Procedure
1. Define Circuit & Test
   a. Choose a circuit that you would like to use for this project. You may want to select another as backup in case your first choice does not work out.
   b. Build the circuit on a breadboard, using components that you are actually going to solder to your PCB. You may additionally simulate your design as well.
   c. *Test that your circuit is working properly. This step is important to do correctly as you need to ensure your circuit works as intended before you start your mask design.*
2. Fabrication Design:
   a. Use Fritzing to create a breadboard view of your circuit.
   b. In PCB view, trace all routes to create your PCB layout.
        i. Size your rectangle board appropriately.
        ii. Set your trace widths to a wide setting.
        iii. Check top and bottom views to ensure the board is as you intend.
        iv. Add in images and text as desired.
   c. Export your PCB as a pdf file. Open the pdf and create a document with 6-8 views of your PCB layout. (This is for possible multiple masks.) Be sure to size the image correctly to match the original size of your layout.
3. Mask & Etch
   a. Print your PCB layout document on glossy paper. Cut out layouts making sure not to touch the toner mask.
   b. Clean and prep your PCB copper board - scrub with fine sandpaper or steel wool until shiny. Use acetone if needed.
   c. Use a hot iron to transfer the toner mask to the copper. Cool and wet the board to remove the paper backing. Check that you have a full clean mask. If not, go back to step b.
   d. Place your masked copper board in a ferric chloride bath for up to 50 minutes. Agitate the board as needed, checking every 10 minutes to ensure your mask does not begin to dissolve.
   e. Remove your PCB and clean under running water. Scrub off any remaining toner with fine sandpaper.
4. Solder & Test:
   a. Use a rotary tool to drill holes into your PCB for each component leg.
   b. Gather the needed components to complete your circuit board.
   c. Solder all components to their correct locations, using your Fritzing PCB view to help you.
   d. Power your PCB and test your circuit to ensure it is working as intended.
5. Document & Present:
   a. Create a Google document that details your design process. Your document should contain the following items.
        i. Title Page - names, date, period, project name, project image
        ii. Table of Contents - corresponding sections and page numbers
        iii. Circuit Specifics - description of circuit chosen, describe intended use, where you obtained the circuit (your own design or found online?), basic schematic, images of your breadboard or Multisim used to test
        iv. Fabrication Design - images of your PCB view and copper mask included and labeled
        v. Solution - description and images of your final PCB with components
   b. Present your final solution to the class.

File Submission - Inbox your **P127 document link**. Final workday **10/25/2019** with presentations on **10/28/2019**. Documentation due **10/26/2019**.

PCB Printing Instructions

Students: Please read the instructions carefully and follow all safety protocols described.

Printing the Layout
1. From Fritzing, from your PCB View, click Export for PCB and select Etchable (PDF) file. Choose a folder for all the files to be written to and continue.
2. From the folder, select the correct .pdf file to etch. <mark>This will likely be your "_etch_copper_bottom" or "_etch_copper_bottom_mirror" depending on where you created your layout and whether you want to print to the same side or opposite side of your components.</mark>
3. Open this file and snip a copy of the layout into a regular Word document. Use this Word document to resize the image to the exact size of your original image (size of your board). Then make a few copies of this layout for printing. 2-3 copies should be fine.
4. Save this file to your flash drive to print using either laser printer onto the GLOSSY paper. Once done remove from the printer and cut out each layout, taking care not to touch the ink.

Masking the Board
1. Prepare your board for masking by cleaning it to a shine. Use acetone on a paper towel to remove any oils and residue. Then use the fine sandpaper or fine steel wool to scrub to a shine. You may want to do this under running water while sanding. Dry completely when done.
2. Warm up the iron to the highest heat setting with NO STEAM. While the iron is heating up, put down a piece of cardstock on the counter, then your cleaned board. Place your paper mask on the board, ink side down. Then place another piece of cardstock over the top.
3. Use the iron to heat up the board fully. Constantly move the iron around over the board for at least 7 minutes. This step will heat up the copper and allow the ink to adhere to the hot copper.
4. Allow to cool for about 10 minutes. Then soak the board in water for about 2-3 minutes to soften the paper.
5. Using the plastic tweezers or your fingers, gently lift the paper away from the board. Do this slowly so that you can see if your ink adhered properly. If there are sections of the ink that are not adhered, do not continue to lift. Replace on the board and re-iron that section with the tip of the iron. Then re-try lifting the paper.
6. Continue to lift gently and re-iron as needed until your entire mask is on the copper.
7. Use the fine steel wool to scrub gently any remaining paper bits stuck to the ink or board under running water. Dry completely when done.

**Your ink mask should be full, meaning no sections are missing and all lines are connected properly. If this is not the case, you will have to use the fine sandpaper to remove all the ink and re-start the process with another mask or use a black permanent marker to complete traces.

Etching the Board
1. Wear safety goggles and gloves during this entire process.
2. Fill a plastic bin with ferric chloride about 2 inches deep. Set a timer for 20 minutes.
3. Carefully drop in your masked board with a pair of plastic tweezers. Be sure the board is face up and fully submerged in the liquid.
4. Every 5-10 minutes, move the board gently in the liquid.
5. After 20 minutes, check to see if all the copper has been etched away. If not, continue in 10 minute intervals until all un-masked copper is removed. Do not leave in for longer than needed as the etchant may start to remove the copper under the mask if left for longer.
6. Remove the board using the tweezers. Let extra etchant fully drain into the tub. Then rinse the board with water to clean off all remaining etchant.
7. Using the fine sandpaper, gently scrub off the ink mask to reveal the copper traces below.
8. Shine with acetone and fine steel wool if needed. Dry the board completely when done.
9. Leave the container of etchant for the next person. Do not pour it down the drain.

Drilling and Soldering the Board
1. Wear safety goggles during this entire process. Wear a dust mask for all drilling.
2. Secure your board with your helping hands and/or clamps to a sturdy surface.
3. Select the micro drill bit of your choice and attach it to the drill press carefully.
4. Carefully drill out the holes for your component leads. Let the tool make the hole for you - just a gently push should be enough to get through the board.
5. When finished, power off and remove the drill bit. Replace the bit and wipe up any dust with a wet paper towel.
6. Now you should be able to solder your components to your board to finish your circuit!