Welcome to

Florida Small Farms and Alternative Enterprises Conference

Turning your Smartphone into a Digital Microscope

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For more information on Small Farms, visit our website at: http://smallfarms.ifas.ufl.edu/ or contact your local County Extension Agent.

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Introduction

Using magnification to make observations of insects, disease symptoms is often used to make routine identification or diagnostic determinations for management decisions on the farm.

Using a smart phone in combination with a second lens from a laser pointer gives the observer the ability to capture high magnification images with the added ability to stream either still photos or movies to other observers.

Step 1: Materials and Tools

The cost of this project is just $10 (smartphone not included), and it only takes about 20 minutes to build.

**Note! This plan is for small phones. Increase the size of your platform to fit your phone!**

**Materials required:**
- 3x 4 3/8” x 5/16” carriage bolts
- 9x 5/16” nuts
- 3x 5/16” wing nuts
- 5x 5/16” washers
- 1/4” x 7” x 7” plywood -- for the base
- 1/4” x 7” x 7” plexiglass -- for the camera stage
- 1/4” x 3” x 3” plexiglass -- for the specimen stage
- Scrap plexi (~ 2” x 4”) for specimen slide (optional but useful)
- Laser pointer focus lens (use two for increased magnification)
- LED click light (necessary only for viewing backlit specimens)

**Tools:** Drill, Assorted bits, Ruler

Step 2: Getting the lens from a laser pointer

The focus lens of just about any laser pointer will act as the macro lens on the microscope stand.

Don't waste money on an expensive model; the lens from the $2 laser is fine. To achieve higher magnification (up to 375x), use a second lens!

**LINKS TO LENSES AND LIGHTS**


Lenses: If you don't have a laser, these lenses have produced comparable results: [http://www.ekaz.com/store/product_info.php?cPath=46/products_id/374/osCsid/37ab630b0e0a5221276defac7e](http://www.ekaz.com/store/product_info.php?cPath=46/products_id/374/osCsid/37ab630b0e0a5221276defac7e)
To get the lens from the laser pointer start by unscrewing the front cone and the back cover of the tube. Remove the batteries. Using the eraser end of a pencil, push the innards out of the front of the tube. The front of this assembly (the side without the spring to contact the batteries) is where the focus lens sits. Unscrew the small black piece of plastic in front of the lens and the lens will come free.

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**Step 3: A few notes on the lens...**

The lens, when viewed from the side is not symmetrical. You’ll see a thin translucent strip (~1mm) on one side of the lens. That side must not be adjacent to the camera. You can determine the correct orientation by sticking the lens between the prongs of a hairpin and taping the rig to the back of a smartphone. The correct orientation will provide you with a larger field of view.

As it is, you can take reasonably good macro photos with this lens and smartphone. This simple rig is limited; not to mention, it’s extremely hard to keep the phone steady when taking zoomed in photos. That’s why we need to build a stand!

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**Step 4: Drilling the bolt holes**

Make a mark with a Sharpie on the front two corners of the plywood base ¾” from both the sides and the front edges. Put a sacrificial piece of wood beneath the plywood base before drilling. You don’t want to damage surface of the bench! Stack the plexiglass camera stage (7” x 7” piece) on top of the base. Then stack the specimen stage (3” x 7”) on top of the camera stage with ¾” of the stage extending off the front of the base.

Drill through the entire assembly. The bolts that stick up through the base must be countersunk in order for the stand to sit flat. Flip the base over and counter sink the holes with a spade bit.

A few tips on NOT cracking the plexiglass when drilling: First, Drill slowly to lessen the chance of cracking the plexiglass. Let the drill do the work and DO NOT press down hard on the drill. Use a sharp bit and press gently on the drill. You can also put a piece of tape over the area that you wish to drill through. It will reduce the chance of cracking the plexiglass.
Step 5: Embedding the lens

Find a drill bit that is the same size as or smaller than the diameter of the lens. Remember, you can always take more plexiglass away; adding extra plexiglass after drilling is not an option.

¾” from the front of the camera stage (in line with the bolt holes) drill a hole for the lens.
If the lens doesn’t quite fit, file or use sandpaper to enlarge the hole. Be sure to do this slowly and test the fit often. It is easy to overshoot and make the hole too large!

Step 6: Drilling the hole for the light source

It is important that a hole for your light source is directly below the focus lens. The best way to mark the placement of the light is to slide the camera stage (without the lens) down to the base, mark with a pencil where the hole is to be drilled, and drill a shallow hole to rest the light in.

Step 7: Assembly

- We are ready to assemble! Start with washers and nuts to hold the bolts tight to the base.
- Then add some upside down wing nuts and then washers to the two front bolts.
- Place the specimen stage on top of the washers and add a nut to each bolt.
- Lower them about 1/2” and rest the camera stage on top of these nuts. A level is handy here to make sure that the stage is actually flat. If you don’t own a level there are plenty of free level apps for a phone!
- When the stage is level both front to back and left to right, tighten down the final nuts.

When using the stand, it is important to have the lens as close as possible to the camera. If you don’t plan on having your phone in a case when you use the stand, make the lens flush with the stage. Otherwise, leave the top of the lens slightly exposed (as is done in the image) so that the lens will rest closer to the camera.
If you are using TWO lenses, stack them on top of another. Insert one lens from below the plexiglass and the second from above.
Step 8: Explore!

Go take some pictures! Or video! With $10 worth of materials and a smartphone, you just made a digital microscope!

Plant cells tend to work best for this particular model, but feel free to experiment. That’s what this is all about, giving you the freedom to explore.

This set up is a viable option for underfunded science classrooms that would not otherwise be able to perform experiments requiring a microscope. But more than that, this device will allow people to rediscover the world around them.

Step 9: Troubleshooting! Lens won’t focus?

This is most likely because the object is not close enough to the lens. If you still can’t focus on the image and the nuts under the camera stage stop the specimen stage from being raised higher use a scrap piece of plexiglass as a slide. This will raise the object into focus. You may also try sourcing thinner nuts to use underneath the top plexiglass will allow the lower stage to be adjusted closer to the lens. Camera focal length varies with the brand of smartphone so you will have to make adjustments when switching phones.

The best way to focus on and object is to set the zoom on the phone to minimum, place a sample on the lower stage, making sure it is laying flat (it is easier to focus on a flat surface). Use the wing nuts to focus before zooming in with the phone camera.

Cracked plexiglass?

The big thing here is GO SLOW. Let the weight of the drill do the work and DON’T PRESS HARD. Use as sharp a bit as possible. Taping over the area you need to drill also reduces the chance of cracking.

I don’t have the tools to make the cuts!

Not to worry! Most hardware stores have a shop and will charge a small fee for cutting the wood and the plexiglass down to size.

Plexiglass only comes in huge sheets!

Many hardware stores will have scraps. I purchased a large piece of scrap to make 8 microscopes for a fraction of the price of a full sheet. Some inexpensive clip boards are made of plexiglass and may even have a ruler on one edge.

I can’t find the same LED light!

Pretty much any LED light will work. Ideally it can stand up straight with the light pointing vertically. If your light is tall, it might raise the minimum height that your specimen stage can be. This of course can easily be fixed by using longer bolts.

My phone is too big for the stage!

Smart phones and tablets are often much larger that the one these plans were developed for. Customize your platform to best fit your phone.