

HOBBIES COURSE

Origami and Paper Folding

10 Chapters

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ORIGAMI AND PAPER FOLDING

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Origami and Paper Folding 🏆

Course 1 · Chapter 1 · Paper and Folds: Your First Square, Your First Crease, Your First Boat

Origami is the art of making shapes by folding paper, and nothing else. No scissors, no glue and no tape, at least in the traditional style. That one constraint is what makes it fun: a flat sheet becomes a boat, a bird or a box using only your fingers and a good crease. This chapter gets you started with the sort of paper you need, how to turn a sheet of A4 into a perfect square, the two folds that everything else is built from, and a boat you can finish in a few minutes.

What Origami Is, and Where It Came From

The word comes from Japanese: *ori* means "folding" and *kami* means "paper" (the sound changes to "gami" when the two words join). Folding paper for decoration and ceremony is old in Japan, and paper folding of various kinds also grew up independently in China and in Europe, so it is a shared craft rather than one country's property. The exact dates of the earliest models are debated (check), and you do not need them to start folding.

> The one rule Traditional origami uses one uncut sheet and no glue. Modern folders sometimes break that rule (cutting, joining several sheets), and later chapters, such as Modular Origami in Origami and Paper Folding 7, join units together. For now, one sheet and your hands.

Choosing Paper

You can fold with almost any paper, but some papers make life far easier. Thin paper holds a sharp crease and takes many layers. Thick paper is stiff and fights you at every fold. Here is a quick guide.

PAPER	FEEL	GOOD FOR	WATCH OUT FOR
Printer paper (A4 or Letter)	Cheap, a little thick	Practice, boats, boxes, first attempts	Not square, and gets bulky after many layers
Packet origami paper (kami)	Thin, coloured on one side, white on the other	Almost every model in this course	Tears if you rub the crease too hard

PAPER	FEEL	GOOD FOR	WATCH OUT FOR
Sticky-note pads	Small and square, a weak tacky strip	Tiny models, desk practice	The sticky edge grabs other layers
Gift wrap	Thin, patterned	Free practice paper, large models	Often has a white or plain back and can crack along creases
Card or cartridge paper	Stiff	Boxes that need to keep their shape	Hard to crease neatly, so avoid for complex models

For this course a pack of ordinary 15 cm square origami paper (about 6 in) is the most useful buy, but printer paper costs nothing and is fine for a first boat. Whatever you choose, keep a stack of spare sheets nearby. Everyone ruins the first few.

Which Side Is Which

Many sheets have a coloured side and a white side. Diagrams usually show the coloured side as shaded and the white side as plain, so you can see at a glance which way up the paper is. Start every model with the side the instructions tell you, and if they say nothing, start coloured side up (check the book or site you are following, since habits differ).

Making a Square from A4

Most origami models start with a square. Printer paper is a rectangle, but you can make a square from it in under a minute, and the maths is neat: the diagonal of a square 210 mm wide is almost exactly 297 mm, the long side of A4. That is not a coincidence. A4 is built so that its sides are in the ratio 1 to the square root of 2, which means folding the short edge diagonally onto the long edge lands the corner exactly on the long edge. Here is a tiny script that checks the numbers.

```
  import math

  w, h = 210, 297
  print('A4 side', w, 'x', h)
  print('Square side', w)
  print('Leftover strip', h - w, 'mm x', w, 'mm')
  print('Diagonal of the square', round(w * math.sqrt(2), 1), 'mm')
  print('Ratio h/w', round(h / w, 4))
```

Output when run:

```
A4 side 210 x 297
Square side 210
Leftover strip 87 mm x 210 mm
Diagonal of the square 297.0 mm
Ratio h/w 1.4143
```

The leftover strip (87 mm by 210 mm) is waste for now, but keep it: it makes a good practice strip for the crease exercises later on.

The Steps

1. Lay the A4 sheet in front of you with a short edge at the bottom (portrait).
2. Take the bottom-left corner and fold it up and across so the bottom edge lies exactly along the right-hand long edge. You now have a triangle sitting on top of a rectangle.
3. Press the crease flat from the fold outwards, running your thumbnail along it.
4. The rectangle at the top is the leftover strip. Crease its lower edge firmly (that edge is the top of the triangle) and then fold the strip back and forth over that crease until the paper tears cleanly along it, or open the sheet out and cut along the crease with scissors. Unfold the triangle.
5. The sheet you hold is a square, and the diagonal crease across it is already in place for later models.

```
# A4, portrait. Fold the bottom-left corner up to the right edge.

 +------------------+           +------------------+
 |                  |           |                  |  <- leftover strip
 |                  |           +------------------+
 |                  |           |                 /|
 |                  |    ==>    |               /  |
 |                  |           |             /    |
 |                  |           |           /      |
 +------------------+           +----------+-------+
                                 bottom edge now lies
                                 along the right edge
```

> Check it really is square Fold your finished square in half along both diagonals. If the corners meet exactly each time, it is square. If one pair sticks out, one side is slightly longer than the other and every model made from it will lean. A square that is off by even 2 mm is worth trimming.

The Two Folds Everything Is Built From

Almost every origami model, however clever, is made from two basic folds and the order you do them in.

FOLD	WHAT THE CREASE LOOKS LIKE FROM YOUR SIDE	HOW YOU MAKE IT	DIAGRAM LINE
Valley fold	A valley: the crease sinks away from you and the paper folds up toward you	Fold the paper toward you, like closing a book	Dashed line: - - - - -
Mountain fold	A ridge: the crease points up at you and the paper folds away behind	Fold the paper away from you, behind the sheet	Dash-dot line: - . - . - .

```
# Side view of the paper, you looking from above

 Valley fold              Mountain fold

   \        /                   /\
    \      /                   /  \
     \____/                   /    \
   the crease is low        the crease is high
```

Here is the helpful trick: a valley fold from the front is a mountain fold from the back. Turn the paper over and the same crease reverses its name. That is why diagrams show the paper turned over so often, and why you should keep the paper on a clean table while you work.

Making a Good Crease

A fold is only as good as its crease. A crisp crease makes later steps easier and the finished model neater.

1. **Line up first, press second.** Match the two edges or corners exactly before you press anything. A fold made to the wrong place cannot be corrected without leaving a ghost crease.

2. **Hold the first point, then press from the middle out.** Pin the corner with one finger and flatten the paper out toward the other end with the thumb of the other hand.
3. **Sharpen with a fingernail.** Run a nail firmly along the fold. For hard-to-crease paper, a bone folder, the side of a ruler or the back of a spoon helps.
4. **Unfold gently.** A "pre-crease" is a crease you make and then open again to mark a guide. Open it slowly so the paper does not stretch or tear.
5. **Don't rework a bad crease.** If it is in the wrong place, start another sheet. Practice paper is cheap, and unfolding and refolding weakens paper fast.

> The table is part of the tool Fold on a hard, flat surface such as a table or a book rather than on a soft sofa arm. Soft surfaces make the paper wobble and your crease blurry.

Your First Model: The Paper Boat

This is the classic fold-it-from-a-sheet boat that most people half remember from childhood. It starts with a plain rectangle, so ordinary printer paper works well. Use A4 for a large boat, or fold a square-ish scrap for a little one. (Several versions exist, and what follows is the common one: if your memory of it differs, that is normal, since it has been passed down by hand for a long time.)

Folds You Will Use

The boat uses valley folds only, plus some opening and flattening at the end.

1. **Half fold.** Lay the paper landscape (long edge at the bottom). Fold the top edge down to the bottom edge, crease firmly, then open it out. You now have a horizontal crease across the middle. Fold the paper in half again along that crease, with the fold at the top.
2. **Fold in the top corners.** Fold the top-left and top-right corners down to meet the centre of the fold so they make a triangle (like a house roof) with a strip of paper along the bottom.
3. **Fold up the cuffs.** Fold the bottom strip of the front layer up over the triangle's lower edge, then turn the model over and do the same on the back.
4. **Open and flatten.** Put your thumbs into the bottom opening and pull the sides apart until the model flattens into a diamond shape.
5. **Fold up the lower corners.** Fold the bottom corner of the front layer up to the top point, then the back one. You now have a smaller triangle.

6. **Open and flatten again.** Open the bottom and flatten into a diamond again.
7. **Pull the boat open.** Hold the top two points and gently pull them apart. The model opens into a boat shape. Squeeze the base so the bottom is flat.

```
# Stage by stage, front view

 1. Half-folded        2. Corners in         3. Cuffs up
 +---------------+        /\                    /\
 | fold at top   |       /  \                  /  \
 |               |      /    \                /____\
 +---------------+     +------+               |    |
                       |      |               +----+

 4. Opened flat        5. Corners up         6. Opened flat
      /\                    /\                    /\
     /  \                  /  \                  /  \
    /    \                /____\                \  /
    \    /                \    /                 \/
     \  /                  \  /
      \/                    \/

 7. Pulled apart: the boat
    \          /
     \________/
      \______/
```

> Common trouble spots If the diamond will not flatten, check that the layers are aligned and that the cuffs are folded in the right direction. If the boat leans to one side, the first half fold was probably off by a few millimetres. Start again on a fresh sheet: the second boat always goes faster than the first.

Challenges

Each challenge has a worked solution you can open after you have tried it.

CHALLENGE 1

Make a square from a sheet of A4 using the corner fold, then prove it is square by folding it along both diagonals. Write down the side length you measured and how far each diagonal crease differs from the

other, if at all.

→ Solution

CHALLENGE 2

On a spare square, fold a valley fold, then a mountain fold, then turn the paper over and describe what has happened to each crease. Then change the numbers in the script so it prints the square and leftover strip for A3 (297 mm by 420 mm) and for Letter paper (216 mm by 279 mm). Does the folding trick still give the same diagonal?

→ Solution

CHALLENGE 3

Fold the paper boat from a sheet of ordinary printer paper, then fold a second one from a small square (for example one quarter of an A4 sheet). Float both in a bowl or sink. Which one floats better, and why do you think that is? Write two sentences.

→ Solution

QUICK REFERENCE

- **Origami:** ori (folding) + kami (paper)
- **A4 to square:** fold a short edge onto a long edge, remove the strip, side = 210 mm
- **Valley fold:** toward you, dashed line
- **Mountain fold:** away from you, dash-dot line
- **Good crease:** align first, press from the middle, sharpen with a nail
- **First model:** paper boat, from a plain rectangle

Next, in Origami and Paper Folding 2, we learn to read the symbols used in fold diagrams, so you can follow any model in any book without a teacher.

Origami and Paper Folding

Course 1 · Chapter 2 · Reading Diagrams: Symbols, Steps and a Simple Box

In Origami and Paper Folding 1 you learned the two folds everything is built from, and you folded a boat by following a written list. Written lists get clumsy quickly, because "fold the lower-left corner of the top layer up to the midpoint of the right edge" is hard to follow and impossible to translate. Folders solved this long ago with a shared picture language. Once you can read it, you can fold from any book or website, in any language, without a teacher. This chapter teaches that language, the handful of names for the common starting folds, and finishes with a simple box.

Why Diagrams Beat Words

A diagram shows you the paper before the step, with a line and an arrow that say what to do to it. The next picture shows the result. If your paper matches the picture, you are on track, and if not, you spot the mistake straight away instead of ten folds later. The standard set of symbols is usually called the Yoshizawa-Randlett system, after the Japanese master Akira Yoshizawa, who developed the conventions, and Samuel Randlett, who helped bring them to a wider audience in the 1950s (check the exact dates and credits). Almost every modern book uses it, with small variations.

> A reading habit worth building Look at the *next* picture before you fold. The picture after the step shows where the paper should end up, and that makes the instruction much clearer than the line and arrow alone.

The Symbols You Need

You already know the first two. The rest are quick to learn, and a small set covers most beginner models. Small drawing details differ between books (check yours), but the meanings below are standard.

SYMBOL	DRAWN AS	MEANING
Valley fold line	Dashed line: - - - - -	Fold the paper toward you so the crease sinks
Mountain fold line	Dash-dot line: - . - . - .	Fold the paper away from you so the crease points up
Existing crease	Thin solid line	A crease you made earlier, or an edge of a folded layer
Fold arrow	Curved arrow ending in the place the paper moves to	Move the paper along the arrow (a solid head usually means valley, a hollow head mountain; check your source)
Fold and unfold	Arrow that goes there and back	Make a crease, then open the paper again (a pre-crease)
Turn over	Arrow looping over a short line	Flip the paper sideways, like turning a page
Rotate	Circular arrow	Turn the paper round on the table by the amount shown
Hidden edge	Dotted line	An edge or fold that is behind the top layer (an X-ray view)
Equal marks	Matching small ticks on two lengths	These two distances are the same
Repeat	A number beside an arrow, such as "x2"	Do this step on the other side, or the given number of times

```
# The two fold lines, drawn the way a diagram draws them

 Valley fold      - - - - - - - - - -
 Mountain fold    - . - . - . - . - .
 Existing crease  ----------------------
 Hidden edge      . . . . . . . . . . .

# Fold and unfold: the arrow goes out and comes back
        .----------.
        |          v
 ------- - - - - - - ------
```

Reading a Step Sequence

A model is a list of numbered pictures. Each picture shows the paper as it is *now*, plus what to do next. Here is how to read one, using a step you already know from the boat.

1. **Find the paper in the picture.** Compare it with your own: which corner is where, which side up?
2. **Find the line.** Is it dashed (valley) or dash-dot (mountain)? That tells you which way to fold.
3. **Follow the arrow.** The tip shows where the edge or corner lands. If the arrow tip touches a corner or an edge, line them up exactly.
4. **Check the next picture.** Your paper should now look like it.

```
# One step, read as a before and after

 Step 3                              Step 4
 valley fold the right edge          the result
 to the centre line

 +--------+--------+                 +--------+----+
 |        :        |                 |        |    |
 |        :     <--+                 |        |    |
 |        :        |                 |        |    |
 +--------+--------+                 +--------+----+
          :  centre line (existing)
```

Notice What Stays the Same

Anything the diagram does not change stays as it was. Beginners often re-fold or flatten something that has not been mentioned. If a step does not say to turn the paper over, do not turn it over. If a step says to "repeat on the other side", it will say so with an arrow or a number.

The Base-Fold Vocabulary

A lot of models begin with the same few folds, so folders gave them names. Knowing these names makes instructions shorter ("fold a blintz") and lets you spot patterns between models. Names vary between books (check), but these are the most common.

NAME	WHAT YOU DO	RESULT
Book fold	Fold the paper in half edge to edge, like closing a book	A rectangle, half the area

NAME	WHAT YOU DO	RESULT
Triangle fold	Fold the paper in half corner to corner	A right-angled triangle
Cupboard fold	Fold two opposite edges in to meet the centre line, like cupboard doors closing	A rectangle with the doors in front
Kite fold	Fold two edges that meet at a corner onto the diagonal	A kite shape
Blintz fold	Fold all four corners to the centre	A smaller square, turned 45 degrees

You will meet the larger bases, such as the preliminary base and the bird base, in Origami and Paper Folding 3. They are all built from these simpler folds.

One fact is worth knowing before you start: every time you fold something in half, you double the number of layers and halve the width. A short script makes the growth clear.

```
for n in range(0, 5):
    print('folds in half:', n, '  layers:', 2 ** n, '  strip width of a 210 mm square: %
```

Output when run:

```
folds in half: 0   layers: 1   strip width of a 210 mm square: 210.0 mm
folds in half: 1   layers: 2   strip width of a 210 mm square: 105.0 mm
folds in half: 2   layers: 4   strip width of a 210 mm square: 52.5 mm
folds in half: 3   layers: 8   strip width of a 210 mm square: 26.2 mm
folds in half: 4   layers: 16   strip width of a 210 mm square: 13.1 mm
```

> Why you can't fold forever Four folds in half already gives 16 layers, which is why thin paper matters and why thick printer paper fights you in complex models. This is also why the preliminary steps in advanced models are done in a fixed order, so you never have to fold through more layers than you have to.

Your Second Model: A Simple Box

Here is a small open box folded from a single square, with no cutting or glue. It is built entirely from the vocabulary above: a few pre-creases (fold and unfold), then a fold that raises the walls.

Use a 15 cm square of origami paper, or make a square from A4 as in Origami and Paper Folding 1. The box has a square base half the width of the paper, and walls a quarter of the width high.

```
for s in (150, 210):
    print('Square', s, 'mm -> creases at +/-', s / 4, 'mm from centre; base', s / 2, 'x'
```

Output when run:

```
Square 150 mm -> creases at +/- 37.5 mm from centre; base 75.0 x 75.0 mm; walls 37.5 mm
Square 210 mm -> creases at +/- 52.5 mm from centre; base 105.0 x 105.0 mm; walls 52.5 m
```

The Crease Map

Before folding, here is the finished crease pattern, as a diagram would draw it. The middle square becomes the floor, the four strips around it become the walls, and the four corner squares are the spare paper that gets tucked in.

```
# Crease map, looking at the paper. 4 x 4 grid of equal squares.
# F = floor, W = wall strip, C = corner square (tucked in)

 +-----+-----+-----+-----+
 |  C  |  W  |  W  |  C  |
 +-----+-----+-----+-----+
 |  W  |  F  |  F  |  W  |
 +-----+-----+-----+-----+
 |  W  |  F  |  F  |  W  |
 +-----+-----+-----+-----+
 |  C  |  W  |  W  |  C  |
 +-----+-----+-----+-----+

 Valley folds: the four lines around the floor
 Each corner square also has its diagonal crease
```

The Steps

1. **Pre-crease the diagonals.** Start with a square, coloured side down. Fold it in half corner to corner (triangle fold), crease, and unfold. Repeat with the other diagonal. Unfold completely.

These diagonal creases will run through all four corner squares.

2. **Pre-crease the centre lines.** Fold the square in half edge to edge (book fold), crease, and unfold. Repeat in the other direction. You now have a plus sign and an X of creases.
3. **Find the quarter lines.** Fold the left edge in to the centre crease, crease it, and unfold. Do the same with the right edge, then the top, then the bottom. Each of these folds is a valley fold on the coloured side. The paper now carries a 4 by 4 grid of creases, like the map above.
4. **Raise two walls.** Stand up the left and right wall strips so they are vertical. The corner squares at the ends will want to buckle in the middle: that is the diagonal crease at work.
5. **Raise the other two walls.** Lift the top and bottom strips up, and as you do, fold each corner square in half along its diagonal so it makes a small triangle, pointing into the box.
6. **Tuck the corners.** Fold each corner triangle flat against the outside of the nearest wall, and press the wall down along its crease so that it stays. Which way each corner tucks (inside or outside) depends on the paper, and either works (check which looks neater with yours).
7. **Square up the box.** Run a finger around the inside of the floor to sharpen the corners, and flatten the base on the table.

> Why this box matters The same box with a slightly larger square makes a lid that fits over it. You will build both, along with other boxes, in Origami and Paper Folding 6. For now, notice how the crease map came first: reading a crease map is the key skill behind every model in this course.

Challenges

Each challenge has a worked solution you can open after you have tried it.

CHALLENGE 1

Here are three diagram steps written out in words. Rewrite each as the symbols a diagram would use (line type, arrow, extra marks): (a) fold the bottom edge up to the top edge, then open it out again; (b) fold the left corner behind the paper to the centre; (c) turn the paper over, then rotate it a quarter turn clockwise.

→ Solution

CHALLENGE 2

Fold the simple box from a square of any size. Measure the base and the wall height with a ruler, and compare them with the numbers the script would give for your square. Then change the script to print the base and wall height for a 100 mm square and a 200 mm square, and say what happens when the paper is twice as wide.

→ Solution

CHALLENGE 3

Go back to the paper boat from Origami and Paper Folding 1. Write the first three folds as a diagram description in words and symbols: for each step, name the base-fold from the table (if one applies), the line type, and what the picture afterwards should look like. Then give your list to someone, or read it back yourself a day later, and fold from it alone.

→ Solution

QUICK REFERENCE

- **Valley:** dashed line. **Mountain:** dash-dot line
- **Existing crease:** thin solid line. **Hidden edge:** dotted line
- **Fold and unfold:** arrow there and back, makes a pre-crease
- **Reading a step:** find the paper, find the line, follow the arrow, check the next picture
- **Base folds:** book, triangle, cupboard, kite, blintz
- **Layers:** each fold in half doubles them
- **Second model:** simple box, base half the width, walls a quarter high

Next, in Origami and Paper Folding 3, we meet the classic bases (kite, fish, bird and frog, plus the preliminary base) and fold the crane, the model most people think of first when they hear the word origami.

Origami and Paper Folding

Course 1 · Chapter 3 · The Classic Bases: Starting Shapes and the Crane

In Origami and Paper Folding 2 you learned to read diagrams and met a handful of simple folds with names, such as the kite fold and the blintz fold. This chapter takes the next step up: the classic *bases*. A base is a standard sequence of folds that turns a flat square into a shape with a few flaps, and a very large number of models start from one. Learn five bases and you can begin hundreds of models. We finish with the crane, which is built from two of them in a row.

What a Base Is, and Why It Helps

Think of a base as a starting block. A base gives you a fixed number of flaps (the parts that will become wings, legs, heads or petals), and the rest of the model is a matter of shaping those flaps. Because the base is the same every time, folders memorise the base once and then spend their attention on the part that is new. Many books say "begin with a preliminary base" and expect you to know what that means, which is exactly why this chapter exists.

> Fold the base first, then ask what it could become Beginners often fold a model start to finish and never notice the structure. Try this instead: fold the base, look at its flaps, and ask what could grow from each one. That habit is the first step towards designing your own models, which we reach in Origami and Paper Folding 10.

The Five Classic Bases

Here is the family at a glance. Descriptions of the flaps are simplified, and different books count and name things slightly differently (check yours).

BASE	BUILT FROM	ROUGH SHAPE AND FLAPS	TYPICAL MODELS
Kite base	A kite fold at one corner	A kite shape with one long point and a short, wide end	Kites, simple fish, dog and cat faces (check)

BASE	BUILT FROM	ROUGH SHAPE AND FLAPS	TYPICAL MODELS
Fish base	Kite-style folds on the lower half of the square, then a pair of squash or reverse moves (check the exact order in your book)	A diamond with four points, two of them long and narrow	Fish, some birds and flowers
Preliminary base	Book folds and diagonal folds collapsed together	A small square of four flaps, open at one end, closed at the other	Crane (via the bird base), lily, many flapping models
Bird base	The preliminary base, plus a petal fold on each side	A long diamond with four narrow points	Crane, flapping bird
Frog base	The preliminary base, plus a squash fold on each flap	A star-like shape with four wide flaps (check)	Jumping frog, lotus-type flowers, many animals

Notice that the preliminary base appears in three rows. It is the parent of the family, and it is the one to learn first and learn well.

How Bases Branch

A tree makes the relationships easier to see than a table does. Each line below means "built by adding to":

```
# Which base grows from which (simplified)

square
├── kite fold ──────────► kite base
│                         └── fish base (check)
├── blintz fold ────────► (many other models)
└── preliminary base
    ├── petal folds ────► bird base ──► crane, flapping bird
    └── squash folds ───► frog base ──► jumping frog
```

The Kite Fold, With a Little Geometry

The kite fold is the simplest of these, and it hides a nice piece of arithmetic. Take a square, pre-crease one diagonal, then fold the two edges that meet at one corner in to lie along that diagonal. Each folded edge is as long as the side of the square, so its far end lands on the diagonal. The crease runs from that corner to the opposite edge and cuts the corner angle in half. A right angle halves to 45 degrees at the kite's tip, and each crease makes 22.5 degrees with the diagonal. A tiny script gives the distances for any size of paper:

```
import math

for s in (150, 210):
    d = s * math.tan(math.radians(22.5))
    print('Square', s, 'mm -> crease meets the far edge', round(d, 1), 'mm from the corn
```

Output when run:

```
Square 150 mm -> crease meets the far edge 62.1 mm from the corner; diagonal 212.1 mm
Square 210 mm -> crease meets the far edge 87.0 mm from the corner; diagonal 297.0 mm
```

The "corner" in the output is the corner whose edge folds in. Measure it on your own paper: if the crease lands within a millimetre or two of the printed number, your fold is accurate. The 210 mm row also shows a neat fact: the diagonal of a 210 mm square is 297 mm, the long side of A4, which is no accident, since A4 is designed so that the ratio of its sides is the square root of 2 (check the standard if you want the details).

The Preliminary Base: Learn This One Well

The preliminary base (sometimes called the square base) is built from the pre-creases you already know. It is a small square-looking shape with four flaps, and it collapses almost by itself once the creases are right.

The Crease Map

Here is the paper opened out, with every crease the base needs, as seen from one face. The diagonals are mountain folds and the centre lines are valley folds, which is the key to the collapse.

```
# Preliminary base, seen from the face where the centre lines are valley folds
# \ and / = diagonal (mountain)     - and | = centre line (valley)

 +-----------+-----------+
 |\          |          /|
 |  \        |        /  |
 |    \      |      /    |
 |      \    |    /      |
 |        \  |  /        |
 +- - - - - X - - - - - -+
 |        /  |  \        |
 |      /    |    \      |
 |    /      |      \    |
 |  /        |        \  |
 |/          |          \|
 +-----------+-----------+
```

The rule is the same in every quarter: the lines through the middle that run parallel to the sides go one way, and the diagonals go the other. That alternation, valley then mountain around the centre, is what lets the paper fold flat. We will see in Origami and Paper Folding 9 that this is not luck but a rule.

The Steps

1. **Pre-crease the diagonals.** Start with a square, coloured side up. Fold it in half corner to corner both ways (triangle folds), creasing firmly each time, and unfold.
2. **Turn the paper over.** Fold it in half edge to edge in both directions (book folds), crease, and unfold. You should now have all four creases, and the paper will want to make a low pyramid on the table.
3. **Make the pyramid.** Hold the paper with the centre-line valleys facing you and let the middle rise into a low pyramid: the diagonals ride up as mountains and the centre lines dip as valleys.
4. **Bring the corners together.** Take the left and right edge midpoints and move them toward each other, folding along the centre lines. The top and bottom edge midpoints fold in on themselves, and the four corners come together at one point.
5. **Flatten.** Press the whole shape flat. You now have a small diamond (or square, when held a quarter turn) with four flaps, a closed end where the folds meet, and an open end at the bottom where the four original corners of the paper are gathered.

If it will not collapse A stubborn collapse almost always means one crease is going the wrong way. Open the paper out and compare it with the crease map: valleys on the centre lines, mountains on the diagonals, all four sharp. If the paper still fights you, re-crease each line in both directions once, and try again.

The Bird Base: Adding Petal Folds

The bird base is the preliminary base with its front and back flaps stretched into long points. The move that does it is called a **petal fold**, and it gets its own proper treatment in Origami and Paper Folding 4. Here you only need to follow it once, and the diagram steps are a good place to practise what you learned in Origami and Paper Folding 2.

1. **Set up the base.** Hold the preliminary base with the open end pointing down, towards you. Work on the front layer first.
2. **Fold the edges in.** Fold the two lower edges of the front layer in to the centre line (a kite fold). Fold the top triangle down over them, crease firmly across, then unfold all three folds.
3. **Lift and flatten.** Lift the bottom corner of the front layer up, and as it rises, the side creases fold in and the top crease acts as a hinge. Flatten it so the layer becomes a long narrow diamond. This is the petal fold.
4. **Turn over and repeat.** Do the same on the back. The result is the bird base, with a closed point at the top, two narrow flaps at the bottom, and two narrow flaps above them on either side (check how your book orients the base).

Crease first, then collapse Steps 2 and 3 show a pattern you will use constantly: make the creases while the paper is flat, unfold, then let the collapse happen all in one move. A collapse is much easier than folding each part separately, because the paper already knows where to go.

The Frog Base in Brief

The frog base starts at the same place as the bird base, the preliminary base, but takes a different turn. Instead of petal folds, you open each of the four flaps and flatten it into a square with a **squash fold** (also covered in Origami and Paper Folding 4). The result is a base with four wide flaps arranged like a star, much better for models that want broad legs. You will use it in

earnest in Origami and Paper Folding 5, so for now it is enough to know it exists and where it comes from.

Your Third Model: The Crane

The crane is the model most people think of first when they hear the word origami. In Japan it is a symbol of long life and good fortune (check), and the story of folding a thousand of them, called *senbazuru*, is told in many places, usually as a wish for health or peace (check the details if you plan to quote the story). Here is the arithmetic of that thousand, since it makes a good side note:

```
# How much paper does a thousand small squares take?
w, h, q = 210, 297, 75
per = (w // q) * (h // q)
print('A4 sheet:', w, 'x', h, 'mm; squares of', q, 'mm per sheet:', per)
print('Sheets for 1000 squares:', -(-1000 // per))
```

Output when run:

```
A4 sheet: 210 x 297 mm; squares of 75 mm per sheet: 6
Sheets for 1000 squares: 167
```

That is the paper count if you cut from A4 sheets with no clever layout (a 75 mm square is a comfortable size for small cranes). For your first crane, use a 15 cm square so the folds are easy to see.

The Steps

1. **Fold the preliminary base.** Follow the steps above, and flatten it with the open end pointing down.
2. **Fold the bird base.** Make the petal fold on the front, turn over, and make it on the back.
3. **Narrow the legs.** With the two split flaps at the bottom, fold the lower left and lower right edges of the front layer in to the centre line. Turn the model over and do the same on the back. The two bottom flaps are now thin.
4. **Fold the legs up (inside reverse folds).** Fold the two thin flaps up, one to the left and one to the right, so they point upward at a steep angle. To do it, crease each flap first, open it

slightly, and push the point up into the inside of the model so the crease becomes an inside reverse fold (more in Origami and Paper Folding 4). One flap will be the neck, the other the tail.

5. **Make the head.** On the flap that is the neck, make a small inside reverse fold at its tip, folding the point down. That is the beak and head.
6. **Lower the wings.** Fold the two upper flaps down on each side so they sit out like wings. Gently pull them apart, and press the body so it puffs out slightly. If you blow into the little hole at the bottom of the body, it will inflate (check the hole is there on your model).

> Which colour ends up outside? The side you start with decides which colour ends on the outside. Fold the preliminary base once and see which face shows. If it is the wrong colour, start again from the other side (check against your paper). It is a common trap with printed or two-tone paper.

Challenges

Each challenge has a worked solution you can open after you have tried it.

CHALLENGE 1

Make a kite fold on a square of any size you like. Measure how far along the far edge the crease lands, and compare it with the number the script gives for your square. Then change the script to print the crease distance for a 100 mm and a 200 mm square, and say what happens when the paper is twice as wide.

→ Solution

CHALLENGE 2

Fold the preliminary base, then open it out and look at the creases. Without looking back at the crease map, draw the pattern on paper, mark each line as valley or mountain, and say which face you were looking at. Then fold it back up and count: how many flaps does the base have, and how many layers are there at the open end?

→ Solution

CHALLENGE 3

Fold the crane. When it is done, name the base each part came from: the body, the wings, the neck, the tail and the head. Then change the sheet-count script to work out how many sheets of A4 you would need for 1000 squares of 100 mm, and compare the answer with the 75 mm case.

→ Solution

QUICK REFERENCE

- **Base:** a standard fold sequence that gives a fixed set of flaps
- **Kite base:** kite fold at one corner, crease at 22.5 degrees to the diagonal
- **Preliminary base:** centre lines valley, diagonals mountain, collapse to four flaps
- **Bird base:** preliminary base plus petal folds, front and back
- **Frog base:** preliminary base plus squash folds on each flap
- **Make the creases flat, then collapse in one move**
- **Third model:** the crane, built from the preliminary base then the bird base

Next, in Origami and Paper Folding 4, we take a close look at the techniques you borrowed in this chapter, reverse folds, squash folds, petal folds and sinks, and fold the flapping bird.

Origami and Paper Folding

Course 1 · Chapter 4 · Folding Techniques: Reverse, Squash, Petal and Sink

In Origami and Paper Folding 3 you borrowed three techniques without much explanation: the inside reverse fold for the crane's neck and tail, the squash fold for the frog base, and the petal fold for the bird base. This chapter slows down and teaches them properly, adds a fourth (the sink), and then puts them to work in the flapping bird. These four moves, plus the valley and mountain folds you already own, are behind most traditional models. Once your hands know them, a diagram stops being a puzzle and becomes a recipe.

The Technique Family at a Glance

Every technique here is really a valley and a mountain fold done together on layered paper, with a specific crease-first, collapse-second rhythm. Here is how they compare. Descriptions are simplified, and different books vary slightly in naming (check yours).

TECHNIQUE	WHAT IT DOES	CREASE FIRST?	TYPICAL USE
Inside reverse fold	Tucks a point into the model, so the point swings the other way	Yes, fold and unfold	Necks, legs, tails, beaks
Outside reverse fold	Wraps a point around the outside of the model	Yes, fold and unfold	Heads, feet, folded-back tails
Squash fold	Opens a flap and presses it flat into a new shape	Usually a single crease	Frog base, widening a flap
Petal fold	Lifts a layer into a long, narrow point	Yes, three creases	Bird base, lily, flower petals
Sink fold	Pushes a point or corner down into the model	Yes, essential	Tidy tips, bases, box corners (check)

The Reverse Folds

A reverse fold changes the direction a point is facing. You make a diagonal crease across a narrow flap, open the flap slightly, and then push the tip so that the crease reverses and the

point folds over onto itself. The difference between the two kinds is simply where the folded part ends up: inside the model, hidden between its layers, or outside, wrapped around it.

The Inside Reverse Fold

This is the one you used for the crane. Practise it on a plain flap, such as one half of a kite base, before using it on a model.

1. **Fold the flap the way you want the point to go.** Crease firmly along the line where the bend will be, then unfold. A sharp crease matters more here than anywhere.
2. **Open the flap slightly.** Gently separate the two layers of the flap at the tip, like opening a book a few degrees.
3. **Push the tip in and up.** Hold the crease and push the tip towards the inside of the model. The crease turns inside out, and the point swings over onto the other side.
4. **Flatten.** Press the whole shape flat, checking that the two sides of the reversed section are mirror images.

The Outside Reverse Fold

The outside reverse fold uses the same crease but the opposite move. Instead of pushing the tip inside, open the model along its spine and wrap the tip around the outside, so the point wraps round the outer layers. It is the move behind many heads and beaks, where you want a clean outer surface with no visible inner layers.

> Inside or outside? Look at the crease If the crease you made is a valley fold when seen from the front, you are about to make an inside reverse fold. If you are about to wrap, the central spine becomes the hinge and the crease flips to the other side. When a diagram's arrow points into the model, the fold goes inside; when it wraps around, it goes outside (check the arrow convention you learned in Origami and Paper Folding 2).

The Squash Fold

A squash fold does what the name says: you open a flap and press it flat so it spreads sideways into a new shape, usually a square or a diamond. The frog base is made of four of them.

1. **Make the crease line.** A squash fold needs one crease from the base of the flap up through its middle. Fold the flap in half along its centre line and unfold.

2. **Lift the flap.** Open the flap and slide a finger inside, lifting its upper layer.
3. **Press down.** Push the lifted layer to one side. Because the centre line is already creased, the layer lands in a neat symmetric shape.
4. **Flatten and check.** The edge that was on the centre line now lies along the side, and the top is a clean point.

> Uneven squashes A lopsided squash usually means the centre crease was not sharp, or the flap was lifted off-centre. Unfold, re-crease the centre line, and try again. A flap that is too thick to squash neatly is a hint to use thinner paper, which we come back to below.

The Petal Fold

The petal fold is a squash and a reverse fold in one collapse. You met it in outline in Origami and Paper Folding 3. Here it is again, step by step, with the reasoning behind each crease.

1. **Start from the preliminary base** with the open end pointing towards you and the closed point at the top. Work on the front layer.
2. **Kite-fold the front layer.** Fold the two lower edges in to meet the centre line, crease firmly, and unfold. These creases tell the paper where the side edges will go.
3. **Mark the hinge.** Fold the top triangle of the front layer down over the kite folds, crease across the line where the side creases cross the centre line, and unfold.
4. **Lift and collapse.** Lift the bottom corner of the front layer up. As it rises, the top crease hinges, and the two side creases fold in. Flatten and a narrow diamond appears.
5. **Repeat on the back.** Turn over and make the same petal fold.

The crease map below shows the front layer opened out, with the three creases and the point that rises:

```
# Front layer of the preliminary base, shown for the petal fold
# \ and / = kite creases (valley)    - = hinge crease (valley)
# the bottom corner is lifted up to the hinge

          /\
         /  \
        /    \
       /      \
```

```
      /--------\ <- hinge crease
     / \      / \
    /   \    /   \
   /     \  /     \
  /_______\/_______\
          ^
      lift this corner
```

The Sink Fold

A sink fold pushes a corner or a point down into the body of the model so that it vanishes inside, leaving a flat or slightly dented top. It is the most advanced of the four: the creases around the point have to flip from mountain to valley all at once. You do not need it for the flapping bird, but you should try it once now, because it appears in later chapters.

1. **Fold the corner over.** Fold the point down to the depth you want it to sink, crease firmly, and unfold. This crease marks the bottom of the dent.
2. **Crease the sides.** Pre-crease the edges of the shape that will fold in, so that the sunk part forms a small triangle of valley folds inside.
3. **Open slightly and push.** Open the layers a little and push the point inwards. The creases around the dent flip from mountain to valley.
4. **Collapse flat.** Press the model flat. If it will not collapse, one crease is not flipping, so find it and flip it by hand.

> An easy practice sink Practise on a preliminary base. Fold the top point down, crease, unfold, and then push the point in. Because every layer is the same shape, you can see what flips. It gets easier on the second try.

Precision and Tidiness

A good fold is not just about the right move. It is about the same small habits, repeated on every crease. Here are the ones that matter most, roughly in order of payoff:

- **Line up edges before you crease.** Hold the edges together, check from above, and only then press the crease.

- **Crease from the middle outwards.** Start in the centre of the fold and drag your thumbnail towards the edge, so the paper cannot slip.
- **Fold on a hard, flat surface.** A table, not a pillow or a cloth.
- **Fold as few layers at once as you can.** Each layer adds a little thickness.
- **Unfold and refold a bad crease once.** A second try is better than a third, because paper fibres tire.

Why Layers Matter: A Little Arithmetic

Each fold doubles the number of layers where the paper is folded flat. Paper is thin, but the doubling adds up fast. This script assumes ordinary copy paper, about 0.08 mm thick (check the thickness of your own paper), and also shows how small errors add up:

```
t = 0.08
for n in range(1, 8):
    print('Folds', n, '-> layers', 2**n, '-> stack', round(2**n*t, 2), 'mm')
print()
err = 0.5
for n in (1, 2, 4, 8):
    print(n, 'creases:', n*err, 'mm of drift')
```

Output when run:

```
Folds 1 -> layers 2 -> stack 0.16 mm
Folds 2 -> layers 4 -> stack 0.32 mm
Folds 3 -> layers 8 -> stack 0.64 mm
Folds 4 -> layers 16 -> stack 1.28 mm
Folds 5 -> layers 32 -> stack 2.56 mm
Folds 6 -> layers 64 -> stack 5.12 mm
Folds 7 -> layers 128 -> stack 10.24 mm

1 creases: 0.5 mm of drift
2 creases: 1.0 mm of drift
4 creases: 2.0 mm of drift
8 creases: 4.0 mm of drift
```

Two lessons come out of this. First, seven simple folds in the same place would already give a stack about a centimetre thick, which is why models never do it, and why thin paper is kinder to complicated models. Second, a half-millimetre slip on each crease looks harmless, but after

eight creases the model is out by 4 mm and the last folds will not meet. Accuracy early in the sequence is worth far more than accuracy at the end.

Your Fourth Model: The Flapping Bird

The flapping bird is the classic traditional model that moves: pull the tail gently and the wings flap. It is built from the bird base (Origami and Paper Folding 3) and uses an inside reverse fold for the neck and another for the head. Use a 15 cm square, coloured side up to start.

The Steps

1. **Fold the preliminary base,** then the bird base: petal fold the front, turn over, petal fold the back. The two long, narrow points hang at the bottom and the closed point is at the top.
2. **Check the layers.** The bird base has a split at the bottom: two narrow points that are the neck and the tail. The two upper flaps on each side are the wings.
3. **Narrow the neck and tail.** If your base has loose edges, fold each lower edge of the two long points in to the centre line, front and back, so they are slim (check against your diagram).
4. **Make the neck (inside reverse fold).** Pick one long point, crease it up at a steep angle, unfold, open, and push it up inside the model. It now points upward and slightly backward.
5. **Make the tail (inside reverse fold).** Do the same with the other long point, so it points up on the other side. Make the two points roughly the same length.
6. **Make the head.** On the neck, make a small inside reverse fold at the tip, folding the point down for the beak. Keep the crease small.
7. **Make the wings.** Fold the two wing flaps down on each side so they lie out from the body, one front and one back, then bring them back up slightly so they stand open.
8. **Make it flap.** Hold the bird by the point where the neck and body meet, with one hand, and gently pull the tail straight down with the other. The wings move up and down. Release and they relax.

> If the wings will not move The wings flap because the body can bend at the join. If it will not flap, the neck or tail folds may be too tight, or the wings may be creased too sharply near the body. Soften the crease with a thumb and try again (check by comparing with a bird that flaps).

Challenges

Each challenge has a worked solution you can open after you have tried it.

CHALLENGE 1

Take a square of scrap paper and fold a preliminary base. On the front layer practise the inside reverse fold: fold up one of the narrow points, crease, unfold, open and push it in. Then do the outside reverse fold on a different point of the same model. Say in your own words how the two results look different.

→ Solution

CHALLENGE 2

Fold a bird base, then open it out and look at the creases. How many petal folds were made, and how many creases does each petal fold use? Then change the script above so the paper thickness is 0.1 mm, and say how many folds it takes before the stack goes beyond 10 mm.

→ Solution

CHALLENGE 3

Fold the flapping bird from a 15 cm square. When it is finished, test it: does it flap smoothly? If not, find out why and fix it. Then fold a second bird from a 10 cm square and compare. Which was easier to fold accurately, and which flaps better?

→ Solution

QUICK REFERENCE

- **Inside reverse fold:** crease, unfold, open, push the point into the model
- **Outside reverse fold:** the same crease, but the point wraps around the outside
- **Squash fold:** open a flap and press it flat along a centre crease
- **Petal fold:** three creases, lift the corner, collapse into a long point
- **Sink fold:** push a point down into the model; the creases flip
- **Precision:** line up, crease from the middle out, fewest layers possible

- **Fourth model:** the flapping bird, from the bird base

Next, in Origami and Paper Folding 5, we put these techniques to work on animals: turning flaps into legs, heads and tails, and folding a fox, a rabbit and a jumping frog.

Origami and Paper Folding

Course 1 · Chapter 5 · Animals: Flaps Become Legs, Heads and Tails

With the reverse, squash, petal and sink folds from Origami and Paper Folding 4, you can now do what origami is best known for: turn a square into a creature. The trick is not to memorise a dozen animals. It is to see that every animal is a handful of flaps, and each flap is given a job. A long flap can be a tail or a neck, a short one an ear or a foot, and a reverse fold gives it a joint. This chapter teaches that way of looking, then folds three animals: a fox, a rabbit and a jumping frog.

Flaps as Anatomy

Every base you met in Origami and Paper Folding 3 has a fixed number of flaps. Choosing an animal is mostly choosing the base whose flaps match the animal's parts. The table is a guide, not a law (diagrams vary, so check yours).

BASE	FLAPS	GOOD FOR	FLAP JOBS
Kite base	1 long point, 2 short side points	Fox, dog and cat faces	Long point = nose, side points = ears
Fish base	2 long points, 2 short points	Fish, simple four-legged animals	Long = head and tail, short = fins or ears
Bird base	2 long points, 2 wings	Birds, swans, long-necked animals	Long = neck and tail, wings = wings
Frog base	4 equal points	Frogs, four-legged animals	Front pair = arms or ears, back pair = legs

Three Moves for Giving a Flap a Job

- **Shorten it.** Fold the tip over or reverse-fold it, so a long flap becomes a short one. Ears and feet are made this way.
- **Bend it.** An inside reverse fold puts a joint in the flap. A neck gains a head, a leg gains a knee.
- **Narrow it.** Fold the two edges to the centre line. Thin flaps read as legs, tails and necks; wide ones read as bodies.

How Long Is a Flap?

Before folding, it helps to know roughly how long each flap will be, because the size of the square decides how much animal you get. In a frog base the points are about 0.7 times the side of the square (a simplification: your folds will shave a little off). This script plans a model with short legs half the length of the flaps:

```
import math
for side in (10, 15, 20):
    flap = side * math.sqrt(2) / 2
    print(side, 'cm square -> flap', round(flap, 2), 'cm, short leg', round(flap / 2, 2)
```

Output when run:

```
10 cm square -> flap 7.07 cm, short leg 3.54 cm
15 cm square -> flap 10.61 cm, short leg 5.3 cm
20 cm square -> flap 14.14 cm, short leg 7.07 cm
```

A 10 cm square gives you a small animal with legs under 4 cm, which is fiddly. For a first attempt, use 15 cm or larger.

Model 1: The Fox Face

The fox is the classic first animal because it is a kite base with the flaps given jobs. Use a square with a coloured side (orange or red) face down.

1. **Fold in half diagonally,** coloured side outside, to make a triangle with the long edge at the top. Crease, unfold, and turn so a corner points down.
2. **Fold the two side corners down** so they meet at the bottom point. You now have a diamond with the fold line across the middle.
3. **Make the ears.** Fold the left and right top corners down at a slant, so each corner makes a small triangle. These are the ears, and the angle sets how pointed they are.
4. **Make the face.** Fold the bottom point up a short way, so the nose is a small triangle. Crease firmly.

5. **Check the symmetry.** Hold the fox up to the light. Both ears should be the same size, and the nose should sit on the centre line.

A face with only a few folds teaches an important point: small changes in the angle of one fold change the whole expression. Try making a fox with wide ears and one with narrow ones, and see which looks friendlier.

Model 2: The Rabbit

The rabbit adds a technique: the long ears are made by narrowing a flap and reverse-folding it, so the animal gets a pair of tall ears and a short body from one square.

1. **Start with a fish base.** Keep the two long points at the bottom and the short points at the sides.
2. **Narrow the long points.** Fold the edges of each to the centre line to slim them.
3. **Make the ears.** Bend each long point up using an inside reverse fold, so the ears stand up on either side of the head.
4. **Shape the head.** Fold the head's tip down with a small inside reverse fold to form the nose.
5. **Make the tail.** Fold the back point under or in with a small inside reverse fold.
6. **Stand it up.** Open the base slightly so the model stands on its flat base, and adjust the ears by eye.

> Ears that droop Soft ears usually mean the inside reverse fold was not creased before it was pushed in. Unfold, crease sharply from the base of the ear outwards, and refold. Slimming the ear once more also helps (check how your book does it).

Model 3: The Jumping Frog

The jumping frog is an old favourite because it does something: press the back and it hops. It is built from a rectangle rather than a square, so use a piece of paper cut or folded to roughly 2:3 (for example, 10 cm by 15 cm). Heavier paper makes a better jumper.

1. **Fold the rectangle in half** lengthways and unfold, to mark the centre line.
2. **Fold the top corners** to the centre line to make a point at the top, like a house roof.

3. **Fold the sides in.** Fold the left and right edges in to the centre line, then fold the point back down.
4. **Make the front legs.** At the top, fold the two corners out to the sides at an angle, so each makes a little leg.
5. **Make the back legs.** Fold the lower corners up and across, then fold them back down so they lie against the sides.
6. **Make the spring.** Fold the bottom edge up to the middle, then fold it back down halfway, like a concertina, so it sits as a flat Z shape.
7. **Jump.** Place the frog on a table and press down gently on the back, then slide your finger off quickly. The Z-fold releases and the frog hops.

> Frog will not jump A soft or thin Z-fold stores no energy. Re-crease the spring sharply with your fingernail, use stiffer paper, and press on the middle of the back. If it jumps sideways, the Z-fold is crooked, so refold it with the edges lined up.

Why the Same Skills Make Different Animals

Look at what the three models share. Each starts from a base, narrows some flaps, shortens others, and bends the rest with reverse folds. That small toolkit is why origami books can show hundreds of animals using only a handful of techniques. Once you can read a model as flaps with jobs, you can often see how an unfamiliar animal is folded before you open the diagram.

Challenges

Each challenge has a worked solution you can open after you have tried it.

CHALLENGE 1

Fold two foxes with different ear angles, one wide and one narrow. Hold them side by side and describe how the expression changes. Which angle looks most like a real fox?

→ Solution

CHALLENGE 2

Fold the rabbit from a 15 cm square. Then label each flap with its job (ear, nose, tail, body) and say which of the three moves (shorten, bend, narrow) was used on each one.

→ Solution

CHALLENGE 3

Fold the jumping frog and hold a jumping contest: three attempts each, measuring the distance. Then change one thing (stiffer paper, a sharper spring, or a longer back leg) and see if it jumps further. Record your results.

→ Solution

QUICK REFERENCE

- **Animals:** a base, with each flap given a job
- **Shorten:** fold or reverse-fold the tip of a flap
- **Bend:** an inside reverse fold adds a joint
- **Narrow:** fold the edges to the centre line
- **Flap length:** about 0.7 times the side of the square
- **Fifth models:** the fox, the rabbit and the jumping frog

Next, in Origami and Paper Folding 6, we move from animals to flowers and boxes: a tulip, a lily, a masu box with a lid, and a first taste of wet-folding.

Origami and Paper Folding

Course 1 · Chapter 6 · Flowers and Boxes: Shapes That Hold Something

After the animals of Origami and Paper Folding 5, this chapter turns to two kinds of model that people actually keep: flowers, which last longer than the real thing, and boxes, which hold small objects. They look unrelated, but they rest on the same skills. Flowers use the preliminary base and shaping from earlier chapters. Boxes depend on precise, evenly divided squares, so they reward the careful creasing you practised before. The chapter ends with a first taste of wet-folding, a technique that gives paper soft, rounded curves.

Flowers: Folding Then Shaping

A paper flower has two stages. First you fold the form (petals, a stem, a cup), then you shape it by curling, pinching and opening it. The second stage is what makes a flower look alive, so do not rush it.

Model 1: The Tulip

The tulip is a good first flower because the bloom is a short run of folds and the stem and leaf are separate, simple pieces. Use a red or yellow square for the bloom and a green square for the stem.

1. **Make the preliminary base** from the bloom square, with the coloured side outside, as in Origami and Paper Folding 3.
2. **Fold the two lower edges** of the front layer to the centre line, then repeat on the back. This narrows the base to a kite-like shape with a point at the bottom.
3. **Make the petals.** Fold the top flaps of the front and back layers down a short way, so the pointed tips of the petals show.
4. **Open the bloom.** Hold the bottom point and gently pull the top layers apart, then blow into the small hole at the bottom (the paper balloon trick). The petals round out into a cup.
5. **Make the stem.** Take the green square, fold it in half diagonally, then fold both lower edges to the centre line. This makes a long thin point. Roll it into a thin stick with a short leaf left free.
6. **Join them.** Push the stem's tip into the small hole at the base of the bloom and add a dab of glue if you want it to stay put.

> A smoother tulip looks better If the bloom looks lumpy rather than round, it usually means the creases were not sharp before the bloom was opened. Re-crease the flaps flat, then open it again, shaping with a fingertip from inside rather than squeezing the outside.

Model 2: The Lily

The lily uses the same base but spreads it into a star shape. It needs a larger square, as the petals curl outwards and look best with room to move. Use a square of 15 cm or more.

1. **Make the preliminary base** again, with the open end at the bottom this time.
2. **Fold the lower edges to the centre line** on the front and back layers, as for the tulip, to make a kite-like shape.
3. **Fold the top flaps down.** Fold the top flap on each of the four sides down so the points show, giving four petals.
4. **Curl the petals.** Wrap each petal tip around a pencil to roll it backwards in a gentle curl. The curl turns a stiff diamond into a trumpet.
5. **Open and arrange.** Open the bloom from the bottom, spread the four petals, and press the centre down slightly to give it a hollow throat.

The Masu Box

The masu is a traditional Japanese box, originally a wooden measure for rice and sake. The folded version is made from one square and is the most useful model in this chapter: it is sturdy, stackable, and can be made in any size. Because it is made by dividing a square into thirds, accuracy matters more here than on any model so far.

Folding the Box

1. **Mark the centre.** Fold the square in half both ways, crease sharply and unfold. The creases cross at the centre.
2. **Fold the corners to the centre.** You now have a smaller square, like an envelope.
3. **Fold two opposite edges** to the centre line. You now have a rectangle.
4. **Unfold the last two folds** so the paper is divided by creases into a grid of nine areas, with the four corners folded in.

5. **Fold the other pair of opposite edges** to the centre line, then unfold them. Every crease the box needs is now on the paper.
6. **Raise the walls.** Open two opposite corner flaps, lift the side wall upright along its crease, and push the corner flap down and inside so it locks the wall in place. Repeat for the opposite side.
7. **Finish the box.** Fold the remaining two walls up and tuck the flaps inside the box so they lie flat against the floor. Press all four corners square.

The Lid

The lid is made exactly like the box, but from a slightly larger square. If the box was folded from a 15 cm square, fold the lid from a 16 cm square, so the lid slides on without being loose. Folding the lid in a different colour makes a gift box with a clear top.

Planning a Box

The finished masu has a square floor whose side is about one third of the paper's side, because the square is divided in thirds (thin paper gives a slightly larger floor and thick paper a slightly smaller one, so treat the result as a guide). The script below plans a box and a matching lid for a few paper sizes:

```
for side in (12, 15, 20):
    box = side / 3
    lid = side + 1
    print(side, 'cm paper -> box floor', round(box, 1), 'cm, lid paper', lid, 'cm')
```

Output when run:

```
12 cm paper -> box floor 4.0 cm, lid paper 13 cm
15 cm paper -> box floor 5.0 cm, lid paper 16 cm
20 cm paper -> box floor 6.7 cm, lid paper 21 cm
```

Gift Boxes

Once the masu works, the same idea scales to other boxes. The table compares the common choices.

BOX	MADE FROM	STRENGTH	BEST FOR
Masu box	One square	Good: walls lock in place	Sweets, small gifts, desk tidy
Masu with lid	Two squares, lid slightly larger	Good: stackable	Gift boxes
Divided box	Several small masus in one larger box	Good, if the sizes match	Sorting beads, buttons or pins
Pinch-top box	One square, with a tucked lid	Medium	Flat gifts, such as cards

> Box will not close If the lid sticks or the box walls bow out, the paper was not divided evenly. Unfold and compare the creases with a ruler: they should split the square into three equal bands. A box folded from rectangular paper will never lock square, so check your starting square first (see Origami and Paper Folding 1 for squaring A4).

A First Taste of Wet-Folding

Everything so far has been dry-folding: crisp, sharp creases in dry paper. Wet-folding, developed by Akira Yoshizawa, uses slightly dampened paper to make soft, rounded forms with no sharp edges. It is how folders produce curved petals, plump animals and models that look sculpted rather than folded.

The Idea

- **Damp paper bends smoothly.** Water loosens the fibres, so the paper can be shaped into curves, and it then dries stiff in that shape.
- **The paper matters.** Thick, strong paper with a size or coating (watercolour paper and some handmade papers) survives dampening. Ordinary copy paper turns to pulp.
- **Work in stages.** Fold the model flat first, then dampen lightly with a sponge and shape it before it dries.

> Try it safely For a first test, take a spare tulip bloom folded from watercolour paper. Brush the outside very lightly with a damp sponge, shape the petals round with your fingers, then leave it to dry. If the paper wrinkles or tears, it was too wet or too thin, so use less water next time.

Challenges

Each challenge has a worked solution you can open after you have tried it.

CHALLENGE 1

Fold a tulip and a lily from squares of the same size. List two differences in how they are shaped, then say which one was harder to open and why.

→ Solution

CHALLENGE 2

Fold a masu box and a matching lid from squares of 15 cm and 16 cm. Check that the lid slides on without being loose or tight. If it is wrong, say which crease is probably off.

→ Solution

CHALLENGE 3

Use the planning script to find the floor size of a box folded from 18 cm paper. Fold it, measure the floor and compare with the prediction. Then fold one more from watercolour paper, use the wet-folding idea on the walls, and describe the difference.

→ Solution

QUICK REFERENCE

- **Flowers:** fold the form first, then shape it
- **Tulip and lily:** preliminary base, petals folded down, then opened
- **Masu box:** a square divided into thirds, walls locked by the corner flaps
- **Lid:** the same fold from a slightly larger square
- **Floor size:** about one third of the paper's side
- **Wet-folding:** lightly damp, strong paper for soft curves

Next, in Origami and Paper Folding 7, we move from single sheets to modular origami: units that lock together, the sonobe unit, and how to build a cube and a star.

Origami and Paper Folding

Course 1 · Chapter 7 · Modular Origami: Many Sheets, One Model

Every model in Origami and Paper Folding 1 to 6 came from a single sheet. Modular origami breaks that rule on purpose. You fold several identical pieces, called units, and lock them together without glue. Each unit is simple, so the skill shifts from clever folding to being accurate and repeating the same fold many times. The reward is models that would be impossible from one square: cubes, stars and balls with many points.

How Units Lock Together

A modular unit has two kinds of feature. A **pocket** is a fold of paper with an opening, and a **tab** (or flap) is a point that slides into a pocket. When every unit has tabs and pockets in matching places, units grip each other by friction, and the finished model holds itself together.

- **Identical units.** Most modular models use one unit, repeated. Making them all the same is what makes the result symmetrical.
- **Colour as a design tool.** Using three or four colours in a fixed pattern turns a plain model into a decorated one, with no extra folding.
- **Small squares work well.** Squares of 7.5 cm (a 15 cm square cut in four) are easy to hold and give a model that fits on the palm.

The Sonobe Unit

The sonobe is the best-known modular unit. It makes a shallow parallelogram with two tabs and two pockets. Fold one carefully, then check it against the description below before making more.

1. **Start with a square,** coloured side down. Fold it in half and unfold, leaving a centre crease.
2. **Fold both long edges to the centre crease,** then unfold them. You now have three equal creases across the square.
3. **Turn the paper over.** Fold the lower left corner up and the upper right corner down so that each corner's edge lines up with the nearest quarter crease, forming two small triangles on opposite ends.

4. **Fold the long edges back in** to the centre crease, folding over the triangles. This gives a long parallelogram.
5. **Fold the two triangular points over** along the line where they meet the strip, so each end of the strip is tucked into a neat triangle.
6. **Fold the unit in half** along the centre crease and open it slightly. You should see two triangular tabs at the ends and two pockets running along the inside.

> Fold one, then fold them all Make a test unit from scrap paper first. When you are happy with it, fold all the units for a model in a single sitting, as your folding gets neater and more consistent by the third or fourth unit.

The Models

The same unit builds different models. The only thing that changes is how many units you use and how you connect them.

MODEL	UNITS	COLOURS	DIFFICULTY
Cube	6	3 colours, 2 units each	Easy
Octahedron (star-like)	12	3 or 4 colours	Medium
Ball with many points	30	5 colours, 6 units each	Hard

Model 1: The Cube

The cube uses six units, one for each face. It is the best first assembly, because the six units are all equal and the result shows at once whether your units are accurate.

1. **Choose colours.** Fold two units in each of three colours, so opposite faces match.
2. **Join two units.** Slide a tab of one unit into a pocket of another. The two units now form a corner.
3. **Add a third unit** into the corner so that all three tabs are used. This makes a cube corner with three faces meeting.
4. **Add the remaining three units** one at a time, tucking each tab into the nearest free pocket. Do not push them fully home until all six are in place.

5. **Tighten.** Once all six units are connected, push each tab firmly into its pocket and square up the edges. The cube holds its own shape.

Model 2: The Star

The star uses thirty units and is the classic larger sonobe project. It looks like a ball covered in points, and the colour pattern matters more here than anywhere: use five colours, and place each colour on six units, spaced evenly around the model.

1. **Fold 30 units,** six in each of five colours. Count them as you go, because the model needs exactly thirty.
2. **Build a ring of units** that form a star-shaped section, with the points all facing out.
3. **Add rings** row by row, connecting each unit to the units beside it and below it.
4. **Close the model** by connecting the last ring. You should find that the final units fit without forcing; if they do not, an earlier connection is loose.

Counting Units

Modular models need exact counts, and mistakes show up late, when you run out of one colour. A small script helps you plan how many units of each colour to fold for a model:

```
models = {'cube': 6, 'star': 30}
colours = {'cube': 3, 'star': 5}

for name, units in models.items():
    each = units // colours[name]
    print(name, units, 'units,', each, 'of each of', colours[name], 'colours')
```

Output when run:

```
cube 6 units, 2 of each of 3 colours
star 30 units, 6 of each of 5 colours
```

Assembling and Keeping Tension

A modular model is held together by friction, so its strength comes from how well the units fit. Most failures come from a few causes, all of them easy to fix.

> The model keeps springing apart If units slip out of their pockets, the cause is almost always a loose or uneven unit, not the assembly. Compare each unit with your best one. Units that are slightly too short, or whose creases are not sharp, do not grip. Re-fold those, or use a slightly thicker paper, and the model tightens.

- **Do not force it early.** Join all the units loosely first, then tighten them in a second pass. Forcing the first connections leaves later ones too tight to fit.
- **Choose paper that grips.** Paper that is too thin does not grip and too thick does not fold. Standard origami paper or light card is about right.
- **Crease firmly.** A sharp crease in each tab and pocket is what makes a connection hold.
- **Add a dab of glue only as a last resort.** A pure modular model should hold without it, and a model that does is a mark of accurate folding.

Challenges

Each challenge has a worked solution you can open after you have tried it.

CHALLENGE 1

Fold one test sonobe unit from scrap paper, then compare it with the description. List the two tabs and the two pockets, and say which crease each one depends on.

→ Solution

CHALLENGE 2

Fold six units in three colours and assemble a cube. Check that opposite faces match in colour and that the cube holds together without glue. If any unit slips, say why.

→ Solution

CHALLENGE 3

Use the counting script to plan a model with 12 units in 4 colours. Work out how many units of each colour you need, then fold them and build the model. Describe how you kept the tension even.

→ Solution

QUICK REFERENCE

- **Unit:** one simple fold, repeated, with tabs and pockets
- **Sonobe:** a parallelogram with two tabs and two pockets
- **Cube:** six units, three colours, opposite faces matching
- **Star:** thirty units, five colours of six
- **Tension:** join loosely first, tighten second, re-fold weak units

Next, in Origami and Paper Folding 8, we look at tessellations and patterns: repeating crease patterns, twist folds, and the idea of a crease pattern as a map.

Origami and Paper Folding

Course 1 · Chapter 8 · Tessellations and Patterns: Folds That Repeat

Origami and Paper Folding 7 joined many sheets into one model. This chapter goes the other way: it makes a single sheet carry a repeating pattern. An origami **tessellation** is a flat sheet covered in a regular grid of creases, folded so that the same shape repeats across the whole surface. The finished piece looks like a woven or tiled texture, and it is often lit from behind so the layers show.

The Crease Pattern as a Map

Until now you have followed steps. A **crease pattern** (CP) is different: it is a map of every fold in the finished model, drawn on the unfolded sheet. It shows where the creases are and whether each is a mountain or a valley, but not the order in which to make them. Reading a CP is the key skill for this chapter and for Origami and Paper Folding 9 and 10.

- **Valley lines** are drawn dashed, and **mountain lines** are drawn dot-dash, using the symbols from Origami and Paper Folding 2.
- **Every crease is folded at the end.** Tessellations are usually pre-creased first, then collapsed all at once.
- **Repeat means copy.** If you can read one tile of the pattern, you can read the whole sheet.

A small corner of a square-twist pattern looks like this. The letters show the crease type, with V for valley and M for mountain:

```
+---V---+---V---+
|       |       |
V   M   V   M   V
|       |       |
+---V---+---V---+
|       |       |
V   M   V   M   V
|       |       |
+---V---+---V---+
```

Pre-Creasing a Grid

Nearly every tessellation starts from an even grid, so the first job is accurate division of the square.

1. **Fold in half both ways** and unfold, giving a cross of four equal squares.
2. **Fold each edge to the centre line** and unfold, giving quarters.
3. **Repeat once more** to reach eighths. An 8 by 8 grid suits a first tessellation.
4. **Crease the whole length** of each line firmly, so that all creases are the same sharpness.

> Accuracy builds on itself An error of 1 mm in the first fold becomes 4 mm by the third division. Use a ruler and a bone folder, and check each fold by holding the sheet up to a light.

The Twist Fold

A **twist fold** is the building block of most tessellations. A square of the grid is collapsed so that its middle rotates, leaving a small turned square surrounded by triangles. The basic square twist works like this:

1. **Pre-crease a 4 by 4 grid** and add the diagonal creases inside the centre four squares.
2. **Pinch the centre** so the creases that should be valleys fold down and the mountains fold up.
3. **Rotate the middle square** clockwise (or anticlockwise, the direction is a choice) while flattening the sheet.
4. **Press flat.** A rotated square sits in the centre, with four triangles around it.

From One Twist to a Tessellation

A tessellation repeats the twist across the whole grid. Neighbouring twists share edges, so the rotation directions must alternate in a chessboard pattern. If two neighbours turn the same way the paper locks and will not lie flat.

TILE	GRID	LOOK	DIFFICULTY
Square twist	Squares	Rotated squares and triangles	Easy
Triangle twist	Triangles (60 degrees)	Stars and hexagons	Medium

TILE	GRID	LOOK	DIFFICULTY
Hexagon tessellation	Hexagons	Honeycomb with small triangles	Hard

Counting Tiles

The number of twists grows quickly with the grid. This small script counts the twists and crease lines for a square grid of a given size:

```
for n in [4, 8, 16]:
    twists = (n // 2) ** 2
    lines = 2 * (n - 1)
    print(n, 'x', n, 'grid:', twists, 'twists,', lines, 'grid lines')
```

Output when run:

```
4 x 4 grid: 4 twists, 6 grid lines
8 x 8 grid: 16 twists, 14 grid lines
16 x 16 grid: 64 twists, 30 grid lines
```

Paper and Finishing

Tessellations pack many layers into a small area, so paper choice matters more here than in earlier chapters.

> The sheet will not collapse If the paper resists, a crease is probably the wrong way round or not sharp enough. Check the pattern against your map one line at a time, then re-crease. Never force a collapse, as it tears the paper at the twist corners.

- **Thin, strong paper.** Tissue-foil, kozo or thin origami paper folds in many layers without bulk. Standard copy paper is too thick for large grids.
- **Start small.** A 4 by 4 grid on 15 cm paper is a good first tessellation, and 8 by 8 follows once that feels easy.
- **Back-light to check.** Hold the finished piece up to a window to see the layers and spot any uneven twist.

- **Frame it.** Press the piece flat under a book overnight, then mount it between glass or on card.

Challenges

Each challenge has a worked solution you can open after you have tried it.

CHALLENGE 1

Pre-crease an 8 by 8 grid on a square sheet. Check the grid by holding it to the light, and note one place where a crease drifted. Say what caused it.

→ Solution

CHALLENGE 2

Fold a single square twist on a 4 by 4 grid. Draw the crease pattern first, label each line V or M, then collapse the paper and compare the result with your map.

→ Solution

CHALLENGE 3

Use the counting script to work out the twists in a 6 by 6 grid, then fold that tessellation. Explain why neighbouring twists must alternate direction.

→ Solution

QUICK REFERENCE

- **Crease pattern:** a map of all folds on the flat sheet, with V and M lines
- **Tessellation:** one tile repeated across a grid of creases
- **Twist fold:** a collapsed square that rotates around its centre
- **Alternate directions:** neighbouring twists turn opposite ways
- **Paper:** thin and strong; start with a 4 by 4 grid

Next, in Origami and Paper Folding 9, we look at the mathematics of folding: flat-foldability rules, folding angles and thirds, and origami in engineering.

Origami and Paper Folding

Course 1 · Chapter 9 · The Mathematics of Folding: Rules Behind the Creases

Origami and Paper Folding 8 treated a crease pattern as a map. This chapter asks which maps are possible. Not every pattern of creases can be folded flat, and a few short rules decide which can. Those same ideas let folders divide paper into exact thirds, reach constructions that a compass and straightedge cannot, and design real-world folding structures such as solar panels and medical stents.

What Flat-Foldable Means

A crease pattern is **flat-foldable** if the whole sheet can be pressed flat with every crease folded and no paper torn or stretched. The key place to look is a **vertex**, a point where several creases meet. Every vertex of a flat-foldable pattern must itself be able to fold flat, so we start by testing vertices.

Maekawa's Theorem: Counting Mountains and Valleys

At any flat-foldable vertex, the number of mountain creases and the number of valley creases differ by exactly two:

|M − V| = 2

- A vertex with 4 creases is 3 mountains and 1 valley, or 1 mountain and 3 valleys.
- A vertex with 6 creases is 4 and 2 either way round.
- The number of creases at a flat-foldable vertex is always **even**, because M and V differ by an even number.

Kawasaki's Theorem: Adding Up the Angles

Maekawa's rule counts the creases. **Kawasaki's theorem** measures the angles between them. Go around a vertex and label the angles between neighbouring creases in order. The angles in odd positions add up to 180 degrees, and so do the angles in even positions:

$a_1 + a_3 + a_5 + \ldots = 180°$ and $a_2 + a_4 + a_6 + \ldots = 180°$

The simplest case is two creases crossing at right angles: four angles of 90 degrees, and 90 + 90 = 180 in each group. Order matters, because the angles are summed in alternate positions around the vertex.

RULE	SAYS	CHECKS	EXAMPLE
Maekawa	$\|M - V\| = 2$	Crease types at a vertex	4 creases: 3 M and 1 V
Kawasaki	Alternate angles each sum to 180°	Angles at a vertex	30, 70, 150, 110 degrees
Two-colouring	Regions can be shaded with two colours so neighbours differ	The whole pattern	A chessboard of faces

> Necessary, not sufficient Both rules are tests for a single vertex. A pattern whose vertices all pass can still fail, because layers elsewhere may be forced to cross through each other. Deciding flat-foldability for a whole pattern is a hard problem in general, so folders treat these rules as a first check, then fold a test sheet.

Checking the Rules With Code

This small script tests a vertex against both rules:

```
def maekawa(creases):
    m = creases.count('M')
    v = creases.count('V')
    return abs(m - v) == 2

def kawasaki(angles):
    return sum(angles[0::2]) == 180 and sum(angles[1::2]) == 180

print(maekawa('MMMV'))
print(maekawa('MMVV'))
print(kawasaki([30, 70, 150, 110]))
print(kawasaki([100, 80, 90, 90]))
```

Output when run:

```
True
False
True
False
```

The second vertex fails Maekawa because 2 mountains and 2 valleys differ by 0, and the fourth fails Kawasaki because 100 + 90 is 190, not 180.

Folding Thirds

Halves are easy: fold one edge onto another. Thirds are harder, because no single fold of a strip gives one third. Haga's method finds an exact third with one extra fold:

1. **Start with a square** and mark the midpoint of the bottom edge by folding in half and unfolding.
2. **Fold the top-left corner** down to that midpoint and crease firmly.
3. **Look at the right edge.** The folded-down top edge crosses it at a point exactly 2/3 of the way up from the bottom (so 1/3 from the top).
4. **Pinch at that crossing** to mark the third, then unfold.

You can check this with coordinates. On a unit square, the fold sends the corner (0, 1) to (0.5, 0), and the image of the top edge meets the right edge at height 2/3. From one exact third, sixths follow by folding in half, and the other third by folding the bottom edge up to the crease made at the mark.

What Origami Can Do That a Compass Cannot

Straightedge and compass constructions have limits. In 1837 Pierre Wantzel proved that a compass and straightedge cannot **trisect an arbitrary angle** or **double a cube** (construct a length of the cube root of 2). Both problems lead to cubic equations, and a compass and straightedge can only reach lengths found from square roots.

Folding is more powerful. The **Huzita-Hatori axioms** list the seven basic single folds that align given points and lines. One of them, which folds two points onto two lines at the same time, amounts to solving a cubic equation. That gives folders exact methods for:

- **Trisecting an angle**, by a method published by Hisashi Abe.
- **Doubling the cube**, by a construction credited to Peter Messer.

These use real folds, not approximations. They show that paper folding, with this fold allowed, is strictly stronger than the classical compass and straightedge.

Origami in Engineering

Folding solves real packing problems: how to carry something large in a small space, then deploy it reliably.

- **Miura-ori.** A pattern of parallelogram creases, developed by Koryo Miura, lets a large sheet fold down into a compact stack and open with a single pull. It has been used for deployable solar panels on spacecraft.
- **Stents.** Folded tube patterns allow a medical stent graft to be compressed small, inserted through a narrow vessel and expanded in place.
- **Airbags.** Folding patterns have been studied to make airbags pack tightly and inflate evenly.

> Do not force a failed collapse If a pattern whose vertices all pass the rules still will not close, do not push. Re-check each mountain and valley against your crease map, because a single reversed crease can stop the whole sheet from folding flat.

Challenges

Each challenge has a worked solution you can open after you have tried it.

CHALLENGE 1

Crease a square along both midlines to make a vertex of four 90 degree angles at the centre. Try to collapse it with 2 mountains and 2 valleys, then with 3 mountains and 1 valley. Which flattens, and how does Maekawa's theorem explain it?

→ Solution

CHALLENGE 2

A vertex has four angles, three of which are 45, 80 and 135 degrees, in that order. Find the missing angle, then use Kawasaki's theorem to show the vertex could fold flat. Draw it with a protractor and test it.

→ Solution

CHALLENGE 3

Use Haga's method to mark exactly one third of a square's edge. Measure it with a ruler to check, then use it to fold the square into three equal strips.

→ Solution

QUICK REFERENCE

- **Maekawa:** at a flat-foldable vertex, mountains and valleys differ by 2
- **Kawasaki:** alternate angles around a vertex each sum to 180 degrees
- **Haga:** fold a corner to an edge midpoint to find a third
- **Beyond the compass:** folds can trisect an angle and double a cube
- **Engineering:** Miura-ori for solar panels, folded stents, airbags

Next, in Origami and Paper Folding 10, we put it all together: designing your own simple model, tree theory in brief, famous folders and communities, and where to go from here.

Origami and Paper Folding

Course 1 · Chapter 10 · Design and Going Further: Making Your Own Models

Nine chapters have taught you to fold other people's models and to read the rules behind them. Origami and Paper Folding 9 showed which crease patterns can fold flat. This last chapter turns that knowledge around: how to design a model of your own, how professional designers plan one, who to learn from, how to choose and present paper, and where to go next.

Designing Your First Simple Model

You do not need a mathematical method to start. Most first designs come from **playing with a base**. Work through this loop:

1. **Pick a subject** with few distinct parts: a fish, a bird, a simple flower or a boat. Count its parts, such as head, tail, two wings, and so on.
2. **Choose a base** from Origami and Paper Folding 3 whose points match that count. A bird base has four points, a fish base has four, a kite base has one long point.
3. **Shape each point** with the techniques of Origami and Paper Folding 4: a reverse fold for a head or beak, a squash or petal fold for a broad wing.
4. **Test, then record.** Fold it again on fresh paper, writing down each step with the symbols from Origami and Paper Folding 2.
5. **Simplify.** Remove any fold that does not change the final shape. Good designs are usually shorter than first drafts.

> Keep a design notebook Sketch each failed attempt and note why it failed. A flap too short, a layer too thick or a point in the wrong place all teach you which fold to try next time. Most designers learn more from their discarded models than from the finished ones.

Tree Theory in Brief

Professional designers plan models with **tree theory**. The idea is to draw the subject as a stick-figure **tree**: each limb, wing, antenna or tail is a branch ending in a **leaf**, and each branch has a

length. The designer then asks how to fit one flap of that length for every leaf into a single square.

TREE TERM	ON THE SUBJECT	ON THE PAPER
Leaf	The tip of a limb, such as a foot or an ear	A flap, ending in a point of the folded model
Branch length	How long that limb is	The length of the flap (the paper it uses)
Circle	The reach of one flap	A circle around the flap's tip on the unfolded sheet
Packing	Fitting all limbs together	Circles placed in the square without overlapping

The core rule is that two leaves joined by a path of length *d* on the tree must be at least *d* apart on the paper. Place one circle per flap so that no two circles overlap, and the gaps between them become the creases. Robert Lang's computer program TreeMaker automates exactly this, and it is how many very complex insects and animals are designed.

A Tiny Packing Check

This script tests whether two flaps are far enough apart, given their positions on a unit square and the tree distance between them:

```
import math

def far_enough(p, q, tree_distance):
    paper_distance = math.hypot(p[0] - q[0], p[1] - q[1])
    return paper_distance >= tree_distance

# Two flaps, tree distance 0.5 apart
print(far_enough((0, 0), (1, 0), 0.5))
print(far_enough((0.2, 0.2), (0.4, 0.3), 0.5))
```

Output when run:

```
True
False
```

The first pair is 1.0 apart, which is more than 0.5, so they fit. The second pair is only about 0.22 apart, so those two flaps would overlap and the layout needs to change.

Famous Folders and Communities

Studying other people's work is the fastest way to grow as a designer. A few names worth knowing:

- **Akira Yoshizawa** (1911-2005) created the modern symbol system you learned in Origami and Paper Folding 2 and made origami an art form, with expressive wet-folded animals.
- **Robert Lang** is a physicist and designer who developed the mathematics of tree theory and wrote widely on both art and engineering uses of folding.
- **Eric Joisel** was known for lifelike masks and figures folded from a single uncut sheet.
- **Tomoko Fuse** is a leading figure in modular origami, building on the ideas of Origami and Paper Folding 7.
- **Koryo Miura** invented the Miura-ori pattern from Origami and Paper Folding 9.

You do not have to learn alone. Most countries have an origami society that holds meetings, conventions and an annual exchange of models, and online communities share diagrams and crease patterns for every level. Folding with other people is also the quickest way to find out what you are doing wrong.

Paper Choices, Display and Gifting

PAPER	GOOD FOR	NOTES
Standard origami paper	Practice, most traditional models	Thin, coloured on one side, cheap
Foil-backed paper	Cranes, modulars, shapes that must hold a crease	Foil gives a crisp, sculptural fold
Washi	Gifts, decorative pieces	Patterned Japanese paper, stronger fibres
Wet-folding paper	Animals and curved shapes (see Origami and Paper Folding 6)	Thicker, holds shape after drying
Large sheets	Display pieces, first tries at complex models	Easier to handle small details

- **Display:** Keep models out of direct sun, which fades colour and weakens paper. A shadow box, a clear lidded jar or a thread hung from a branch all work well.
- **Gifting:** A crane, a flower or a small box makes a thoughtful present. A thousand cranes strung together is a traditional gift of good wishes.
- **Storing:** Keep finished models in a rigid box with tissue, and keep unused paper flat and dry.

> Credit the designer When you share or sell a model you did not design, say who did. When you publish diagrams of your own, expect others to fold them, and say how you want them credited. This is a basic courtesy in the origami community.

Challenges

Each challenge has a worked solution you can open after you have tried it.

CHALLENGE 1

Design a simple model of your own choosing, such as a fish, bird or flower, starting from one of the classic bases. Fold it three times, refining it each time, and write out the final step list.

→ Solution

CHALLENGE 2

Draw a tree for a simple insect: one body, two antennae and six legs. List the flaps you need, then decide which classic base has enough points and which flaps must be split further.

→ Solution

CHALLENGE 3

Fold a model from this course, choose suitable paper, and prepare it as a gift: decide how to display or package it, and write a short card that credits the designer.

→ Solution

QUICK REFERENCE

- **Design loop:** pick subject, choose base, shape points, test, record, simplify
- **Tree theory:** one flap per leaf, circles that do not overlap
- **Keep learning from:** Yoshizawa, Lang, Joisel, Fuse, Miura
- **Paper:** standard for practice, foil for crisp folds, washi for gifts, heavy paper to wet-fold
- **Always:** credit the designer of any model you share

Course Complete: Where to Go From Here

You have come a long way from a first valley fold. In ten chapters you have covered:

- **Origami and Paper Folding 1 to 2:** paper, creases, and reading diagrams.
- **Origami and Paper Folding 3 to 4:** the classic bases and the core folding techniques.
- **Origami and Paper Folding 5 to 7:** animals, flowers, boxes and modular models.
- **Origami and Paper Folding 8 to 9:** tessellations, crease patterns and the mathematics of folding.
- **Origami and Paper Folding 10:** designing your own work.

Good next steps, depending on what you enjoyed most:

- **Repeat the models you liked** on better paper. A second fold is always cleaner than the first.
- **Move up a level** by folding a model from a published book or an online diagram set with 30 to 60 steps.
- **Try a specialism:** modular origami, tessellations, wet-folded animals or box making.
- **Join a group** or attend a convention, and trade models with other folders.
- **Create and share:** diagram your own best design and let someone else fold it.

Paper is cheap, patience is the real material, and every fold you make teaches you something. Keep folding.