Solar Powered Brick Making Lunar Rover

(using recycled plastic trash)

Collapsible Concentrating Mirror/Lens

Glenn Johnson

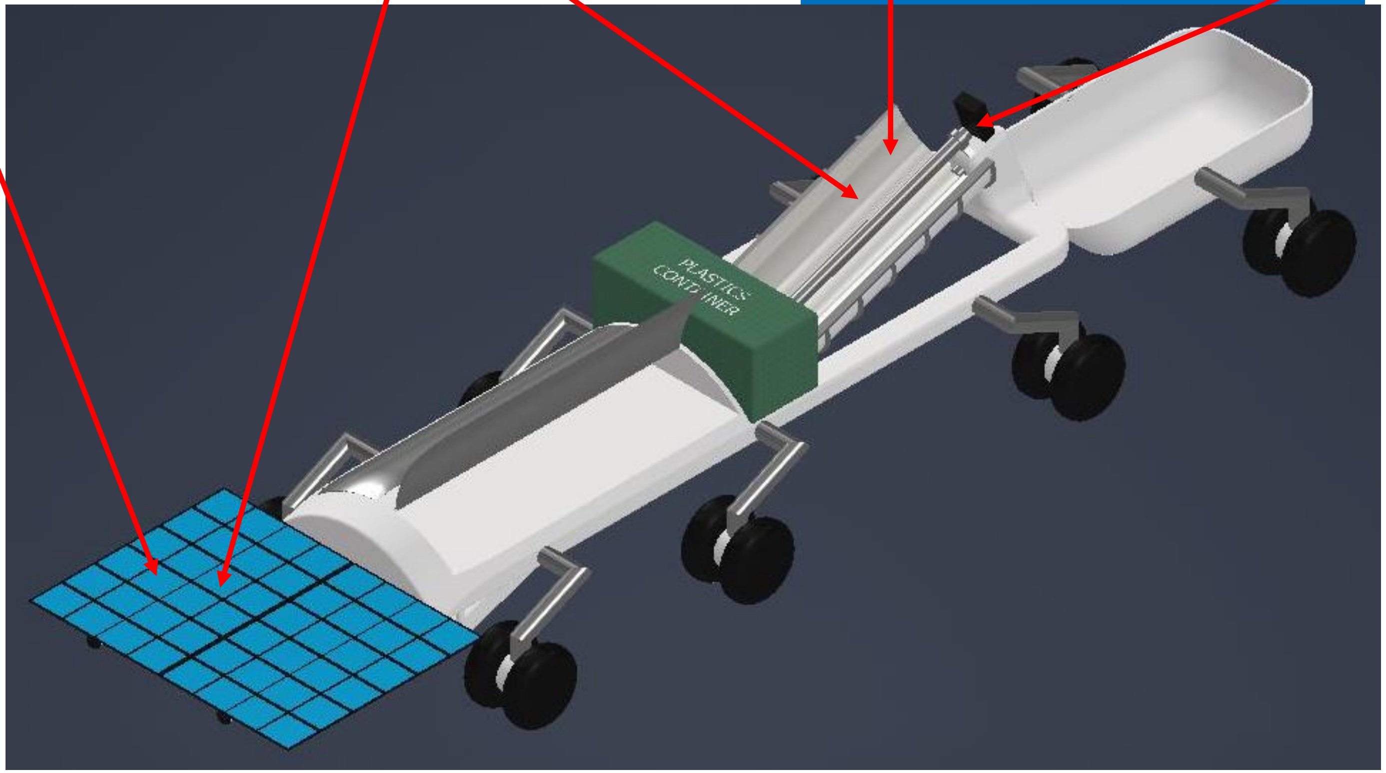
4 separate projects

Software and mechanisms for tracking the sun for the moving rover

Method for cleaning lunar dust off mirrors and solar panels

Collapsible parabolic mirror for melting plastic and heating lunar soil

Pipe and auger for mixing and extruding lunar soil and plastic trash bricks



The Big Picture—Lunar soil

Mechanical properties

- Lunar Regolith is the powdery soil like material on the moon that is the result of rocks being broken apart by impact from meteors striking the moon. It is very jagged and abrasive to the touch since there isn't any flowing air or water to tumble the particles and round them off. There isn't any organic material or microbial life like the soil found on Earth nor has it gone through chemical weathering—it is mostly broken rocks and minerals. Because the regolith is more jagged, the particles can bind together and prevent some motion. When hammering poles or spikes into the ground, the spike required a lot more force than when hammering into Earth sand. It was much easier if using a rotary motion like a drill. All of this can make it a good material for making bricks since the jagged pieces will aid in holding the bricks together but it can also make it very abrasive to the equipment and make the materials wear down quicker. Dust can be a very significant problem on the moon. Even though there isn't wind to blow the dust into a storm, the moon is only $1/6^{th}$ the gravity of Earth so if the dust is kicked up off the ground, it goes higher and it takes 6 times as long before it settles to the ground.

Static electricity

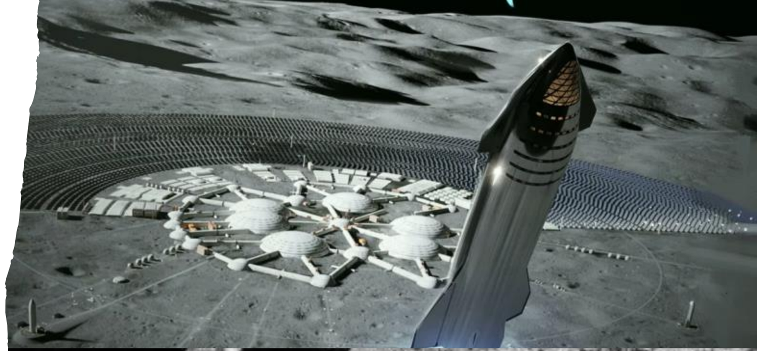
- When the sun hits the regolith, some of the electrons are pushed off the dust particles giving some of them a static electric charge. On the terminator line (the line between the dark and light side of the moon) the Apollo astronauts reported seeing a curtain of dust particles rising up off the ground as they flew over. This is where the positively charged dust (dark side) was mixing with the electrons (from the light side). This doesn't sound like a lot of mass moving but the dust can get into very small areas and damage equipment, not to mention the static electricity that might damage the electronics.
- https://lasp.colorado.edu/home/2020/09/02/lasp-researchers-develop-method-to-clean-lunar-dust-from-surface/

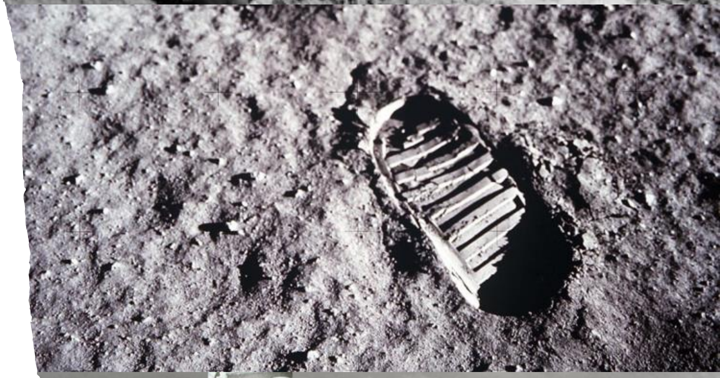
Construction material

- NASA is interested in using lunar regolith as a building material for structures on the moon. These structures will be for protecting the astronauts from radiation, micrometeorites, to make roads, provide good landing surfaces and many other applications. Because of the variety of uses there will probably be a need to have multiple shapes and types of construction materials and methods of manufacturing the building materials. These will also use a variety of different robotic rovers and robotics to accomplish the many needs.

https://www.usatoday.com/story/tech/2014/01/05/nasa-brings-moon-indoors-to-kennedy-space-center/4329773/

Even though this is loose dirt, notice what it is like when he is raking the lunar regolith simulant.



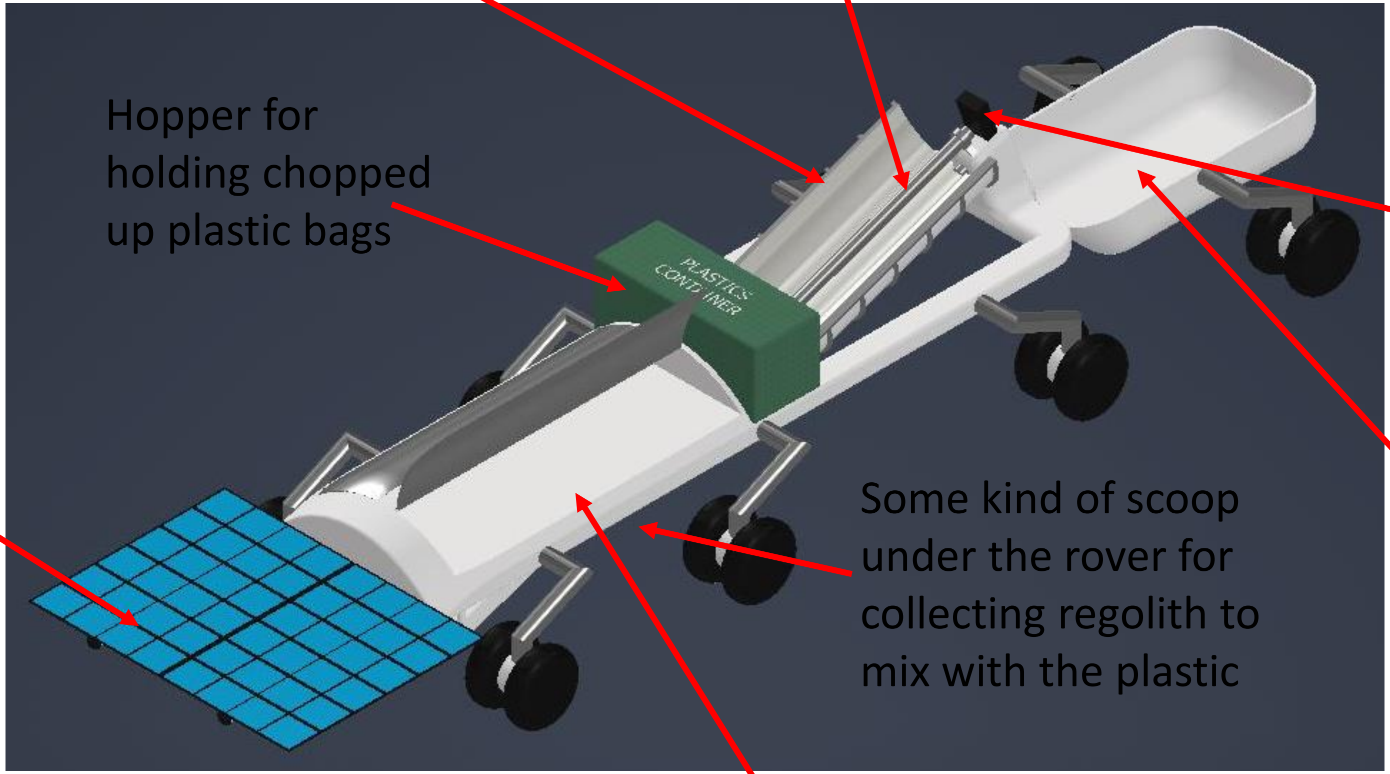


Recycling plastic packaging into bricks

- One of the many difficulties of a lunar base with people is the amount of trash that will be generated. Although the astronauts will be eating most or all of the food that is sent, there will be a significant amount of plastic food packaging sent to the moon. This packaging will be similar to clear plastic wrappers used on Earth and melts around 125 to 132 C.
- **Our goal is to make bricks out of the lunar soil using the plastic trash that is sent to the moon as packaging.**
- Although it is easy to use electricity to make heat, it is also very power hungry. Solar panels are only able to convert around 20% of the light that hits them into electricity. Then the electricity has to be converted into heat—also not very efficient. It would be much easier and more efficient to concentrate the solar energy using mirrors to heat the lunar regolith and plastic– around 80 to 90% efficient. The power of the Sun at the Earth, per square meter is called the solar constant and is approximately 1370 watts per square meter (W/m^2). This will be similar on the moon. That is a lot of heating power for a fairly small space.
- The plastic and lunar regolith need to be heated to the same temperature so they will mix evenly.
- One option is to have a rover that scoops up regolith and brings it back to one location where it is mixed, heated and extruded. The other option is to scoop up the regolith and mix, heat and extrude as the rover goes. This makes for a bigger rover but hopefully keeps the dust down near the habitats and other equipment and maybe less dust on the mirrors and solar panels. Its also more fun to build a rover than a stationary brick maker.
- The higher the percentage of sand in the brick, the more bricks we can make with the amount of plastic available but the more compression needed to press the material together when manufacturing the brick. The more plastic in the brick, the less compression needed for making the brick.
- https://www.youtube.com/watch?v=iFcPqXxAUWM

Rover Concept and components

This is a concept of how a brick making rover might look but the details each HUNCH team makes will influence the final design. The purpose of this model is only to give a visual idea of the main components. It should be expected that the solar panels and mirrors will need to be much larger to gather enough power and heat for the job.

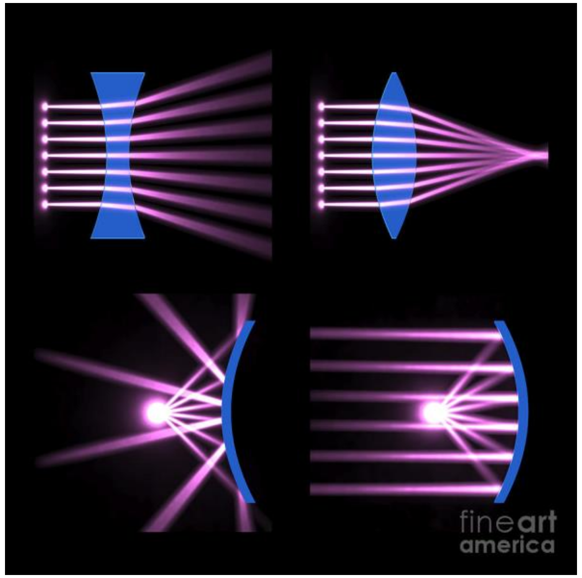


The rover the parabolic mirror will ride on will be solar electrically driven. It will need solar panels to power the wheels to drive it along and the motors to pick up the soil and mix it with the plastic as it heated up by the solar concentrators. The solar concentrators only job is to heat the shredded plastic and lunar regolith.

Problem:

NASA needs a parabolic mirror or lens that can concentrate enough solar energy to melt shredded plastic bags and heat the lunar soil so the two materials will mix together well to be extruded out as a brick. This concentrating optics will be placed on a rover but is expected to be fairly large to be able to heat the materials at a reasonable rate for production. The mirrors or lenses need to be packed into a relatively small space to make transportation easier and to prevent damage during launch and landing. Once on the moon, the concentrators will be deployed and remain in the deployed configuration.

This concentrator is the central component to the purpose of the rover. It will have to be large enough to heat up the regolith and plastic, but it is important for it to be as small and compact as possible for delivery to keep the rover to a size that can be delivered to the moon.



Lens

Mirror

Objective:

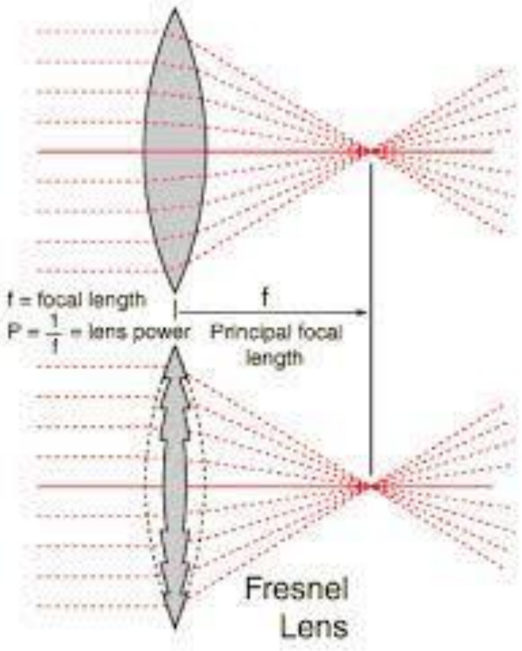
Design and build a scaled, collapsible, concentrating mirror or lens that will collect solar energy and concentrate the heat to melt shredded plastic bags and heat lunar regolith so they can be mixed into a consistent paste sufficient for making bricks.

- The scaled, functional model you present should be no longer than 24 inches long so that it will fit on a table for demonstration and display.
- Either folds or collapses into a space that is at least half the volume of its deployed position.
- Has an interface to the sun tracking system
  - Gears that attach to the mirror frame
  - Cogs directly on the frame
- Give a good estimate for how large the real mirror would have to be and if/how your model might be modified to work on the larger scale.
- Perform testing to estimate how much energy your configuration is transferring to the plastic/regolith and estimate how much bigger your set up would have to be to produce the desired number of bricks.
- To collect enough light and energy to heat the soil and plastic at a reasonable rate, it will have to be fairly large. But to keep the size of the rover small for launch to get it off the earth, the mirror needs to be collapsible. Once it gets to the moon, the mirror needs to expand out to its full size. We don’t expect it will have to re-collapse for any reason on the moon but make sure you can collapse it repeatedly for testing.

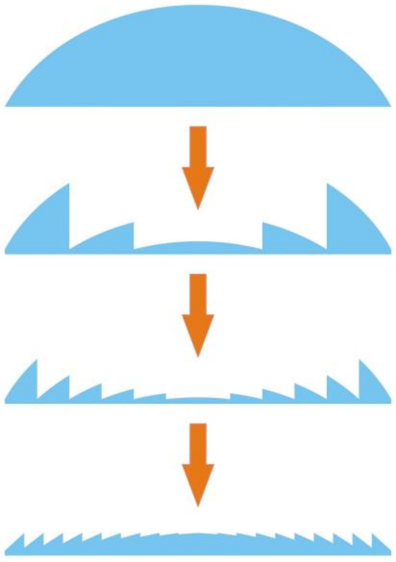
Tips:

- The top inch or so of lunar soil should already be around 250 degrees F if it has been sitting in the sun for long.
- The goal is to make 100 rectangular bricks 1” x 1”x 5”per 24 hours of lunar light. Since a lunar day is about 28 Earth days, where 14 Earth days are in daylight and 14 Earth days are in darkness we would like to make around 1400 bricks during the daylight.
- Coordinate with an extruder team to decide batch process or continuous process.
- Coordinate with a dust team to determine a good method for cleaning the mirror with as little scratching of the surface as possible
- Coordinate with a tracking team for gearing or other mechanisms that will rotate your mirror
- A parabolic mirror will reflect sunlight to hit the bottom of a pipe or container
- A lens will focus the heat on the top of the pipe or container.
- Project teams should be kept separate incase one advances but the other does not.

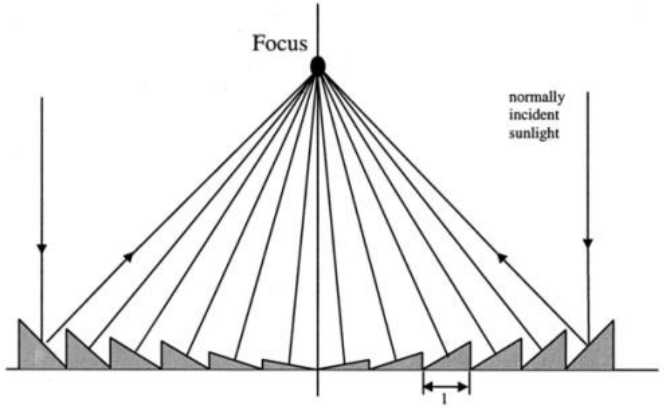
Focusing light—ask your physics teacher



In a lens, the curved part of the glass is what bends the light to focus it to a point.



A Fresnel lens is where they remove some of the glass to make the lens lighter and thinner. This was first done when making the optics for the rotating lenses for light houses.



Similar to a Fresnel lens, this is a Fresnel mirror that has taken a parabolic mirror and made it flat by removing most of the vertical components of the mirror.

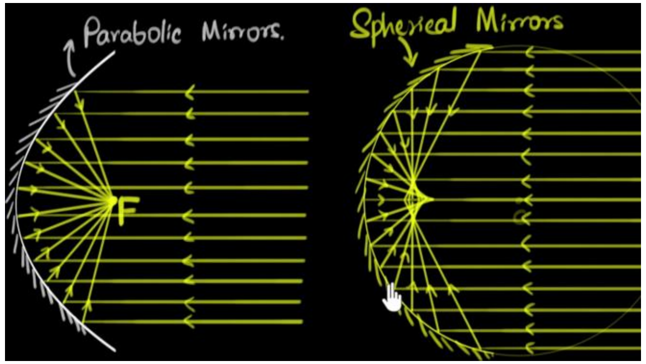
Some solar power plants are made of lots of mirrors that are all tracking the sun and focusing that light at a similar spot to heat up the central tower where water is being pumped through and turning to steam for power generation

Concentrating the sun light with mirrors

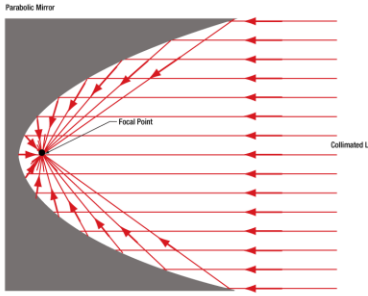
We need a mirror or set of mirrors that will concentrate the light coming from the sun to heat up the mixture of regolith and plastic. The mirror(s) need to be collapsible so we can get them to the moon in as small and light weight of a package as possible--$1.2 million per pound to land materials on the moon. Once the rover is on the moon, the mirror(s) will be deployed and are not expected to be collapsed again. There are two main options for using parabolic mirrors.

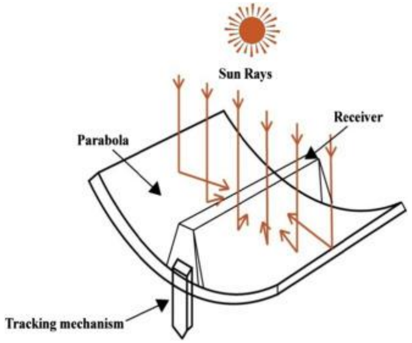
One option is a circular parabolic mirror that lends itself more to a batch process and it may be able to fold up in a smaller space

Segmented parabolic mirror heating a black pot for cooking.



Notice the difference in the focal point from parabolic to spherical mirrors.

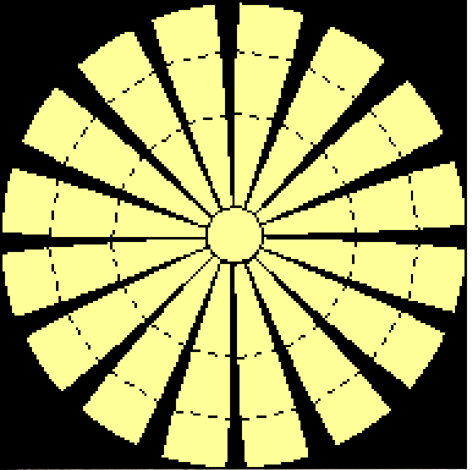




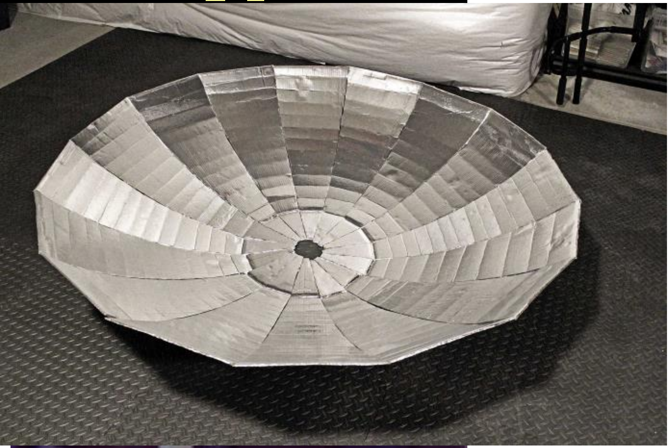
The more narrow the parabola, the closer the focal point to the mirror. The wider the parabola, the more energy the mirror collects and the further the focal point from the mirror.

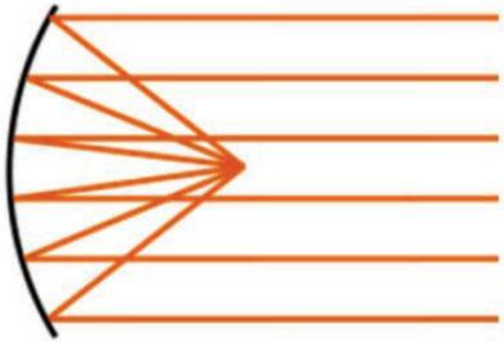
The other option is a parabolic trough mirror that could be good for either a batch process or a continuous extrusion process but may require more work to get it small.

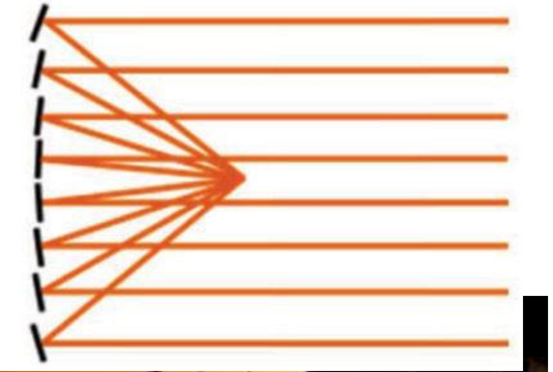
Parabolic trough mirror heating a black pipe with water flowing through. Heats the water up to 500 F.

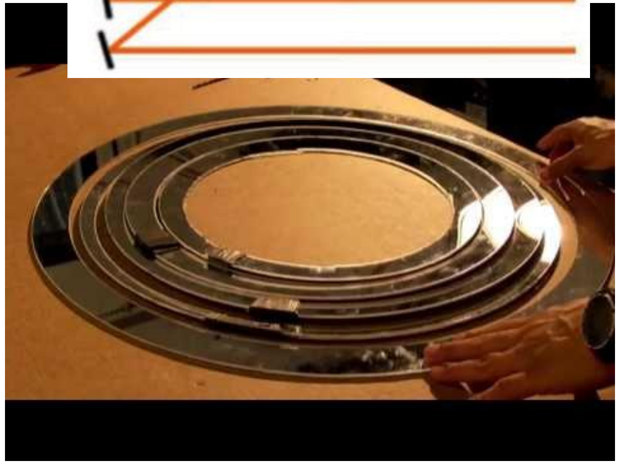


There are many ways to make parabolic mirrors. Large, rigid mirrors can be many smaller, rigid parts that slide or rotate into final positions.





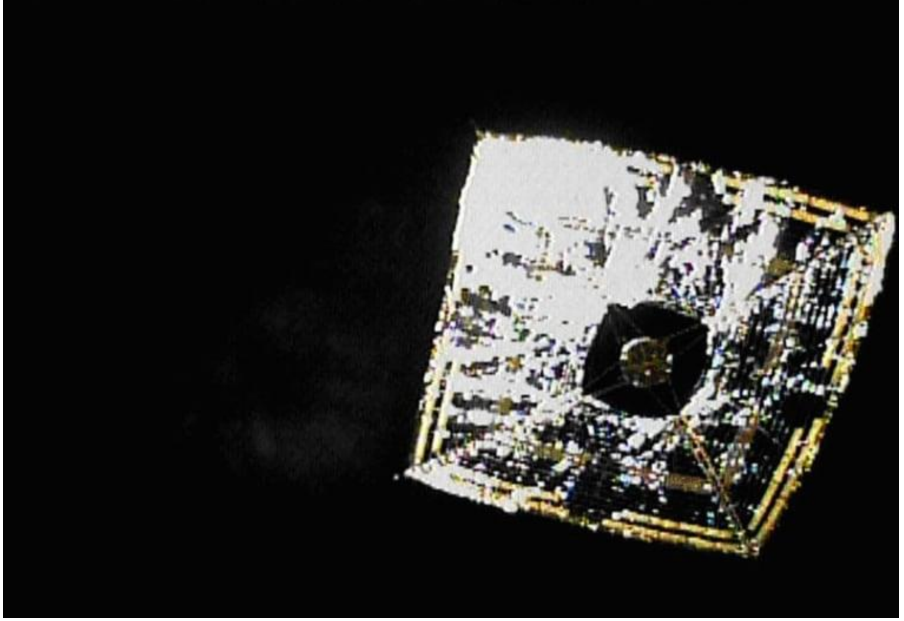




Making a Fresnel mirror out of flat acrylic mirror
https://www.youtube.com/watch?v=1fSnHztkqI0

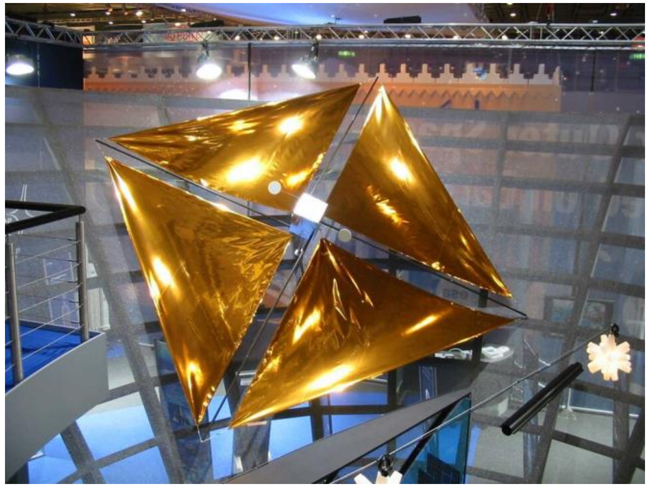
Testing of the composite mirrors for the James Webb Space Telescope rotating into place
https://www.youtube.com/watch?v=xHTciBIEtmY

Small mirrors being placed on a curved surface to make a parabolic mirror.



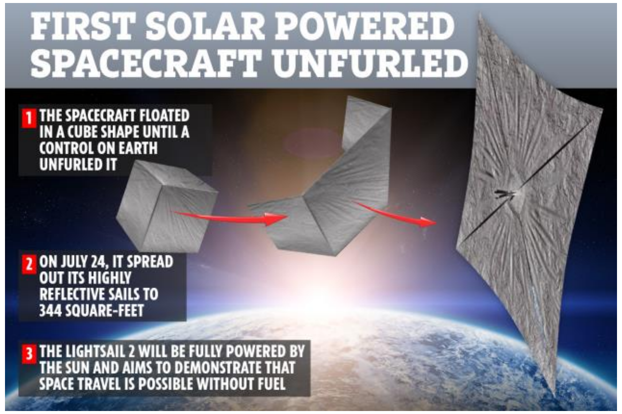
Flexible, folded mirrors might be made from space blankets like those used in emergency kits or camping which are made of mylar which is a strong, light weight plastic that can be coated with aluminum and can be folded up to fit in very small places. Depending on the thickness of the aluminum, they may not reflect all of the light but only a portion of it. Mylar insulating blankets were invented by Marshall Space Center in 1965 for use in the Apollo program on the Lunar Lander.

IKARUS, the first solar sail by JAXA on its way to Venus. Made from mylar that was folded up in a small space and unfurled to a flat rectangle.



Parabolic mirror
https://www.youtube.com/watch?v=St-0HWKAY4k
https://www.youtube.com/watch?v=8CLRTa_ocmo
https://www.youtube.com/watch?v=gvaObFjOuWQ
https://www.youtube.com/watch?v=EaBdsks41A4
https://www.youtube.com/watch?v=_8sd9UgjXLE

Square parabolic mirror
https://www.youtube.com/watch?v=FyCLOXF1188

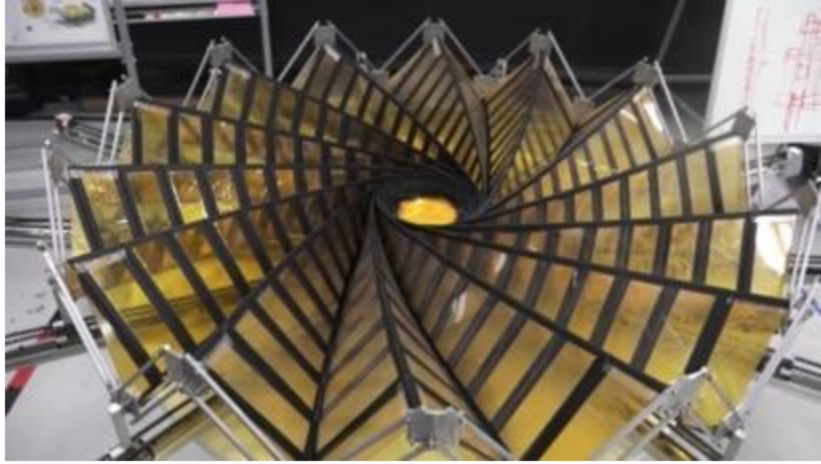


Concentrating light with lenses

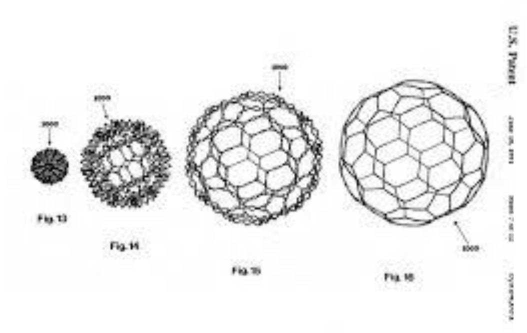
- Fresnel lenses from old style rear projection TVs or from old overhead projectors.
- https://www.edmundoptics.in/knowledge-center/application-notes/optics/advantages-of-fresnel-lenses/
- Fresnel lens foundry—tracking system
- https://www.youtube.com/watch?v=drE54ctrHBY
- https://www.youtube.com/watch?v=cUxv1PSCj3I

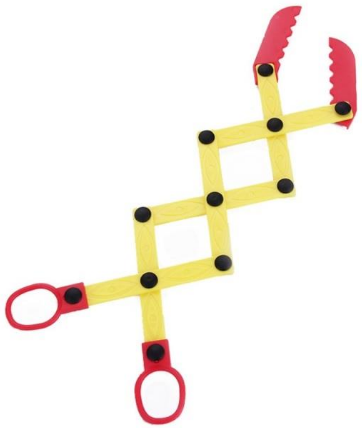
Folding and expanding

- https://www.youtube.com/watch?v=lGU1xOW0Sus
- https://www.youtube.com/watch?v=3E12uju1vgQ
- https://www.nytimes.com/2021/04/29/learning/origami-in-space-engineering-rediscovering-the-meaning-of-discovery.html



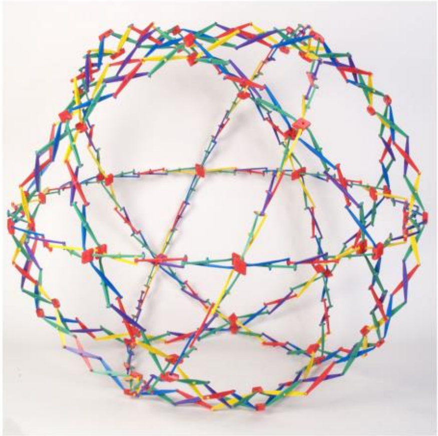
There are many ways to extend a structure. How to make it work for a parabolic mirror is the current challenge. It only has to be able to



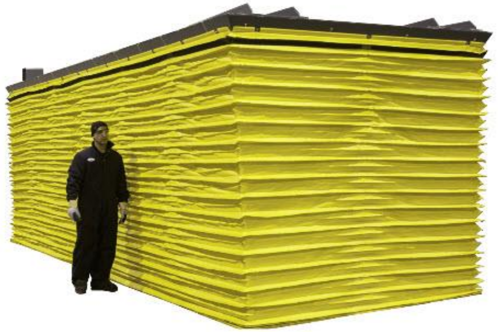


Expanding Staff

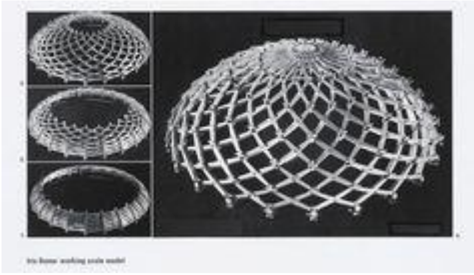
https://www.youtube.com/watch?v=5cWm44ynXQ0



https://www.hoberman.com/portfolio/expanding-geodesic-dome/



https://www.youtube.com/watch?v=OCq8adZdKP4



There may be a way to use an accordion style bellows to fold up your concentrator when in transit to the moon.