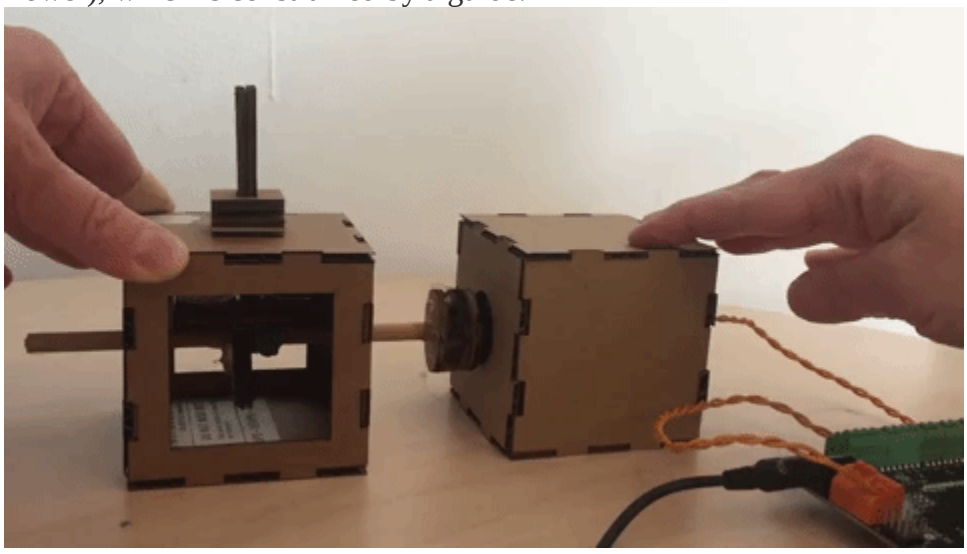
SAMS 2018

Mechanisms in Motion

Cams

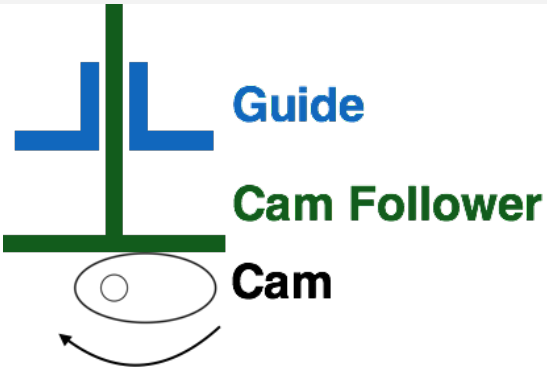
This lab is adapted from the Hummingbird Robotics Kit web pages
https://www.hummingbirdkit.com/teaching/sketches/laser-cut-mechanisms

In this lab, you will be building a cam mechanism in which a rotating disk (the cam) moves a post (the follower), which is constrained by a guide.



This mechanism has three main parts:

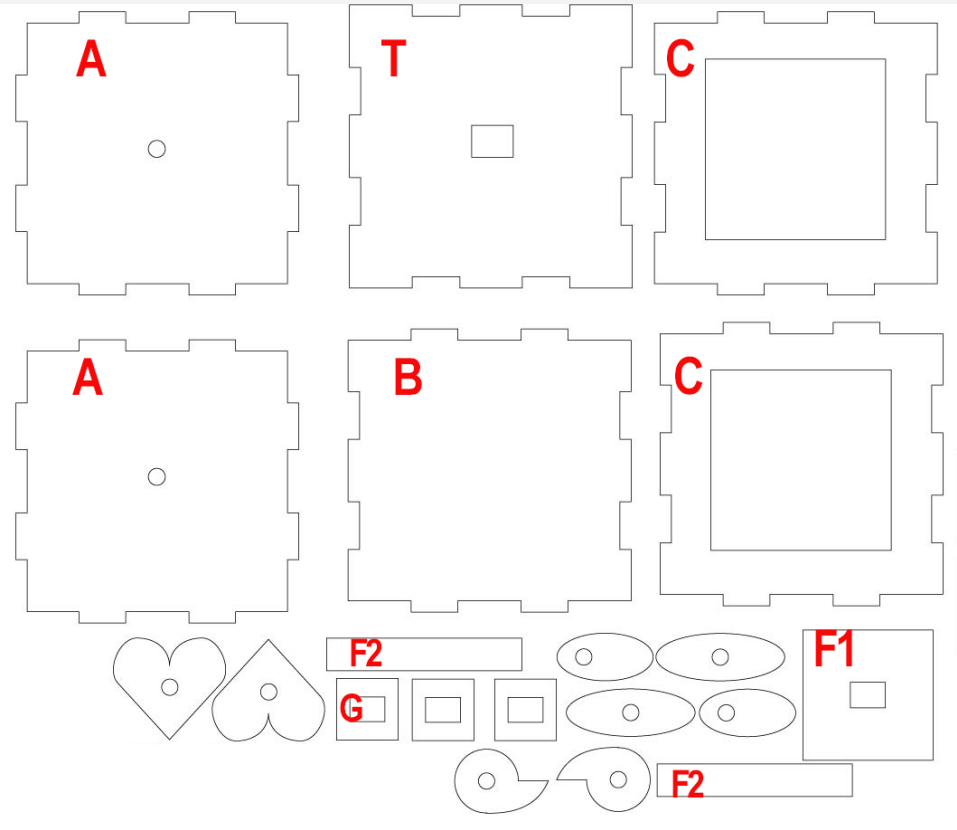
- A cam is a flat disk that is rotated by a motor.
- The cam follower sits on top of the cam. It moves up and down as the cam rotates.
- The guide is fixed in place; its purpose is to keep the cam follower positioned above the cam.



The cam follower moves loosely in the guide. The cam pushes the follower up, and gravity pulls it down. This means that a cam mechanism transforms rotary motion into vertical motion.

1. Building the Cam Mechanism

The box for the cam mechanism is different from the other boxes you have constructed because it has 5 of the 6 sides are special. The diagram below shows the parts that you should have from the laser cutter. The A sides will have an axel going through them; the C sides are windows so you can see your cam; the B is the bottom; the T side is the top with a hole to guide the follower, F; and the G parts form the guide for the follower.



Assemble your cube (without glue) so you see how it all fits together. Then make a corner out of an A, B and C piece:

Next, assemble the follower from the F pieces

Put the follower through the slot on piece T.

Before you put together any more of the box, we'll work on the cams and axel so that everything is ready to go for the final box assembly.

- Glue the three guide pieces, G, together and glue them to the T piece. (Make sure not to glue the follower to the guide.)
- Glue each pair of cams together.
- Glue two of the simple circles together and glue them to your axel. (The simple circles didn't make it into the screen capture above, but they should be there in your parts bin.)

Wrap a rubber band around the middle of your axel:

Stretch one loop of the rubber band out along the axel and thread the oval shaped cam onto the axel. Wrap the rubber band on the other sides of the axel.

The rubber band provides friction to keep the rubber band in place.

The next few stops require some coordination.

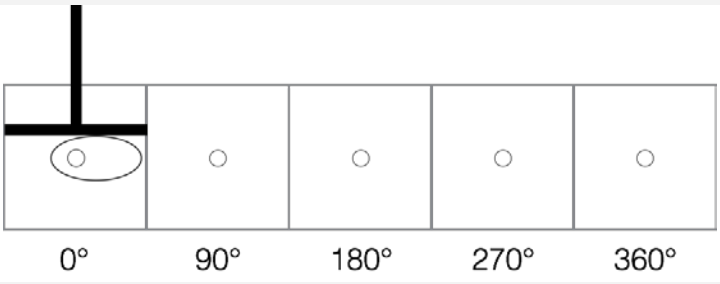
- Glue the second C side on, being sure that the C sides are opposite one another,
- Thread the axel through the A piece that is already glued in,
- **Press fit** the second A piece with the axel through it, but don't glue it or we won't be able to change the cam.
- Finally, being sure that the follower is threaded through the guide on the T piece, add the top to the box.

2. Drawing Your Observations

2.1 First oval cam

The first entry in the table below shows the cam pointing to the right and the cam follower on top of it. Imagine that the cam rotates clockwise.

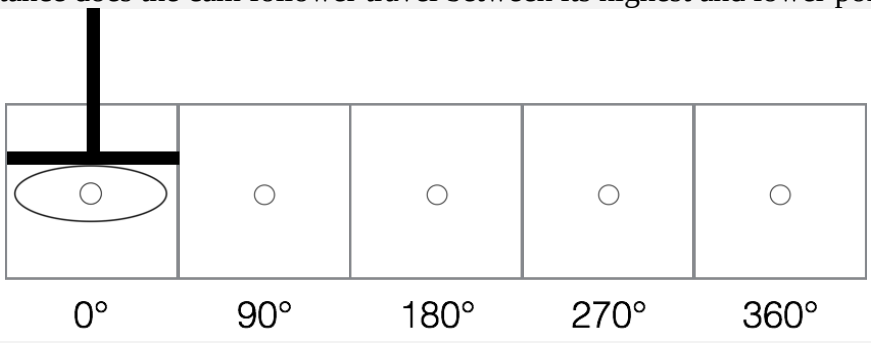
1. Where will it be after it rotates 90°? Draw that position in the table.
2. Draw the position of the cam after it rotates 180°, 270°, and 360°.
3. For each angle, draw the position of the cam follower.
4. At what angle will the follower be at its highest point?
5. At approximately what angle will the follower be at its lowest point?
6. How can you find the distance that the cam follower travels between its highest and lower points?



2.2 Second oval cam

Consider the second oval cam, shown in the table below. Imagine that the cam rotates clockwise. Draw the position of the cam for each angle in the table below, and then draw the position of the cam follower.

1. At what angle will the follower be at its highest point?
2. At approximately what angle will the follower be at its lowest point?
3. What distance does the cam follower travel between its highest and lower points?



4. Put the second oval cam on the dowel rod. Turn on the motor and observe the movement of the cam mechanism.
5. Does its movement match your predictions? How does the movement differ from what you observed with the first cam?
6. Turn the cam in the opposite direction. How does this affect the movement of the cam follower?
7. At what position(s) of the cam does the cam follower move most quickly? Where does it move slowly?

2.3 Snail Cam

Complete the table below for the third cam, which is called a snail cam. For the table, assume that the cam rotates clockwise.

1. What do you think will happen when the cam rotates counterclockwise? After you complete the table, test your predictions.

2.4 Heart Cam

The last cam is the heart cam. Consider its shape.

1. When will the cam follower be at its highest point?
2. When will the cam follower be at its lowest point?
3. At what position(s) of the cam will the cam follower move most quickly? Where will it move slowly?
4. Test your predictions. Is there anything you did not expect about how this cam moves?

2.5 Finding More Information

- Cam Mechanisms: This website animates the movements that results from different cam shapes.
- Cams and Followers: You used a cam follower with a flat bottom in this lesson, but you can learn about other choices for the cam follower here.
- *Karakuri: How to Make Mechanical Paper Models that Move* by Keisuke Saka: This book describes a number of mechanisms. It comes with paper models of different mechanisms and examples of how they can be used in fun ways.