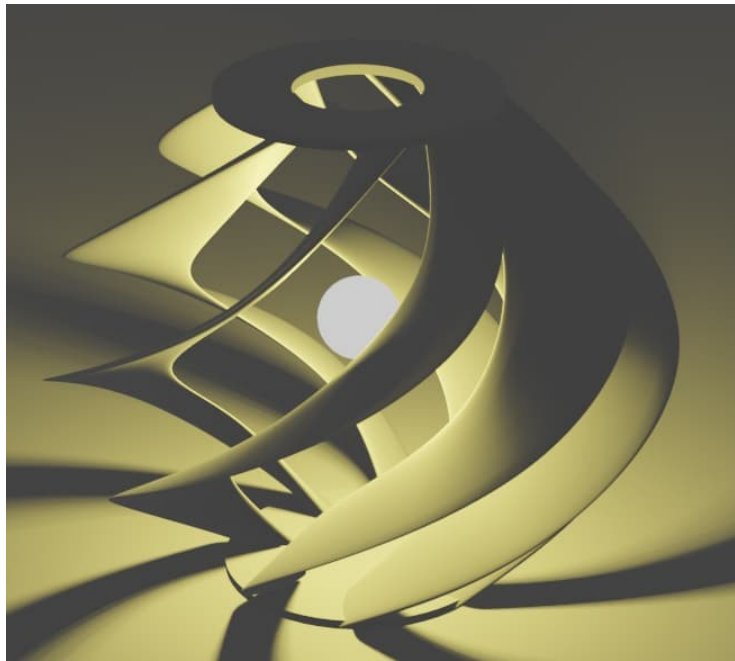


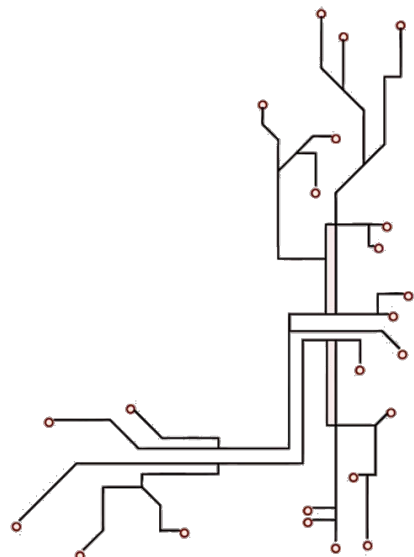
3D Design and Printing

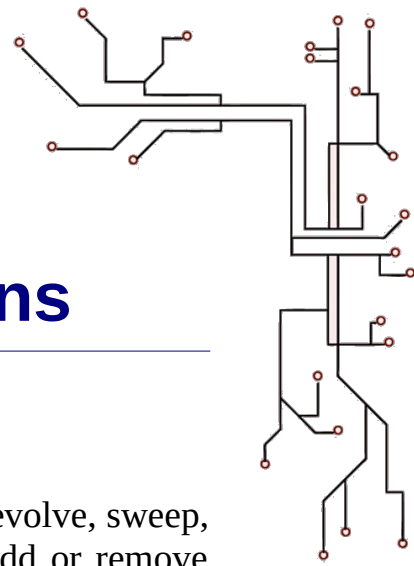
Chapter 4



Scope

- Repeating with Patterns
 - Linear Pattern
 - Mirror
 - Circular Pattern
- Design Challenges



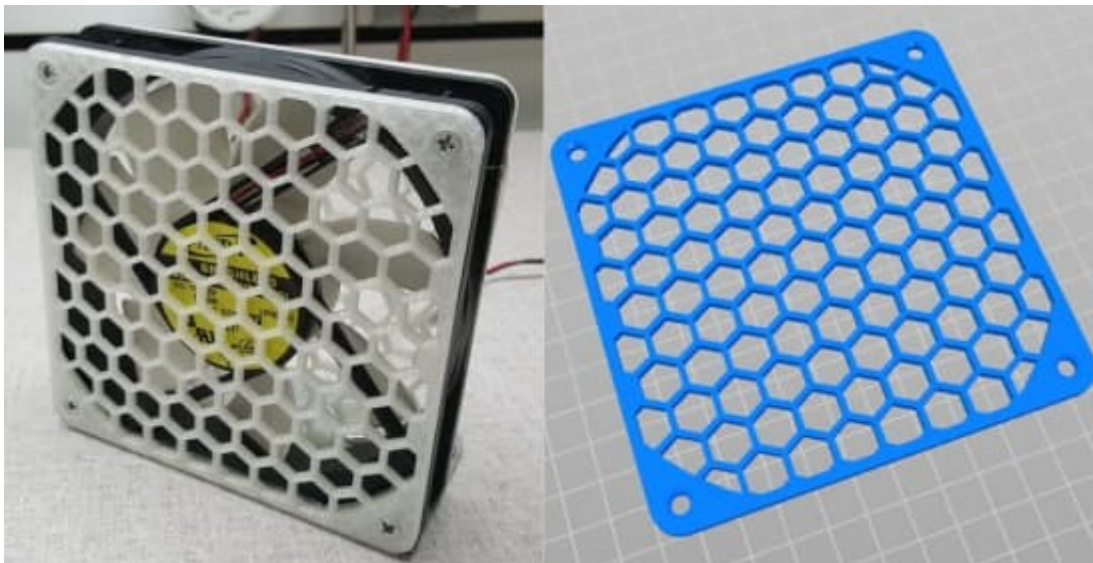


4.1

Repeating With Patterns

Introduction

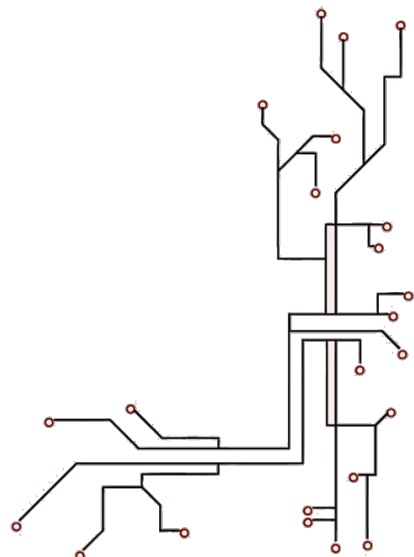
In the previous lessons, we learned to create parts using extrude, revolve, sweep, and loft. We also learn that each of these steps can be used to add or remove materials from the design. That's really enough to cover nearly all your design needs, but what happen when you have a design like this...



You can manually draw each and every one of these hexagons (...there are 101 in total), but it going to take you a while. You probably have better things to do with your time.

In this lesson, we'll be using patterns to repeat a design feature. You can think of it as a shortcut to help you create complex designs fast. We'll be covering 3 types of patterns today:

- Linear Pattern
- Mirror
- Circular Pattern

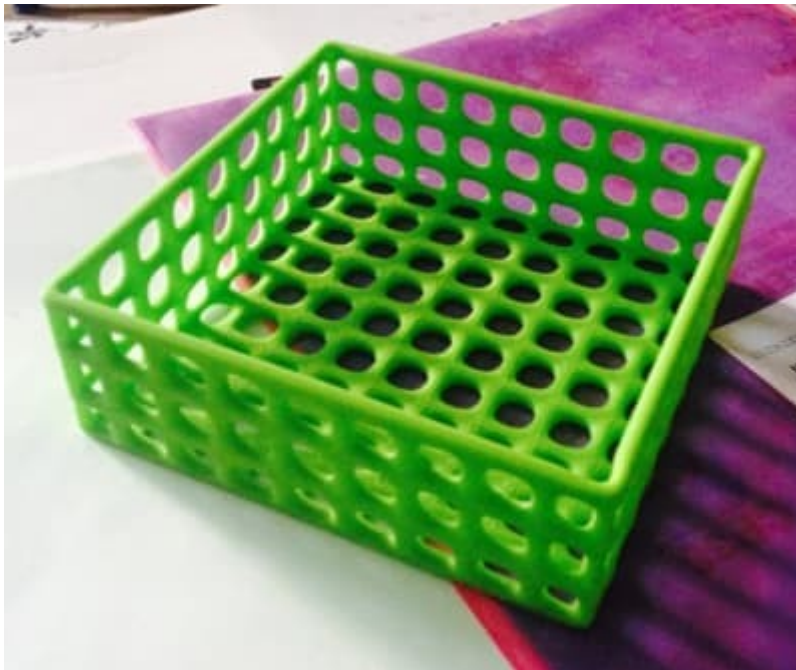


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Linear Pattern

A linear pattern is used when we want to repeat a feature in one or two direction (eg. up-down, left-right). For this first exercise, we'll be re-creating this storage basket design...



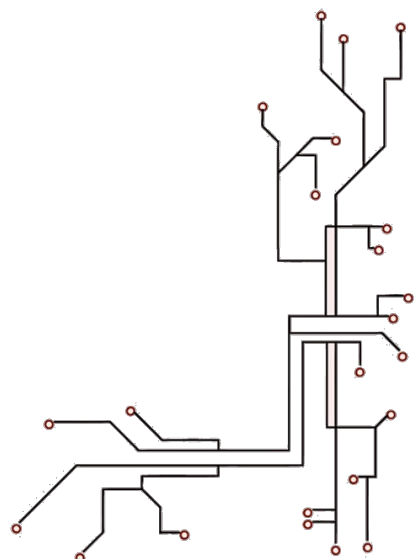
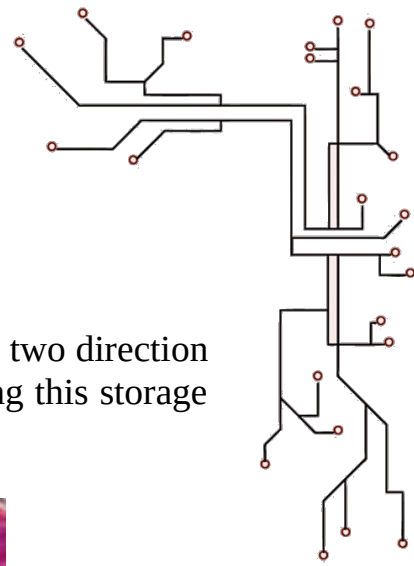
The holes in the basket are ideal for a linear pattern.

New Design

From here on, we'll be using the Onshape software. Open the Onshape website and login. We'll be creating a new design. Go ahead and click...

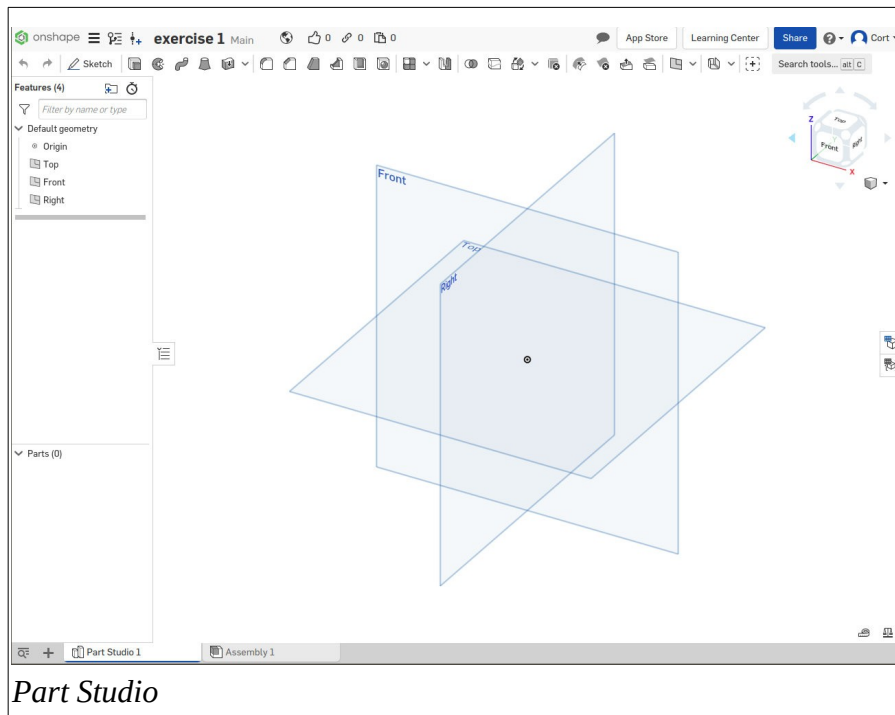
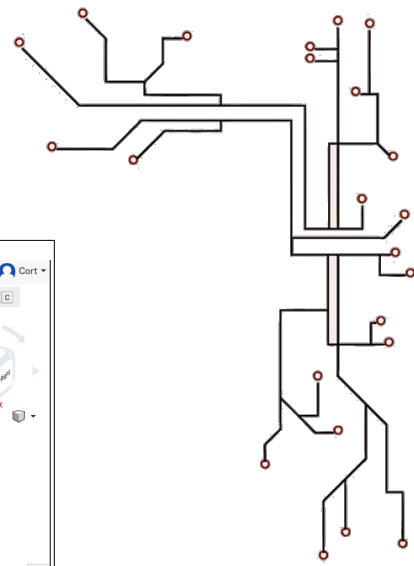
Create ▾

.. select “**Document...**”, and give it a name (eg. “Linear Pattern Exercise 1”). You should now be in the **Part Studio**, which looks like this...



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Part Studio

Selecting a Surface (Main Body)

We'll start by creating the main body of the box without holes. As before, we'll need to start by selecting a surface to sketch on. There are 3 default planes available for us to select (Front, Right, Top). For this exercise, I'm going to choose Top.

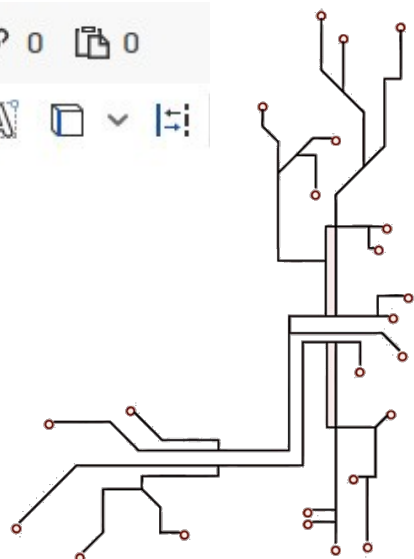
Click on the surface to select it (...it'll turn orange), then click...



You're now in the sketch mode, and the tool bar will change to show the sketch tools...



Sketch tools



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Sketching (Main Body)

The main body of the box is basically a square, so we'll start with that. Draw the following using a **center point rectangle**.

Dimensions (Main Body)

After you are done sketching, set the dimensions accordingly.

Click on the dimensions button...

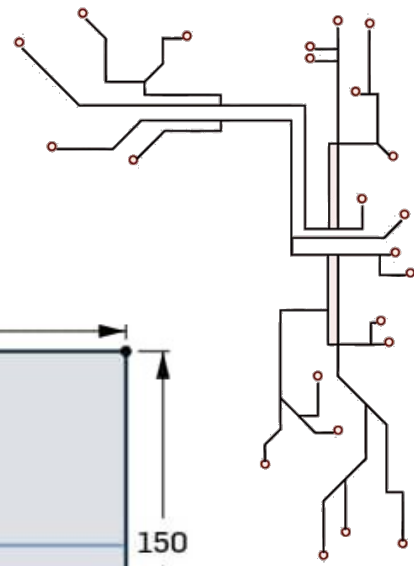
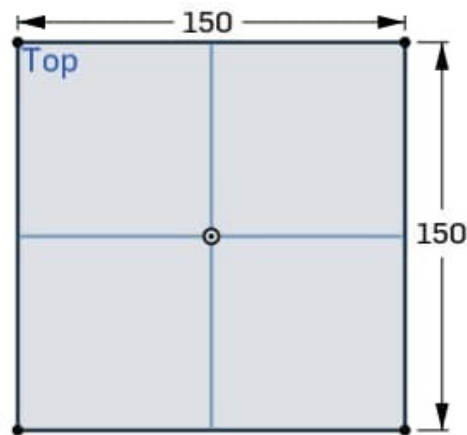


...then click on the drawing to set dimensions.

- Click on the vertical line and set the length to 150mm
- Click on the horizontal line and set the length to 150mm

If you have done all of these correctly, there should be no blue lines or points remaining. The sketch is now “fully defined”.

Sketch 1



Extrude (Main Body)

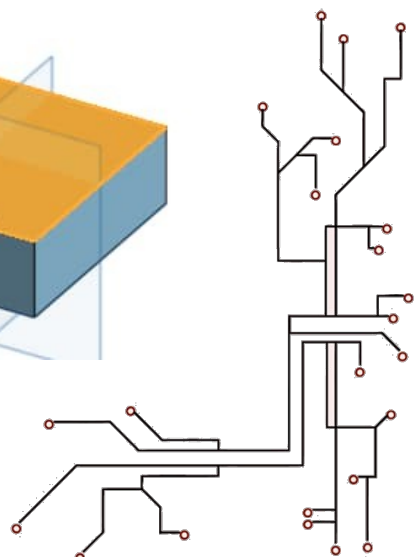
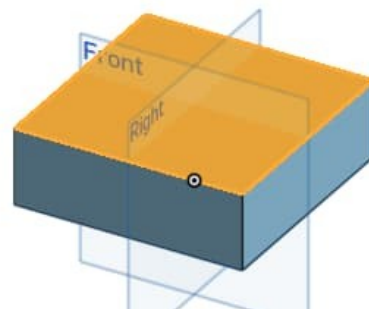
We want our box to be around 50mm tall, so select the sketch and click the extrude button.



Selecting a Surface (Compartment)

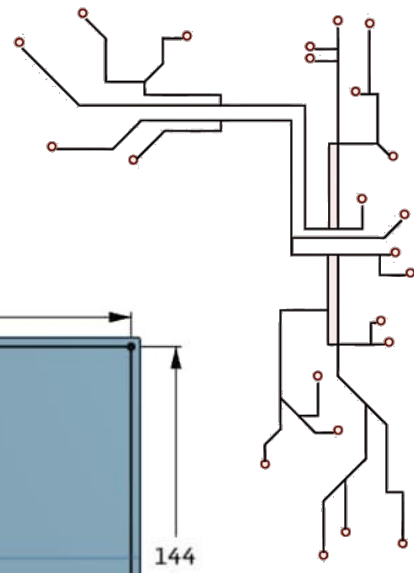
Now our shape is just a plain box. We'll need to cut out the compartment in the middle or we won't be able to store anything in this basket.

Select the top surface of the box.



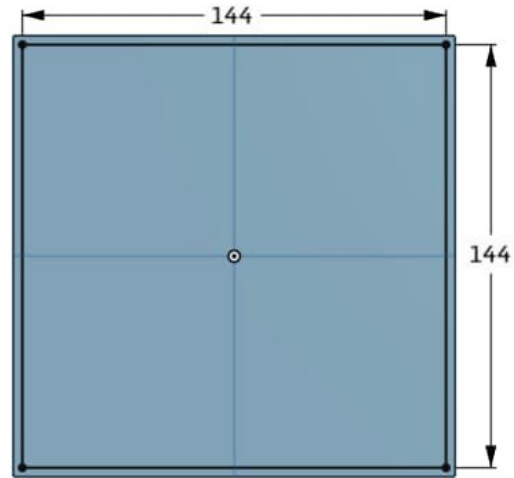
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Sketching (Compartment)

Draw the box as follows, again using a center point rectangle.

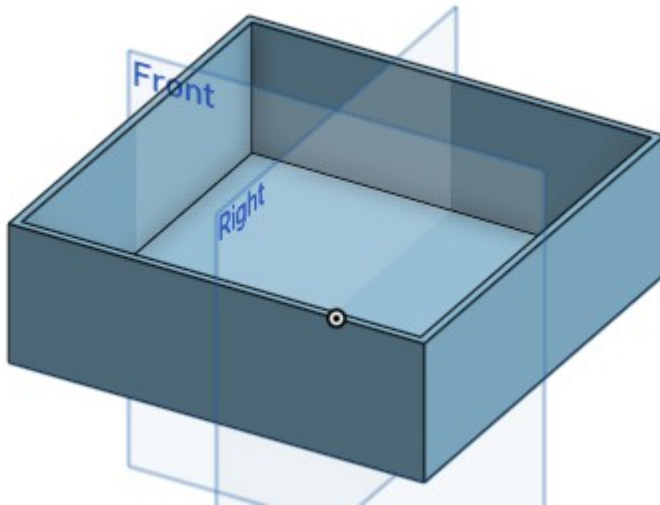


Dimensions (Compartment)

We want the walls of the box to be 3mm thick, so the opening in the center should be 144mm wide. Draw the following.

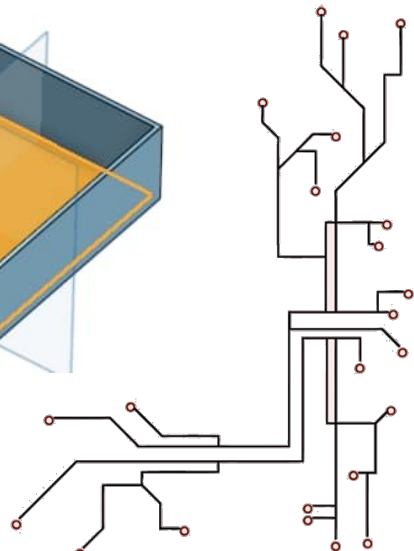
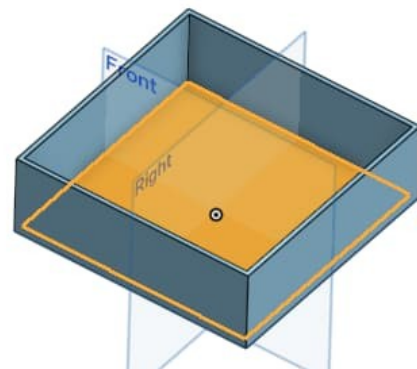
Extrude (Compartment)

Since our box is 50mm tall, and we want the bottom floor to be 3mm thick, we'll need to cut 47mm away. Click on the extrude button, select "Remove", and set the depth to 47mm. At this point, you should have this...



First Hole (Bottom)

Select the bottom of the box...



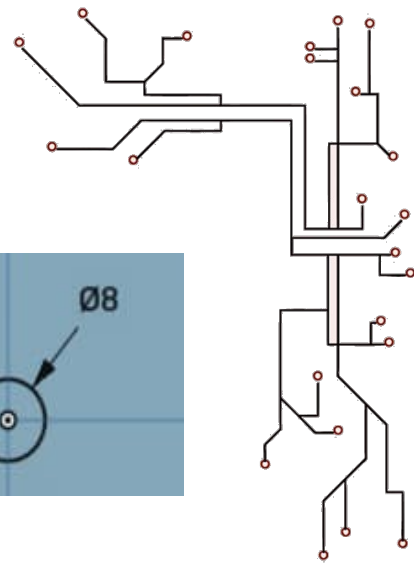
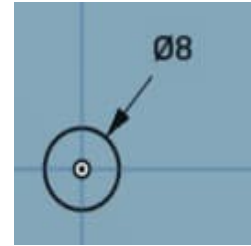
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...and sketch the following.

The circle should be centered on the origin.

When done, select the sketch, click extrude and choose “Remove”. The depth should be at least 3mm.



Linear Pattern

Now that we have the first hole, we are ready to repeat it using patterns.

Click the Linear Pattern button. If the Linear Pattern button isn't shown, you may need to click the arrow next to it.

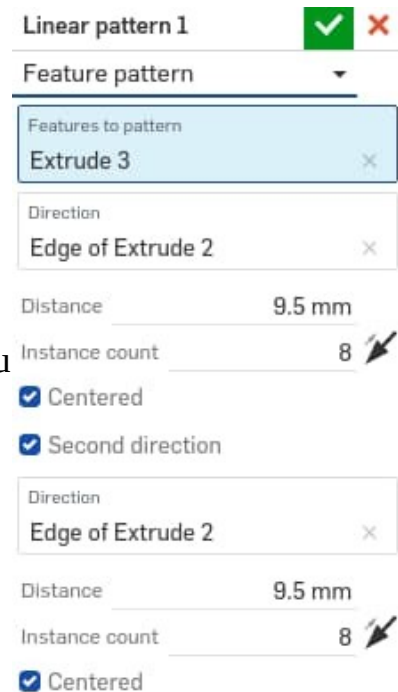
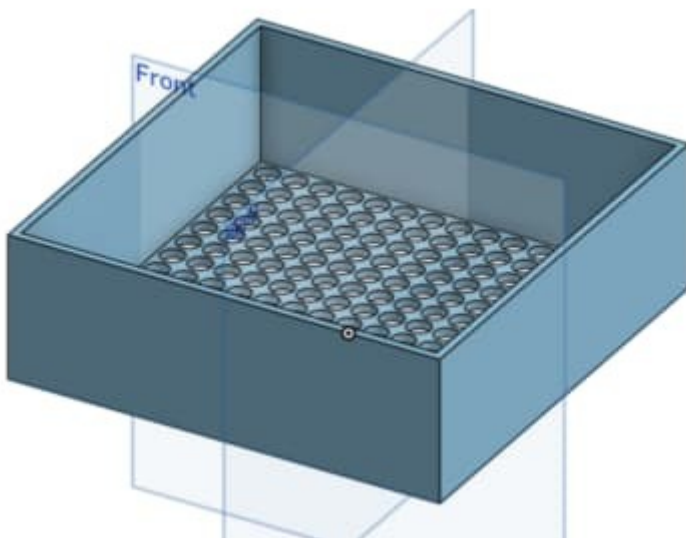


There are a few types of pattern:

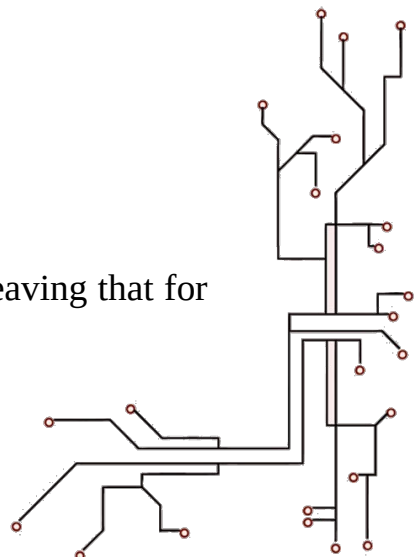
- Part pattern
- Feature pattern
- Face pattern

Make sure to choose “Feature pattern”.

Set everything according to the image on the right. You should now have a model that looks like this...

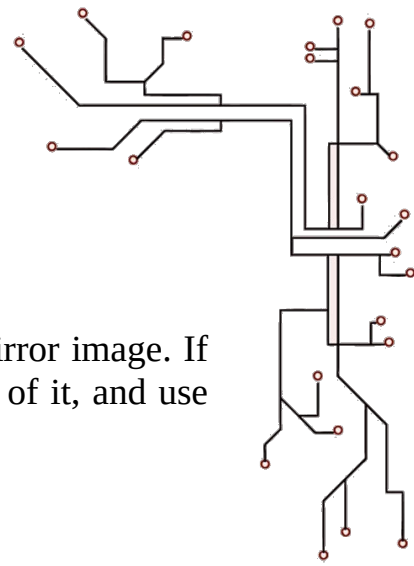


The model is still missing the holes on the side walls, but I'll be leaving that for you to attempt in the later design challenges.



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Mirror

A mirror pattern is used when we want to repeat a feature in a mirror image. If your design is symmetrical, this will allow you to draw only half of it, and use mirror to create the other half.

Circular Pattern

A circular pattern repeats a feature around an axis. This is useful when our model is circular in shape (eg. a wheel or a gear).

New Design (Gear)

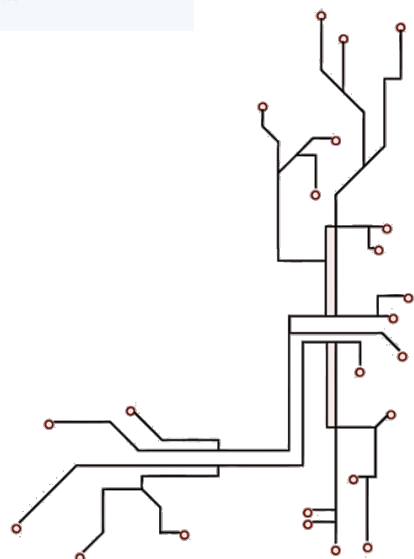
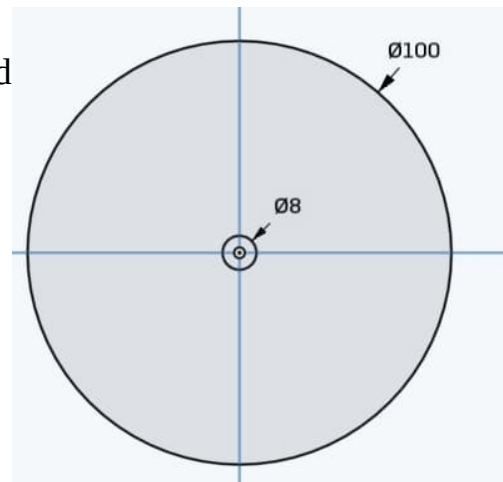
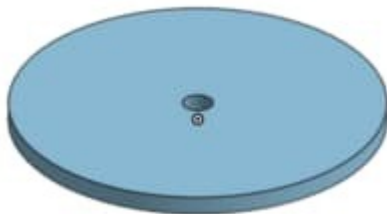
Save your previous design and create a new document. We'll be using mirror and circular pattern to create a gear in this exercise, so you can name your document "Gear exercise".

At this point, I'm going to assume that you already know the basics of selecting surface, sketching, and dimensioning, so I'm not going to go through every single step.

Main Body (Gear)

Sketch the following on the top plane and extrude it to a thickness of 5mm.

You should end up with the shape below...



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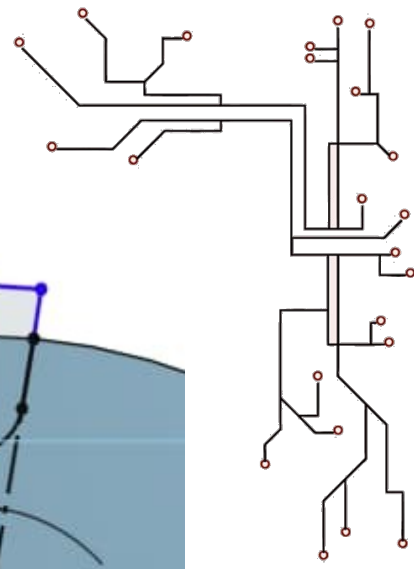
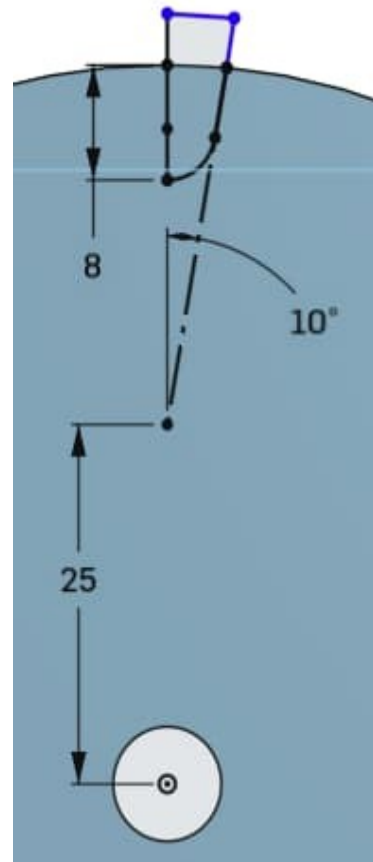
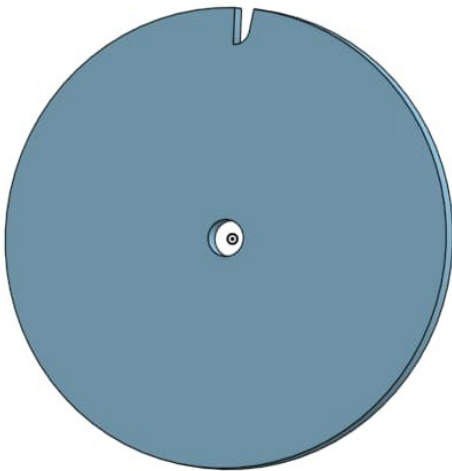
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Half a Gear Teeth (Gear)

Sketch the following. This is a tricky sketch, so take note of the following.

- The 8mm vertical line is aligned to the origin.
- The diagonal construction line connects the top of the 25mm to the side of the circle.
- The diagonal black line is drawn using the construction line as a guide.
- The dimensions of the lines outside of the circle are unimportant, but the lines **must** be there.

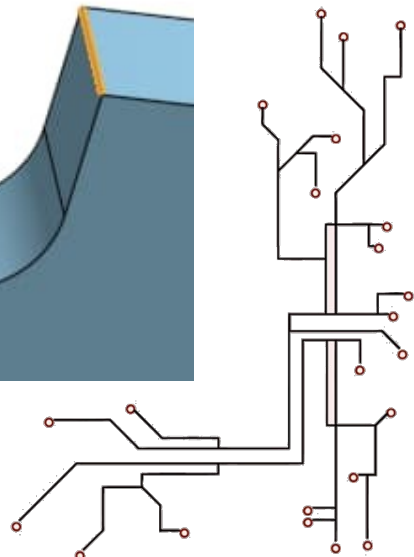
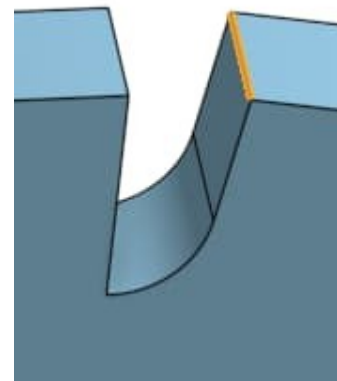
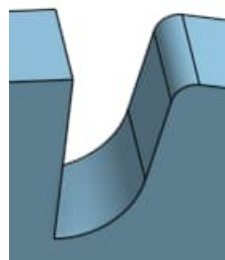
When you're done with the sketch, perform an extrude (remove). Your model should now look like this...



Fillet One Side (Gear)

Select the edge shown on the right, and perform a fillet. Set the fillet to 1mm.

After the fillet:



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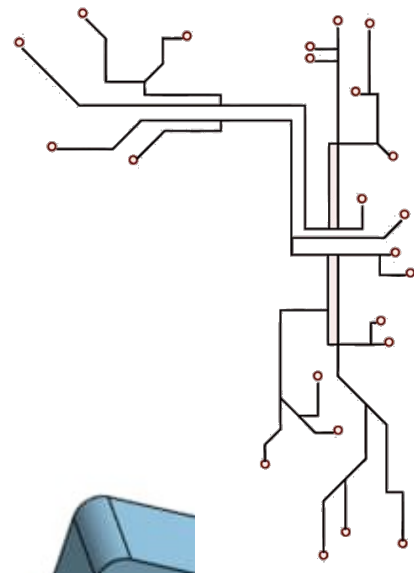
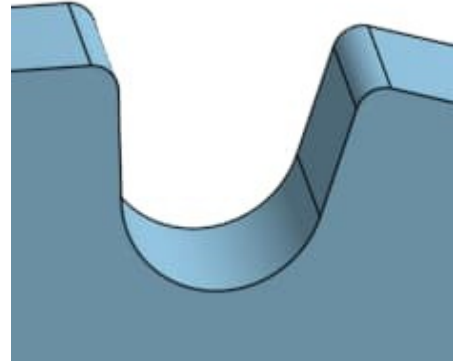
Mirror (Gear)

Click the mirror button. 


Under “Features to mirror”, select both the last extrude and the fillet.

Under “Mirror plane”, select the Right plane.

When you’re done, you should have this model...



Circular Pattern (Gear)

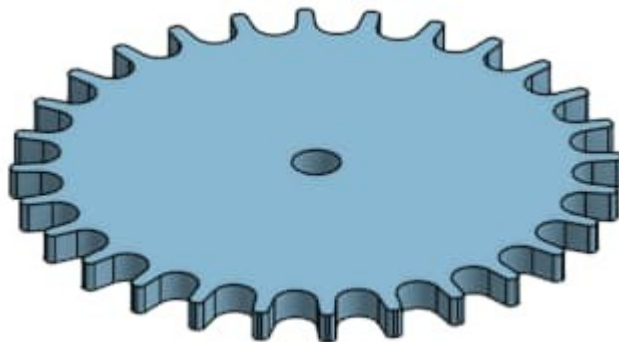
Click the “Circular Pattern” button. If the Circular Pattern button isn’t shown, you may need to click the arrow next to it. 

Set it to “Feature pattern” mode, then under “Features to pattern”, select the last extrude, fillet, and mirror.

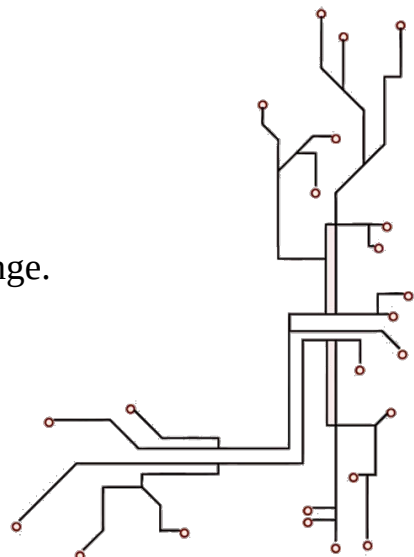
For “Axis of pattern”, select the edge of the main body (...either the outer circle or the small inner circle). This will set it to the axis of the circle.

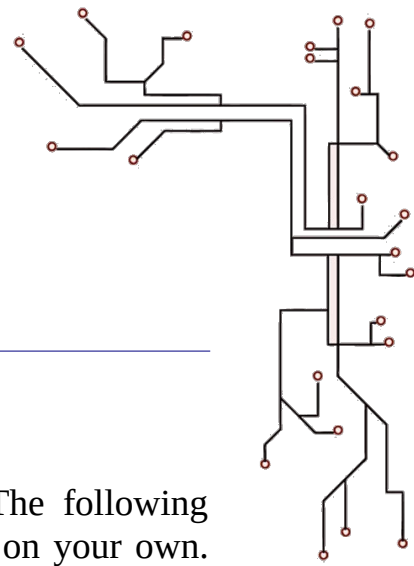
For “Instance count”, set it to 28.

When you’re done, your model should look like this...



Save your design, you’ll be using it again during the design challenge.





4.2

Design Challenge

Why?

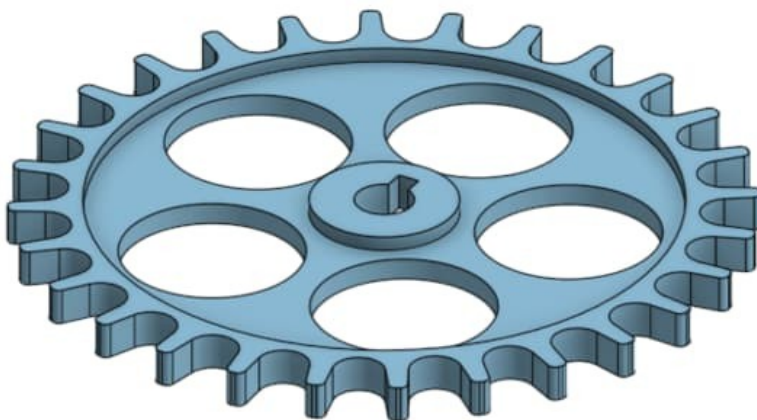
You'll never truly learn if you're just following instructions. The following exercises challenges you to figure out how to create the designs on your own. We have already covered all the necessary techniques, so it's just a matter of applying them.

How?

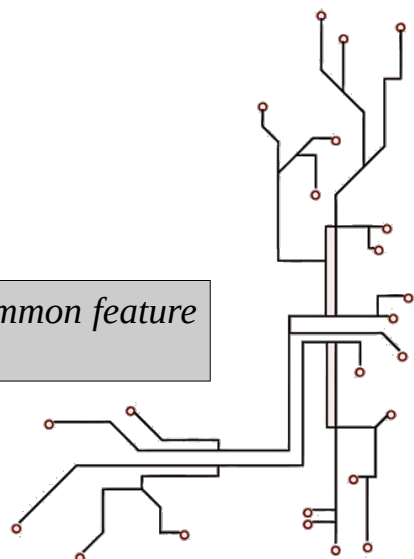
1. Pick a challenge. You don't need to start from the first one.
2. Look at the image of the complete design.
3. Read the tips (...if any)
4. Note that dimensions are not given. You should choose your own. Because of that, your model may look a little different, and that's ok.
5. Some of the challenges make use of past designs. You can open up your past designs and continue from there.

Challenge 1

This is a continuation of the gear that we have drawn earlier. Modify your design to look like the following...

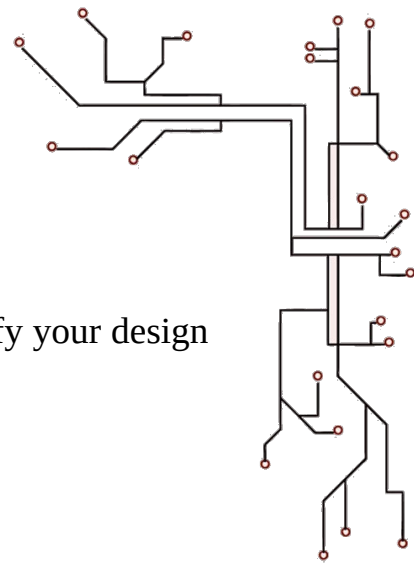


The rectangular hole in the center is called a "keyway". It's a common feature in real gears.



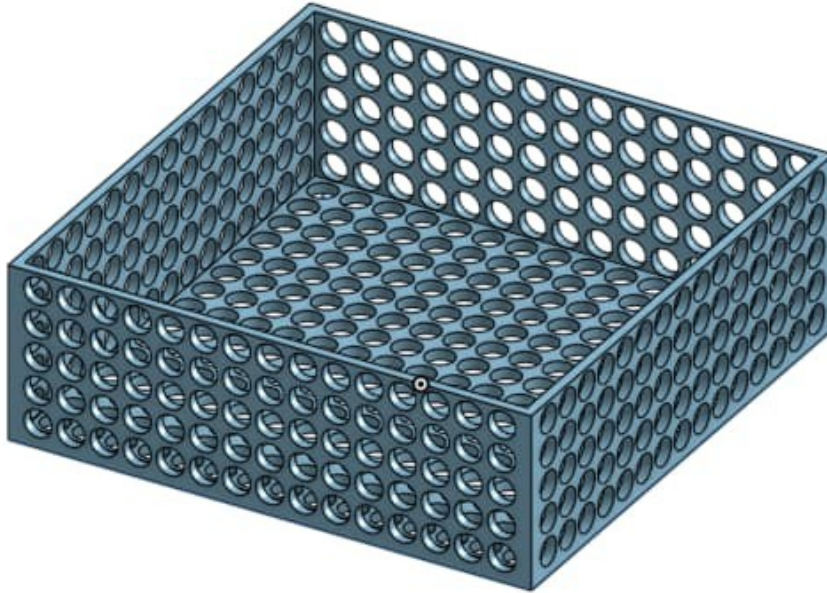
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Challenge 2

This is a continuation of the box that we have drawn earlier. Modify your design to look like the following...



Tip: If the linear pattern is not appearing in the correct direction, you can change the direction using this button (...next to Instance count).

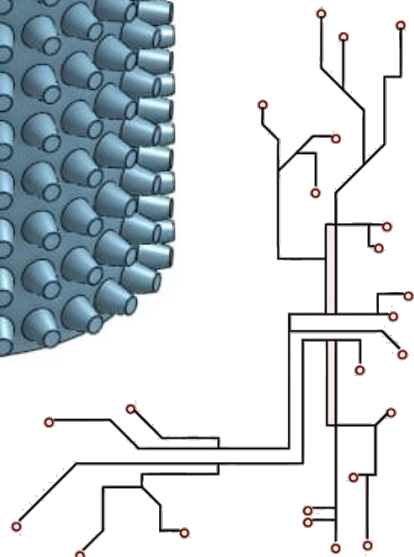
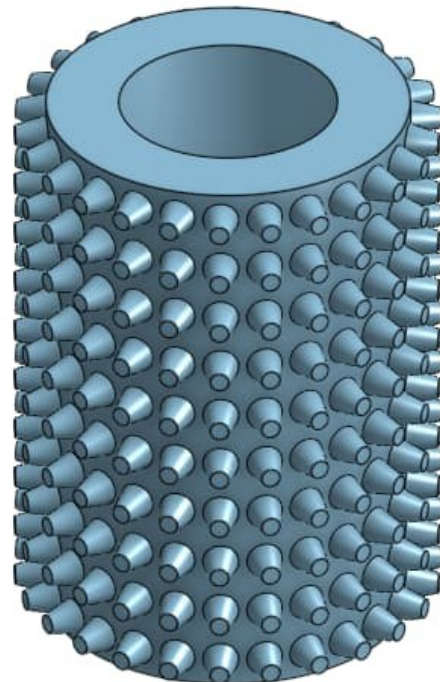


Challenge 3

This is a new design. It may look intimidating, but it's actually very easy to create.

Tips:

- Create one spike using revolve.
- Multiply the spike using a circular pattern followed by a linear pattern

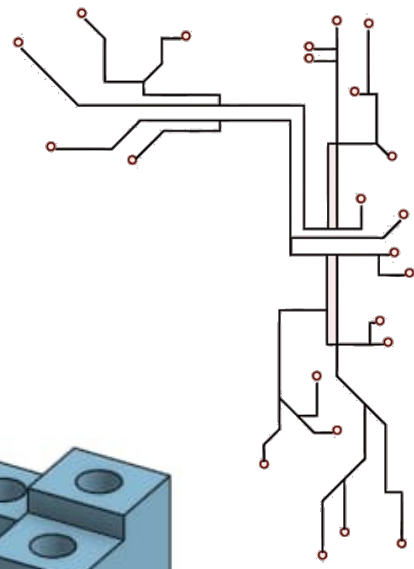
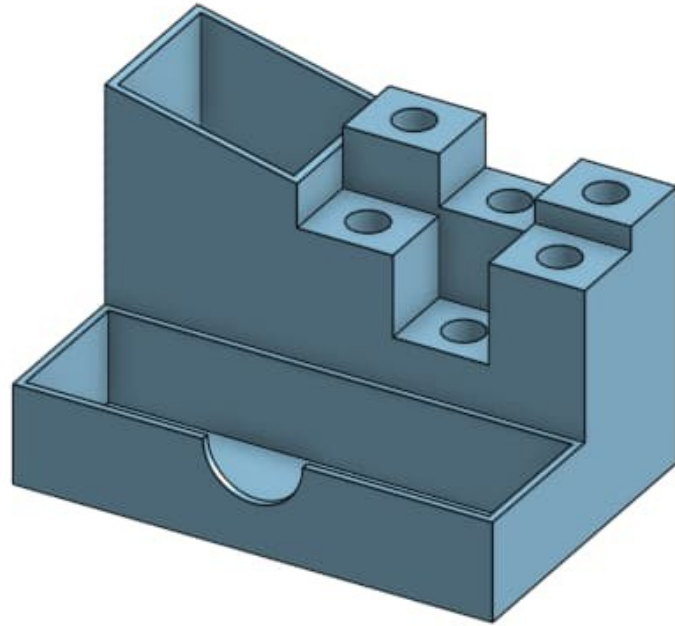


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Challenge 4

This stationary holder appeared in the first lesson. Can you recreate this design? It can be created using only sketches and extrudes.



Challenge 5

This lamp shade design uses loft and circular pattern.

