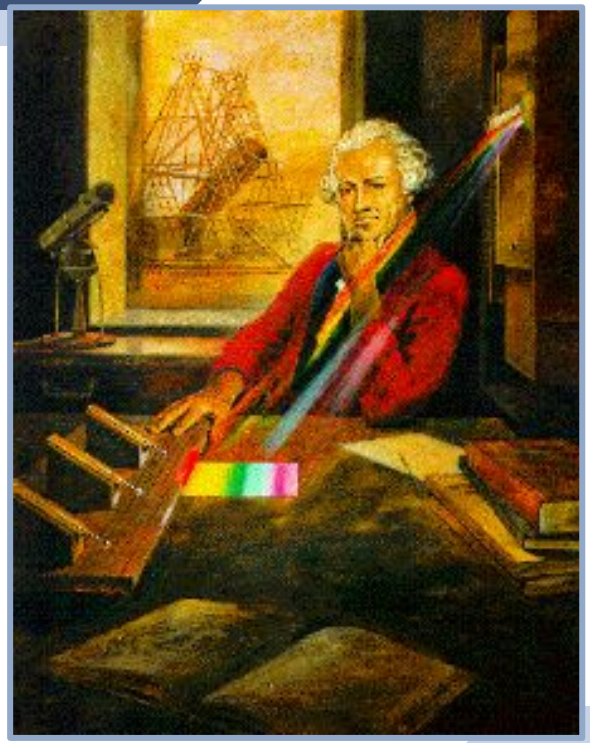
DRS Herschel Project (IR Demo)

ORIGINAL HERSCHEL EXPERIMENT

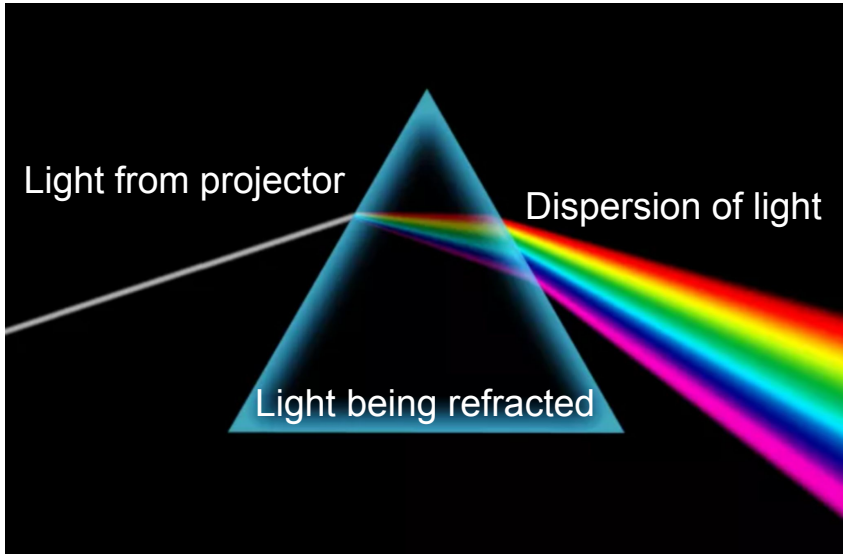
Experiment Overview

- In the 1800's, William Herschel conducted an experiment with sunlight
- He used a glass prism to divide the colors
- Measured the temperature of each color
- Temperature was increasing from purple to red
- Discovered infrared (beneath red) radiation



SYSTEMS AND THEORY

Light hitting a prism will cause the colors of the white light to refract at different angles, causing the different colors that you see. This allows us to measure the temperature of the different colors.

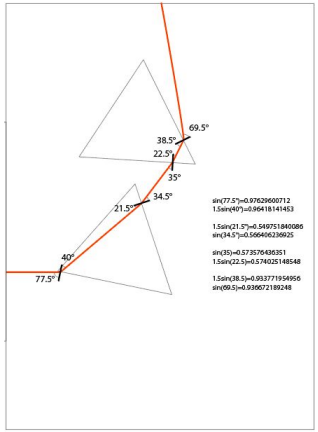


SYSTEMS AND THEORY

Optical Theorem states that the amplitude and scattering of light can be calculated through the length of a prism.

Snell's law allows you to calculate the refraction of light through the cross section of an object. $n_1 \sin\theta_1 = n_2 \sin\theta_2$

The prisms allow for the white light from the projector to be separated into their individual colors. They also help the light to bend so that the colors' temperature can be read by the sensors.

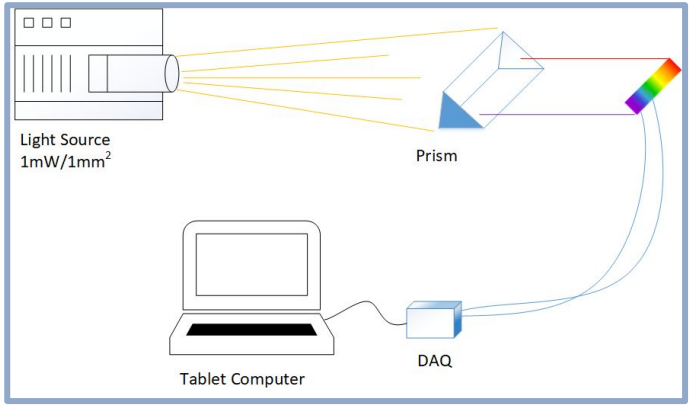


DEMONSTRATION RESULTS

- Violet/blue:23 degrees C
- Green:23 degrees C
- Orange/Yellow:24 degrees C
- Red:25 degrees C
- Infrared:25 degrees C
- Ambient temperature:21.5 degrees C

CORE PROJECT GOALS

- Design and create user friendly hardware for replicating the experiment
- Create software that displays temperatures and information in a clean GUI
- Allow users to learn about the original experiment



MAIN PROJECT REQUIREMENTS

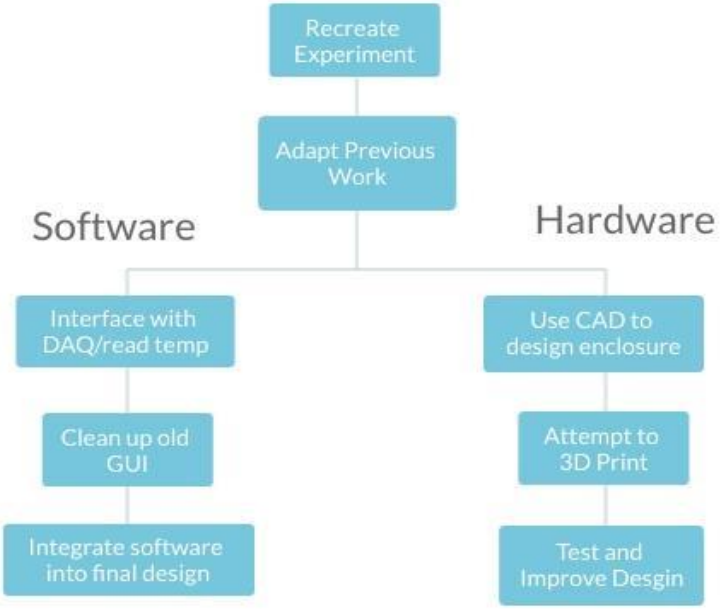
Requirements	Passed?
Prove experiment using the Projector, Prism and temperature sensors	Y
Design fixture to hold prisms in place	Y
Select components for use with DAQ	Y
Create software to read and display temperature of light bands	Y

HARDWARE PROJECT REQUIREMENTS

Initial Requirements	Passed?
Demonstrate light source from projector can be separated into color bands	Y
Measure separate temperatures of individual color bands	Y
Design enclosure to protect from outside light.	Y
Display temperature data on a graphical user interface	Y

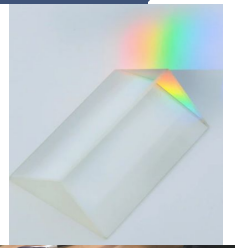
PROJECT WORKFLOW/PROCESS

- Designs and code from the previous team(s) were studied
- Based on skill sets, team members were split into appropriate groups
- Procedures used and progress were documented on Trello boards

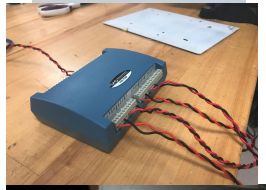


Main Materials

Glass Prism



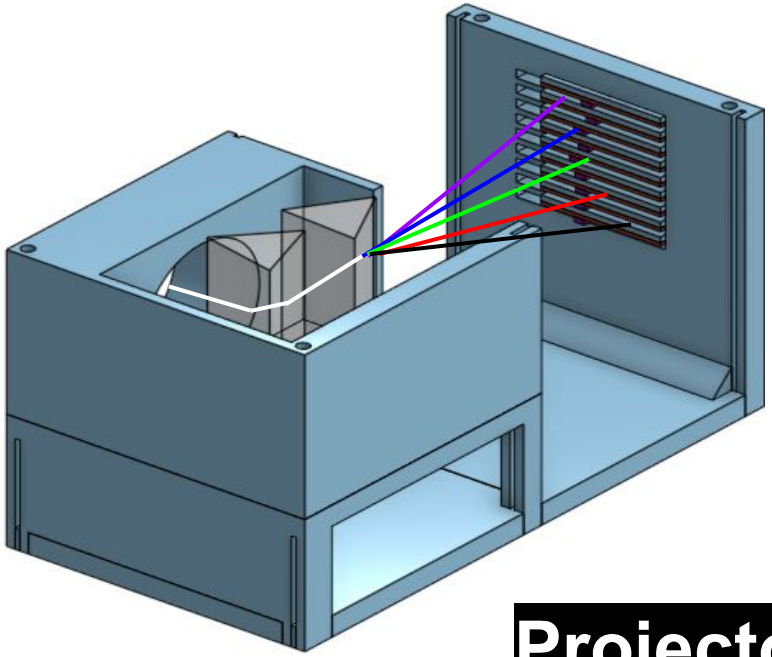
DAQ



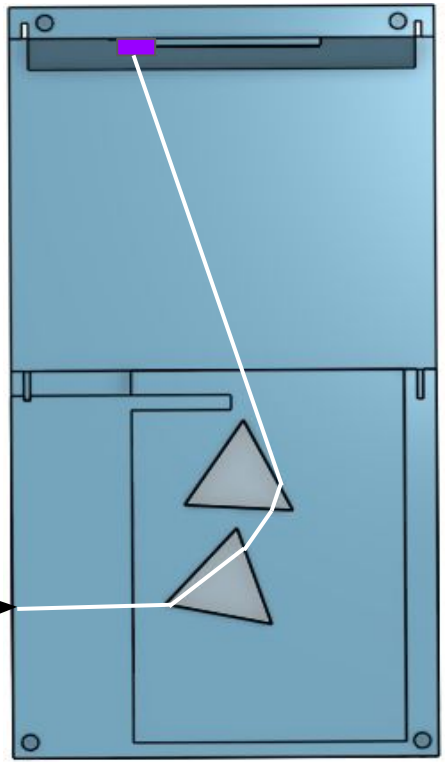
Sawyer’s 550 RF Slide projector

Platinum 100 Ohm RTD (Resistance Temperature Detector

Light Diagram



Projector.



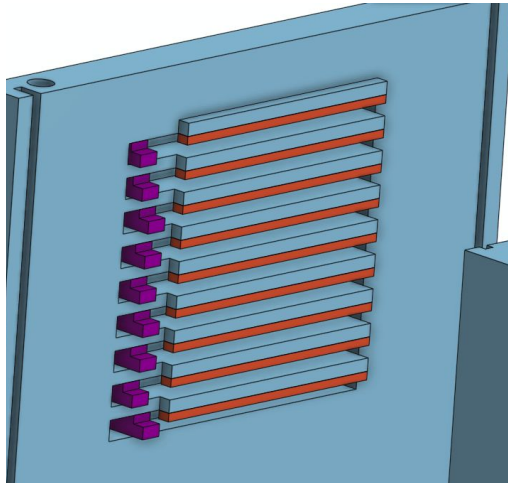
Birds eye view of the prisms

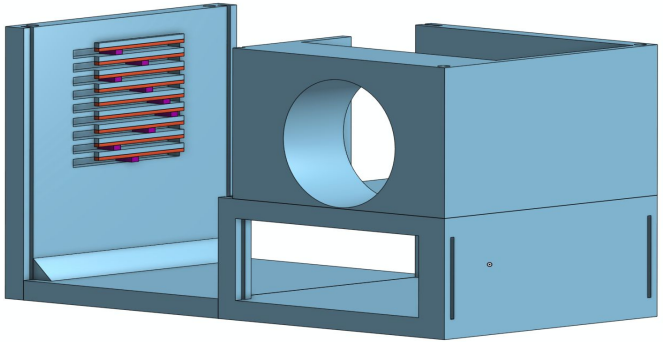
The birds eye view shows the difference in color and how the prisms allow the color bands to be placed precisely in the center of the back wall.

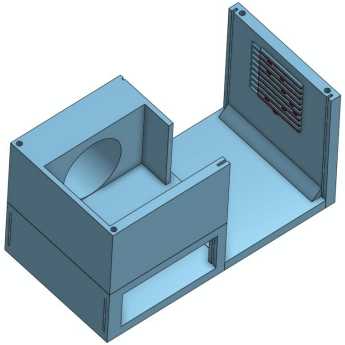
HARDWARE

The projector holder provides support for the projector and is designed to keep all parts together. The projector holder helps demonstrate the Herschel Experiment conveniently.

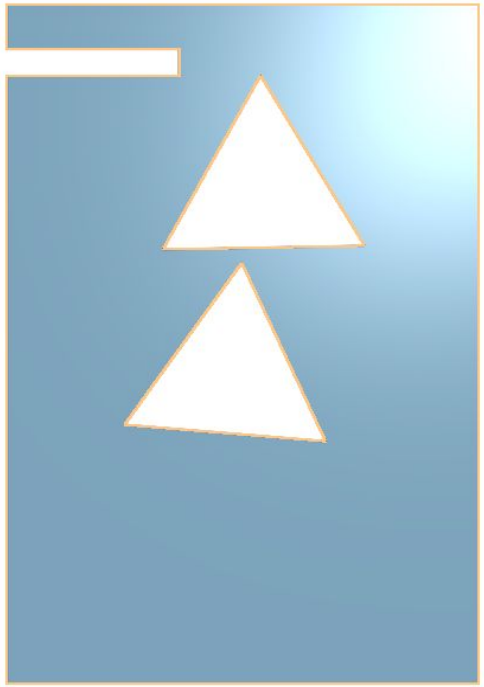
The back wall's purpose is to be able to move the sensors around to measure the temperature of the light. Since we don't know exactly where the light will be, having them mobile will save us a lot of time when we put everything together.







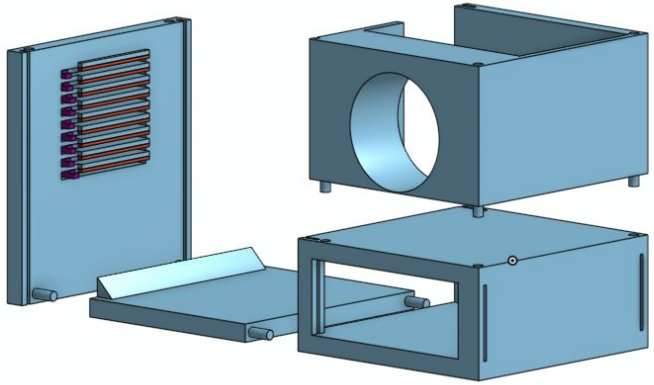
Prism angles

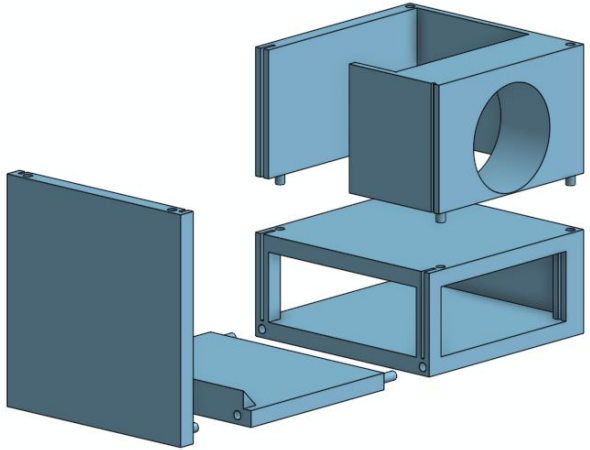


The angles of the prisms in this particular set up has been chosen to optimize the amount of light dispersed onto the temperature sensors to fulfill the goal of providing the most realistic and accurate temperature results. This could be predicted by using Snell's Law to accurately measure the angles at which light would be refracted when going from air to glass and glass to air twice throughout the length of the distance traveled from the light projector to the temperature sensors.

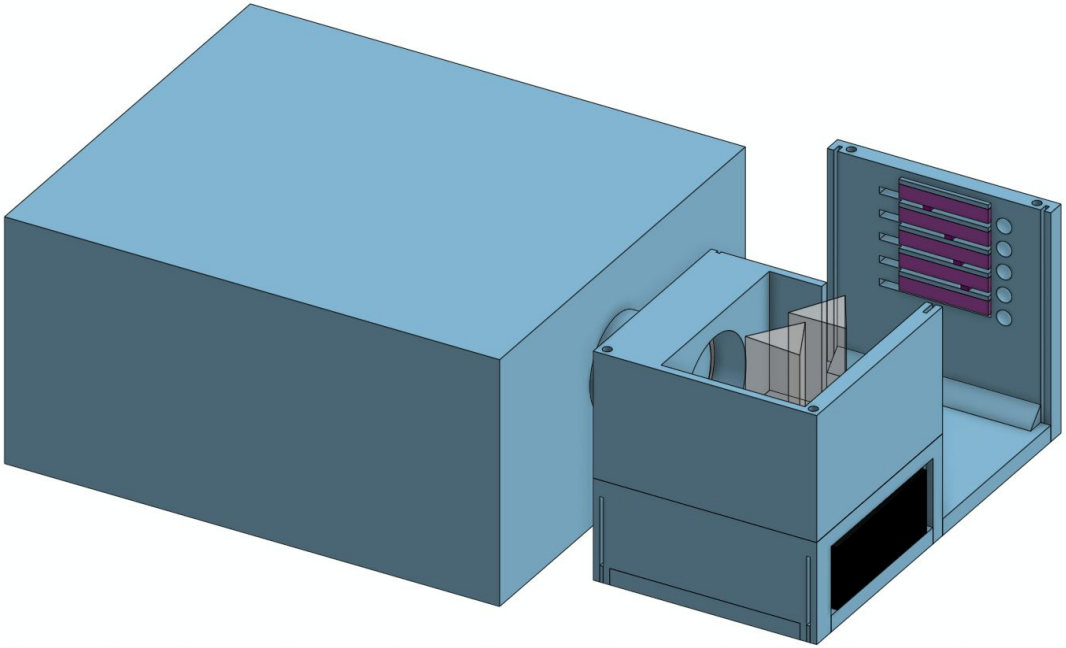
HARDWARE (cont.)

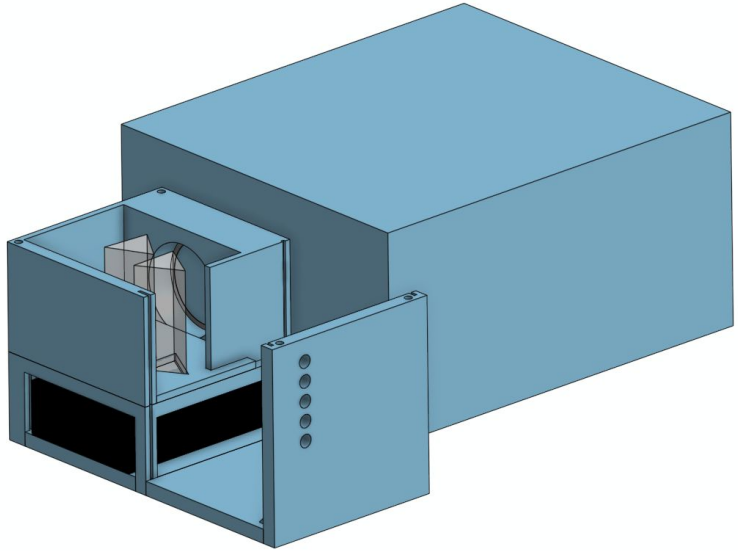
We separated the projector holder into 4 different parts. Breaking the holder up helped the 3D printing go smoothly and stopped jams. We are able to put everything together with the pegs and holes, that we then glued to form the final holder.





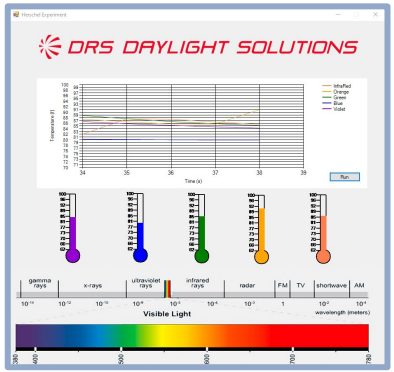
Full Assembly





SOFTWARE (cont.)

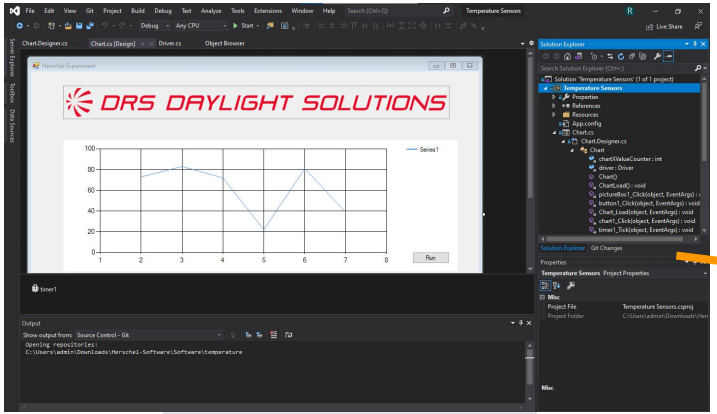
DAQ converts the analog readings from RTD sensors into digital readings for the computer.



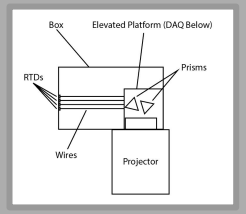
Temperature readings over time are compiled into a chart using data from the DAQ

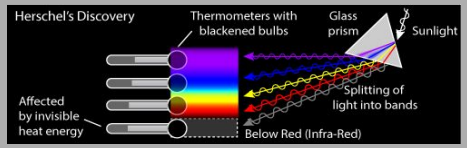
Plans to improve GUI, potentially create a whole program for an enhanced UX

SOFTWARE

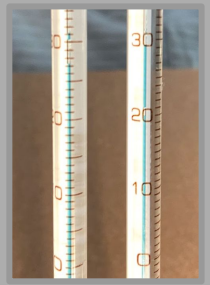


Use Visual Studio to develop a multi-screen program





Users can learn about how the light is split by the prisms, how the hardware works, and test the real experiment for themselves



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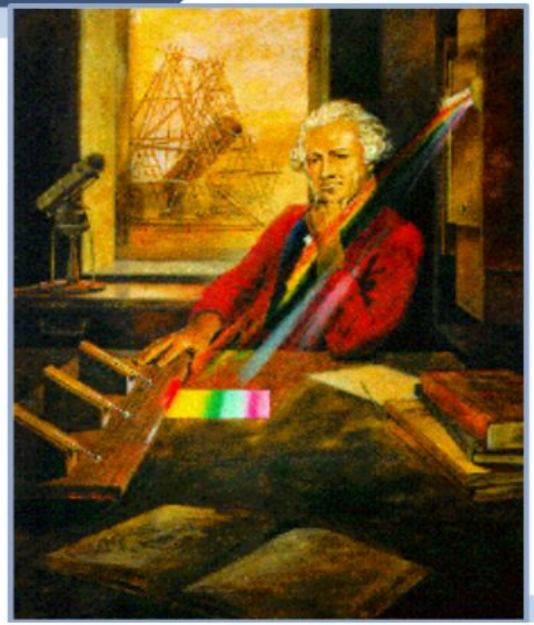


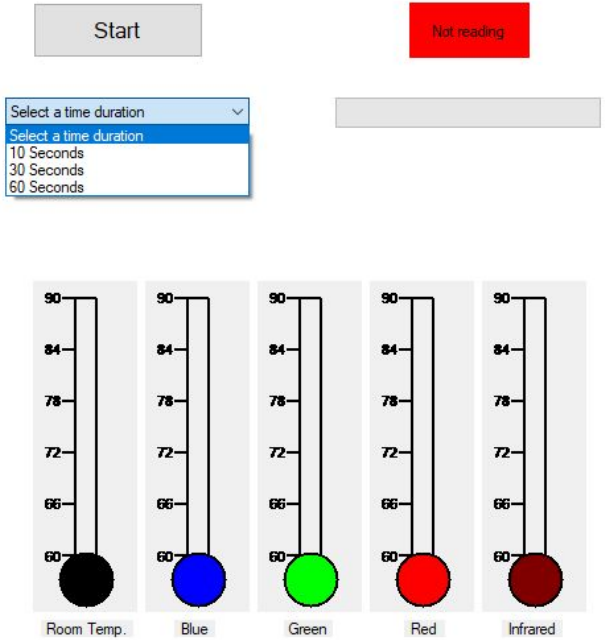
Exit App

Return

Next

SOFTWARE (cont.)

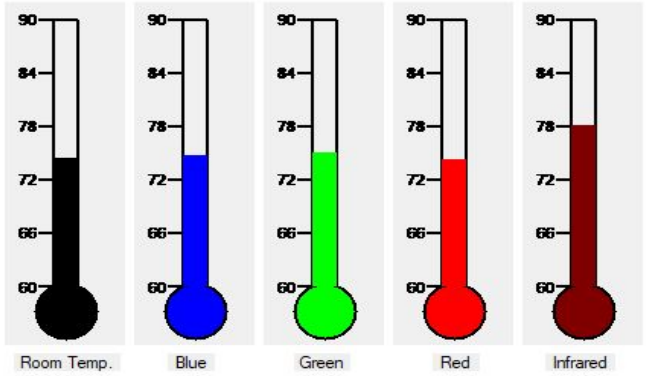
- Select between 10, 30, and 60 seconds
- Multiple formats for viewing data
- Graph automatically resizes based on lowest and highest values
- Graph only shows last 20 seconds

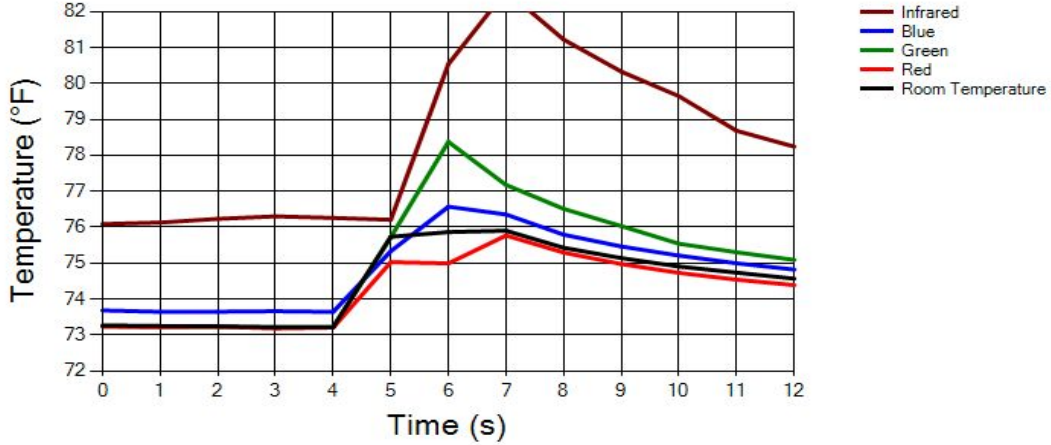


Pause

Reading for 48 seconds

Color	Room Temp.	Blue	Green	Red	Infrared
Temperature (°F)	74.57 °F	74.82 °F	75.09 °F	74.39 °F	78.24 °F





Exit App

Menu

SOFTWARE (cont.)

Calibration Routine

- Goal is to “calibrate” the sensors
- Applies an offset to each color
- Slow (15 seconds) and Fast (5 seconds) modes
- Additive or Coefficient calibration
- Implemented after initial testing

Requirements
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Design fixture to hold prisms in place
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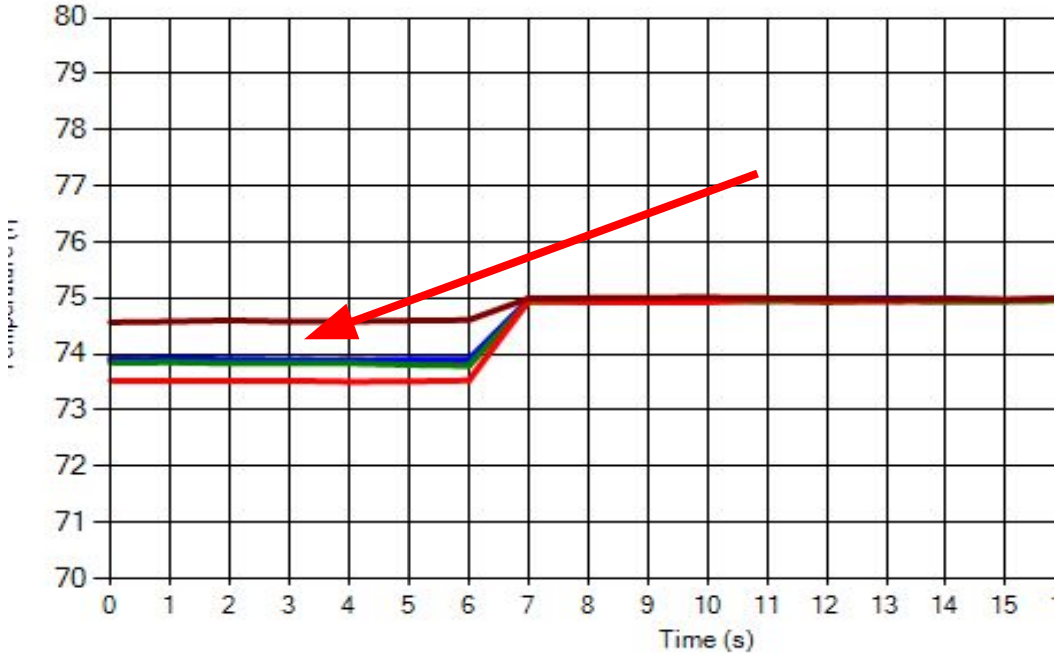
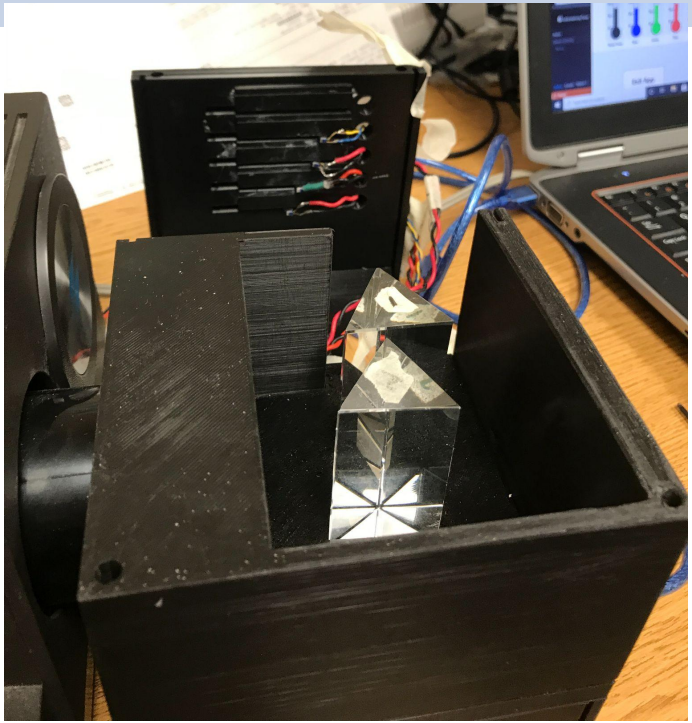
SOFTWARE (cont.)

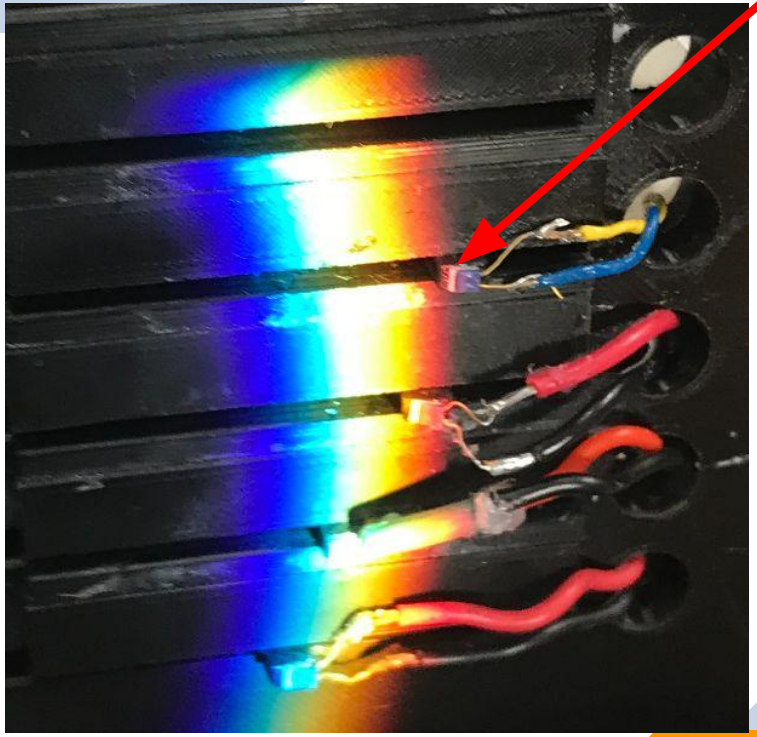


- Performed at ambient temperature with a target of 75 degrees
- Calibration requires constant/linear conditions
- Still allows for some variation (not perfect)
- Further testing under experimental conditions required

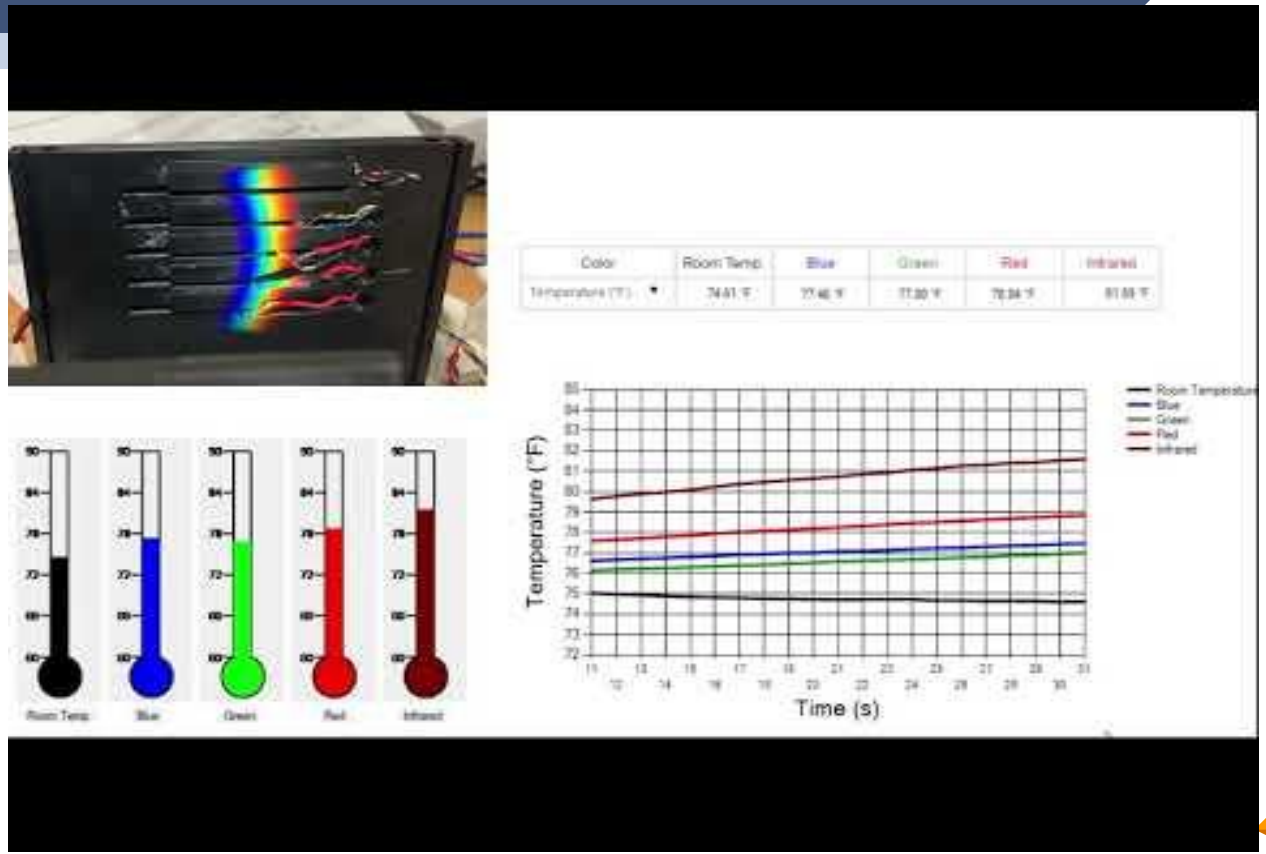
TESTING



IR Sensor is not in the path of visible light



VIDEO DEMONSTRATION



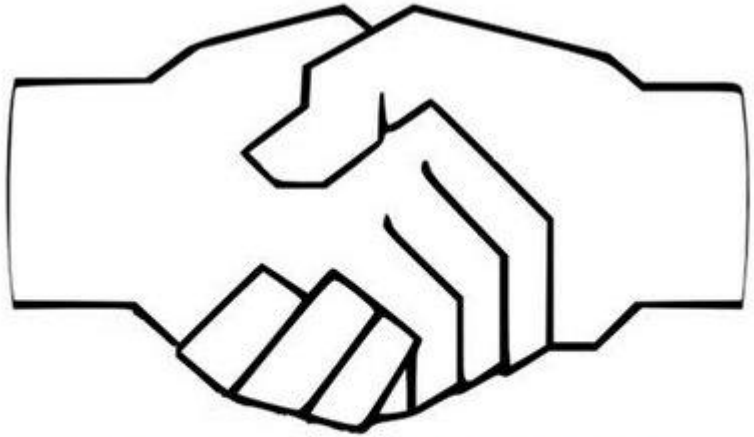
Challenges During Design Process

- Since we were all starting the project during online school it made it harder to communicate and to show progress.
- Had to learn how to use Visual Studio and develop in Windows Forms
- Not many of us were familiar with onshape so it took longer to make the projector model for the mechanical team

Future plans

- Teach students during the summer time how different kinds of light have different temperatures and teach them about another kind of light called infrared light
- Make design more robust and portable
- Set up demonstration at a S.T.E.M. outreach event

Thanks for Listening!



Jack

Any Questions?