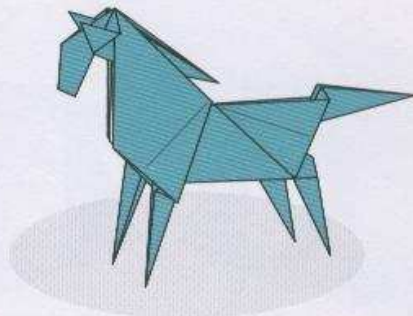


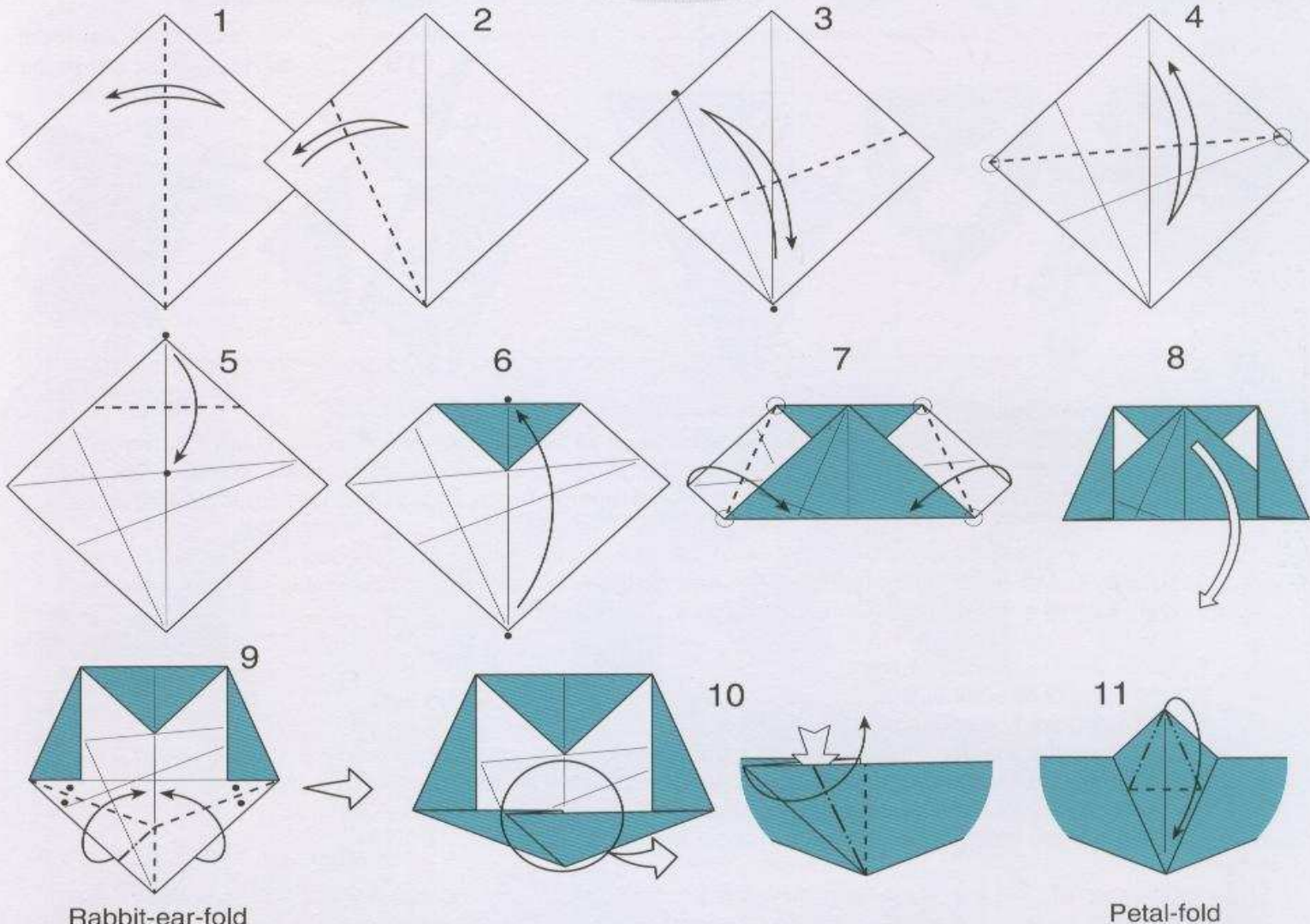
Horse

Theme: Geometric construction

Fold using 6" (15 cm) or preferably larger origami paper.



You can draw a line on a sheet of paper by folding it. At the same time, you can use the sheet itself as a straight-edge and compass, and beyond.

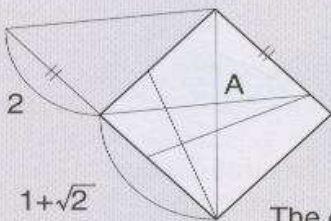


Rabbit-ear-fold

Petal-fold

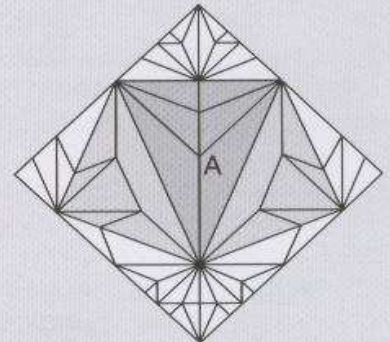
Folding the landmark in this model

While the main design aspect of this Horse is its mane, its structure is the Y pattern at the center with two isosceles right triangles on the sides. Though it is clear, this structure requires some clever folds to find the landmark A, which divides the diagonal in $2 : 1 + \sqrt{2}$. The picture below explains the meanings of the construction made in steps 1-4.

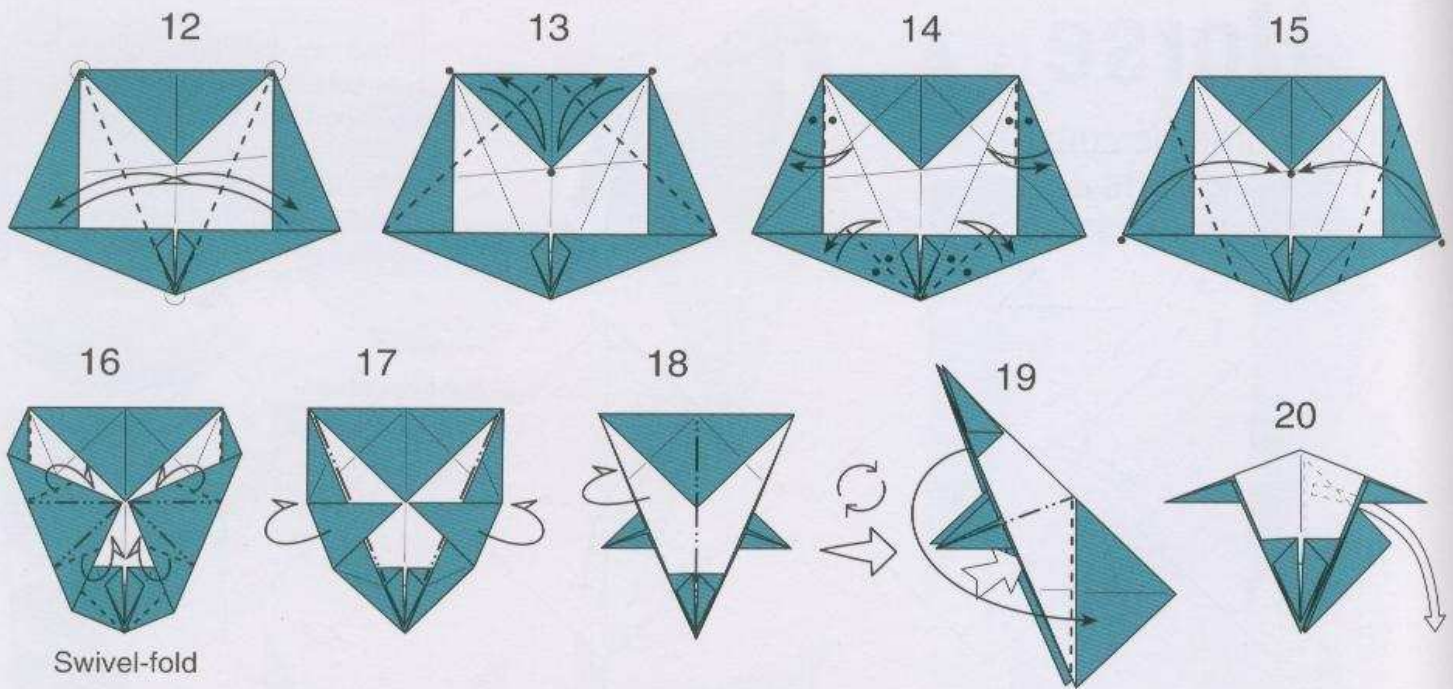


The construction made in step 1-4

We extend the side to obtain the desired ratio, and transfer that ratio onto the diagonal by folding the parallel line. This method can be applied in many cases.



The crease pattern of Horse (mountain and valley folds are not shown; underlying triangles are shown in gray).



Swivel-fold

Constructions in origami

We have already seen some constructions in this book, such as the trisection of a side with Haga theorem in *Conch*, dividing a side into five in *Gift Box*, and folding the golden ratio in *Connected Cranes: Kotobuki*. Because folding flat is equal to drawing a straight line, it is natural to regard origami as a tool for geometric constructions.

Humiaki Huzita formulated six folds, each of which draws one straight line that has definite landmarks, and Jacques Justin added the seventh. Huzita called them axioms, but they are not axioms in the mathematical sense. They are rather "origami procedure that draws one straight line."

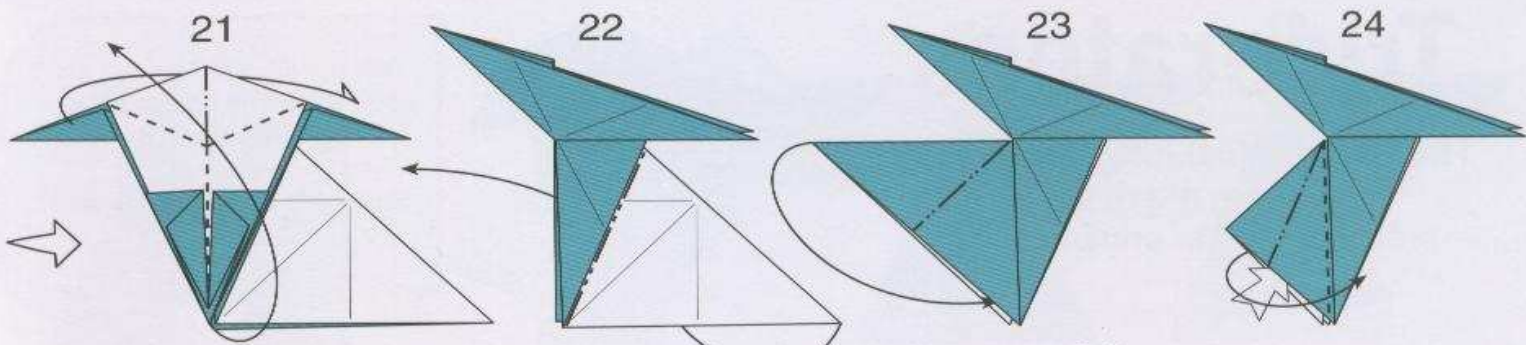
1. Fold a point onto another point.
2. Fold a line onto another line.
3. Fold along the line connecting two points.
4. Fold along the line that passes through a point and is perpendicular to a line.
5. Fold along the line that passes through a point and places another point onto a line.
6. Fold a point onto a line and another point onto another line.
7. Fold along the line that places a point onto a line and is perpendicular to another line.

The combination of folds 1 through 5 is equivalent to solving quadratic equations, which in turn is equivalent to the constructions with a straight-edge and compass. The construction in this *Horse* and other constructions like making a pentagon are possible with these folds. A typical example of fold 4 is step 4 of *Tree*, and that of fold 5 is step 3 of *Penguin*, which comes later in this book.

By adding fold 6, some constructions that are impossible with a straight-edge and compass become possible, since the fold is equivalent to solving cubic equations. Fold 6 is not unnatural. In fact, fold 3, which corresponds to drawing a line with a straight-edge, is sometimes more difficult than fold 6 unless points are placed on the edges.

Hisashi Abe emphasized these when he solved two of three **Classical Greek Problems**, **angle trisection** and **doubling the cube**, using fold 6.

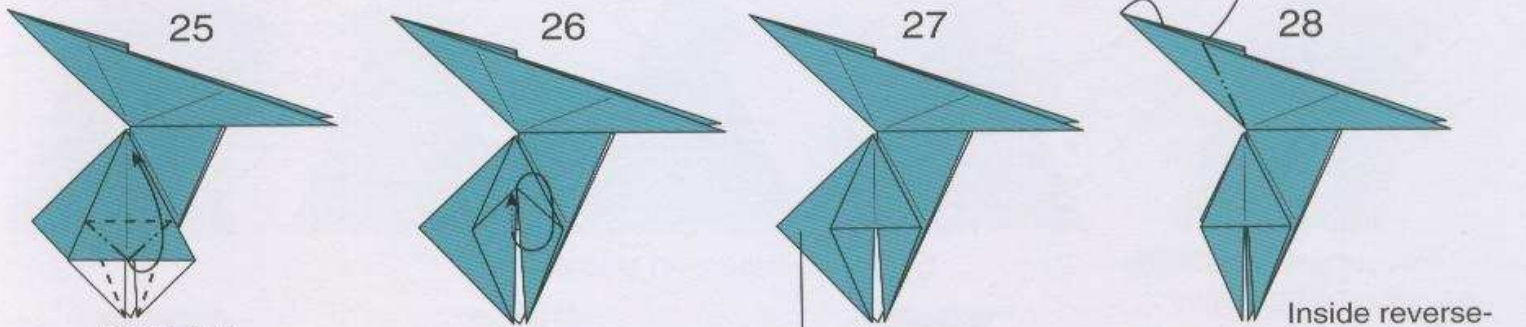
Note that these two problems cannot be solved with finite procedures of a straight-edge and compass. In the 19th century, Pierre Wantzel proved this by relating geometric constructions to the order of equations. It is also known that these constructions are possible if we use special tools. That is, origami is just one of such tools that is different from a straight-edge and compass. The other problem, **squaring a circle**, is also proved to be impossible because it involves the circular constant, which makes this problem more difficult.



Rabbit-ear-fold while folding the model in half

Inside reverse-fold

Inside reverse-fold

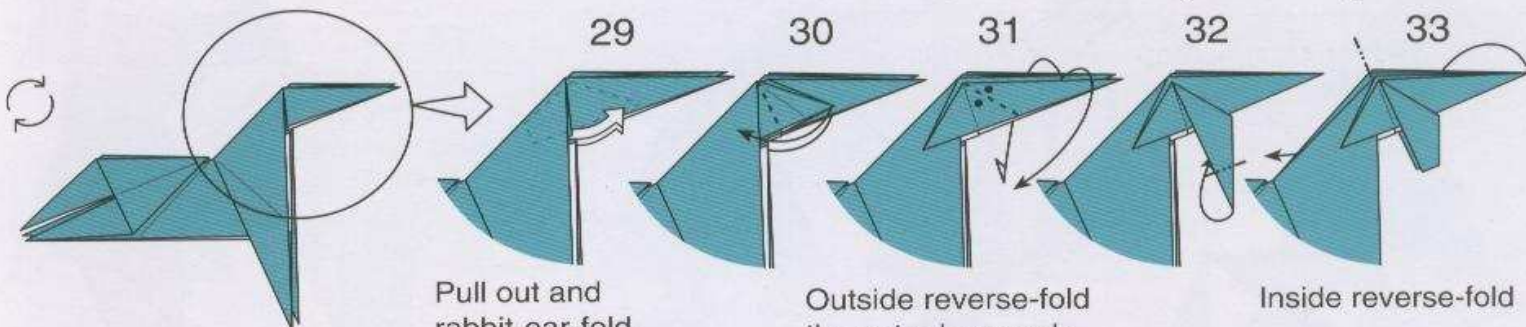


Petal-fold

Reverse the flap inside.

Repeat steps 24-26.

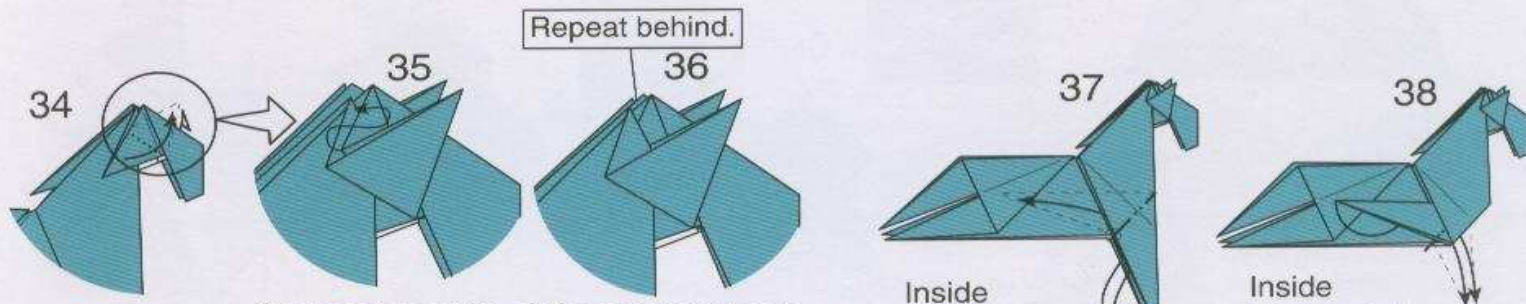
Inside reverse-fold through the center gap using the existing creases



Pull out and rabbit-ear-fold.

Outside reverse-fold the outer layer only

Inside reverse-fold

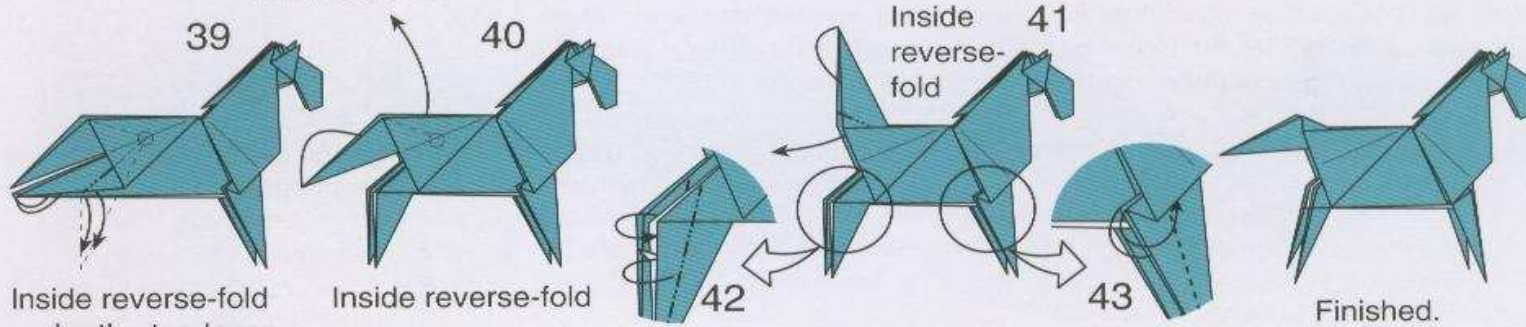


Repeat behind.

Change the order of the layers to keep the head closed and to open the layers for the mane.

Inside reverse-fold

Inside reverse-fold



Inside reverse-fold under the top layer

Inside reverse-fold

Inside reverse-fold

Repeat behind.

Inside reverse-fold

Finished.