

Drexel University Society of Physics Students
Sigma Pi Sigma Undergraduate Research Award
Dynamic 3D-Image Projection System

For the Sigma Pi Sigma's 2010 Undergraduate Research Award, we proposed a model for a "Dynamic 3D-Image Projection System". Our goal was to create an optical lens system with the capabilities of generating a 3D image by focusing a column of light to a single point, and then quickly and smoothly moving that point to generate an artificially solid image.

To simplify the entire process we broke the system into a few basic steps that we could follow to a finished product. The first step was to determine the size and specifications of the entire model, and also generate a theoretical version of a lens system that fit within that model. This required that we read up on lens systems containing two lenses and also learn the complexities of even larger lens systems. To match our original model, we needed a total of 3 lenses, two of which we found for sale through Edmund Optics. The third, which allows for the final focus to occur over a long distance, was unavailable at the focal length we desired. To solve this we changed our design to a system with four lenses. Our four-lens system can be looked at as two separate lens pairs working together to create the final focal length. The first lens pair contains a 3mm diameter concave lens with a focal length of 9mm and a 50mm diameter convex lens with a focal length of 200mm. The first lens' small diameter was used so that the laser beam could be spread as quickly as possible. The second lens' diameter determines the final diameter of the collimated beam, so we picked the largest we could find. To find the focal length of a two-lens system, we used the following equation:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

where f is the desired focal length, f_1 and f_2 are the known focal lengths and d is the distance between the two lenses. To collimate the beams we wanted $f = 0$, so in our model these first two lenses are 191 mm apart. The second lens pair contains a 50 mm diameter convex lens with a focal length of 100 mm and a 50 mm diameter concave lens with a focal length of 100 mm. These two lenses work together, using the same relationship as the first set, to generate a much longer focal length than 100 mm. The benefit of using two lenses here is that we are not fixed to a single focal length; instead we can change the distance between these last two lenses and get a new total focal length. After finding these lenses we were able to purchase them, along with lens holders, mirrors and other supplies and move on to our next step.

The second step, which is the step we are currently working on, is to build a stationary 2D model. By 2D, we mean a complete model that is capable of generating a single point on a vertical plane in the air, using but not moving, all four lenses and three mirrors. Our Physics Department has supplied us with laboratory workspace this has given us a permanent place to set up our model as well as a secure location to store our supplies. The components are working as expected within this model, and our lens calculations were correct, as we were able to generate our desired focal length using the lenses we purchased. Along side the development of a real model, we are beginning work

on a computer program that, using Visual Python, is able to recreate the images seen in the physical model. The goal of this program is to help us calculate the angles and locations of the different model components to create a desired image. It is also providing the groundwork for a program that will eventually connect to the real model and physically control the locations of components.

It can be seen, from the different steps needed to create a fully functioning model, that more than just a knowledge of physics is required to complete this project. This is why we have recruited roughly six members from a range of Drexel's science and engineering departments, all of whom have an interest in physics and are dedicated to this project. Having such different academic backgrounds contributing to the project gives us the ability to work with the array of motors, computers and lenses required to build a fully working 3D model.

Our planned future tasks are to first learn to control the point on its 2D plane and then apply that understanding to make the final step into 3D. This will involve adding motors to the moving parts and calculating the speed that each part will need to move in order to generate a solid looking object. As we progress, we constantly keep this final goal in mind so that we can create a model that can be upgraded to the final product and not be constantly reconstructed as new pieces become necessary. We hope to complete the first step model over the next month. Over the summer term we have fewer students working so progress will be slower. We will spend that time discussing what type of motors would best work to drive the different moving parts. The moving parts include a pivoting mirror (to change the height of the point), a rotating mirror (to change the points location in the air) and a sliding lens (to change the focal length). We have various motors that might work for each of these parts, but we are not at the point where a price estimate can be made for these. Motors are very expensive, so that is where a majority of the remaining budget will go. Our Physics Department has told us they can supply an additional \$1000-\$2000 dollars if our budget needs it. Besides the motors, most of the other main parts of the model have been purchased, but we hope to keep a small surplus for building supplies (i.e. plastic, wood and metal for structural components). When more students return after the summer term, we will spend the fall term (10 weeks) building a working 3D model. After that our goal is to research and assemble a computer-controlled model. The Drexel University Engineering Department has supplied the necessary components that should be able to do this.

Budget:

Polarizing Film (Decreases brightness of laser):	\$24.11
Laser Pointer w/ On-Off switch:	\$37.90
Three-Screw Ring Mounts (Three):	\$161.36
Lens Tissue (Cleaning and Maintenance):	\$10.54
Convex Lens 50mm dia x 200mm fl:	\$45.19
Convex Lens 50mm dia x 100mm fl:	\$45.19

Our current design for the final 3D version:

