Hands-on Physical Principles of Living Systems

Phonescope Redesign

Spring 2016

I. Objective

The objective we established for our final HOPPOLS project was to redesign and improve the phonescope used in class all semester to be able to observe and document dynamic systems in nature.

II. Introduction

A phonescope is essentially a microscope that uses a smartphone camera to capture pictures of a specimen. For the HOPPOLS course it has been used in multiple experiments but has not been efficient in being able to capture consistently clear pictures. When the HOPPOLS course progresses to a larger size class, we believe that an efficient phonescope apparatus is vital so future class members can produce high-quality experimental results without spending more time on trying to take the pictures than on the lab.

III. Background

For the current phonescope device [Figure 1], we identified improvements that could be made to contribute towards taking pictures efficiently. The current device functions by placing your phone on the stand and centering your phone camera lens over a glass bead (this is the magnifying lens) that is placed in the rubber strip. The slide is placed in a slit behind the rubber strip and in order to view the specimen on the slide the rubber strip must be pulled on either side to move the glass bead. While doing this your phone must also be centered on the glass bead and not move in order to still be able to view the sample. Underneath the slide a strip of LED lights is used as a light source, with kim wipes to diffuse the light. The following list of problems were identified as areas to improve:

i. The slide is not able to be moved to view a specimen, only the rubber strip with the glass bead is. This caused problems because of the flimsy slits where the rubber strip was attached. Multiple students broke the plastic when pulling the rubber strips. This also caused unnecessary movement of the phone camera when trying to keep it centered over the glass bead while it moved.

ii. The light source underneath the slide needed to be adjusted for every picture. Figure 2 shows how the light affects the picture quality, without diffusing the light enough or too much then the phonescope does not function properly. Students had to move their phonescope further away from the light source as well until a clear picture was able to be taken. This normally was the most time consuming step in using the phonescope.

iii. The glass bead lens, though less costly than other lenses, did not always function properly. When first setting up the phonescope and selecting a glass bead, some were not perfectly spherical. Also, it was a very time consuming process to try and insert the glass bead into the rubber strip to use, and with the consistent stretching of the rubber strip when moving it back and forth sometimes the glass bead would slip out.

IV. Methods

After considering the list of problems encountered while using the phonescope we decided to focus our redesign to incorporate the following list of features: ability to move the slide instead of the rubber strip, adjustable height of the slide for focusing the picture, using an enhanced microscope lens that is still economically viable, using a light source that does not need to be consistently modified in order to obtain a clear picture, and having it be entirely 3D printable except for the lens and light source. Solidworks was used to design the improved 3D printed phonescope. For the light source improvements, we tested different color filters made for LED lights. First we used the original technique to take pictures, then we placed a plastic color filter over the light source and took a picture to determine if its quality was improved. Our early designs [Figure 3] had a movable platform for the microscope slide, with slits on the top platform where the phone was to be placed in order to secure the phone with a rubber strip so it did not move while taking a picture. However we forgot that holes would need to be cut in order to allow the light source through to the slide so we incorporated that in our next design. We also decided to use a threaded rod with a wingnut to be able to adjust the platform with the slide more sensitively. This design however was too large to be printed and unnecessarily thick. We also weren't able to design a threaded rod to be 3D printed.

V. Results

A rendering of our final 3D printed design can be seen in Figure 4. This design incorporates the following improvements: the ability to move slide instead of rubber strip, being able to adjust the height for focusing the picture, and using an enhanced microscope lens. The phonescope would be printed in three separate pieces: the top platform, the bottom platform, and the moving middle platform. Unfortunately the top and bottom piece took 30 hours to print and there was not enough time to print both of them. A modified setup [Figure 5] was used to test our design. We were able to see major improvements with different color filters [Figure 6]. On the left is using the original light setup and on the right is with the color filter. The picture is visibly clearer using the color filter, and it was efficient to place one piece of plastic over the light and not have to constantly adjust anything. We were unable to test an enhanced lens because the shipment did not come in time.

VI. Discussion

Our phonescope design did not improve in every area we wanted to, but is a step towards a design that will be more efficient to use. The major problem with our improved design is the time it takes to print because of the thickness and size. It could be thinner and a little smaller so it does not take as long to print. Although we were unable to test the entire design all together, with our modified setup it was clear that not having to move the lens like in the previous design with the rubber strip was more user friendly and the moving platform worked for moving the slide in order to focus it. In future redesigns we would like to be able to 3D print all the pieces (including the threaded rod) and have a design that can be printed in a reasonable amount of time. Also, we were unable to test a different lens so we believe that with a different lens more improvement would be shown on the quality of the pictures taken.

Figures:

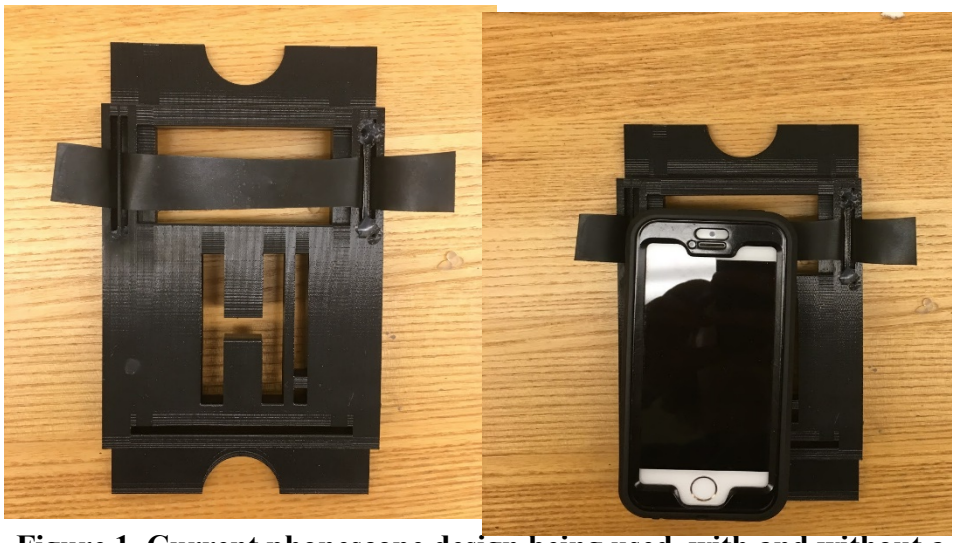

Figure 1. Current phonescope design being used, with and without a smartphone.

Figure 2. Pictures showing how different light setups affect quality. They are all of the same slide, with different layers of kim wipes over the light.

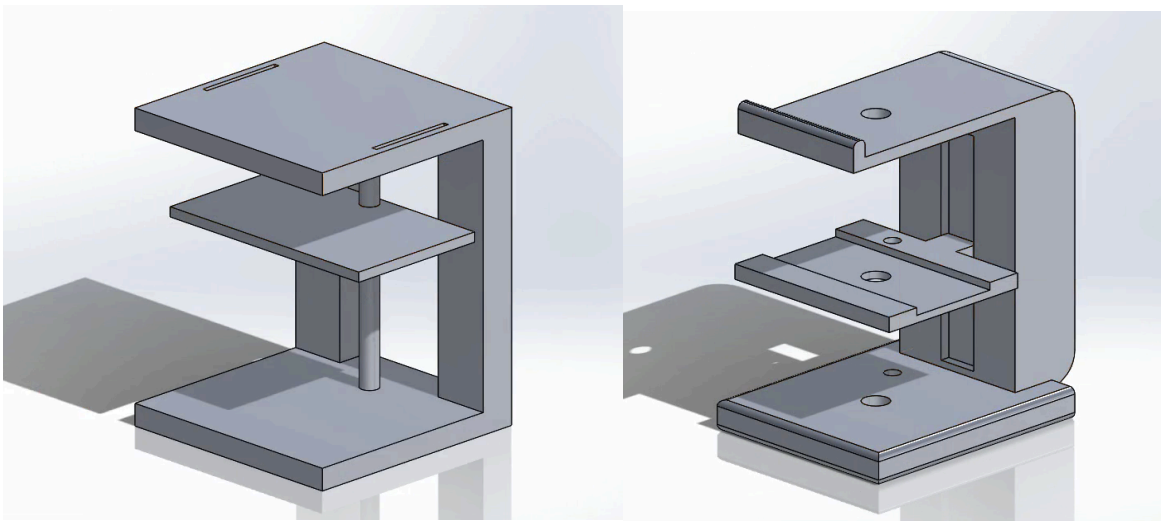

Figure 3. Early redesigns. The left picture shows our design without holes for the light and lens. The right picture shows our design that was too large

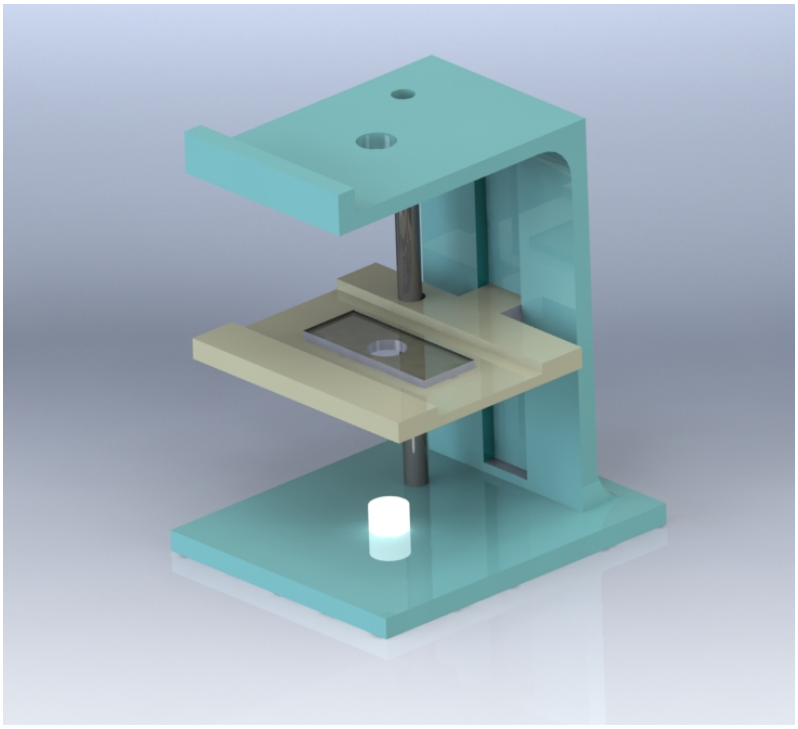

Figure 4. Final solidworks rendering of our phonescope design.

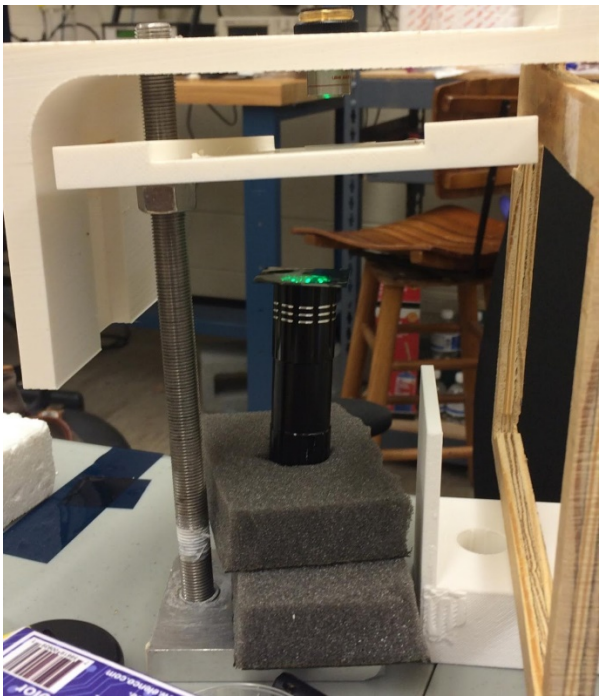

Figure 5. Modified setup used to test middle and top platform. This is similar to what it would look like if the bottom had been printed.

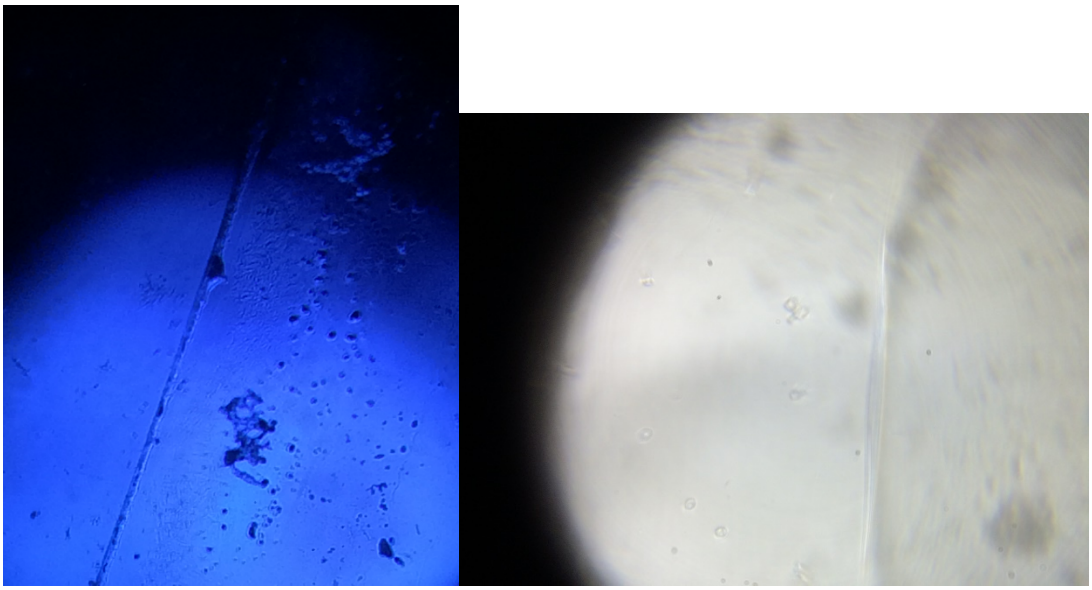

Figure 6. Picture of coverslip taken with blue plastic color filter over the light and with the original light setup (this one is slightly more zoomed out because it was unrecognizable zoomed in the same).