Integrative Project in Computer Science and Math

section 00001

User Guide

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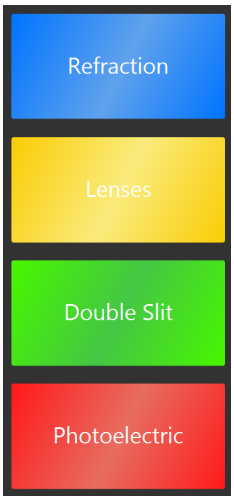
Main Menu

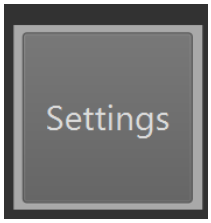
Upon launching the application, the user will be greeted with the main menu.

Launching a simulation
To get started, users can select one of the four colored buttons on the left side of the screen.

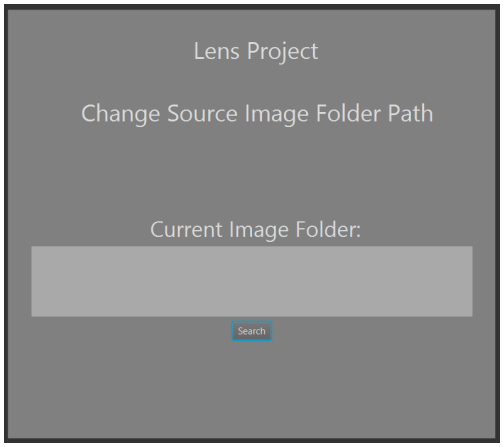


Each button will open a preview image and description of what the simulation will cover. To launch the selected simulation, simply click the "Start" button in the bottom right, and the simulation will commence.

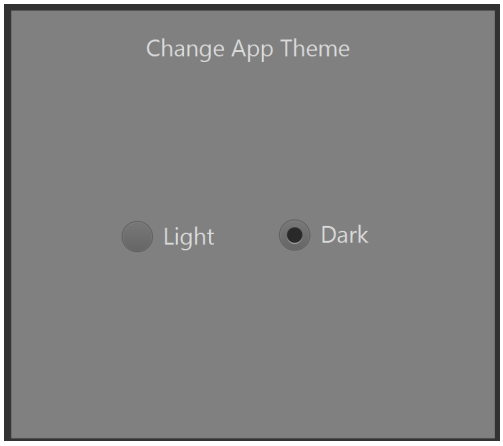
Accessing the settings
On the bottom right hand corner of the main menu is the "Settings" button. Upon pressing it, users will be greeted with the following menu.



Changing the app theme
By default, the app is set to dark theme.
The right hand side of the settings screen has a toggle which allows users to swap between light and dark themes. These themes only apply to the Refraction, DoubleSlit, and Photoelectric simulations.



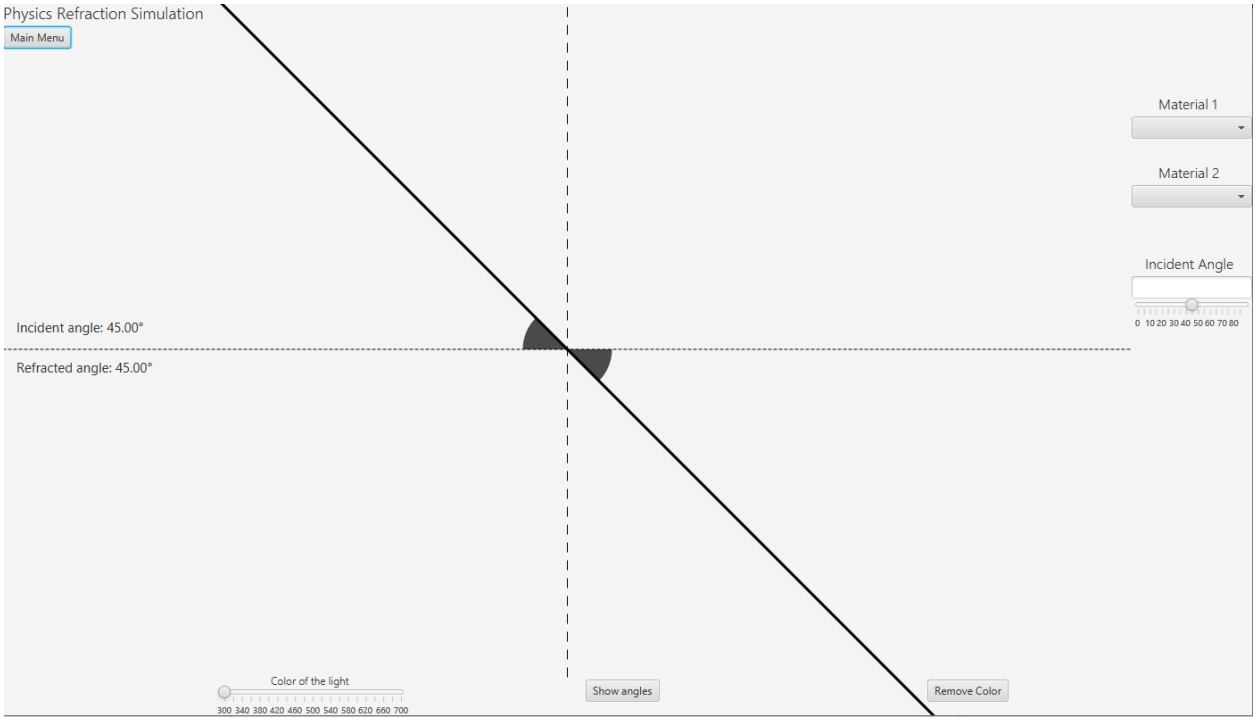
Changing the folder path for the Lens project source images
On the left hand side, users can search for a folder on their device to set as a path for the lens project to pull images from. PNG, JPEG, GIF, and BMP files can be used.



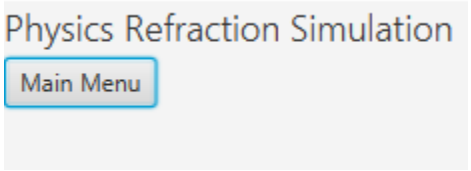
Refraction project

Introduction:
Snell's law, also known as the law of refraction, describes the behavior of light waves as they pass through the boundary between two different media, such as air and water. The law states that the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant, which is equal to the ratio of the refractive indices of the two media. In other words, the angle at which the light wave enters the second medium (angle of incidence) affects the angle at which it is bent as it travels through the medium (angle of refraction). The greater the difference in refractive indices between the two media, the greater the bending of the light wave.

Upon clicking the refraction button from the main menu, this is what the user should be able to see.

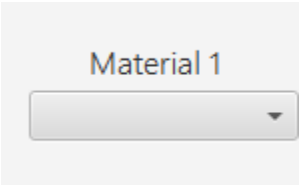


Main Menu Button:



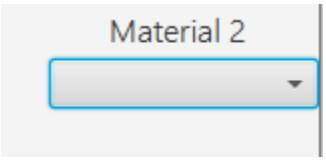
This button makes the user go back to the main menu.

Material 1Choice Box:



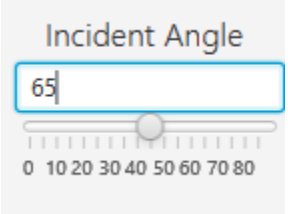
The choice box here lets the user change the material for the top half of the animation pane. It lets the user choose the material that has a unique refractive index.

Material 2 Choice Box:

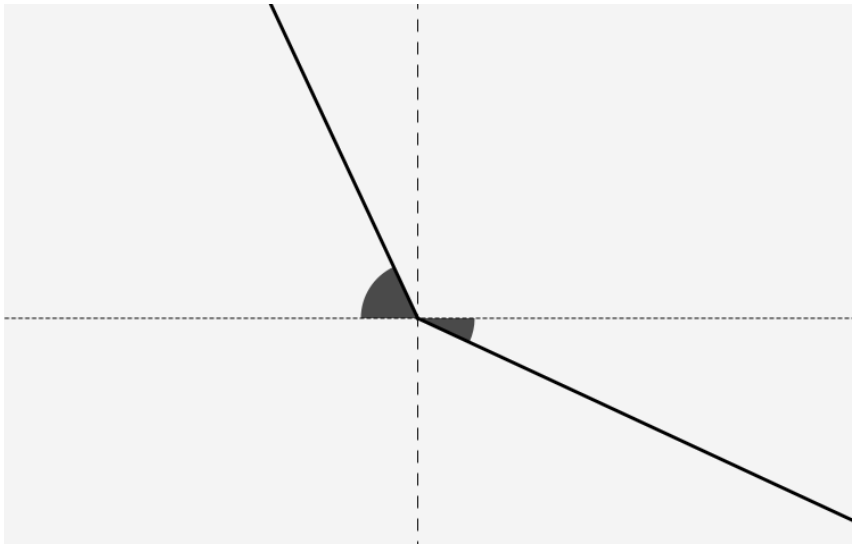


The choice box here lets the user change the material for the bottom half of the animation pane. It lets the user choose the material that has a unique refractive index.

Incident Angle Text Field and Slider



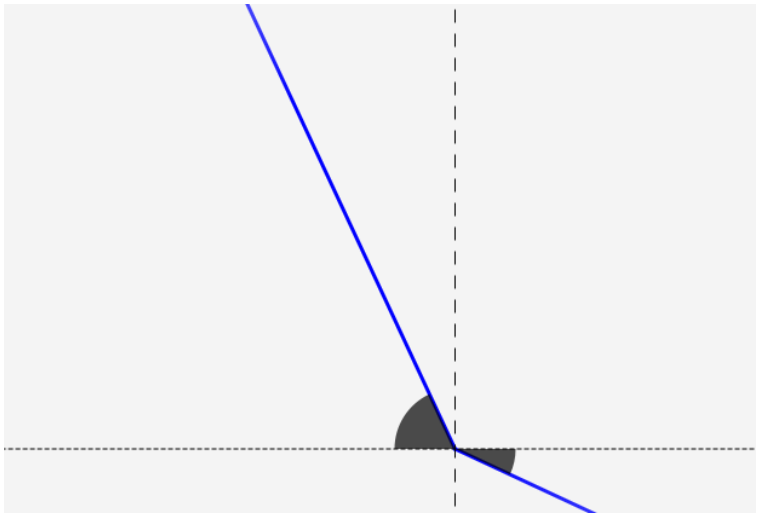
There is the text field that lets you input manually an angle so that the incident angle changes. For example, in the next screenshot,



if we input an angle of 65 degrees, the incident ray changes, which is the first ray that is at the left of the screen. Then, it makes the refracted ray change, which is the ray at the right of the screen.
There is also the slider which makes the angle change dynamically. The slider is able to input values from 0 to 90 degrees.

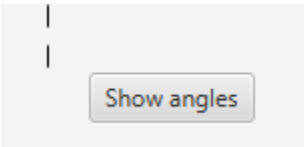
Color Change slider

This slider let's the user change the color of the light. The values are 300 to 700 nm to represent the visible light that the human eye can see. It goes from red/brown to blue/purple. In fact, it follows the rbg gradient but in the red-green-blue order. Here is an example,

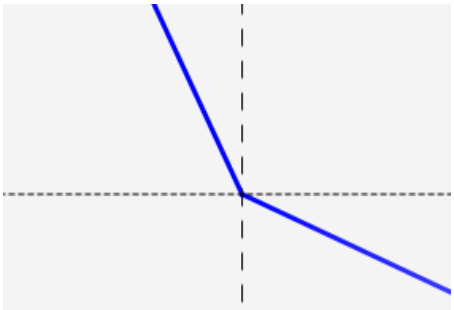


The color of the light is around 620 nm and it has a blue color.

Show Angles buttons:

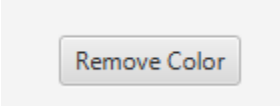


This button right here lets the user remove the angles so that they can see the light better. For example,

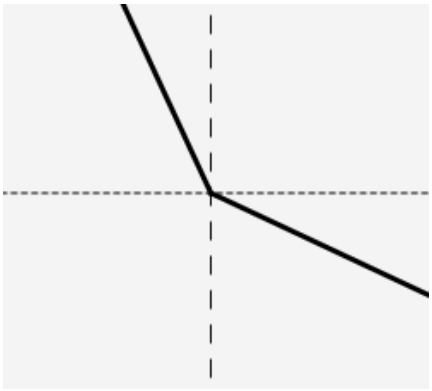


The arcs that were showing the angles are removed.

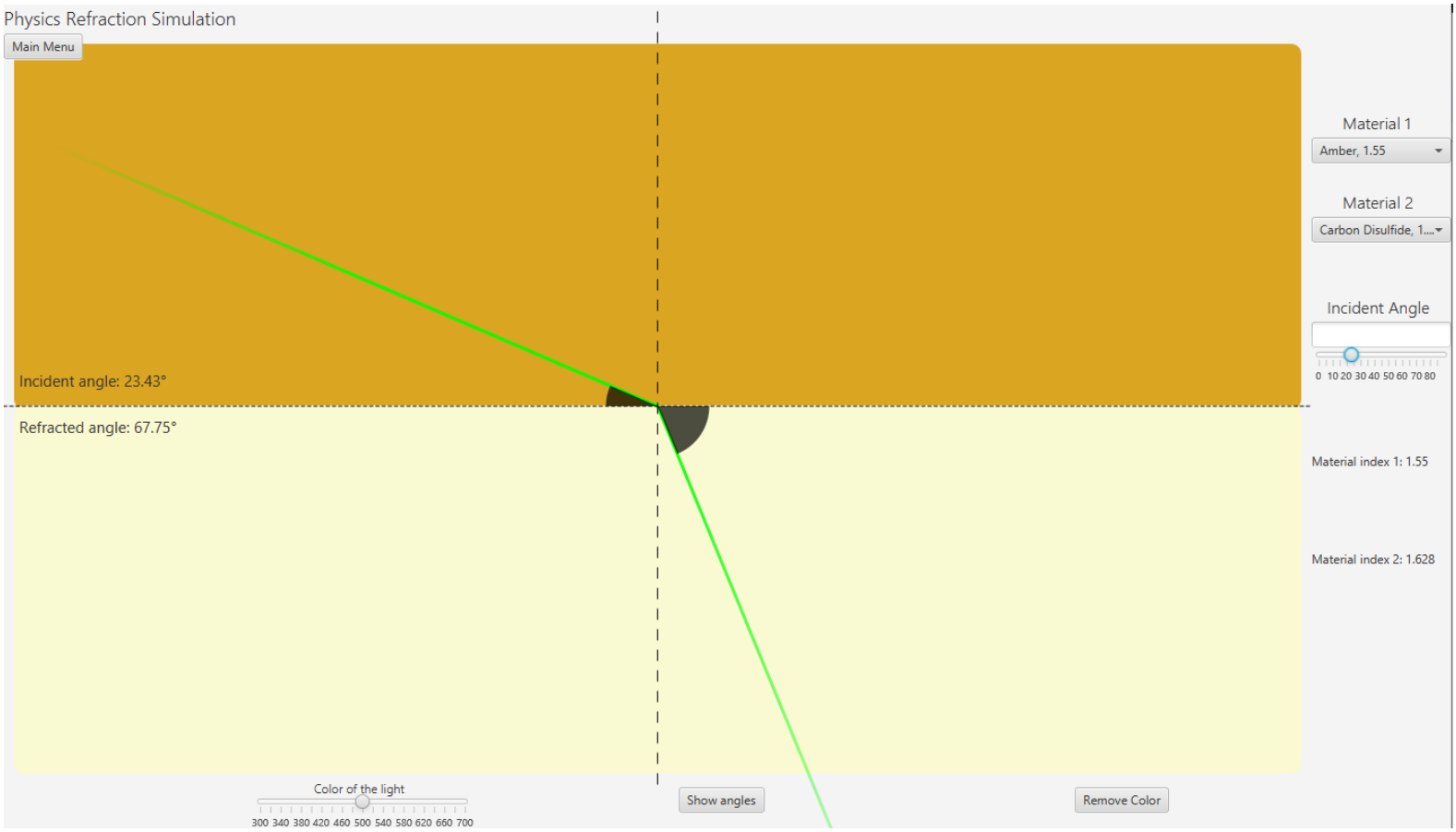
Remove color button:

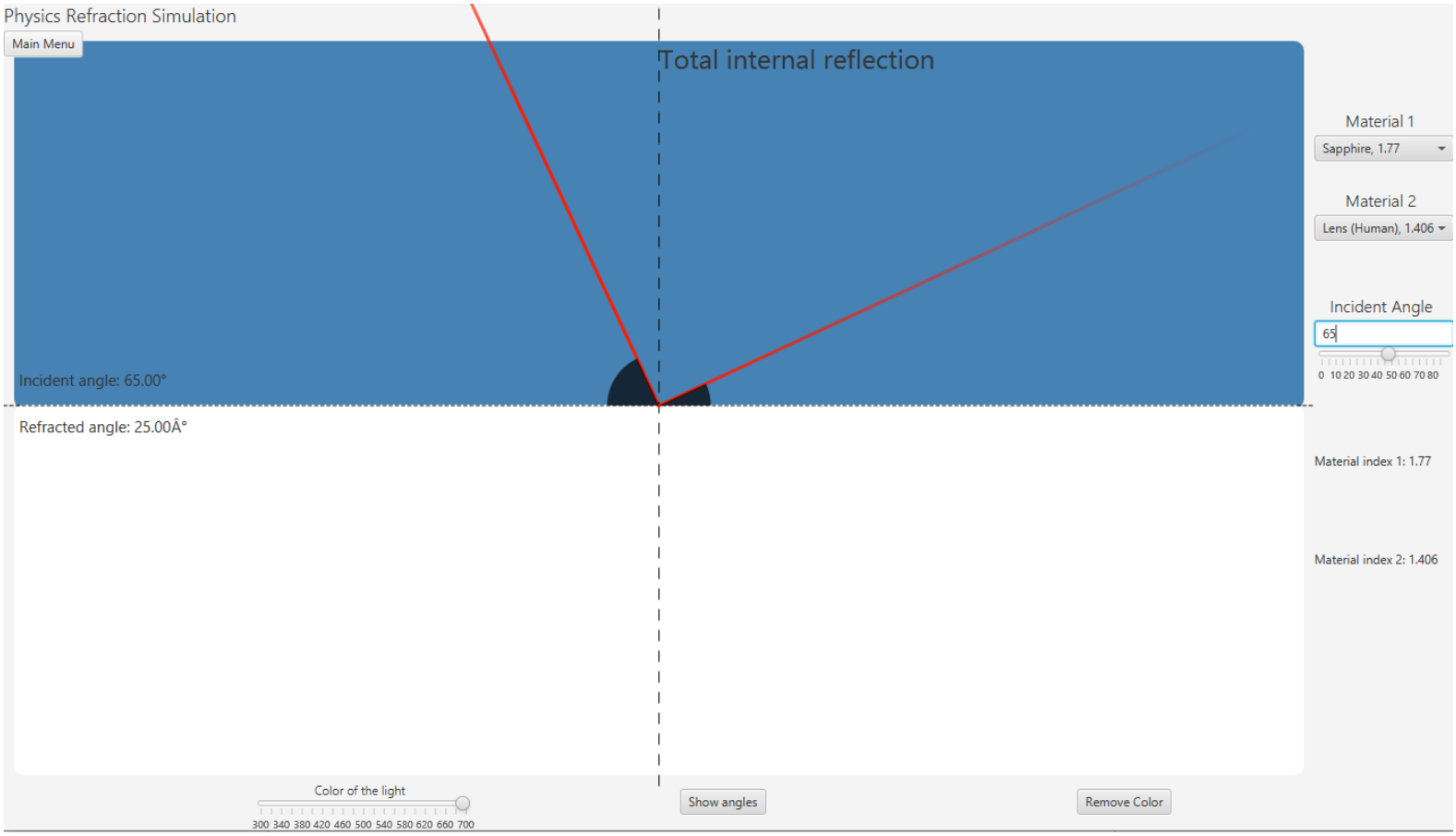


This button removes the color that are on the rays. The button is useful because sometimes the color of the light is the same as the color of the material, so it helps to see the simulation better. Here is an example, the image will be the same as the one aboves but it will go back to its original color.



The project in action:

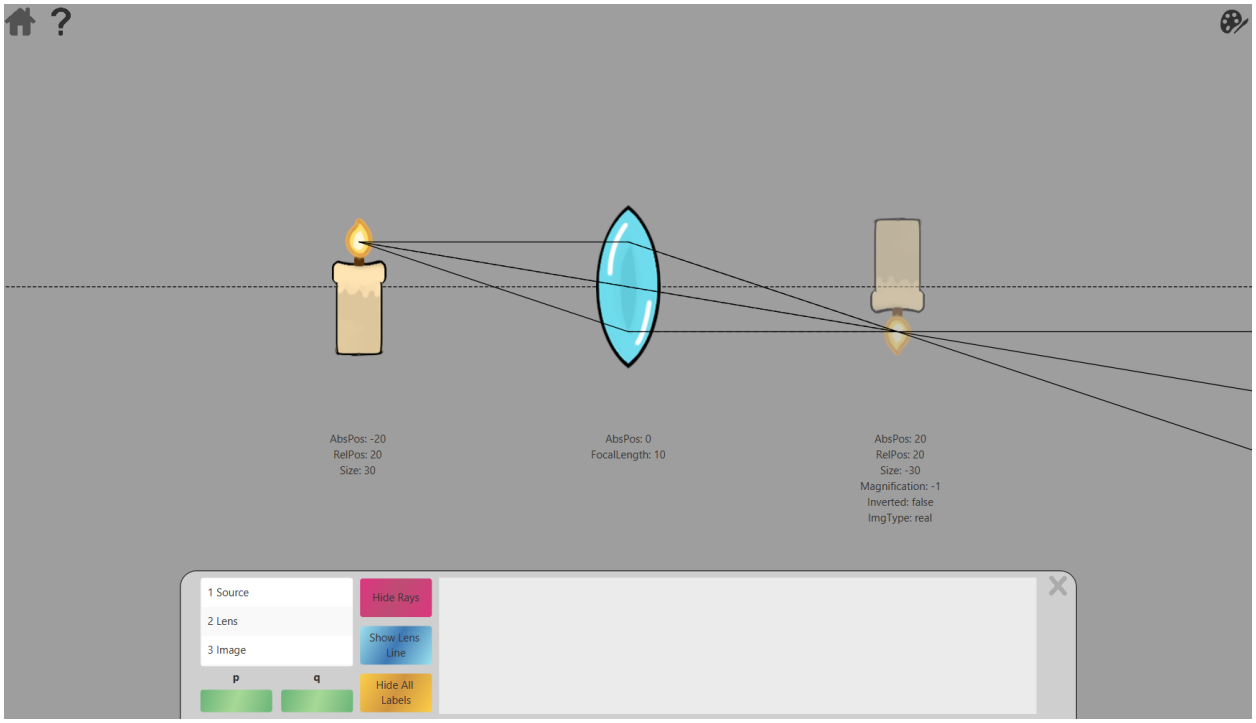




Lenses Project

The study of light as rays is the explored concept of the lens project. Lenses are used to redirect and focalize rays of light reflected off a source object and onto a lens, refracting and finally forming an image. Depending on variables such as a lens' focal length and type, as well as the position of a source object, the generated image can vary in position, size, magnification, and even type. This project allows the user to take control of the various variables and simulate the formation of images through thin lenses.

Upon launch, users are greeted with the following menu, with 3 “items” along a horizontal line. In order from left to right, there is a “source”, a “lens”, and an “image”.



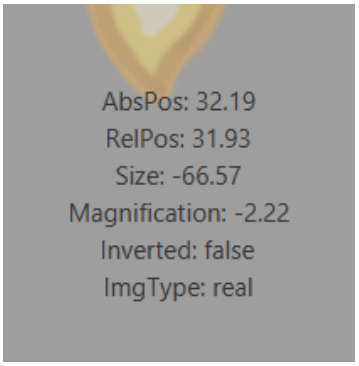
Basic displacement controls

Users can click and drag both the source and the lens horizontally, displacing them along the line. The source can not be moved past the lens.

As these items move, the associated image is adjusted according to physically accurate calculations.

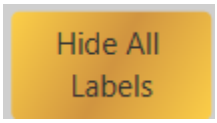
Data visualization

The different variables involved are displayed in two ways.

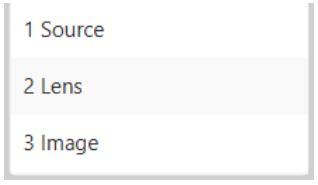


1. Item Labels

Item labels are found directly underneath the item's visual representation. They update as objects are moved or adjusted. Their visibility can be toggled through the yellow "Hide/Show All Labels" button.



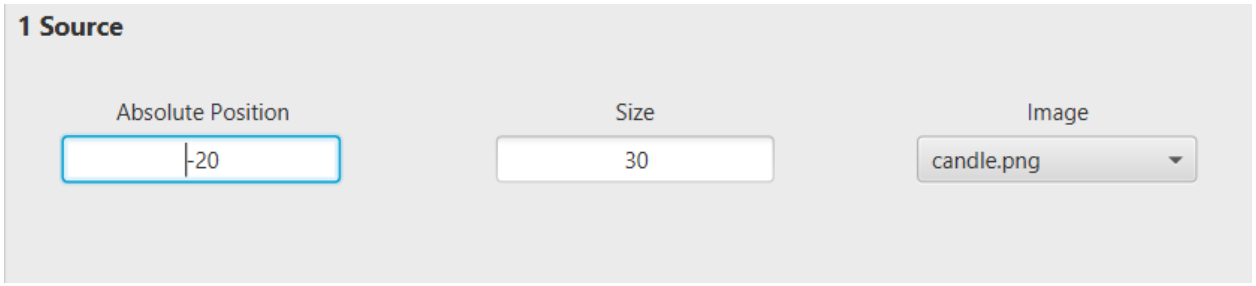
2. Data tables



A data table for each item can be opened through either right clicking that item's icon or selecting the associated entry on the item list. Modifying values in these data tables will adjust the graphics accordingly.

2.1 Source Data Table

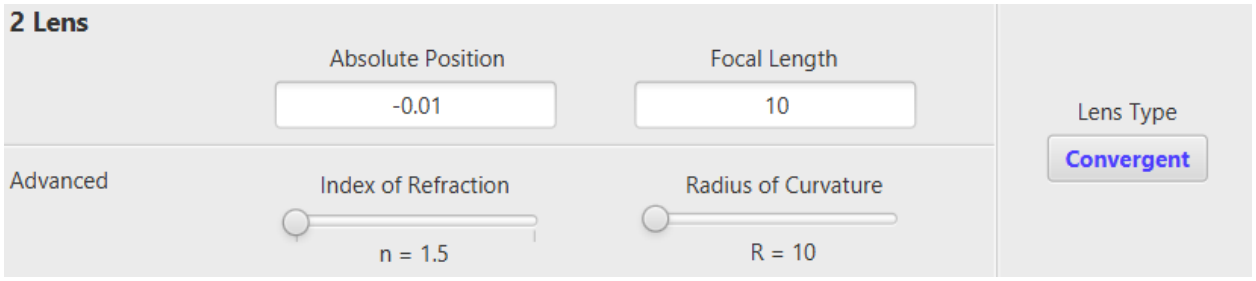
The source object's properties can be viewed, and adjusted here.



The source's node image (not to be confused with the source's image) can be changed through the dropdown menu. A path to a folder containing images must be specified through the main menu settings in order for other images to appear in the drop down.

2.2 Lens Data Table

The lens' properties can be viewed, and adjusted here.



The lens' focal length can be adjusted here through 3 different means.

The simplest of the three is through directly changing the value of the focal length. Inputting a negative focal length will switch the lens to a diverging lens, and a positive one will give a converging lens.

The next two ways are more complex, involving the lens maker equation.

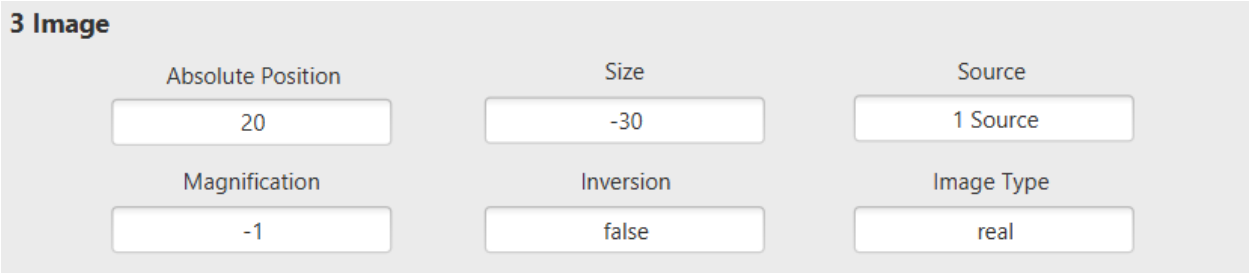
The second way to adjust the focal length is by modifying the index of refraction. The slider allows the user to adjust this variable between 1 and 2.5.

The third way is by adjusting the radius of curvature of the lens. This parameter adjusts both curves of the lens, making it essentially a symmetric lens. The values are capped between 10 and 300.

Lastly, the user can simply switch between using a converging and diverging lens at the press of a button, toggling the lens type.

2.3 Image Data Table

The image's properties can be solely viewed here.



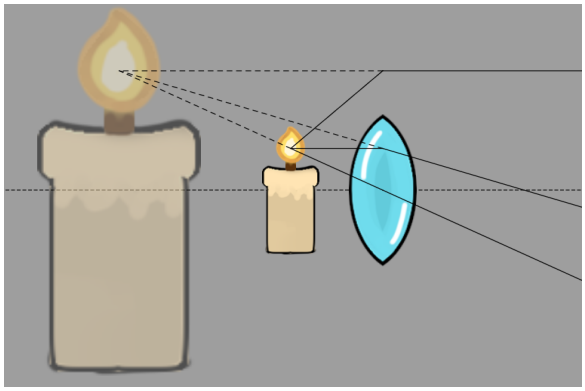
These values are read only, allowing the user to make readings on the image **after** an item is displaced. The values update once the user stops dragging an item.

'p' and 'q' displacement

Physics students will be familiar with this notation, as the p and q text fields allow the user to modify the relative object and image positions respectively. These will result in an instant adjustment to the graphical representations, with respect to the position and focal length of the lens.

Toggleable settings

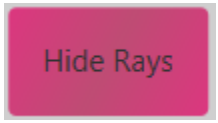
Users have 3 toggleable settings at their disposal.



1. Toggle Rays

By default, the principal rays are visible. They allow the user to see how light from one on the source is refracted through the lens and converges onto where the image is formed.

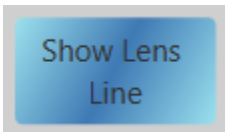
Users can disable this if needed by simply clicking on the “Hide/Show Rays” button.



2. Toggle Lens Line

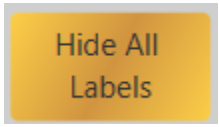
By default, the lens line is not visible. It allows the user to visualize the vertical axis along which the lens is refracting the light rays.

Users can disable this using the “Hide/Show Lens Line” button.



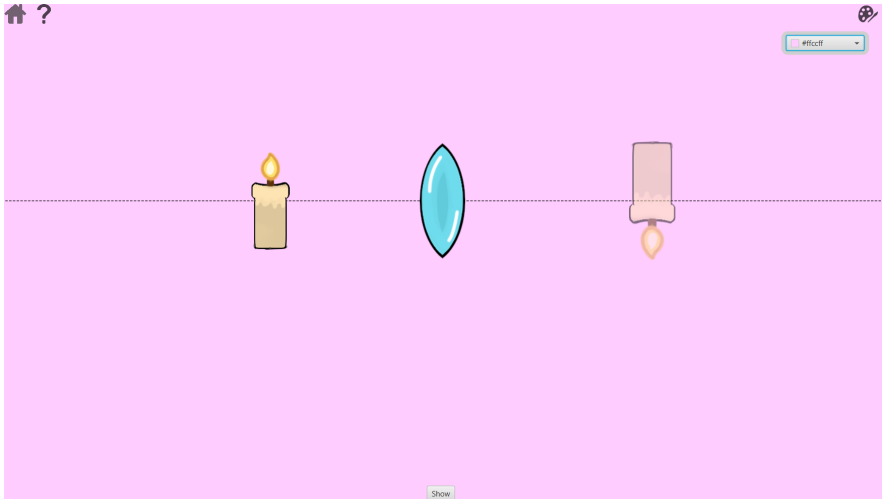
3. Toggle Labels

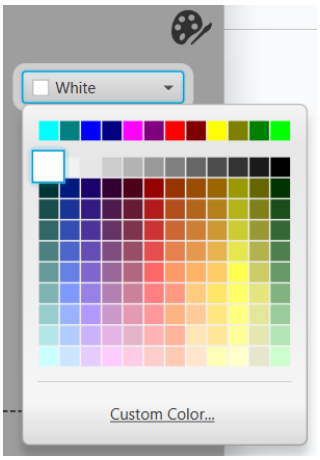
By default, the labels are visible. They allow the user to make readings off the items, as presented earlier. They can be disabled using the “Hide/Show All Labels” button.



Change background color

In the top right hand corner of the screen, users will find the painting palette icon. Upon clicking it, a color picker will be displayed, allowing the user to change the background color to any color they wish. Simply clicking the palette icon again will hide the color picker.





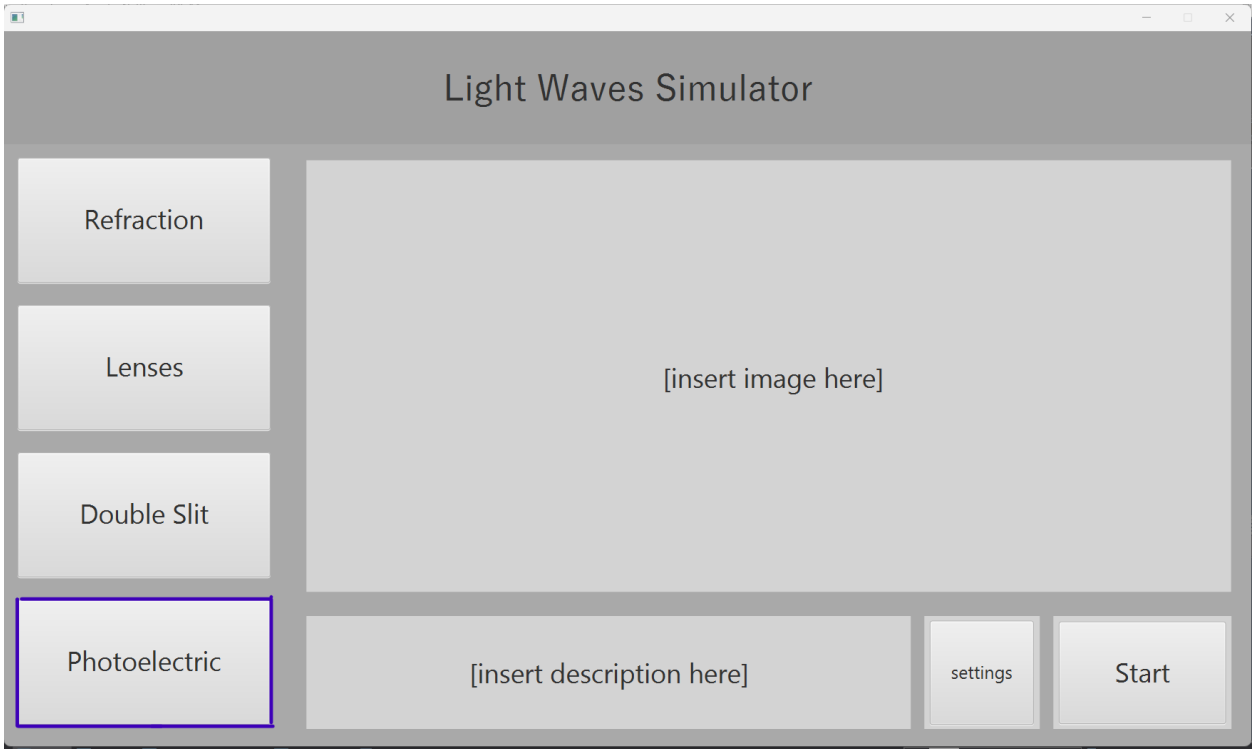
Photoelectric Effect Project

Introduction

The goal of the photoelectric effect project is to create a simulation that replicated the photoelectric effect experiment first observed by Heinrich Hertz in 1887 and later explained by Albert Eirstein in 1905. It is the phenomenon where electrons get ejected from a metal plate when the energy of the light shaun upon it is greater than the work function of the metal.

Getting Started

First step to running this simulation is installing a IDE that support applications in Java. In this case, the project was build on NetBeans. After cloning and initializing the project, the user will be brought to the main menu.

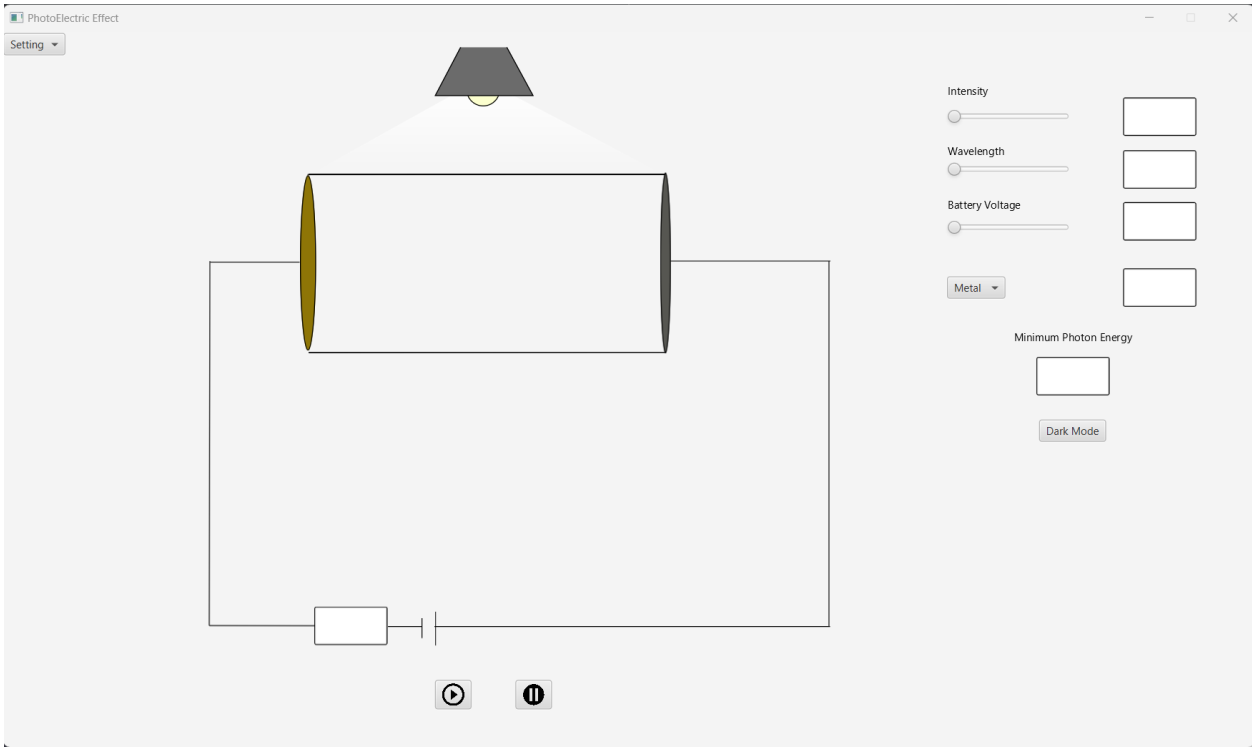


Note: this may be an older version of the final main menu

Upon clicking the photoelectric button, the user will be brought to the photoelectric effect user interface.

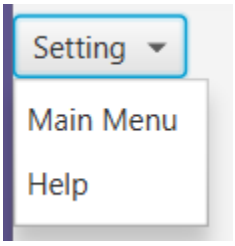
User Interface

The user is now in the photoelectric effect menu. First we will go over all the User Interface components that can be seen on screen and explaining their functionality and features.



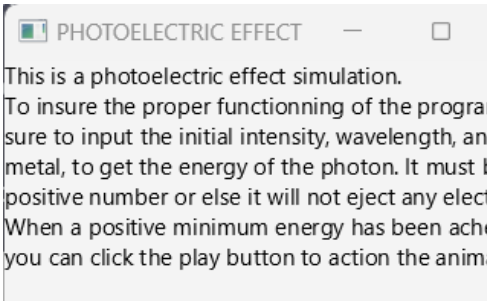
Buttons

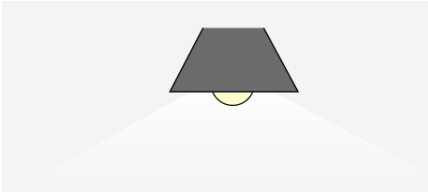
On the top left corner is situated the “Setting” button.



It contains two menu items: “Main Menu” and “Help” options. The Main Menu bring you back to the main menu and the help button opens up and gives information on how to use the simulation.

Upon clicking the “Help” button, a pop-up shows up on screen explaining what to do to run the simulation. It does not say why it does that but only the functionality of the simulation.





The middle of the photoelectric menu contains the setup where the animation will take place. On top is located the light source. As taught in physics, light has both wavelength and particle duality known as wave-particle duality principle. While the double-slit experiment demonstrates the wave characteristics of light, the photoelectric effect shows the particle nature of light. It will change colours depending on the wavelength chosen by the user.

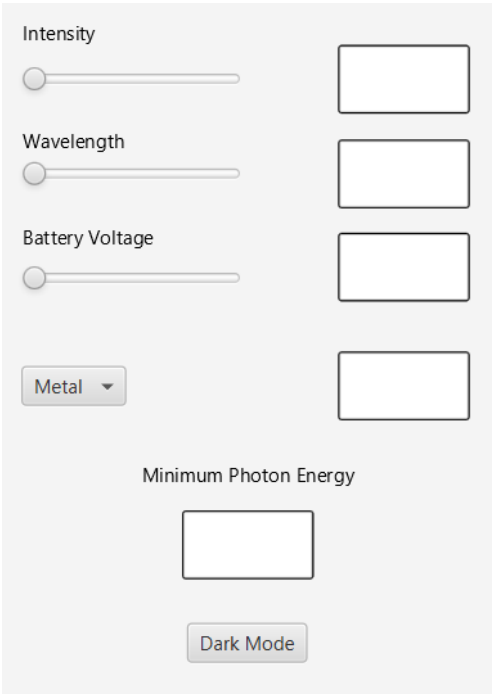
Right below it is a cylinder which represents a vacuum tube with and ellipse representing as a metal surface, known as the photocathode. It is made out of a metal that usually have a low work function. The vacuum helps to eliminate any contamination of air from the outside.

Right below it is a cylinder which represents a vacuum tube with and ellipse representing as a metal surface, known as the photocathode. It is made out of a metal that usually have a low work function. The vacuum helps to eliminate any contamination of air from the outside.

It is connected to a circuit, with the metal plate connected to the negative side of battery, hence the name photocathode. The voltage is used to calculate the maximum kinetic energy of the emitted electrons. The rectangle implemented on the circuit showcases the potential difference across the circuit.

At the button there are two buttons: “Play” and “Stop”. The “Play” button is used to start the animation once all the variable are chosen, it cannot start without pressing the button once to ensure all the variable to calculate the minimum energy required has been made. Two images were used to a visual aspect to the buttons.

Now for the parameters. The first one is intensity which increases the number of photon. It can increase the number of electrons that get ejected from the metal plate so the are directly proportional, if the frequency of the light is above the threshold. The user can drag the slider from a range from 0 to 100 %.

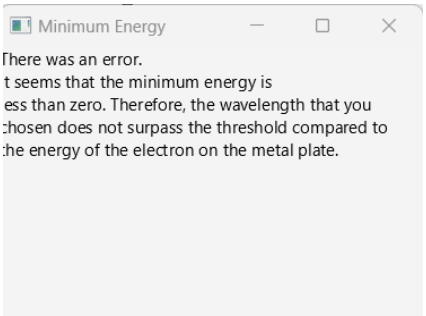


Speaking of frequency, it is equal to the speed of light divided by the wavelength. The user can drag a slider to choose a wavelength from 200 to 700 nm. This will make the light go from ultraviolet until red.

The last slider is for the battery voltage. It ranges from 0 to 10 V. It displays on the circuit.

There is a list of metals the user can chose from which will display their work function in the box to the right. The list of metals are: Magnesium, Aluminium, Calcium, Copper, and Gold. Upon selecting a metal, the metal plate will change colour indicating the selection of metal. The minimum photon energy will appear in the box below. If it is negative, that means that the energy of the photon is not high enough to surpass the threshold. If it positive, it surpassed the work function of the metal. The user can modify the variable to get the desired minimum photon energy.

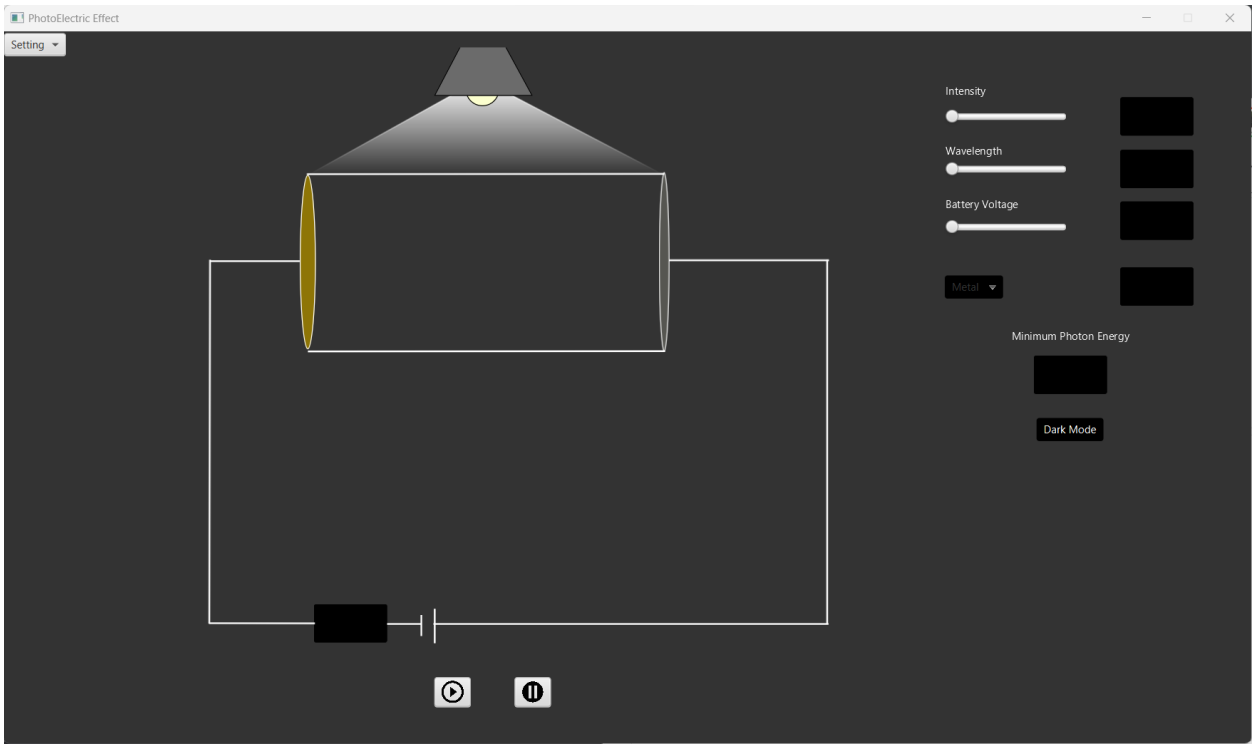
Once all the variables are selected, the user can then click on the play button and the animation will run whether the minimum photon energy has been met, or else it will be met with this pop-up:



The user will have to modify the variable accordingly.

Nevertheless, once the play button is pushed, the user can modify the intensity of the light to change the animation of change the wavelength. If ever the minimum photon energy becomes negative, the animation will stop immediately, but the user can stop it regardless by pushing the stop button.

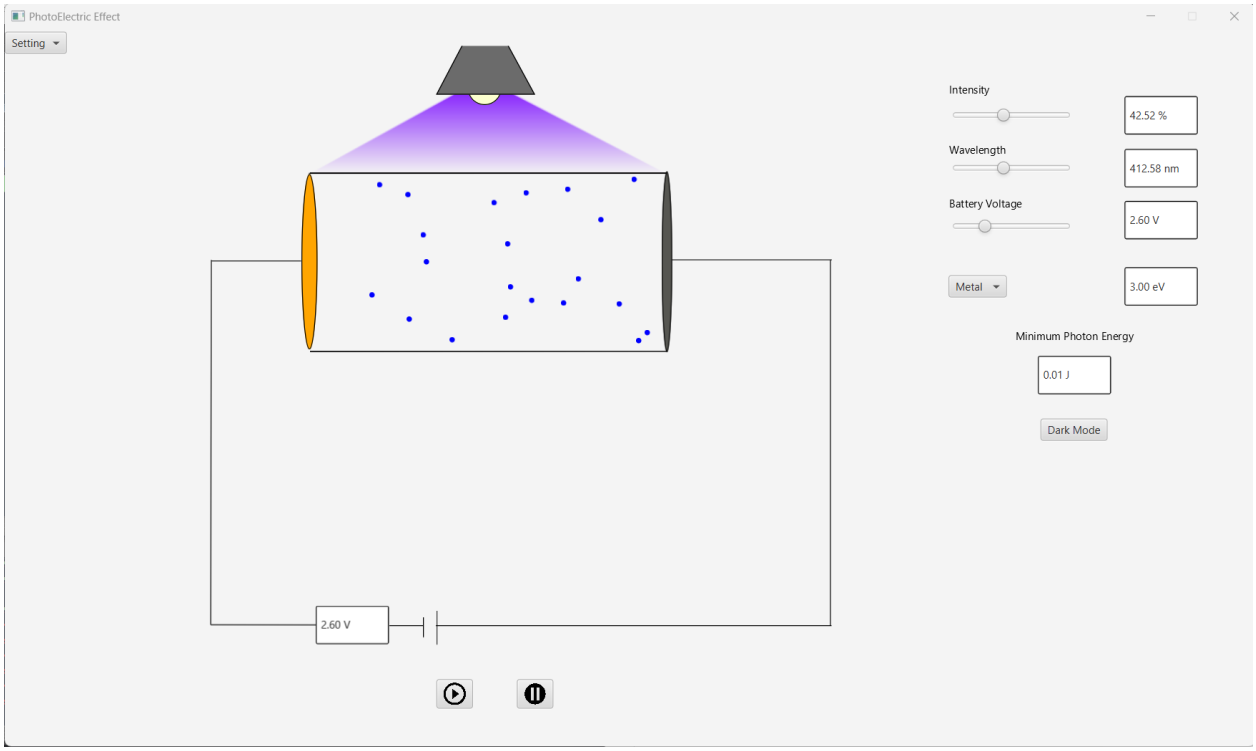
The last feature of this project is the “Dark Mode”. Upon clicking the button, the simulation will have a different theme, black and white.

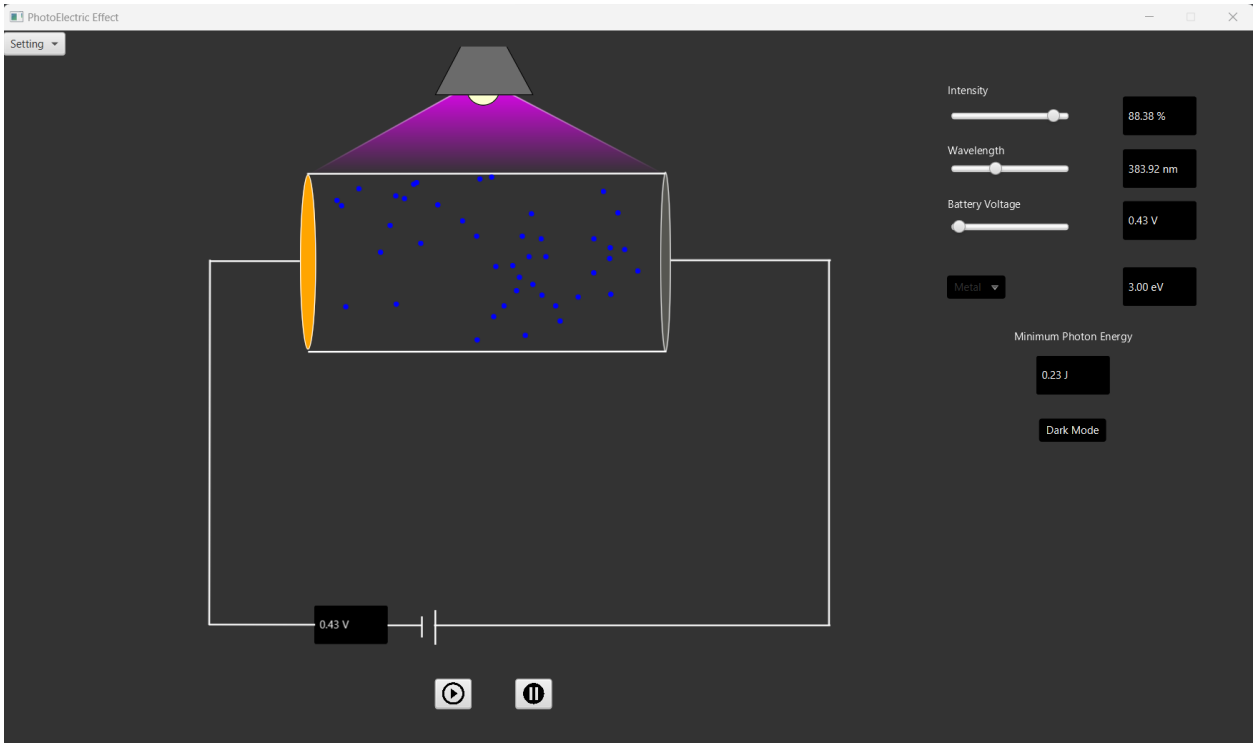


The lines were charged to be white, the button have changed images as well. The boxes are black like the background and most writing is in white.

Appendice

Here are some example of data and what it is suppose to look like in action.

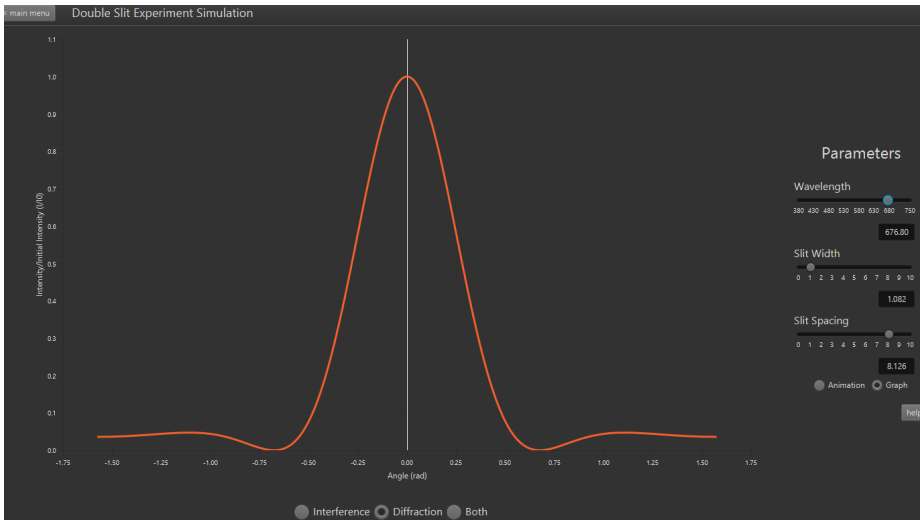




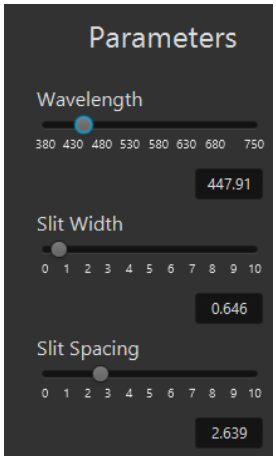
Double Slit Experiment Project

Introduction:
Young's double slit experiment demonstrates that single monochromatic photons shot through 2 slits will behave as a wave and showcase interference and diffraction. The interference pattern can be observed on a screen, and it follows the overlap of the interference and diffraction of the photons.

When the user selects the double slit experiment in the main menu, this is the scene that shows up. It is automatically set to graph mode and the user can switch between the graph or animation view.



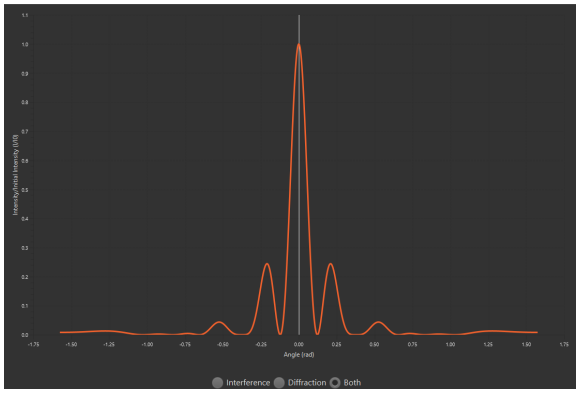
The 3 parameters that can be controlled are the wavelength (nanometers) of the light source, the slit width (micrometers) and the slit spacing(micrometers). They can be modified with either a slider or a textfield and they both update according to the new value. The parameters options are the same for the animation and the graph.

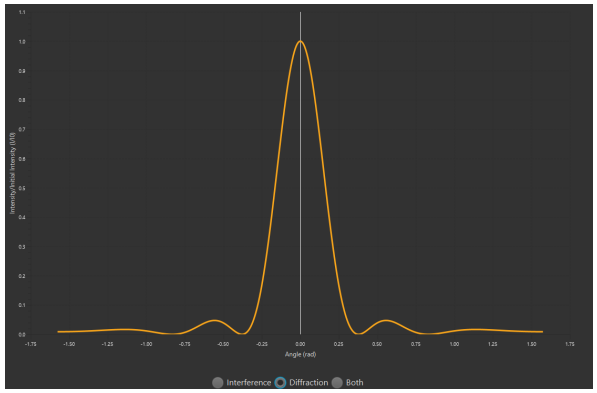


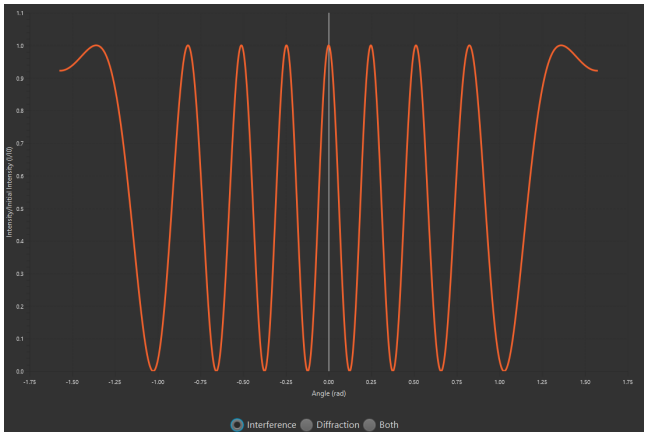
Graph mode

The user can switch between the graph of interference, diffraction or both with the following toggle group.

Examples of each option:

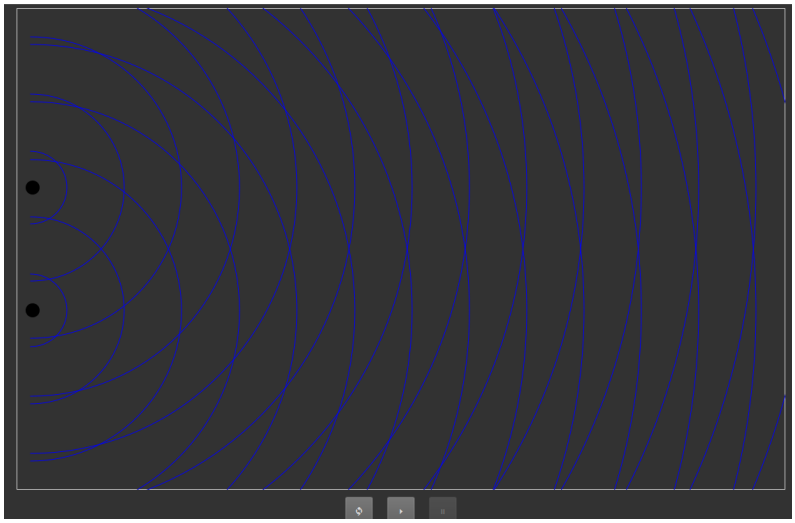






Animation mode

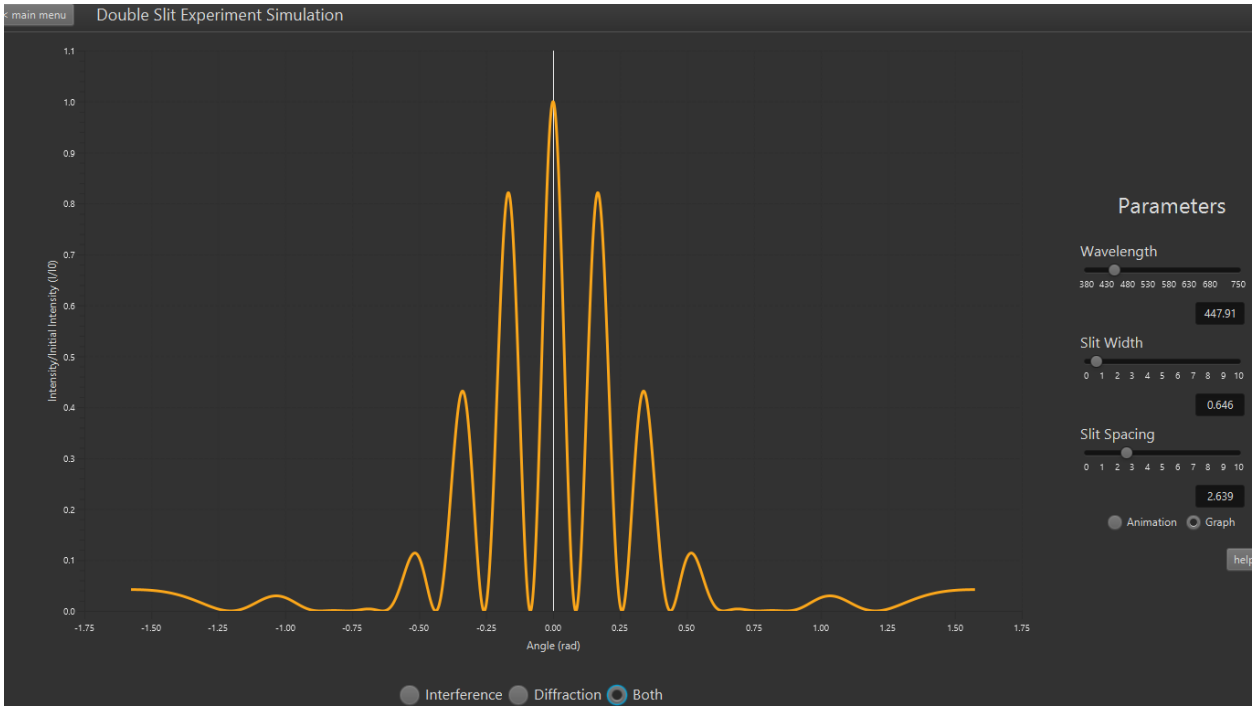
In the animation mode, the wavelength changes the color of the rays as well as the spacign between each wavefront. The user can also modify the slit spacing by dragging the circles that represent the slits. The wavefronts are not at scale, simply to give an idea of what the waves look like. In reality they are much smaller than the slits.



The user can play or pause (pressing one disables the other) the animation with the buttons at the bottom and reset the animation.

The project in action:

Graph mode



Animation mode