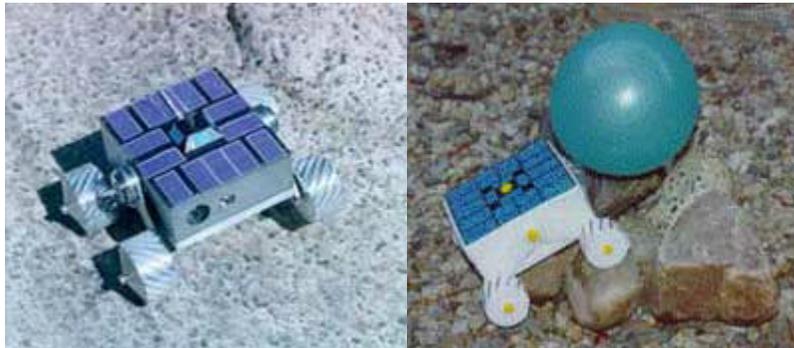


The Space Place

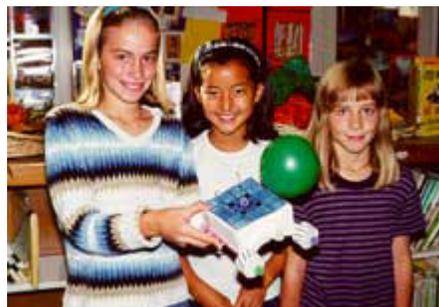
Make a Balloon-powered Nanorover!



Which is the real rover that will explore an asteroid?

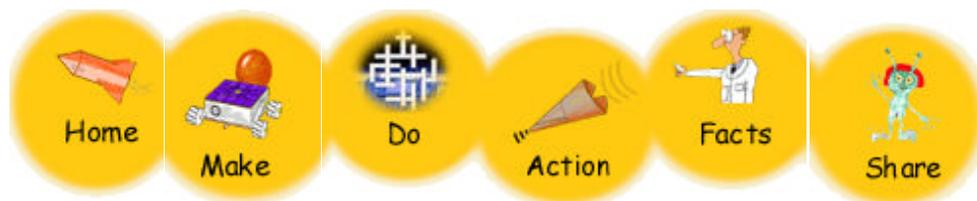
Roving a mini-"planet" calls for a "mini-rover." The Japanese are sending a spacecraft to Asteroid 4660 Nereus in 2002. With the spacecraft will be a sample return vehicle and a little rover just a couple of inches high. The "nanorover" ("nano" meaning very tiny) is designed and built by the U.S. National Aeronautics and Space Administration's Jet Propulsion Laboratory. The rover will explore the surface of the asteroid and take pictures.

You can build a nanorover too. Try this one, made from three styrofoam meat trays. This project is a little bit hard, so you might want to ask a grown-up or big brother or sister to do it with you.



[How to build your nanorover.](#)

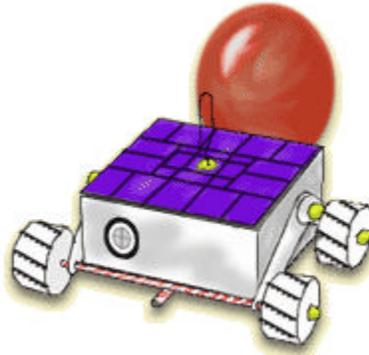
[More about the real nanorover.](#)



The Space Place

How to Make Your Nanorover

This page may take a while to load.
It has lots of pictures to show you what to do!



What you need:

Three large **styrofoam meat trays** (at least 9 x 11 inches)

Important! If the meat trays have been used, be sure to wash them very thoroughly with hot, soapy water first. It's also a good idea to use bleach to kill any remaining bacteria (ask an adult to do this).

Ruler

Four flexible plastic drinking **straws**

Three small (10-inch) **bamboo skewers** (for making shish-ka-bobs)

Seven pea-sized blobs of **clay** or **Play-doh®**, or seven small **gum drops**

One large wire **paper clip**

One small (7-inch) party **balloon**

One small **rubber band**

Transparent **tape** (not the removable kind)

Printed [pattern, decals, and wheel treads](#) (all on 2 sheets of paper)

This is a 2-page Adobe Acrobat file. If you don't have Acrobat, you can get it free now.



Ball point **pen** (for tracing around pattern)

Scissors (for cutting paper pattern pieces and styrofoam)

Small **knife** (for scoring styrofoam on fold lines)

Lots of **patience** and--maybe--a grown-up (or teen) **assistant!**

What to do:

1. Print out pattern sheet, plus sheet with top and camera decals and wheel treads. Cut out pattern pieces, top decal, camera decal, and wheel tread strips.
2. Place pattern pieces on styrofoam trays (avoid curved areas on edges) and trace around them with the pen. Be sure you have traced the correct number of pieces: 2 body pieces, 8 wheels, 4 wheel struts, and 2 shoulders.
3. Carefully cut out the styrofoam pieces. Make the wheels as perfectly round as you can and all exactly the same size.
4. Mark the exact centers of wheels by poking the tip of a bamboo skewer through the mark on the pattern and into the styrofoam. Also, mark the holes on the body pieces, wheel struts, and shoulders the same way. Mark the fold lines just on the very edges of the body pieces.

5. On the body pieces, use the ruler and the small knife to score (cut just part-way through) the pieces on the fold lines.



6. Now, fold the sides (the flaps) down on the score lines to make each piece into half of a box.



7. Tape the sides together on the inside to make corners stay put.



Hint: For most taping jobs (except on the wheels), you will find that long pieces (about 2 inches) of tape work best.

8. Put the two halves of the nanorover body together to make a box and tape corners and edges on outside.



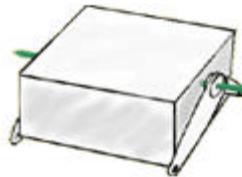
9. Using the sharp end of a skewer, poke holes in the exact center (as marked on the pattern) of two opposite sides of the body.

10. Now, poke the sharp end of a bamboo skewer through the mark on one of the shoulder pieces, then through the smaller mark on each of two strut pieces.

11. Now, insert the skewer into one of the holes you made in the side of the nanorover body. Looking through the little hole in the opposite side of the nanorover to help you line up the skewer, poke the skewer the rest of the way through the body.



12. Finally, thread the other two struts and the other shoulder piece onto the skewer.



Leaving about 1/2 inch of the skewer sticking out on both sides, carefully cut or break off the excess length of skewer. Put a blob of clay or Play-doh, or a gum drop, on the ends of the skewer.

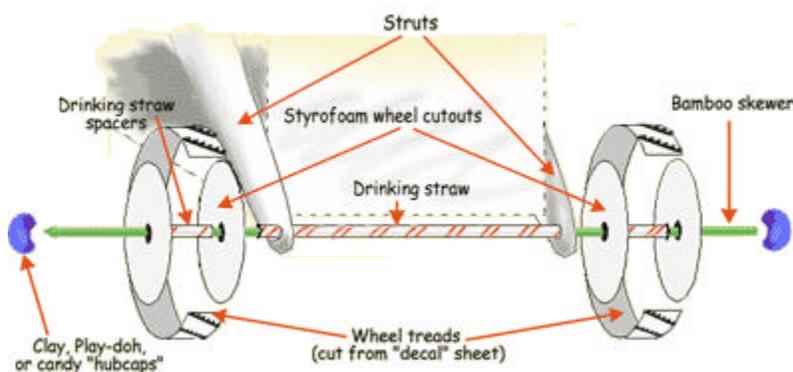
13. Now decide which is the bottom of your nanorover body. Line up the free end of each strut with a bottom corner of the nanorover body and use the ballpoint pen to poke good-sized holes in the smaller ends (will be near the larger hole marks on the pattern). You want to position these holes so that when the drinking straw "wheel axle" is threaded through them, the straw will fit right against the bottom front and back corners.



14. Thread a straw through the holes in the front struts and another straw through the holes in the back struts. Tape the straws to the bottom edges of the nanorover body. Trim the straws so they stick out about 1/4 inch beyond the struts on both sides.



15. Look at the picture below as you follow these directions for assembling the wheels:



- Put two styrofoam wheels together to make a form and wrap one of the paper "tread" strips around it, taping the end.



- Take the styrofoam wheels out of the tread strip, which we will now call a tread circle. Set the tread circle flat on the table and drop one of the styrofoam wheels into it. The styrofoam wheel should lie flat on the table with the tread circle surrounding it. Tape the wheel to the tread circle from the inside. This makes the outside of one wheel.



- Poke the sharp end of a bamboo skewer through the exact center of this styrofoam wheel. Cut a small piece (about 3/4 inch) from one of the straws. Slide this piece onto the skewer and into the inside of the wheel you are making. Now slide another styrofoam wheel-through its exact center-onto the skewer and right against the tread circle and drinking straw spacer (to make the inside surface of the wheel). If the spacer is too long and prevents the inside wheel from resting against the tread circle, slide the piece of the straw off the skewer and trim it a bit.



- Tape this second styrofoam wheel onto the tread circle using four small pieces of tape.
- Slide the skewer with its wheel through one of the straw axles already attached to the body of the nanorover.



- Make the second wheel as you did the first one, sliding it onto the skewer after taping the first styrofoam wheel onto the tread circle, then adding the straw spacer, and the second styrofoam wheel.



- Put a blob of clay (or Play-doh or a gum drop) onto the blunt end of the skewer.



- Adjust the spacing of the wheels and straw on the skewer so that there is about 1/4 inch between the ends of the straw and the wheels. Be sure the wheels do not touch the straw, or they will not turn easily. Carefully break or cut off the excess length of skewer on the sharp end, and put another blob of clay or a gum drop on that end.

- Repeat for the second set of wheels.

16. Blow up the small balloon once or twice to stretch it out a bit.
17. Bend the last straw at its flexible neck. Use the rubber band to attach the balloon securely to the end nearest the bend in the straw.
18. Tape the long part of the straw to the bottom of the nanorover, crosswise to the wheel axles. Tape the short end with the balloon against the front (or

back--it makes no difference) of the nanover.

19. Color the top "decal" to look like solar cells (dark blue) or any color you like. Tape the decal to the top. You can make "double-sticky" tape loops for this job so the tape doesn't show on the decal.



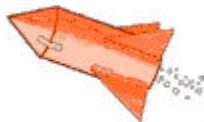
20. Tape the camera lens decal to the back or front of the rover. (On the real rover, it is on the front; on your rover, you might imagine the balloon, which is on the front, might get in the way of the camera!). Use a small double-sticky tape loop for this job too.

21. Straighten out half the large paper clip. Poke it through a blob of clay or a gum drop, then through the circle on the top to make an antenna.

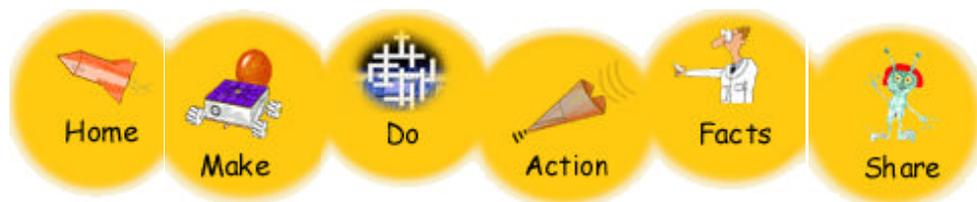
22. Blow up the balloon through the straw, put your finger over the end of the straw, set the nanover on the floor or a clear table and let it go. You may find that the nanover goes better on a smooth, hard surface, than on carpeting.



Your nanover won't go very fast, but it still goes faster than the real one!



[About the real nanover](#)



The Space Place

The Real Asteroid Rover

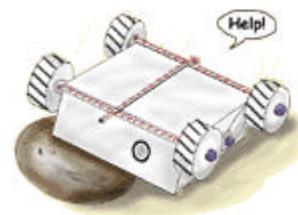


The MUSES-CN nanorover will be the smallest rover ever to fly on a space mission. (MUSES stands for the Mu Space Engineering Spacecraft--which is being built by the Japanese Institute of Space and Astronautical Science--C means it is the third in a series, and N stands for NASA's part in it, which is to build the nanorover.)

The nanorover wheels are attached to struts--kind of like our toy nanorover, except that each wheel of the real nanorover operates independently, rather than in pairs. Why do you suppose it is designed this way?

Well, gravity can be a wonderful thing. We take it for granted here on Earth. But on asteroid 4660 Nereus, there is so little gravity that a rover will barely stick! The nanorover weighs one kilogram (a little over two pounds) here on Earth. But on Nereus it will weigh only 1/10th of a gram. A penny weighs 30 times more! A little bump will make the nanorover bounce way up in the sky and could easily flip it over. So it needs to be designed to operate even if that happens.

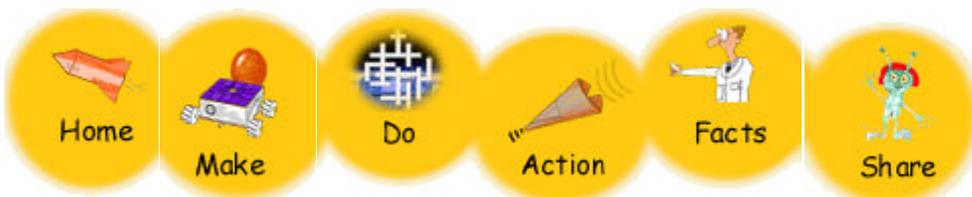
If the nanorover were to flip over, its struts can rotate to put the wheels back down on the ground! Solar energy cells on its belly will be able to provide enough power to get it turned back over.



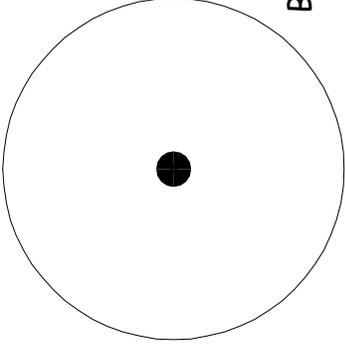
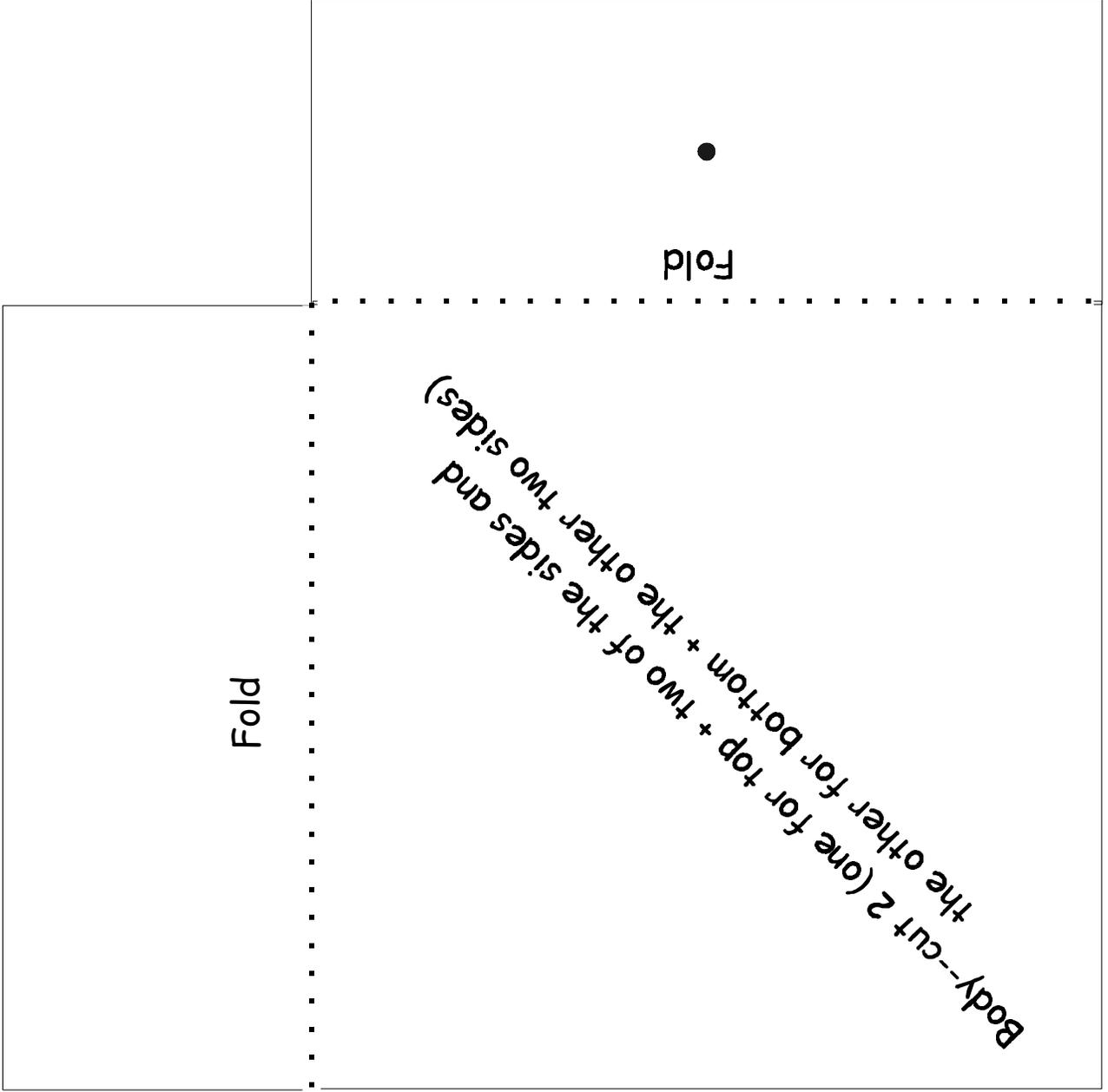
There is another clever thing about this design. When the struts move the wheels close together, the body of the rover can rotate so that its camera points straight up or straight down.

The nanorover doesn't just roll on its wheels. It hops! The strut design lets it hop 20 centimeters (8 inches) per second. Rolling, it can go only 1 millimeter per second in the tiny gravity of Nereus. At this rate, it would take 18-1/2 days to go one mile! So, as you can see, The Space Place toy nanorover is a real hot rod!

[Here is a computer animation of the nanorover hopping over a big crack.](#) (900-Kb .mpg file).



Cut these pieces out of two large (9 x 11 inches, or larger) styrofoam meat trays.

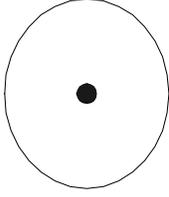


Wheel--cut 8

Be sure to mark center on each piece



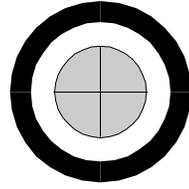
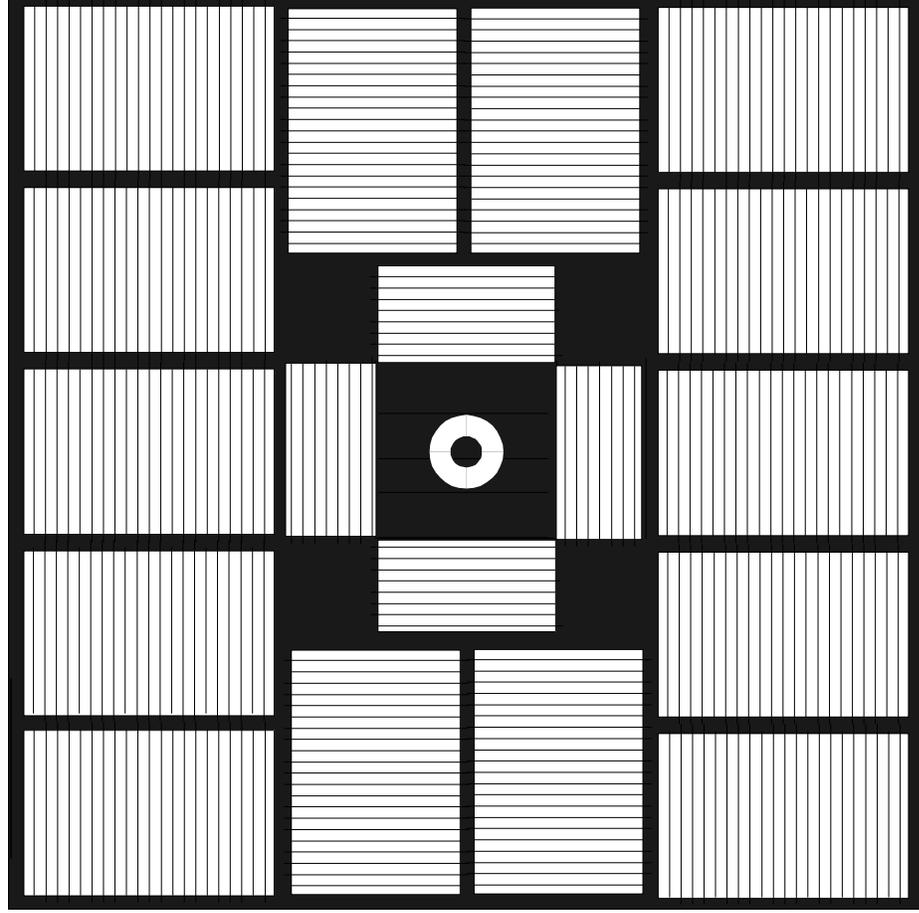
Wheel struts
(cut 4)



Shoulder
(cut 2)

**Cut out decal and wheel tread strips.
Cut out paper only. If you wish, you can
print these on heavier or colored paper.**

Decal for top of nanorover. Color, if you like.



Decal for
camera lens

**Wheel "treads."
Cut on lines and wrap
around wheel circles.**

