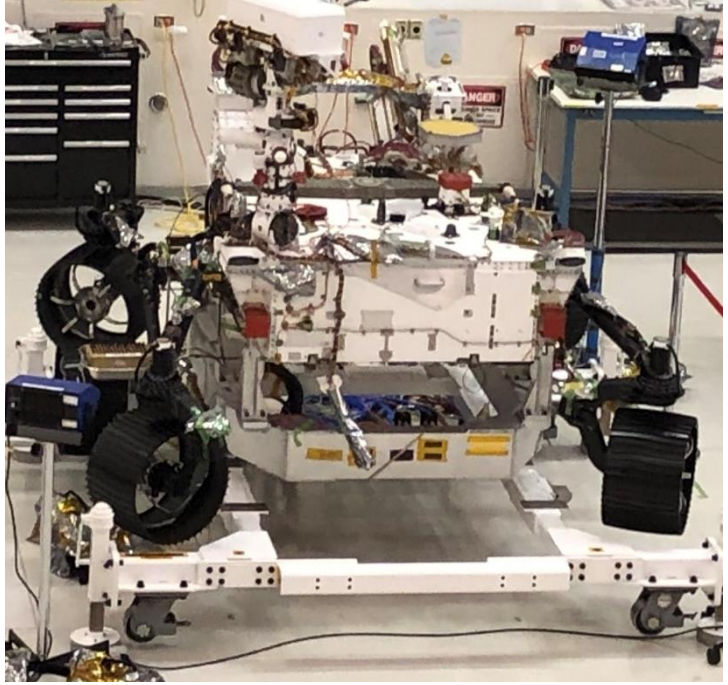
Hopeful Lunar Rover



Rover wheel that was tested in the JSC Mars yard.

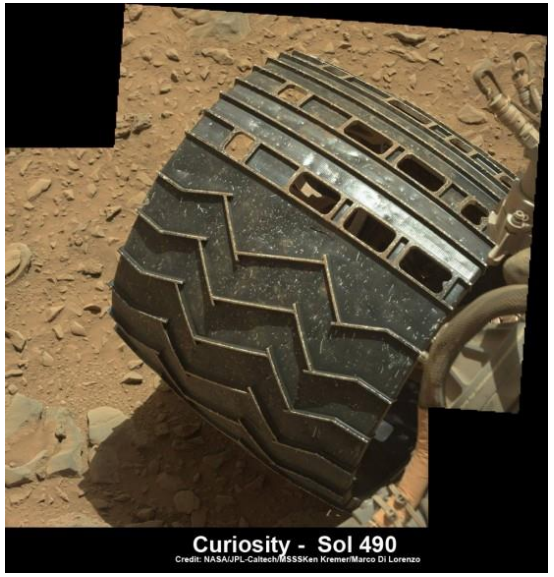
This is a wheel that was proposed and tested on a rover. It is composed of an aluminum hub and a rim that are connected by Kevlar straps. You can see that the straps are tight on the top and loose at the bottom of the wheel. The weight of the rover is hanging from the straps. Although rigid spokes do hold some weight, all wheels function the same. Flexible spokes do not take as much side load, important while turning.

Mars Rover wheels



Mars 2020 Rover being assembled at JPL

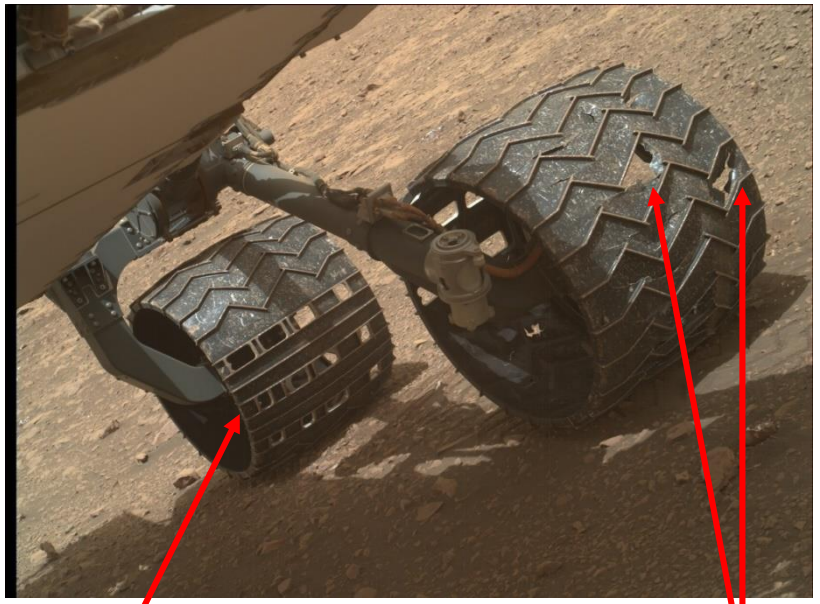
Pneumatic tires (air filled) act as shock absorbers and help even out some of the minor bumps. Rigid wheels are much more bumpy to ride on. Pneumatic rubber tires can not handle the temperature differences on the moon without cracking in the cold and the air would expand and contract as it heats and cools. The wheels on the Curiosity and the new Mars Rover are rigid aluminum and will stay round, the shape and length of the spokes for the rover act as the shock absorbers for the vehicle. Both the Curiosity rover and the new Mars Rover use similar spokes but the aluminum wheels have a different tread to minimize wear on the wheels.



Curiosity Rover wheel on Mars. The angles were determined to cause stress in the aluminum.

Not Pneumatic

- The Curiosity wheels that are on Mars have had difficulties with dents, cracks and holes. Some of this is due to the shape of the treads as well as the rocky surface but this is over several years of driving.
- There are different treads for different purposes. Some treads are for driving traction and other treads for being pulled--tires for freeway driving, mud tires for trucks, slicks for race cars, tractor tires, trailer tires. Don't be afraid to stop at a tire store and learn about different types of tires and treads.



Morse Code that spells out "JPL"

Damage to wheel

Testing

- To give everyone the same measuring system and frame to build off, buy a folding sports utility wagon from Academy.
  - https://www.academy.com/shop/pdp/academy-sports-outdoors-folding-sports-wagon-with-removable-bed?campid=7170000050238202&adgroupid=58700004915302623&device=c&keyword=92700043554051080&Channel=pla&gclid=EAIaIQobChMIv9-m5tX24wIVDY_ICh216gXwEAkYAyABEgJ10vD_BwE&gclsrc=aw.ds#repChildCatid=6960003
- I am not suggesting that this is the best wagon style to emulate for pulling around on the moon but it hits some of the main issues for what we need in a sample/tool carrier:
  - Cheap and accessible for any school that wants to do this.
  - Collapsible
  - Fairly light weight
  - Relatively easy to pull (not good for loose sand)
  - Replaceable cloth bag for holding rock and soil samples

  Reasons this wagon isn't good:
  - Made of steel (aluminum would be lighter)
  - Wheels are terrible for dry loose sand
  - Could be taller for easier accessibility when in a space suit
  - Could use tool holders
  - Could have sample bags

If you choose to make your wheels with a larger diameter or larger width (suggested), you will need to make larger castors to fit your wheels.

- This wagon may carry:
  - Tools: Geology rock hammer, Sample Tongs, Shovel, Rake, Core tubes, Drill
  - Samples: 2 football sized rocks, 5 softball rocks, 5 sandwich bags of sand. (this is obviously not exact but an estimate)
- These are not rules for a competition but guide lines for comparing the functionality.
- We are pulling around tools and rocks so there is not a big need for a suspension system but we also don't want the rock samples and tools to bounce out as we go over rocks and bumps.