Design and Fabricate a Ferris Wheel

Grade Span
3-8

Subject Area
Math

Materials
- Fab@School Maker Studio
- Digital fabricator or scissors
- 65 lb or 110lb cardstock
- Glue or tape
- Paper straws (optional)

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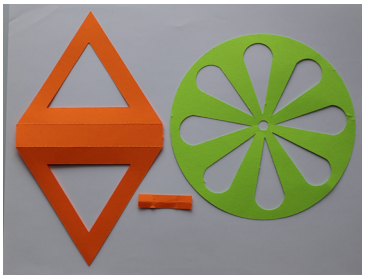
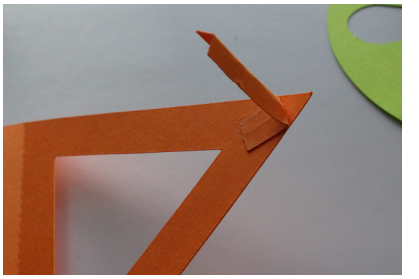
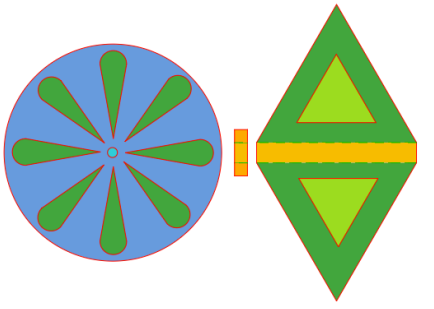
There are three primary parts in order to build a Ferris wheel: a **Circular Wheel**, an **Axle** that passes through the wheel at its center, and a **Frame** to hold the wheel up vertically by the axle. Pictured below is an example of these parts in action.

It is not complicated to design these parts using Fab@School Maker Studio. They are constructed using basic shapes and a few special tools in the software. You will be using the **Circle**, **Square**, and **Triangle** shapes and the **Select**, **Zoom In/Out**, **Magnetize**, **Weld**, **Copy/Paste** and **3D Preview** tools. Pictured below is an overview of the three parts you will learn how to create:



Objective

- Students will learn Fab@School Maker Studio features and engineering tips for designing and assembling their own paper Ferris wheel prototype.

Big Idea

Functions help to determine form.

Driving Question

How does probability relate to playing a game?

Learning Standards

CCSS

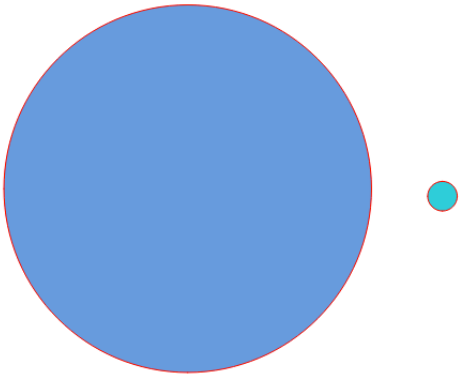
- CCSS.ELA-LITERACY.CCRA.SL.2
- CCSS.MATH.PRACTICE.MP2
- CCSS.MATH.PRACTICE.MP4
- CCSS.MATH.PRACTICE.MP6

MA DLCS

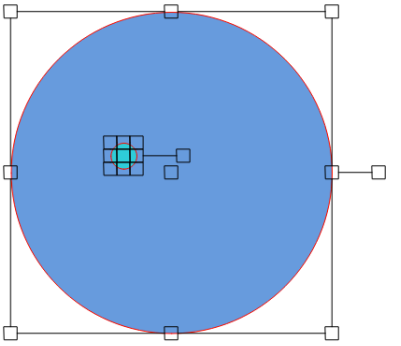
- 3-5.CT.e.2
- 6-8.CT.e.2

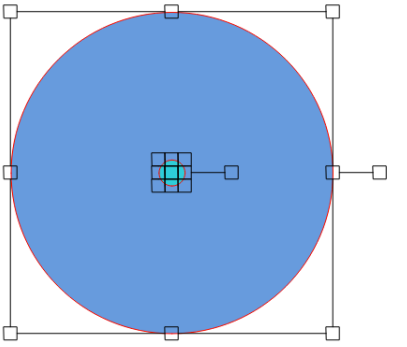
Part 1 - Wheel

1. Open a new Fab@School Maker Studio project. Use the **Shape** tool to create two **Circles** within the workspace. Resize them so that one is large and the other very small. The large circle will be the main body of the Ferris wheel and the smaller circle will be the hole in the middle that the axle passes through.



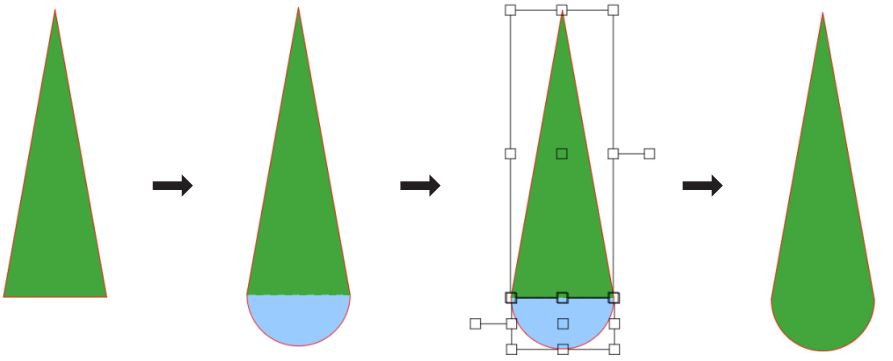
2. The small circle needs to be placed in the exact center of the large circle. Because shapes have **Red Cut Lines** by default, this will effectively create a large circle with a hole in the center once fabricated. Select both shapes with the **Select** arrow and then in the **Properties** tab click both **Center Align** and **Middle Align** to center the shapes.





3. In order for the wheel to have individual spokes, shapes need to be created that act as holes to be cut out of the main circle. Pictured below is a fabricated wheel with teardrop shaped holes cut out to leave spokes behind.

To create the teardrop shape, use the **Shape** tool to create an **Isosceles Triangle** and a **Semicircle.** Use the **Select** tool to adjust the base of the triangle and semicircle so that they are the same length. With the **Magnetize** tool on, drag the circle to the triangle so that the edges are nearly touching. When the semicircle is released, it will snap the two shapes together, producing a **Green Fold Line**. With the **Select** tool, select the two shapes and click the **Weld** tool. This will join the two shapes together as a single one.

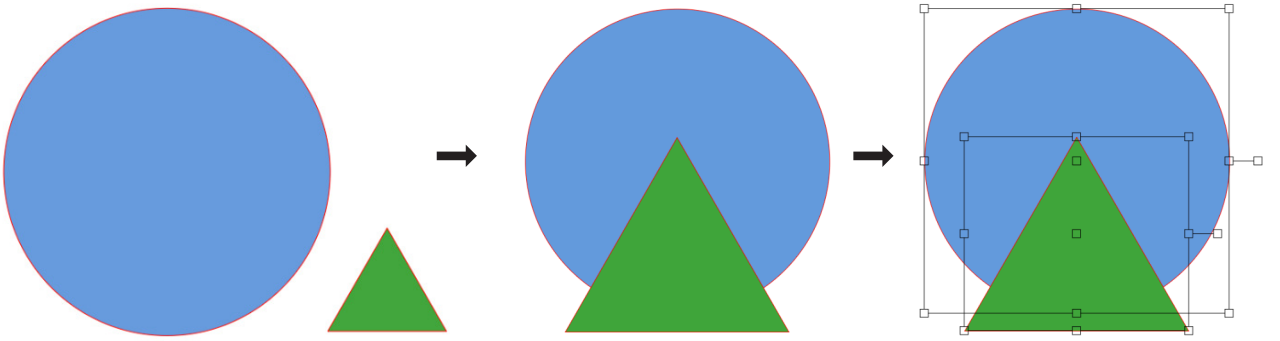


4. Size and place the teardrop so that it sits comfortably between the small circle in the center and the inside edge of the large circle. Using the **Copy/Paste** tools, create enough duplicates of the teardrop shape to ring around the circle. When rotating shapes, holding the **Shift** key forces them to rotate in increments of 45 degrees. With the teardrops placed, the wheel is complete.

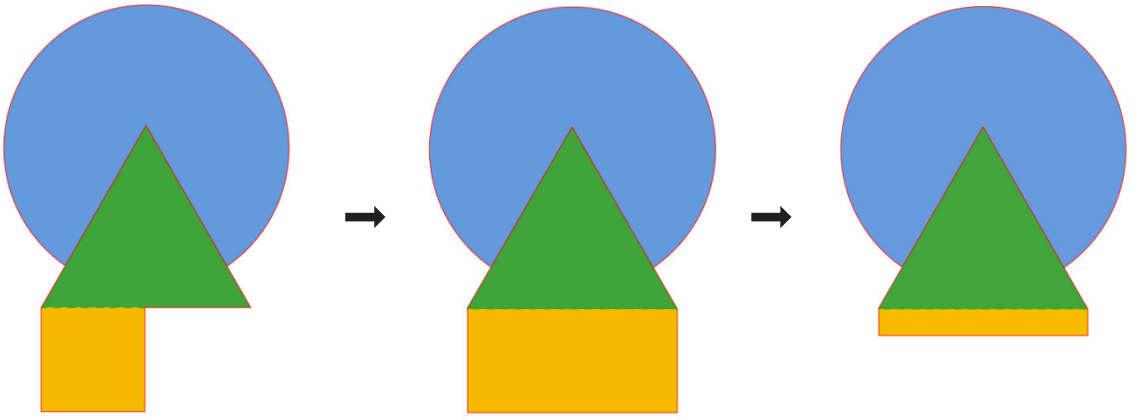
Part 2 - Frame

The frame is next. This part holds the wheel from either side and serves as a flat base for the whole model to stand with.

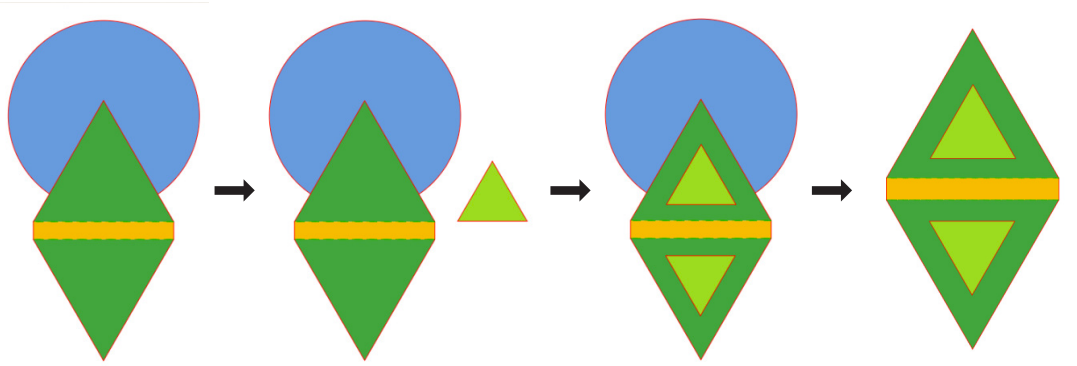
1. Use the **Copy/Paste** tool to create a duplicate of just the large circle from the wheel. This will serve as an easy size reference when designing the frame. Create a **Triangle** with the **Shape** tool and size it so that the height of the triangle is greater than the circle's radius. The tip of the triangle should extend past the center point of the circle. This ensures that the frame is tall enough to hold the wheel off the ground so it can spin. You can select the shapes with the **Select** arrow to reveal black guides which can be used to size the triangle.



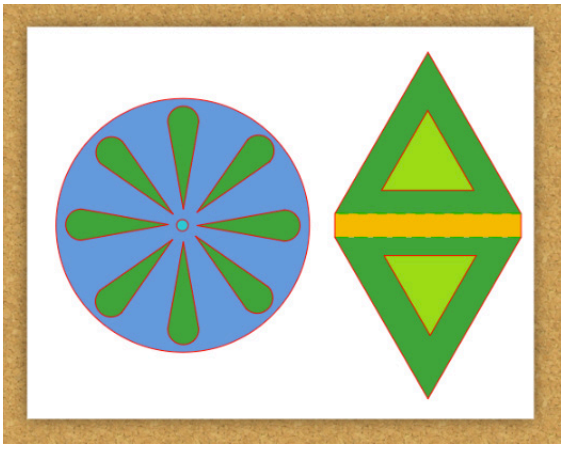
2. Create a **Square** with the **Shape** tool, and with the **Magnetize** tool on, snap it to the bottom of the triangle, creating a green fold line between them. Click on the square with the **Select** tool and stretch the square so that it is as wide as the traingle edge. Adjust the height of the rectangle so that it is relatively thin. This shape will determine the width of your ferris wheel frame. You may need to re-snap the rectangle to the triangle in order to create the fold line.



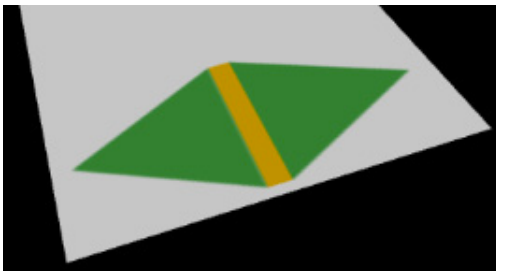
3. Use the **Copy/Paste** tool to create a duplicate of the triangle. Use the **Select** tool to rotate the duplicate 180 degrees so that it is upside-down. With the **Magnetize** tool on, snap it onto the other side of the rectangle, creating a green fold line. Create a **Triangle** with the **Shape** tool and size it so that it is smaller than the triangles already used for the frame. **Copy/Paste** a dulplicate of the smaller triangle, and rotate it 180 degrees with the **Select** tool. Center the smaller triangles over the larger ones, treating each smaller triangle as a hole that will be cut into the frame. The circle that was copied for size reference can be deleted by dragging the circle to the **Trash** or selecting it and pressing the **Delete/Backspace** key. The frame is now complete.

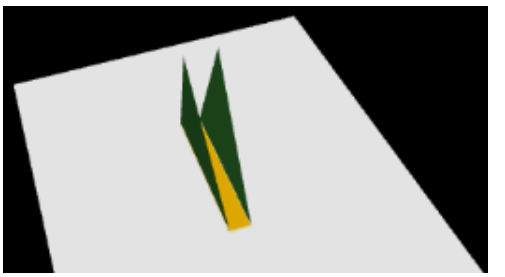


4. Position and size the wheel and frame you have designed so that they both fit within the white work area. This will ensure that it can be fabricated by the digital fabricator.



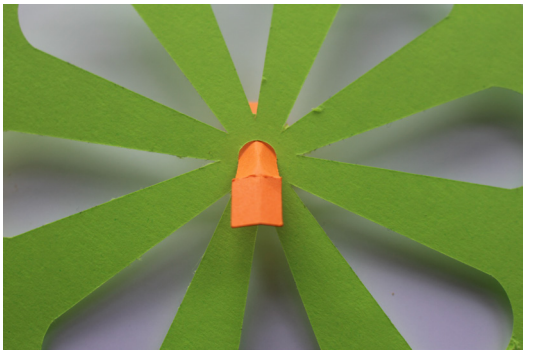
5. Open the **3D View** tool and move the slider on the bottom to view the folding action of the frame. Use this to visualize how the Ferris wheel will assemble.



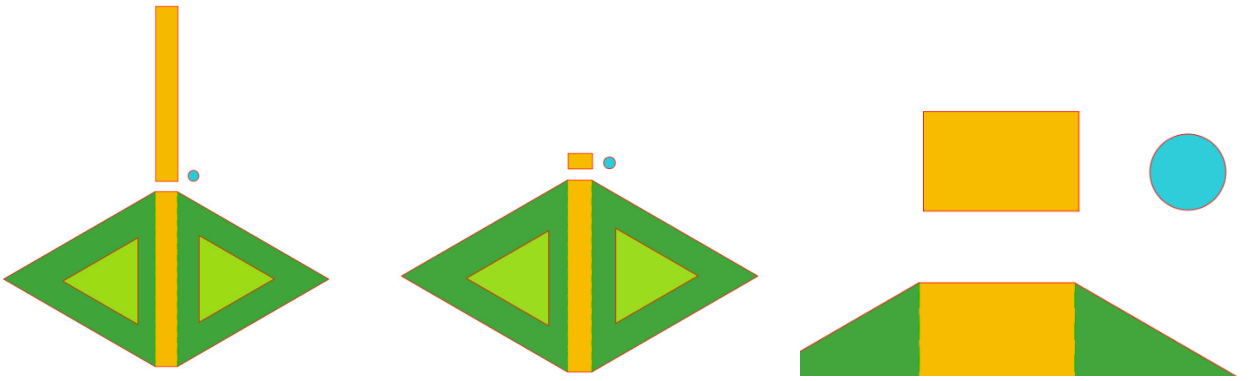


Part 3 - Axle

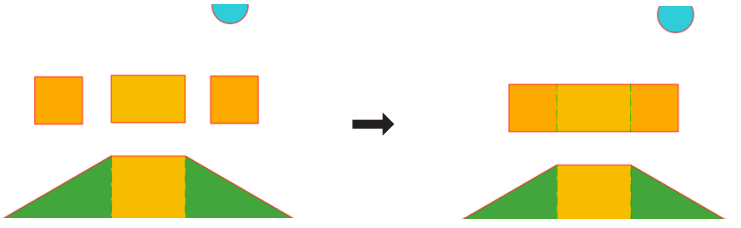
The last piece to design is the axle that joins the two ends of the frame and supports the wheel. Designing the axle so that it has to be bent slightly in order to fit through the hole helps form a tight and rigid connection that allows the wheel to spin well. Pictured below is a close-up of a fabricated axle through the center hole in the wheel.

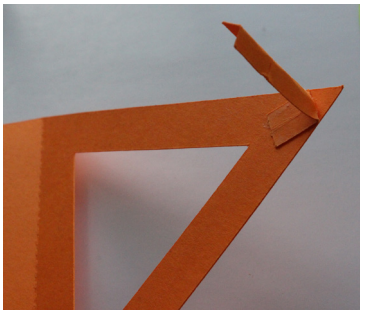


1. **Copy/Paste** duplicates of the center hole from the wheel and the rectangle from the frame as size references. Using the **Select** tool, shorten the duplicate rectangle until it is slightly thicker than the small circle. This will ensure that the axle will need to be folded in order to fit through the hole once fabricated. Keep it the same width as the rectangle in the center of the frame.

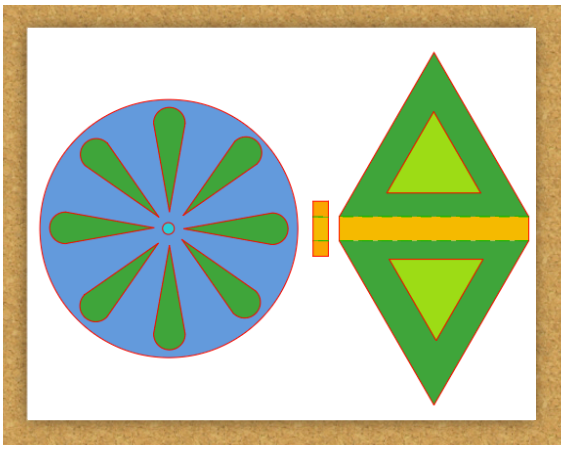


2. **Copy/Paste** two duplicates of the axle rectangle, resize them so that they are relatively square, and place one on either side like the image below. With the **Magnetize** tool on, snap these squares onto either side of the axle rectangle, creating two green fold lines. These two parts on either side of the axle will act as tabs to glue the axle to the frame. Pictured below is an example of an axle glued to one side of the frame. The small circle that was copied for size reference can now be deleted.





3. Position the wheel, frame, and axle so that they all fit within the white workspace. Take a moment to make sure that all of the joined edges on the frame and axle have green fold lines. The Ferris wheel is now ready to be sent to your digital fabricator for fabrication.



Fab@School Maker Studio Tips

Magnetize: If you want shapes to automatically snap and create fold lines when you drag them together, be sure **Magnetize** tool is on. To learn more about the tool, have students watch the Fab@School Maker Studio Shapes Tutorial video.

Resizing Shapes: When creating nets or flat patterns, it's easiest to resize shapes before you snap them together. If you resize a shape that's already snapped to another, you will need to drag the shape away and resnap it to maintain the fold line. To learn more about shapes, have students watch the Fab@School Maker Studio Shapes Tutorial video.

3D View: Expand the 3D View tool in the lower right to preview your folded construction. Note that the first shape you place will be the base and the construction will fold from that plane. Tabs don't show in 3D View.

Cut Fold Tab: Use the **Cut Fold Tab** tool on the left toolbar to change lines and shape edges into cuts, folds, or tabs. To learn more about cut fold tabs, have students watch the Fab@School Maker Studio Cut Fold Tab Tool Tutorial video.

Math Tools: Try using math tools like the **Grid**, **Ruler**, and **Protractor** on the left toolbar to measure elements of your design. You can also display the dimensions of a selected object by opening **Settings** on the top toolbar, and selecting **Show Dimensions** in the **General** tab.