LIFE BEYOND

Imagining our Future in Space

PRACTICAL ACTIVITIES : ORIGAMI FOR SPACE

UK Centre for Astrobiology

THE UNIVERSITY OF EDINBURGH

SPS SCOTTISH PRISON SERVICE

Fife College

BONUS HANDS-ON ACTIVITY: ASTRONAUTS AND ORIGAMI

DESCRIPTION OF THE ACTIVITY

What does origami have to do with space exploration? More than you might think! Origami is the art of paper folding, often associated with Japan. In fact, it even makes an appearance in the selection process for Japanese astronauts. Space travel requires a lot of patience, and an ability to maintain focus when performing boring or routine tasks.

Think about your long journey to Mars, or about all the time you will have once you've made it to your destination. **In space, simple tasks can become a matter of life and death, so you must take care to precisely complete each one, even if you have done it a thousand times**. For this reason, aspiring Japanese astronauts are tasked with creating 1,000 perfect paper cranes. This mimics the need to accurately complete a repetitive task under stress and/or boredom.

This is your chance to **make your own paper crane** (or more if you like) as part of getting ready for the challenges of space travel. You will a sheet of **A4 paper** for this activity.

HOW TO GET A SQUARE SHEET OF PAPER FROM A4

The **paper crane** needs to be made from a **sheet of square paper**. Luckily it is simple to turn an A4 sheet into a square.

Fold the short edge of your A4 paper diagonally so that it lines up with the long edge. The crease should be where the dotted line is (as above).

There will be a **rectangular strip** on the other side of your paper (lower section in diagram). Fold this over both ways so that it is well creased.

With a **sharp enough crease** on the vertical, you should be able to carefully **tear the paper**, leaving you with a squar.

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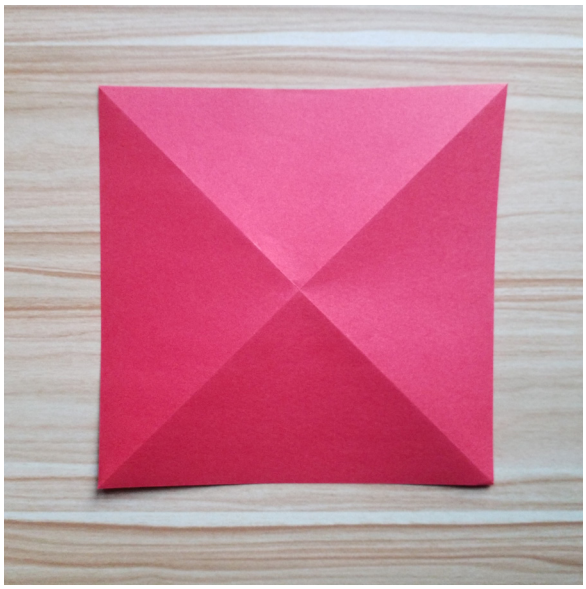
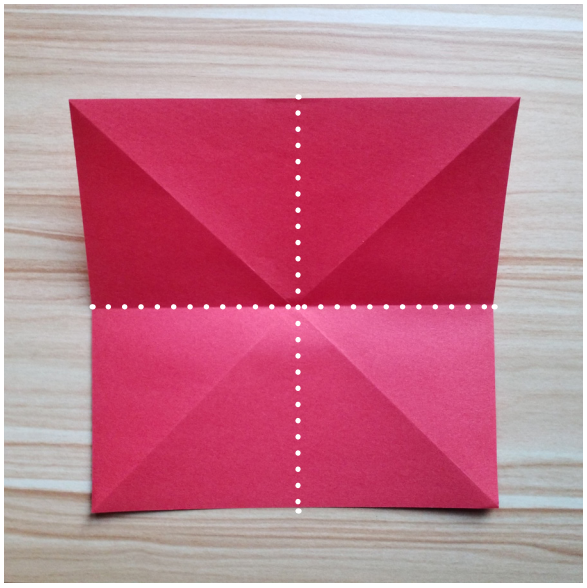
PAPER CRANE INSTRUCTIONS

In this tutorial, I have used a sheet of coloured origami paper to help with the contrast, but it can be done with any colour of paper.

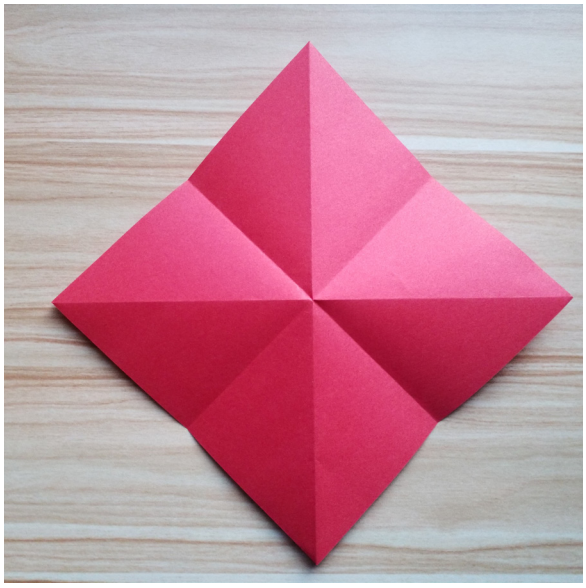
1. Begin by folding your paper along the diagonal in both directions so that you get an X on your square.



2. Flip your square over so that the creases face downward. Your square should be slightly tented.

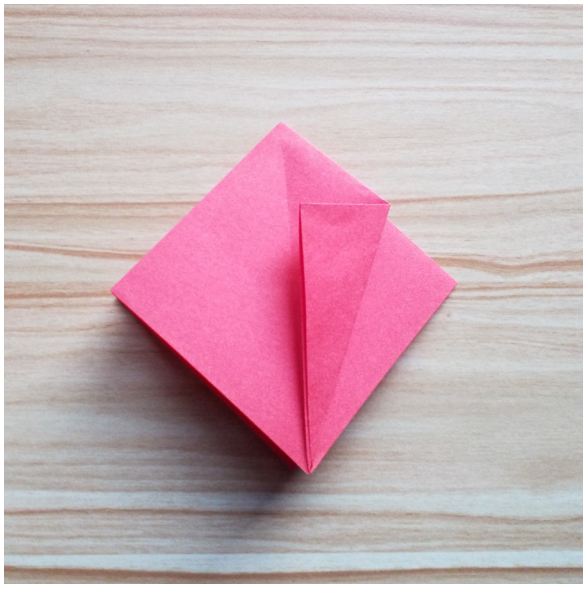


3. Next, you want to fold the paper in half vertically and horizontally.

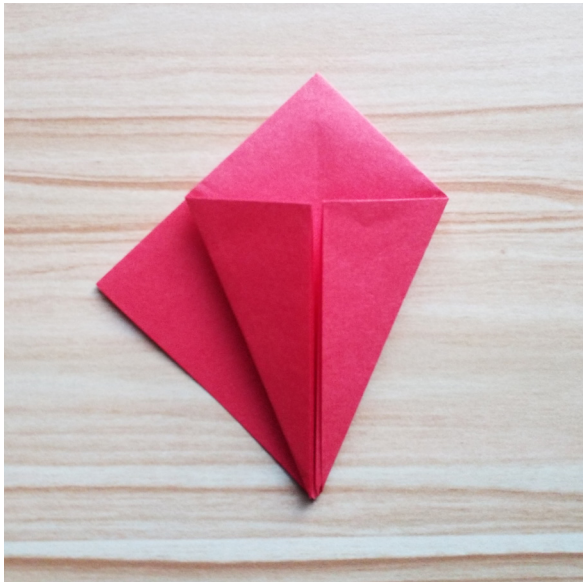


4. Once you have finished, your paper should have 8 triangular segments. You want to rotate it so that one of the corners is facing you.

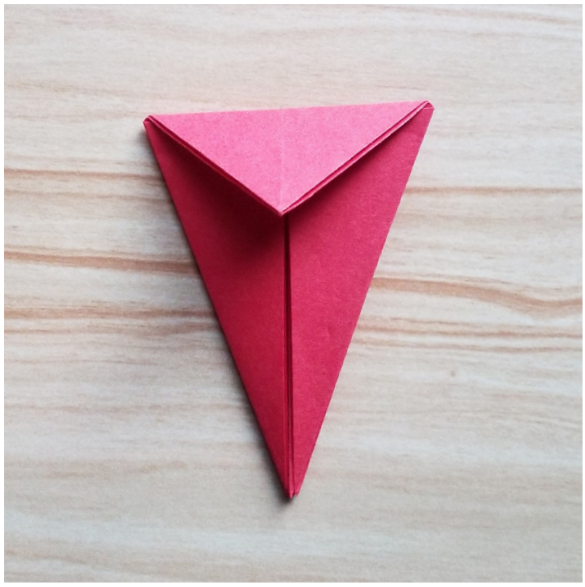
5. If your creases are tented upward as shown in Figure 4v, press the centre down so the creases are tented downward. Now you want to take the left and right corners and press them inward while folding them along the horizontal crease. Your paper should easily collapse into a smaller square.



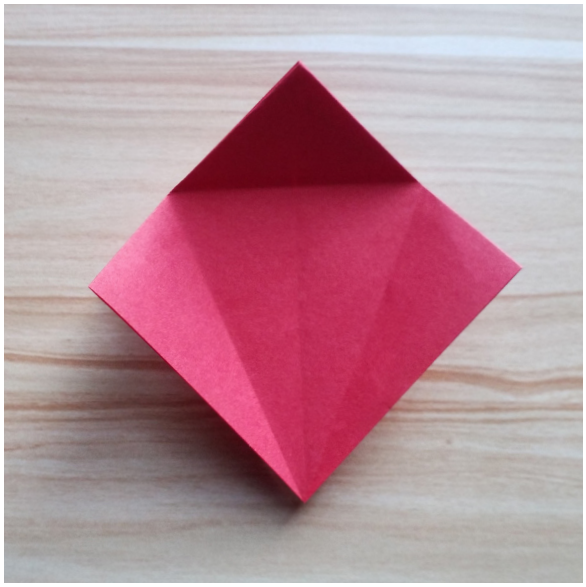
6. Take the lower right edge of the upper flap of your small square and fold it inward so that it is along the vertical center line.



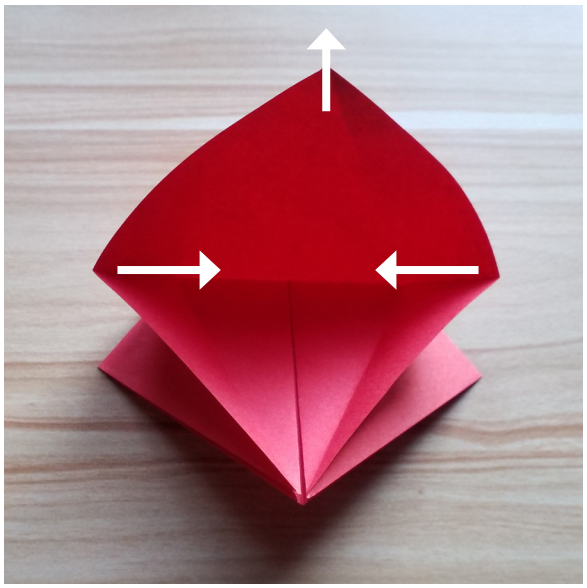
7. Repeat this with the left upper flap, then turn your paper over and do it with the other two flaps. You should have a diamond-shaped paper at the end.



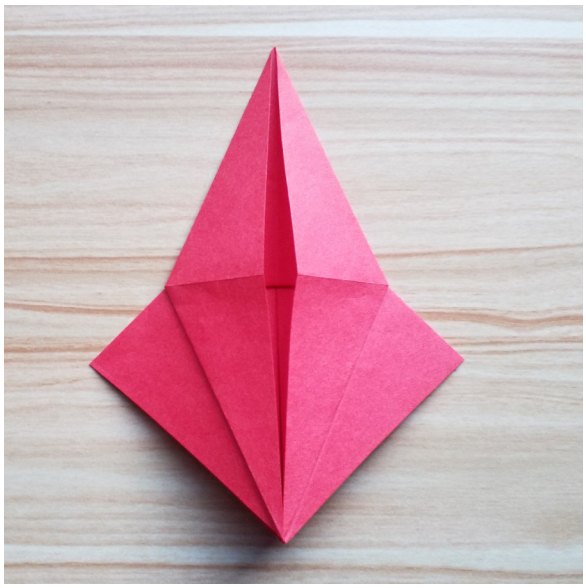
8. Now fold the top triangle over to make a crease, this will help you later.



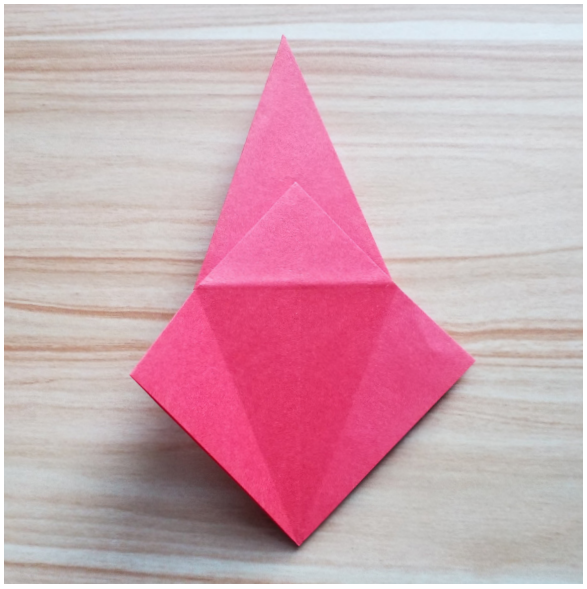
9. Now undo all the folds from steps 6-8. Your square should look like this.

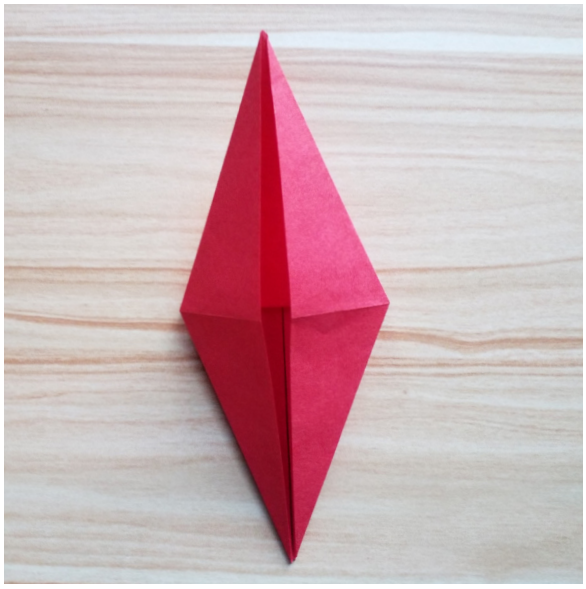


10. Next pull up the uppermost corner closest to you. You will gently push this away from you, and the paper should crease along the folds you just made. The outer corners should naturally want to come together, as indicated by the arrows.

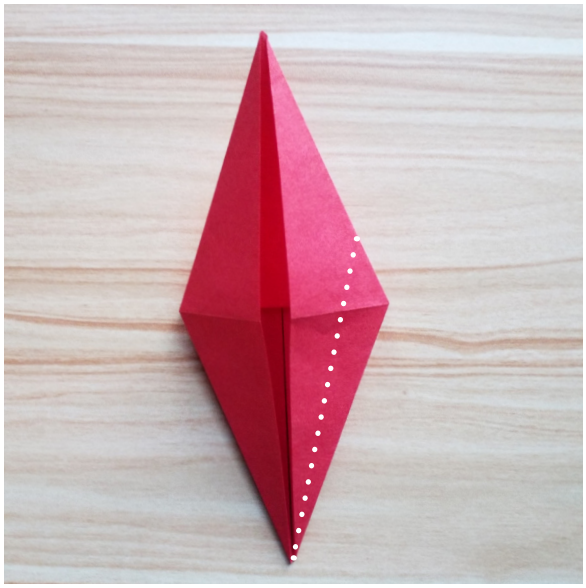


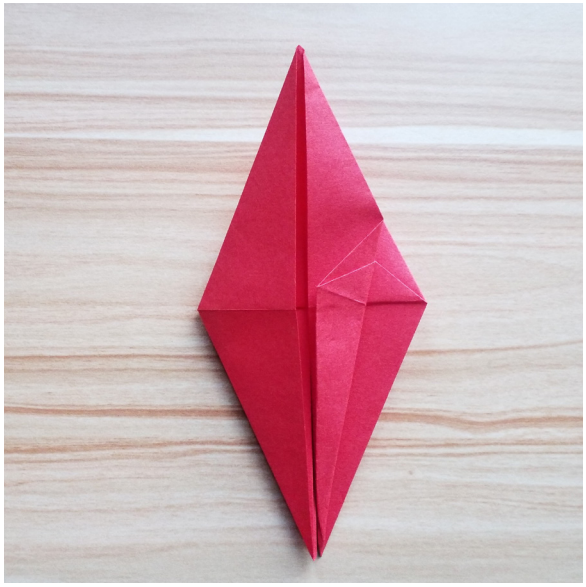
11. When you are done with step 10, your paper should look like this. You'll want to press this flat to ensure a good crease.





12. Now flip your paper over, keeping the same corner pointing to you and repeat steps 9 and 10.

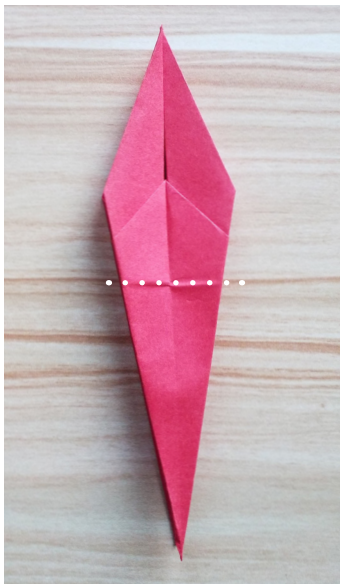


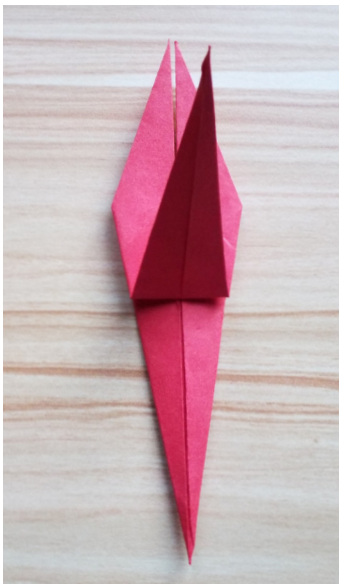


13. Make sure that your diamond is oriented so that the half that is split vertically down the centre faces you. You'll want to take the top layer of the lower-righthand flap and fold it inward to the centre line, like you did in step 6.

14. Repeat step 13 for the left flap, then flip your paper over and repeat the process on the other side. When you have finished your paper should look like this.

15. Now you want to fold the two upper halves together and fold the two lower halves together so that their faces are touching. The left image below is an intermediate step, where the whole piece has been rotated by 90 degrees so that the top face from step 14 is on the left, and the bottom face is now on the right side. Pressing the halves closer together will give you the image on the right. Once it looks like the right image, press your paper flat to give you better creases.



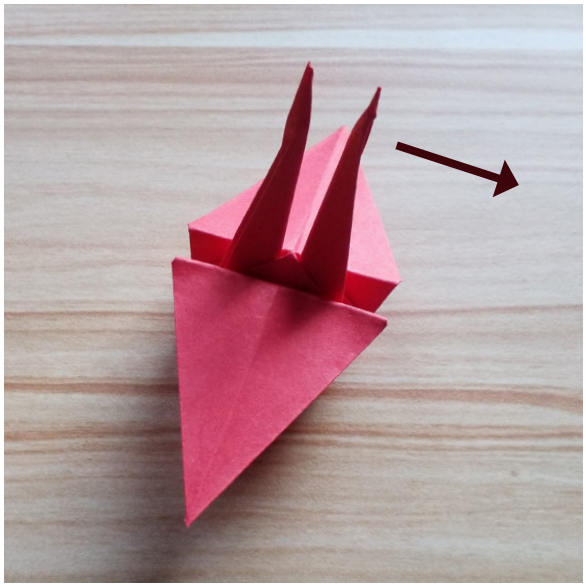


16. Next, take the upper layer of the bottom corner and fold it towards the top corner, along the horizontal crease that is already there. Flip over and repeat for the other side.

17. As you did in step 15, you want to fold the two top halves and two bottom (table-side down) halves of your paper together.

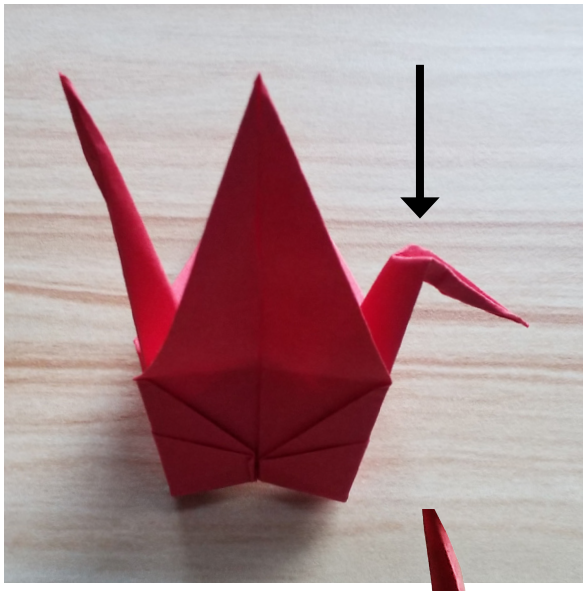
You should now have something like this.

18. You are ready to make the wings! Fold the flap of paper facing you over, and repeat for the other side.



19. Now you want to take the right inside bit that is poking out and pull if further rightward so that its edge is aligned with the rest of the piece.

20. Repeat step 19 for the other side.



21. For whichever bit of paper you think is prettier, fold it downward about a centimetre from the tip while pressing inward on the vertical crease so that the crane's head is folded flat instead of flaring outward (see arrow). You'll want to adjust the four corners of the base so that the crane can stand on its own.

YOU HAVE MADE AN ORIGAMI CRANE!

What did you think of the crane origami task? Did you like it? Can you imagine making 999 more without any mistakes? While this was a low-stakes activity, the need for perfection is much more serious in space.

MAKING THE WALLS OF YOUR SPACE HOME USING ORIGAMI

THE MIURA FOLD

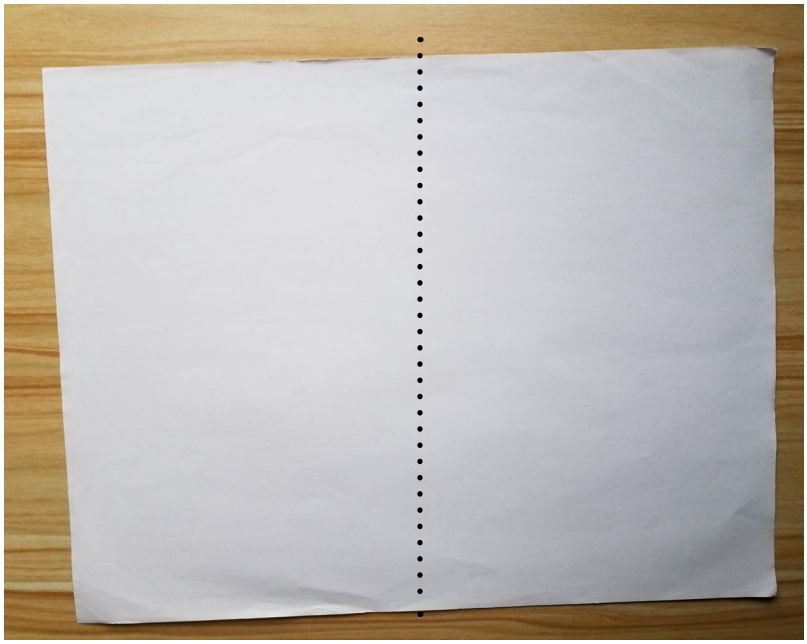
There are other reasons why astronauts might care about origami besides as a training activity.

Carefully placed folds and creases allow us to transform a flat, 2D material like a piece of paper into a 3D structure, such as the walls of your Mars or Moon station. Depending on the layout of these folds, this structure can have special properties. One example of this is the **Miura (Meerah) fold**, designed by **Japanese astrophysicist Koryo Miura**. This herringbone design has a few interesting properties that make it appealing to use in space exploration applications.

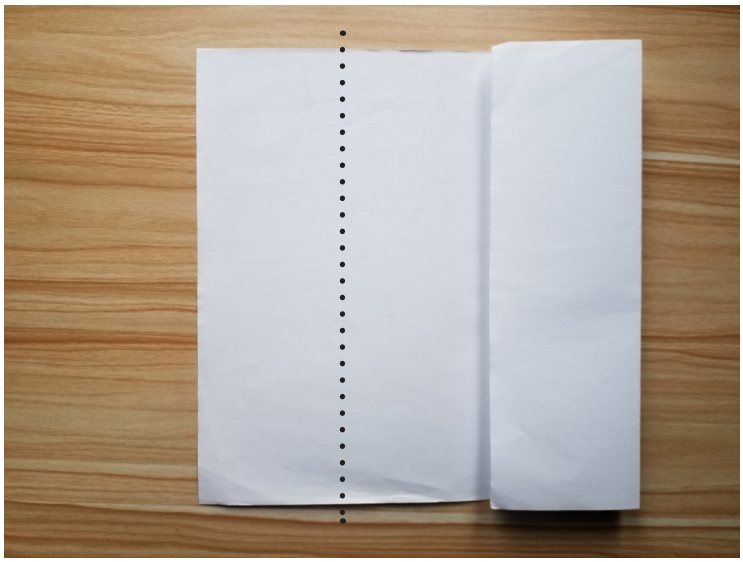
The **Miura fold** is easily compressed in one direction and can be easily expanded along both directions of the sheet by pulling it in only one direction. Compare this with most other materials. If you pull on a cloth square, it will grow long in the direction you pull, but shrink in the opposite direction. The Miura fold grows in both directions if you pull outward and shrinks in both directions if you compress the fold in one direction. This pattern has been investigated as a way to build a lightweight, shape-shifting radiator that dissipates heat to protect temperaturesensitive components in satellites, for example. Special folding techniques have also been used to deploy solar panels, allowing for a tightly packed product during transit that smoothly expands when needed.

You now will have a chance to **create your own Miura fold, using nothing more than a sheet of A4 paper**.

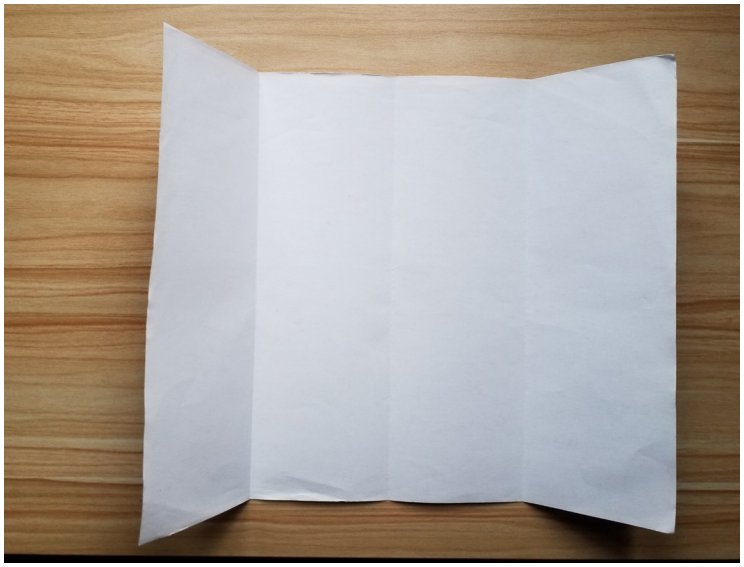
INSTRUCTIONS



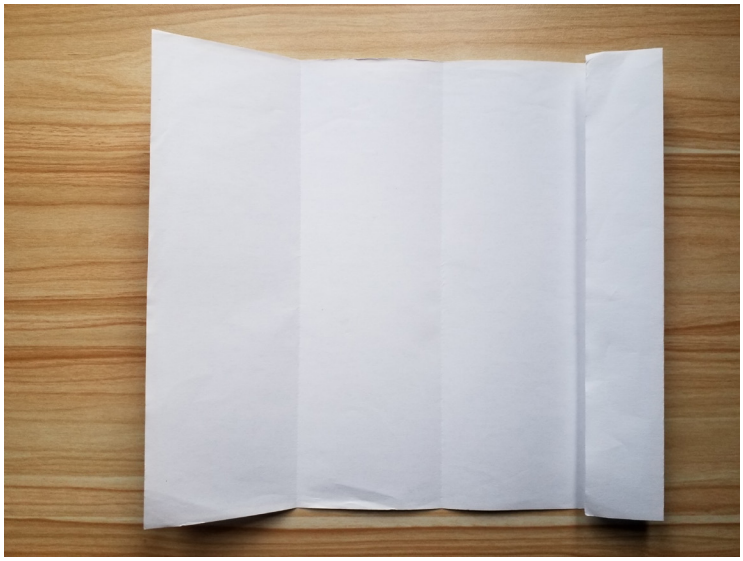
1. Start with a sheet of paper and fold it in half along the short side.



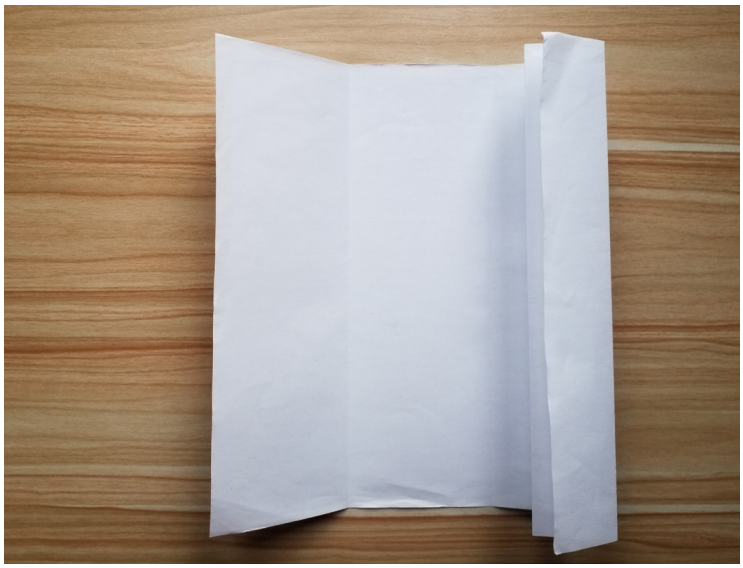
2. Open your sheet back up, then fold the paper into quarters by folding each half into half again, folding each edge inward to the centre crease. The first of these two folds is shown.



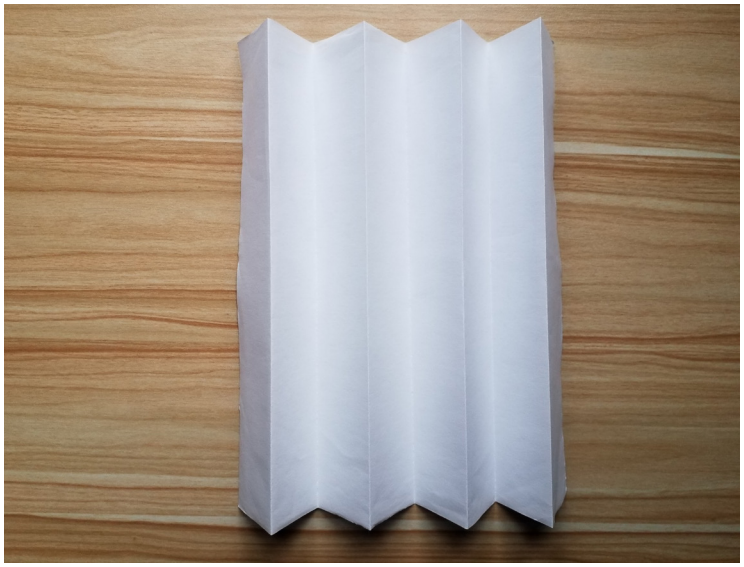
3. When you open it up, you should now have 4 equally-sized rectangles.



3. When you open it up, you should now have 4 equal-sized rectangles.



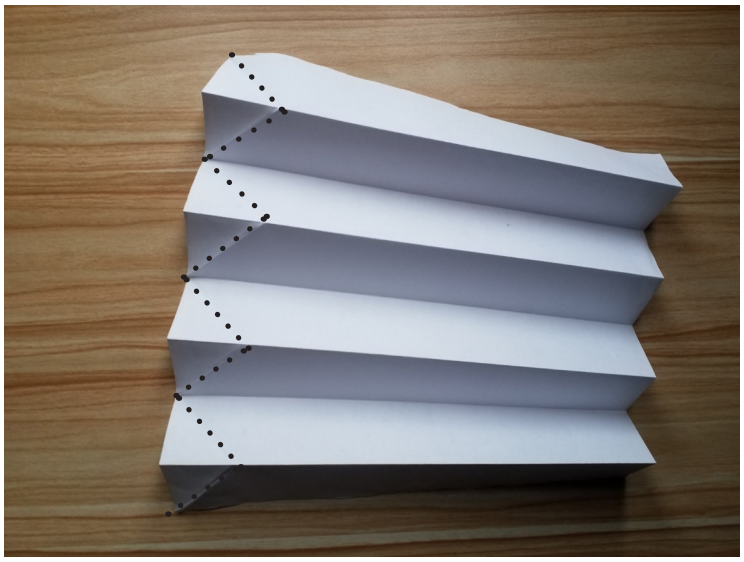
4. Now you want to repeat this process so that you end up with 8 equally sized rectangles.



This time, while you do the folds, alternate the direction you fold the paper, so that you get a zig-zag pattern as you fold it up. It should look like this image when you are done..

5. Fold up your paper so you have a thin rectangle. Rotate it so that the long side is parallel to the edge of the table near you and so that the free edges are facing you. The peak creases shown in the image above should be facing away from you. Fold the top-left corner downward so that the short side is parallel to the long side, making a right triangle as shown.

6. Unfold this corner then fold it over the other way along the same crease. You are still only folding the left corner of your rectangle. The paper in this photo has been flipped so that the free edges are now facing away from you.

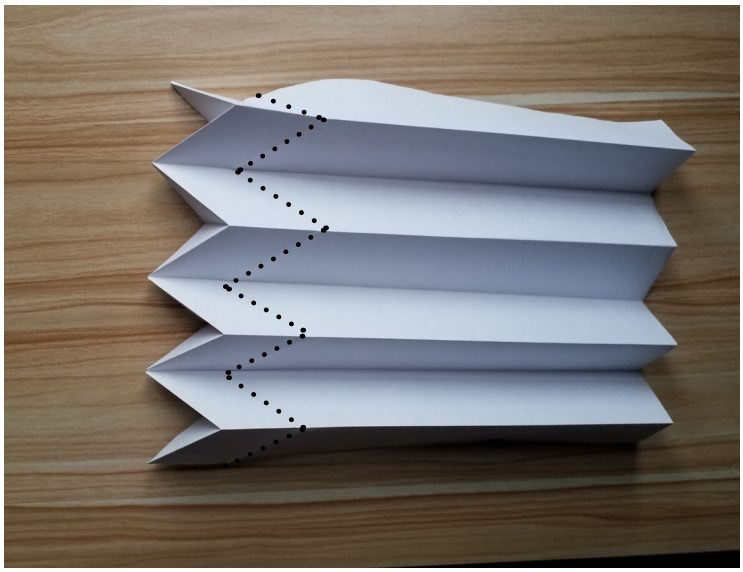


7. Unfold the corner again and expand your paper. You should see the triangular creases along the left edge.

8. Pressing in along these creases, pop the triangles inward. The image shows this for three of the four triangles.

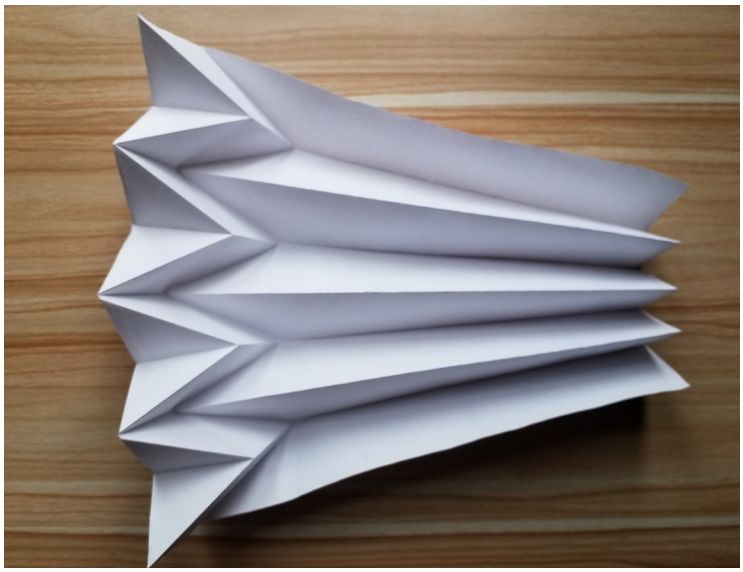
9. Fold everything inward once more so that you have the same long rectangle with a triangular corner missing. You will fold the long side upward along the dashed line so that another right triangle is formed at the leftmost corner. The two solid lines show what sides should touch. (The pen is just keeping the right side from unfolding.)

10. Like last time, undo this fold then repeat it in the other direction so the crease goes both ways.

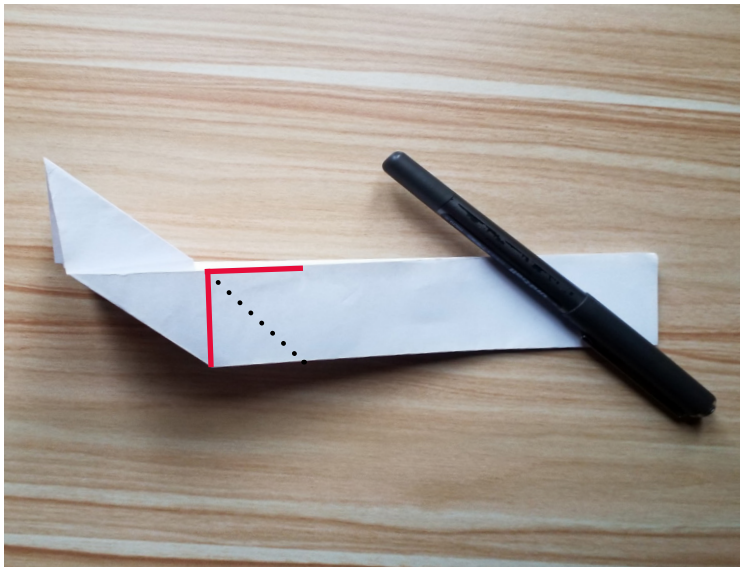


11. When you unfold the accordion again, you should start to see your herringbone pattern.

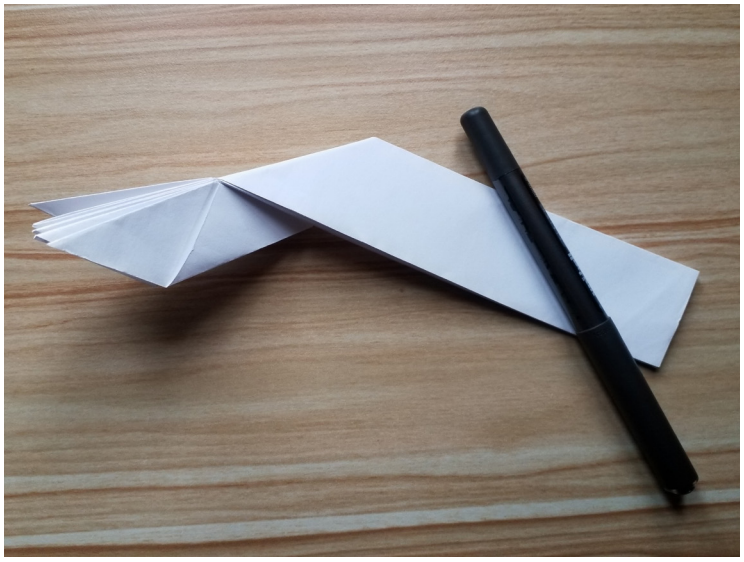
12. **Now for the tricky part!**
For every horizontal crease to the right of the dashed lines in the above image, you want to reverse the direction of the crease so that the high points become the low points, and the low points become the peaks. It's easiest to start at the side closest to you and work your way along the paper, using the herringbone creases you just made to help you. You can see this in two intermediate stages.



When you have finished reversing the order of horizontal creases your paper should look like this.

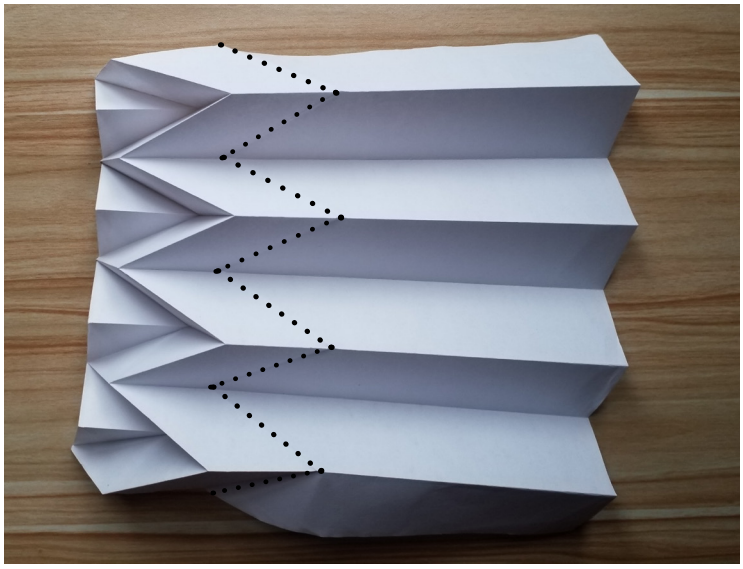


13. Next, you are going to collapse everything again as you last did in step 9. Press along the fresh creases so that everything is laying as flat as it can. Once more, you will fold so that it forms a triangle with your previous fold as shown below. Again, the dotted line is where you are folding. The two solid lines represent the points that should touch when you fold.



Once folded, your paper should look like this (there will be a right triangle if you press everything flat against the table).

14. As usual, undo this fold then repeat it in the other direction so the new crease goes both ways.



15. Now undo this fold and open up your paper again. You should have a new row added to the herringbone pattern.

16. Repeat step 12, reversing the direction of the horizontal creases to the right of the dashed lines shown. This will give you the second set of herringbones.

17. Repeat steps 13-16 until you fill your paper. It's okay if there is a little overhang on the last fold, that's just a consequence of the shape of your sheet of paper. When you're done, you should have something like this:

CONGRATULATIONS! YOU HAVE COMPLETED YOUR MIURA FOLD!

Take some time to play around with this and note its features. Note what happens when you compress it, pressing vertically on the top and bottom of the sheet--it collapses nicely! What happens when you try pressing the sheet in on the left and right sides?

Also notice how pulling in one direction expands the sheet in the other direction as well! Now think about how this could be useful for building the wall of a lunar or Mars station.

EVALUATION FORM

Below is a short evaluation form. Please do fill this in and send it back with your work. It's not compulsory, but it's really important for us to know what you think about this course so that we can improve it for future participants. Beyond that, many people ask us about the value of our work and it's important for us to be able to provide evidence that the course has been of benefit and interest to you. It won't take long to complete. Of course, you may also feel free to criticise the course! **Tell us what you don't like, so we can modify the course to make it better for the future.**

Did you find this course interesting (yes/no)?

What did you most like about this course?

What would you improve in this course?

Did this course make you think any differently about educational projects and courses of this type?