Lunar Habitat Shoes

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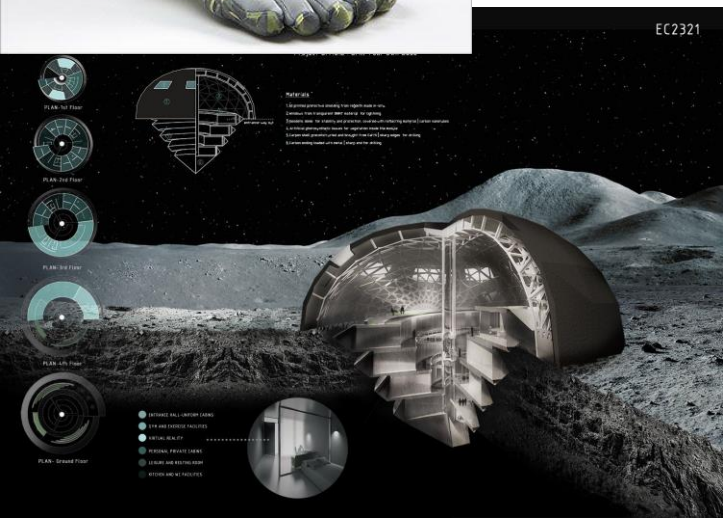
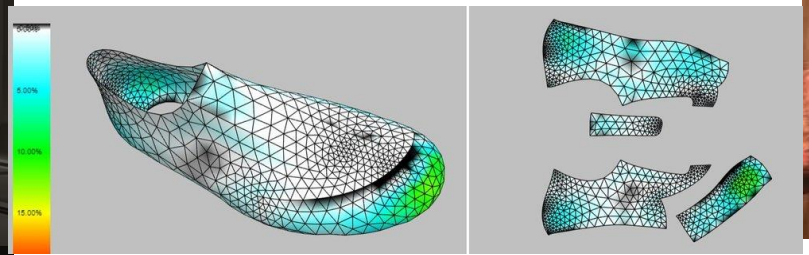
What kind of shoes are needed for the inside of the lunar habitats that will give good traction in **low gravity** without generating static electricity? What kind of flooring will be flexible yet durable and cleanable and provide good traction for the shoes?



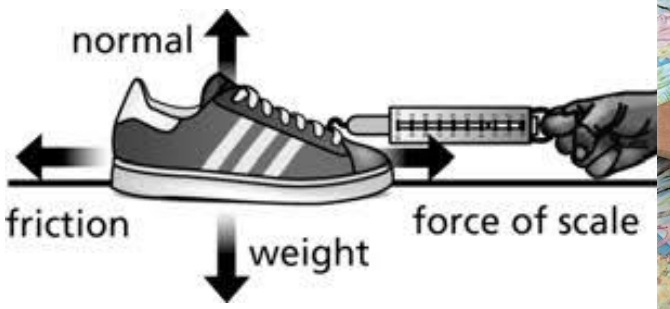


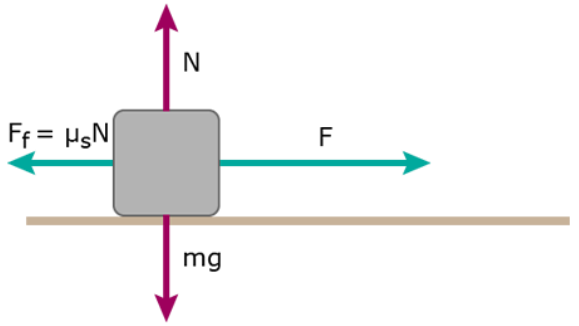
Why lunar habitat shoes?

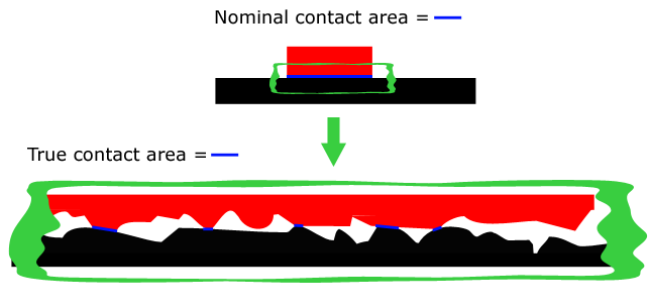
While on the moon, the astronauts will walk around in space suits with specialized work/hiking boots for their Lunar Space walks. However, when they come inside and remove their space suits, they will want (need) to wear more than socks while in their habitat. Less weight from the lower lunar gravity will also mean less friction. $F_f = \mu mg_{moon}$ where $g_{moon} = 1.62\ m/s^2$. This means that if you weigh 150 pounds on earth, you will only weigh around 25 lbs on the moon and that you will have only about 1/6th as much friction for pushing yourself around as you walk (or maybe bounce) around the lunar habitat. This will have some similarities to when you are trying to walk around in a pool where you have some buoyancy picking you up and not much

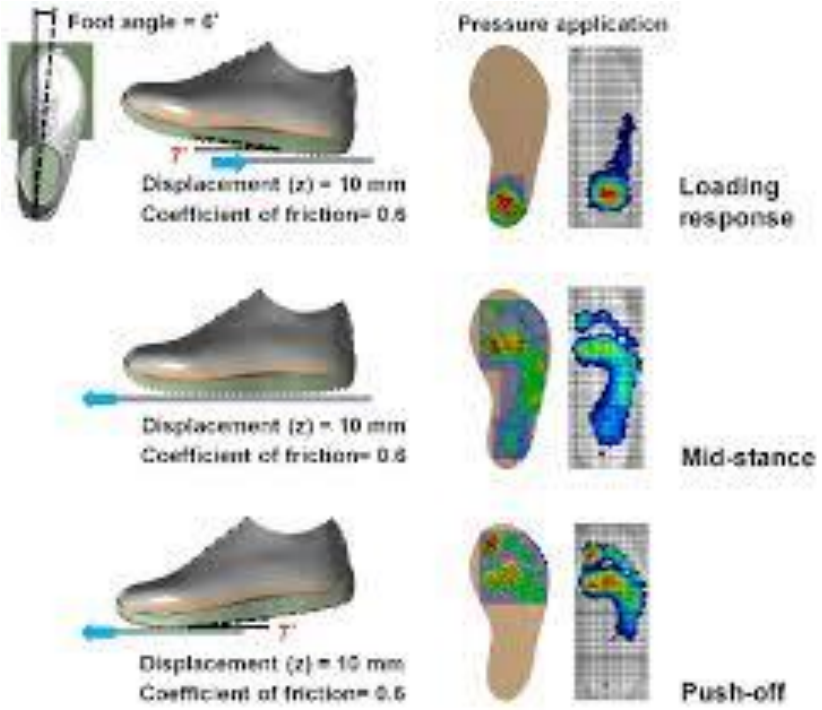
Because we expect it to be a very dry environment, it may be very prone to static electricity. This will be bad for any moon dust that gets inside with the space suits as the dust is more like shards of glass than rounded sand particles. Static electricity may make the dust cling to equipment, the walls, everything. Static electricity could also be an ignition source so things sent to the moon should also be as non-flammable as possible (similar to the Space Station).

This shoe may also be valuable in the Mars habitats that will be similar to the lunar habitats. The walking surface we use in the Lunar and Mars habitats would probably very similar to those used in the space craft that are rotated to simulate gravity for long missions like going to Mars. This just means there are a few specific places these shoes may have value.









Lunar Habitat Shoes

Problem:

The Lunar habitat will be a fairly unique location where NASA may need a specialized shoe to aid the astronauts in this new environment. Because of the 1/6th gravity you will also have 1/6th friction for walking around. Static electricity sparks can cause fires. Because the lunar dust is sharp like shards of glass, the floor needs to be easy to clean.

Objective:

Develop the shoes the astronauts will wear in the lunar habitat and the inside surface of the habitat they will walk on.

Shoes for the inside of the lunar habitat

- good traction
- light weight
- No spikes or sharp edges that could damage the walking surface or puncture the inflated habitat
- nonflammable materials
- must have some kind of arch support
- easy to put on and take off
- must not build up static electricity
- good insulation from the floor but minimizes sweaty feet
- arch support
- less padding so that bones are able to receive more shock despite low weight
- Choose a flexible, cleanable material for the floor of the habitats
- While these shoes may have many similarities to many existing shoes, I'm certain that no current shoe would fit all of the astronauts' Lunar habitat needs.

Options to consider

- zippers, Velcro, laces, elastic, buttons???
- like a scuba booty/ wrestling shoe, aqua sock, slippers, <u>more than a sandal</u>
- Leather, Nomex, beta cloth

If your school has a fashion design class or sewing classes, this would be a great project for collaboration.

Do not limit yourselves to these ideas. There are many other thoughts you can consider.

Aqua socks

Slippers with traction

Scuba booties

Zippers and laces

Roofing shoes for high incline, smooth surfaces with replaceable soles

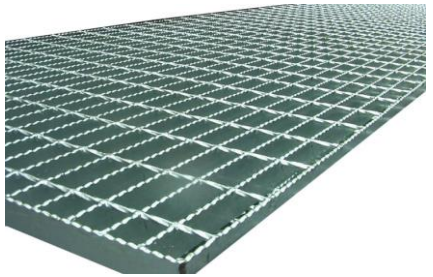
Moccasins

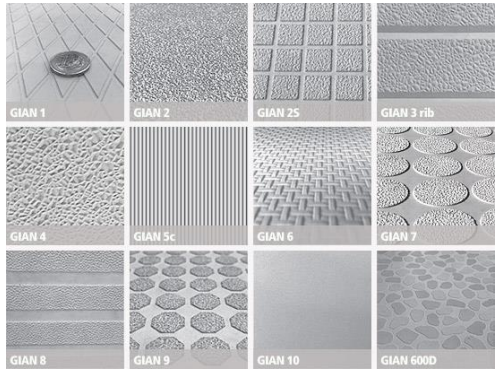
Boxing shoes

Rock Climbing shoes

Racing flats

Habitat interior walking surface



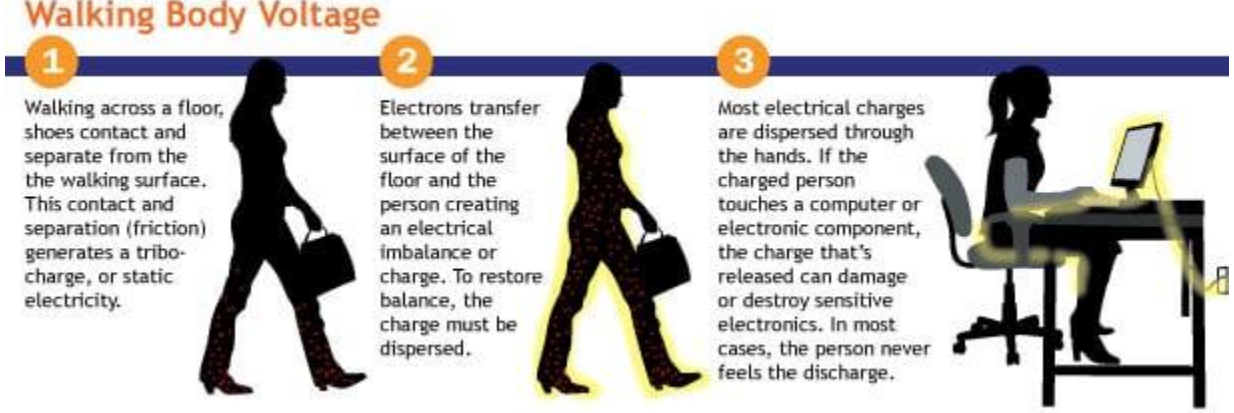


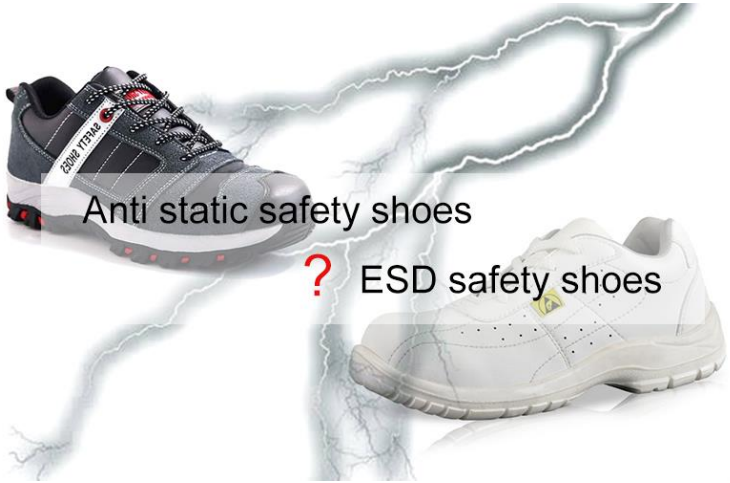
Normally when people are developing shoes they either have to design for many surfaces both inside and out or they design for a specific range of surfaces. In this case you can influence or determine the inside material for the lunar habitat. Assume the astronauts will rake the surface soil smooth and remove any big pointy rocks before they place the habitat on the ground and inflate it.

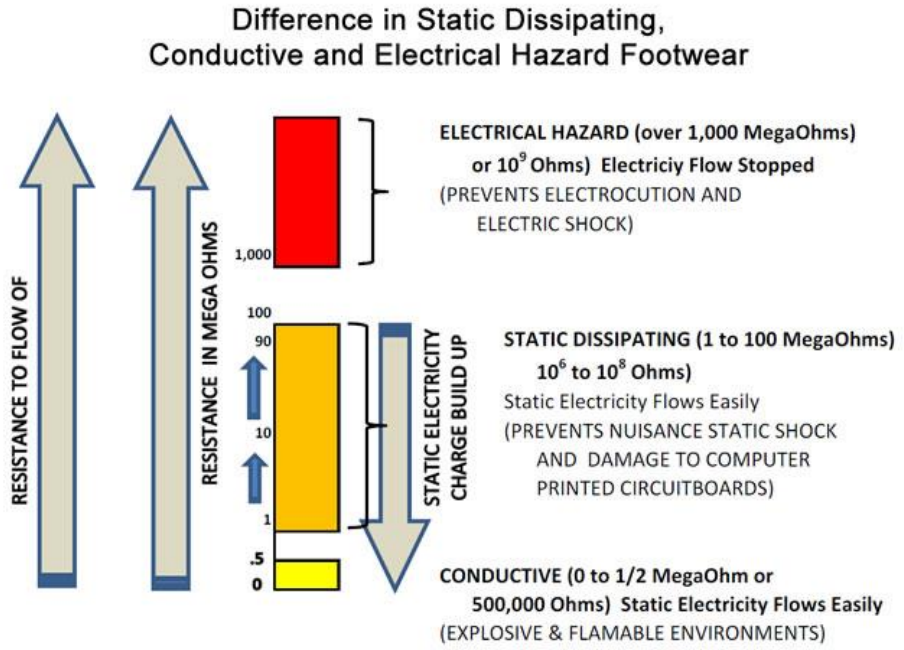
- durable so it won't wear out quickly or scratch off leaving dust and grit.
- easy to clean with brushes or vacuum cleaner. There may be something like a Roomba that will help control dust in the habitat.
- light weight so it doesn't add too much weight to the habitat
- nonflammable materials
- must not build up static electricity in conjunction with the shoe
- good insulation properties
- Will the surface be hot or cold for the people living in the habitat?

Static Electricity

- We should expect that the temperature and humidity on the lunar base will probably be similar to that on the ISS—70 degrees F and around 40% humidity. That is fairly dry and will allow significant static electric build up. Computers and electronics can be damaged by static electricity generated by walking across the room. Static electric sparks can also be cause fires if they happen in flammable materials. As much as NASA works to prevent fires by using nonflammable materials, there will always be some materials like plastic bags, paper, and even hair from people. Some of this can be controlled by choosing materials for the floor and the shoes. This may take a little searching and some testing.







What kind of sole do you want to make?

TPU or ninja flex for 3D printers give you lots of options to print out a flexible sole that fits your ideas.

Something else?

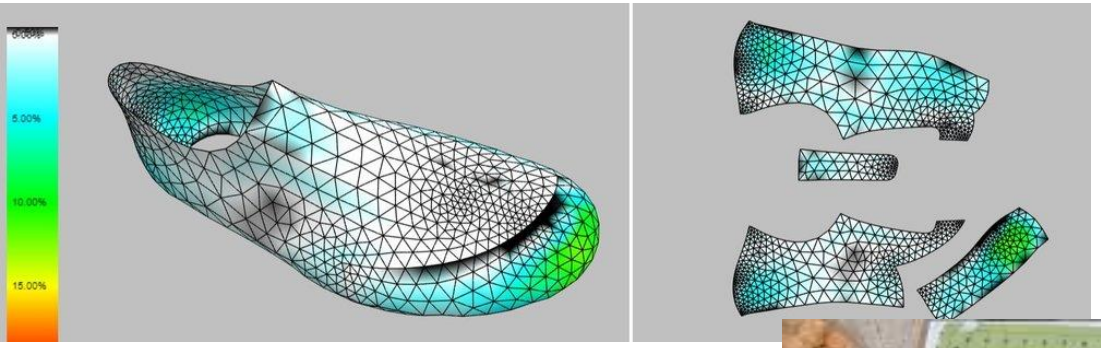
These are the replaceable soles for roofing shoes that Velcro onto the bottom of the work boot.

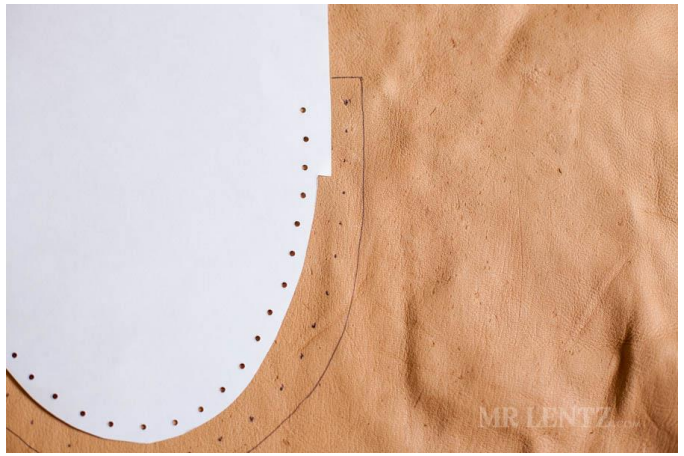
Steal from an existing shoe—purchase from the internet or take it off another pair of shoes

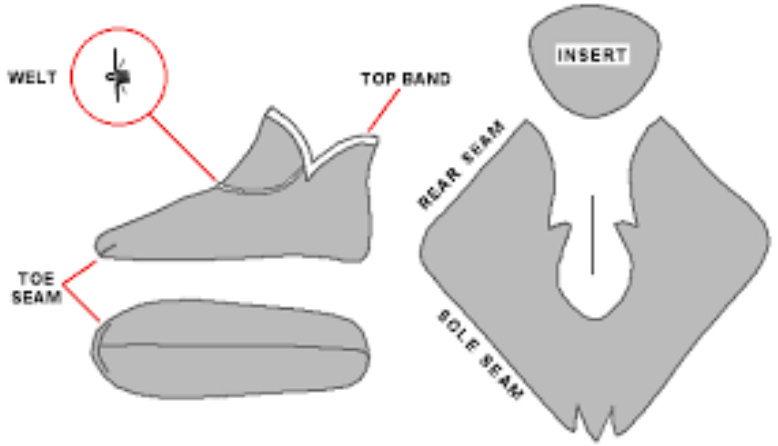
I do not expect you to make the shoes out of the same materials as would be used on the moon nor will they be exactly like the ones that fly. **You should be able to demonstrate some of your ideas with your prototype and tell the materials that should be used.**

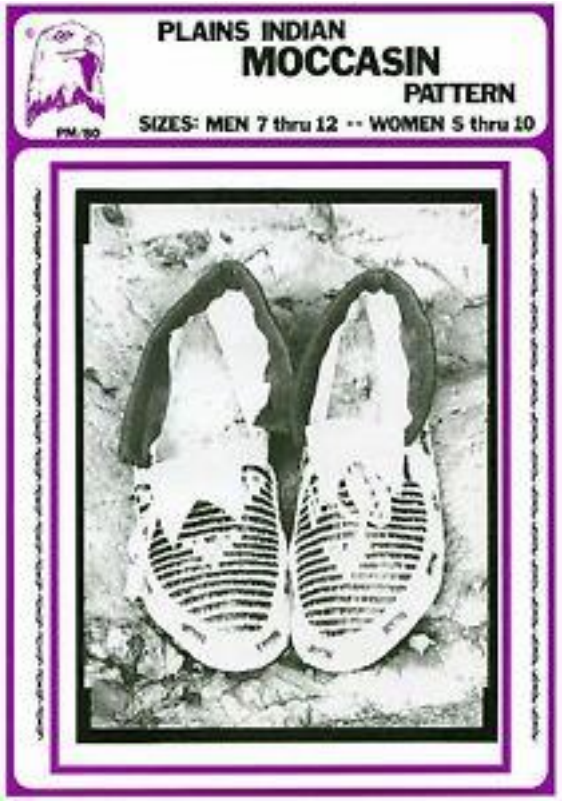
Shoe Goo can be used to make a flexible sole for your shoe with good traction

Shoe patterns









Tutorial for making a shoe pattern
https://www.youtube.com/watch?v=huL9Fg4zXN4

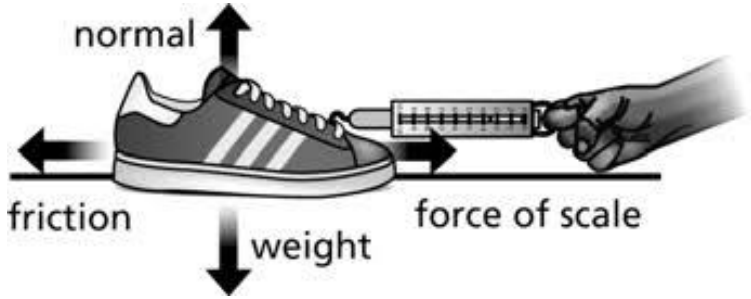
Testing-- This would be a great time to talk to a Physics teacher at your school.

- Just like the shoes you are wearing today give you more or less traction on different surfaces, the flooring material you choose for the inside of the habitat will provide a specific amount of friction for your shoe.
- It would be helpful for your team to do a comparison between the friction your shoe would have on Earth to the friction your shoe would have the moon. It may be valuable to have a simulated or real foot to spread the force through the shoe. (a simulated foot doesn't wiggle)
- Place your shoe on the appropriate flooring sample. Try to distribute the Earth or Lunar weight for a specific person on your team similarly to how a foot would inside the shoe.
- Use some kind of force measuring tool (spring scale, digital scale,…) to measure horizontal force of friction while shoe is being pulled across the flooring material.

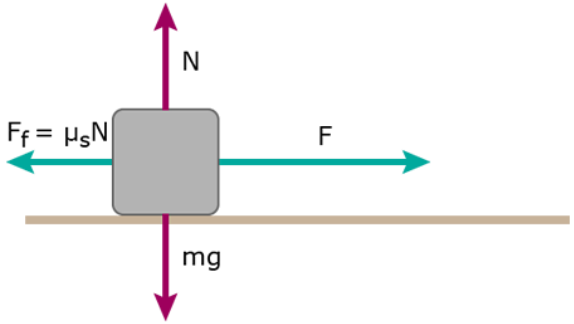
- There are two types of friction to measure.
  - Static friction—force required to start the shoe to move
  - Kinetic friction—force required to keep the shoe moving at a constant rate (not accelerating)
- How much force does it take to start the shoe moving?
- How much force does it take to pull the shoe once it is moving?
- We are mostly interested in the static friction since we are hoping the astronauts are not sliding around.
- Is there a difference between forward or backward forces (could be due to the type of tread you put on the bottom of the shoe. What about side forces?
- Knowing the coefficient of friction for both the static and kinetic friction could be helpful.

- There may be other types of testing that would also be appropriate, but this is a good starting point.

Friction on Earth
Friction on the moon



Weight on the Earth
Weight on the moon



This testing could be treated just like the friction experiment you may have done in your physics class.

https://www.youtube.com/watch?v=fo_pmp5rtzo