

LAFAYETTE COLLEGE

Department of Mechanical Engineering



Effect of light in Special Collections

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Summary:

The goal of this project is to use a photoresistor to determine the light levels inside the reading room in Lafayette College's special collections area. Using an Arduino board and sensors the light levels and UV levels were analyzed. It was found that the light levels were significantly higher than the recommended values. Action has to be taken in order to reduce the light levels and prevent the pieces from damage.

[10/10/18]

I. Background

Problem Statement

The librarians special collections sections of Skillman Library have concerns about the UV light levels and the effects it will have on the artifacts they are working on or displaying in the workroom and the reading room. The library has UV filtering sleeves over the fluorescent bulbs in the reading room and the workroom and the librarians assume that the windows also have a UV protective coating on them. A solution to this problem would measure the UV and visible light levels in the room to determine whether or not the artifacts in special collections are being damaged.

During an interview with the librarians they expressed concern about four areas. They were concerned about the damage dealt to objects in these four areas and how effective the UV filters are with filtering the harmful rays. The pieces that are displayed and worked on are made of various materials and all need to be protected from damage. Natural light and fluorescent lighting are both present in some of the areas. There are UV filters placed along the lights that are rated to last for 10 years that they got from University of Products.

The special collection room in Skillman library is where most of the old materials and records of Lafayette College are stored. Some of those collections are exposed in public so that they can be seen, contemplated and studied by the visitors and students. They are directly exposed in a direct light of lamps or the sun. However, many materials are particularly sensitive to light: paper, cloth, leather, photographs, and media (inks, colorants, dyes, and many other materials used to create objects and art). Aside from fading, there may be damage to the physical and chemical structure of materials. Light and ultraviolet radiation (UV) provides energy to fuel the chemical reactions that lead to deterioration and while UV is blamed for most of this damage, visible light is also problematic. Most museum collections can be displayed at 50-150 lux (lux: illuminance of light) for up to four months without fading. If the lux exceeds 150 lux, the time exhibited must be decreased.

LIGHT LEVELS MEASUREMENT

II. Method.

The measurement of the intensity of light that is exposed to those collections was made by the use of a photoresistor and Sparkfun Red board. The data was stored into the Electrically Erasable Programmable Read-Only Memory or EEPROM which is a non-volatile memory in the red board. The collection began when a button in the circuit was pressed. An LED in the circuit turned off when that measurement began. It only turned on when the data collection finished. The limitation of EEPROM is that it does not store a number greater than 255. Yet, in other rooms of the special collection, the measurements exceeded that value. Another script was used to read the data from the EEPROM and output it to the Serial Monitor. After a fixed period time, the data printed in the serial was copied to a file.

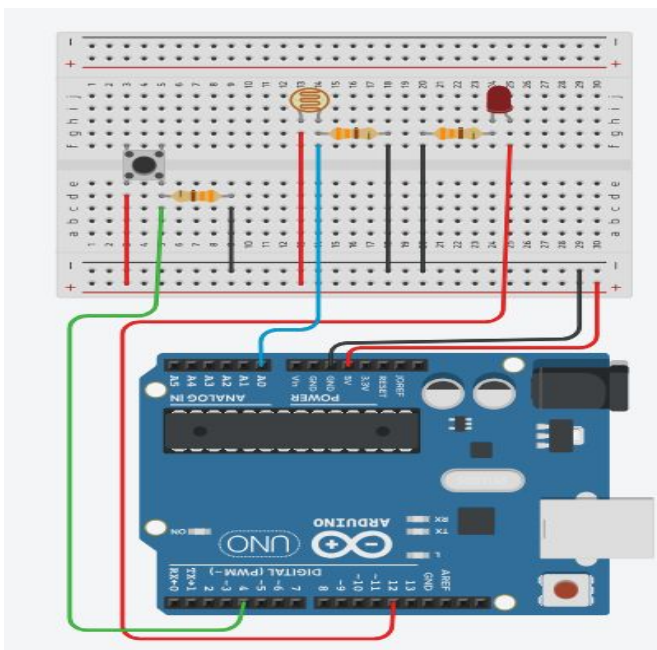


Figure 1: The representation of the circuit

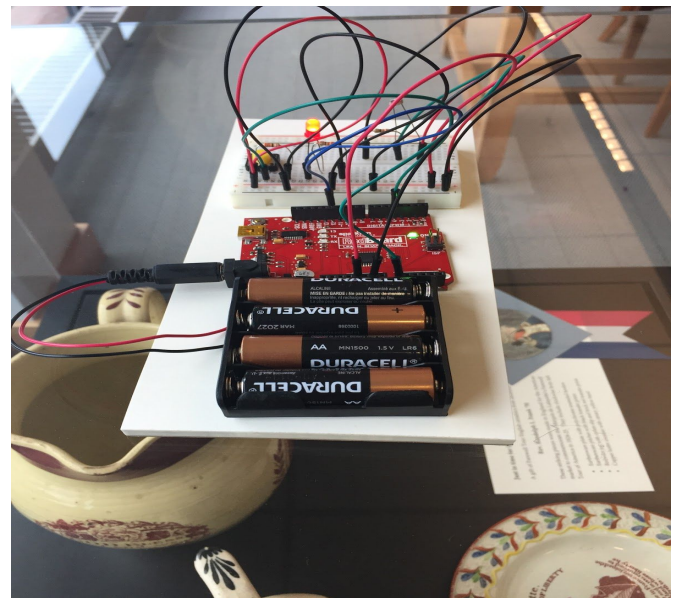


Figure 2: The sensor placed in top of the glass

NB: In this figure, the Redboard is replaced by Arduino uno.

The data collected are not yet converted into a lux value. The conversion process was made in spreadsheet.

How to know the accuracy of the data?

The conversion formula of the analog value of the sensor is

$$\text{lux} = (1.25 \times 10^7) \times R^{-1.4059} .$$

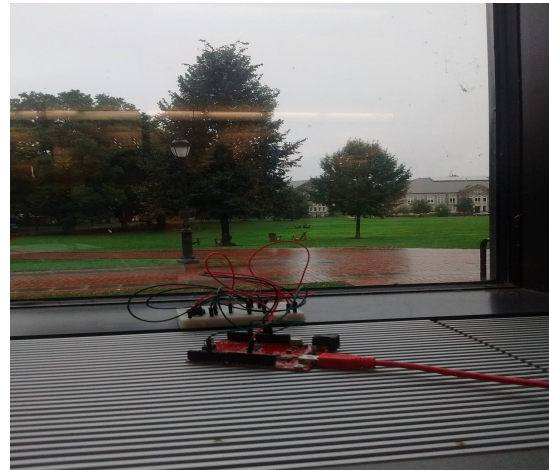
In which R is the resistance of the LDR. It was found on the internet. The link is presented in the reference source. To measure its accuracy, two methods were used:

- The first one is to use some Android application which allow to measure lux value and compare them with the converted value. However, it was not an efficient technique because even the smartphone themselves present very different values each other.
- The other method is to compare the converted data to a database which holds the measurement of a specific situation. If the two data are close that means that they are accurate. If not, there is a mistake in the conversion formula.

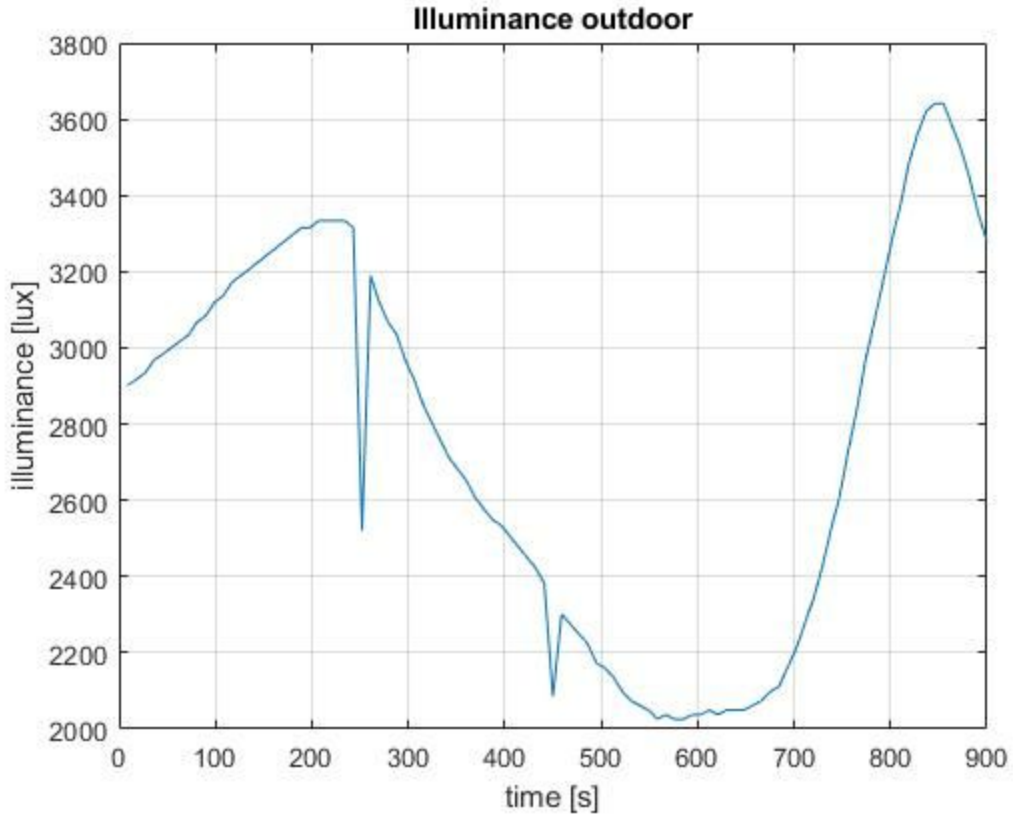
On October 11, 2018 at 02:00 pm when the measurement was made, it was raining in Lafayette College. It looked like an overcast day.



The day in during the measurement



The sensor protected from the rain



The average is 2,748.398537 which is between 2,000 lux and 3000 lux. It is approximately the illuminance value of an overcast day according to the databases below.

Condition	Illumination	
	(ftcd)	(lux)
Sunlight	10,000	107,527
Full Daylight	1,000	10,752
Overcast Day	100	1,075
Very Dark Day	10	107
Twilight	1	10.8
Deep Twilight	.1	1.08
Full Moon	.01	.108
Quarter Moon	.001	.0108
Starlight	.0001	.0011
Overcast Night	.00001	.0001

Data from national optical astronomy observation

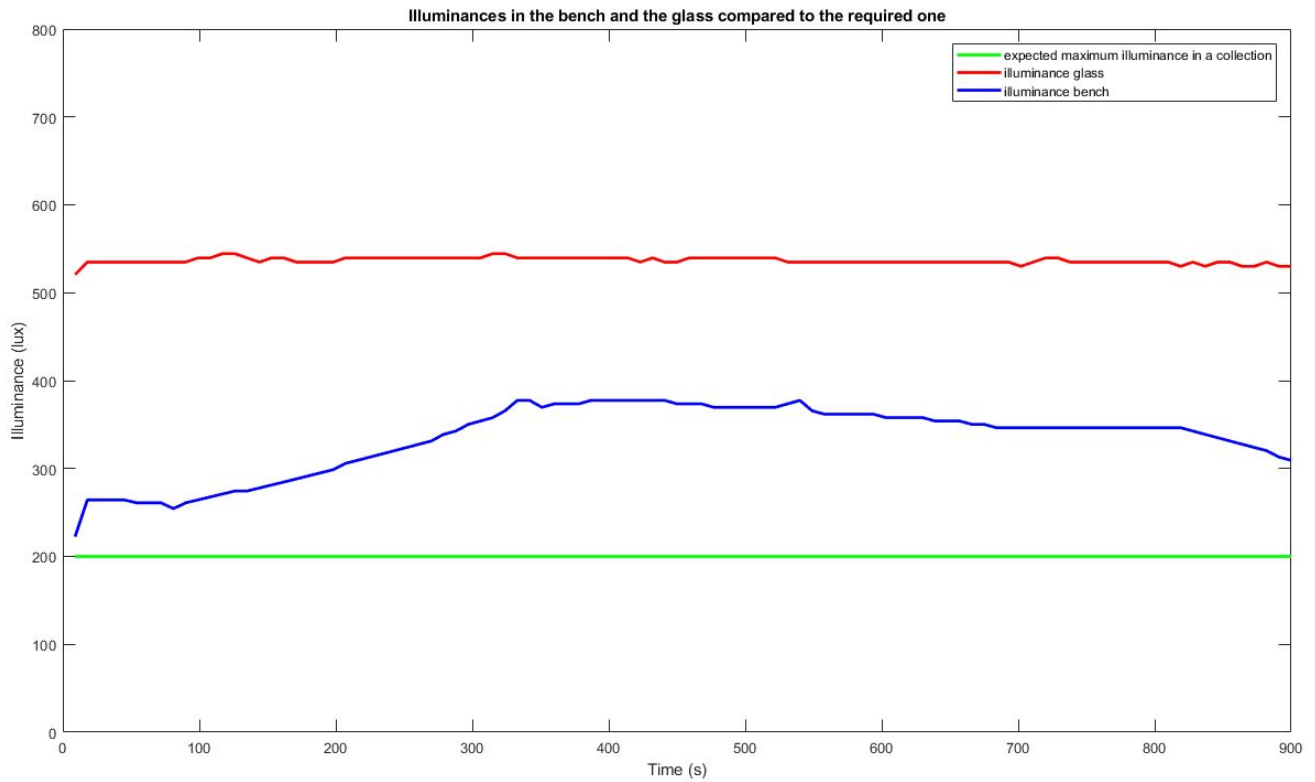
Illuminance	Example
120,000 lux	Brightest sunlight
111,000 lux	Bright sunlight
109,870 lux	AM 1.5 global solar spectrum sunlight
20,000 lux	Shade illuminated by entire clear blue sky, midday
1,000 - 2,000 lux	Typical overcast day, midday
<200 lux	Extreme of thickest storm clouds, midday
400 lux	Sunrise or sunset on a clear day (ambient illumination)
40 lux	Fully overcast, sunset/sunrise
<1 lux	Extreme of thickest storm clouds, sunset/rise

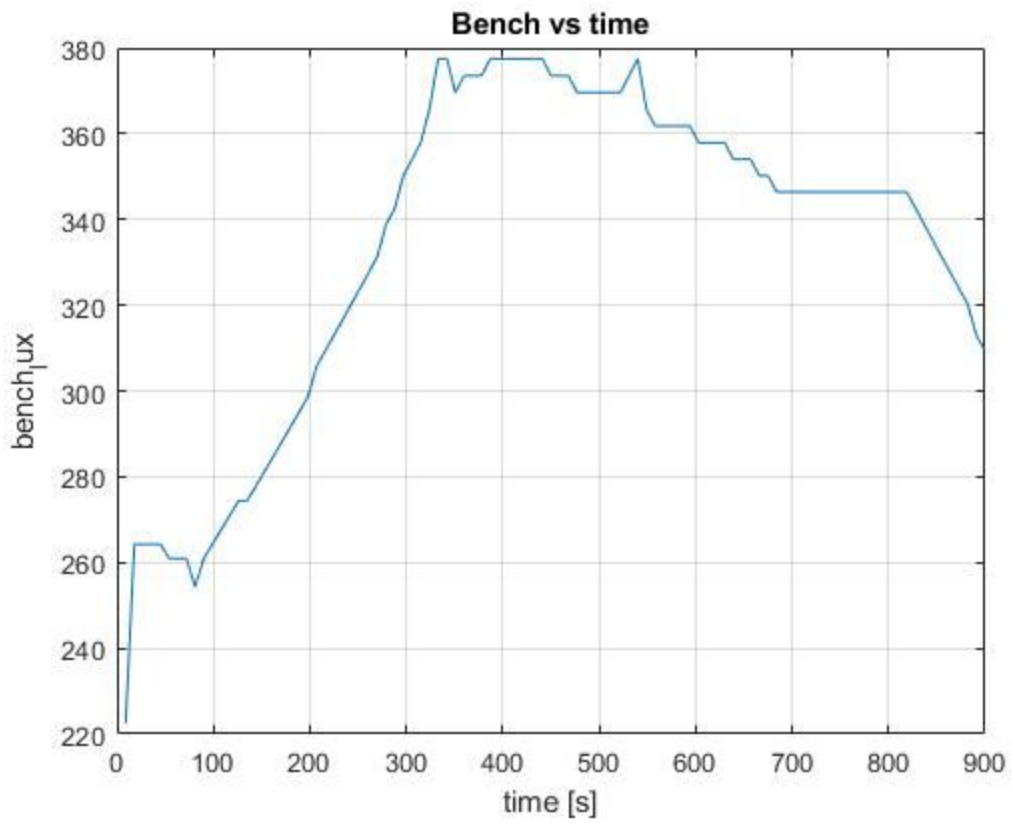
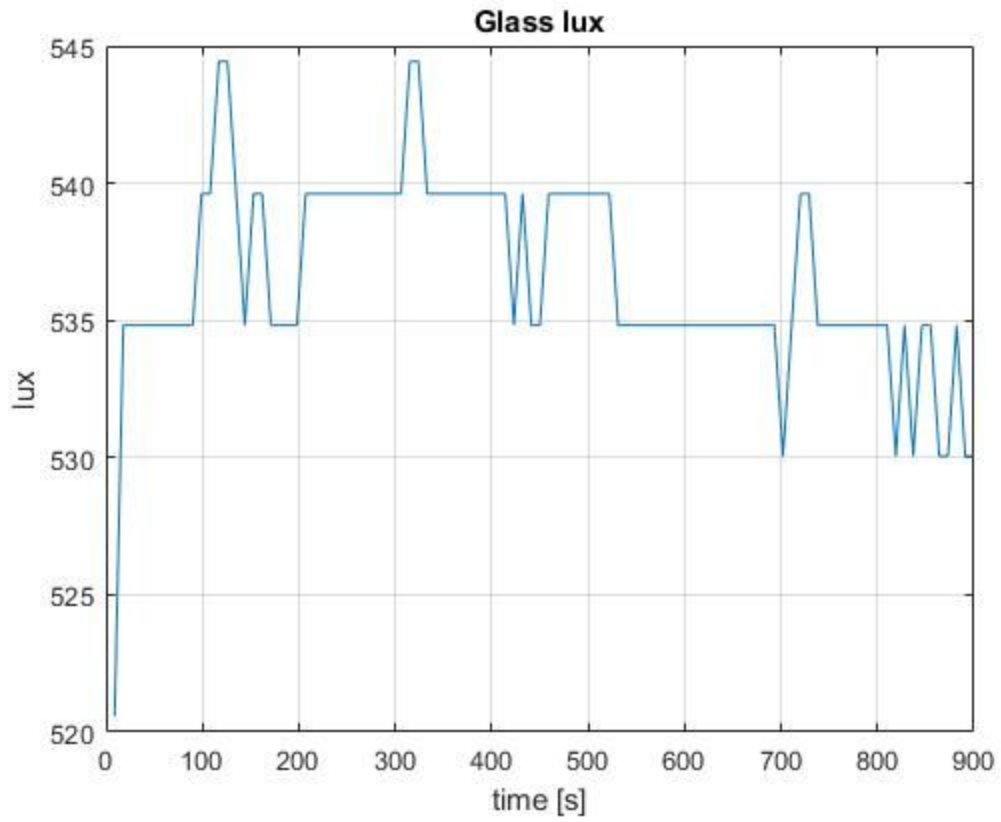
Data from wikipedia

The data converted can be considered as accurate

III. Results

After realizing experiments on different locations of the collection room, the following graph interpret the data we stored.



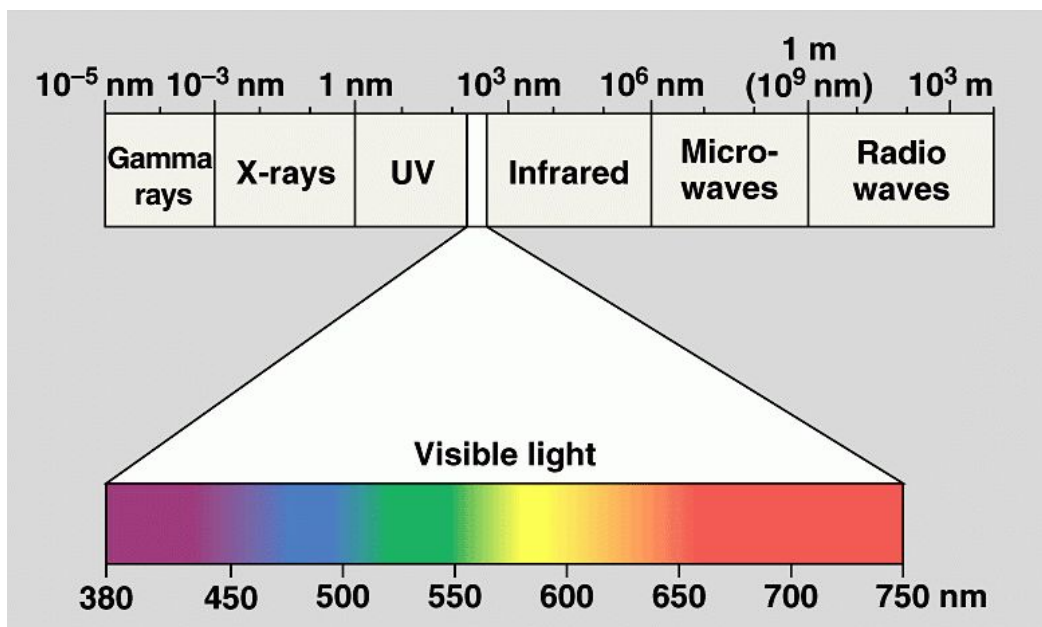


The data collected during these tests shows that the light levels inside the special collections reading room exceed the museum standards for light levels. The average illuminance recorded by the entrance of the reading room was about 334 lux which is more than double the maximum accepted value of 150 lux. The average illuminance level in the window near the prints and the display case was about 536 lux, which is more than triple the maximum accepted value.

UV INDEX MEASUREMENT.

IV. Method

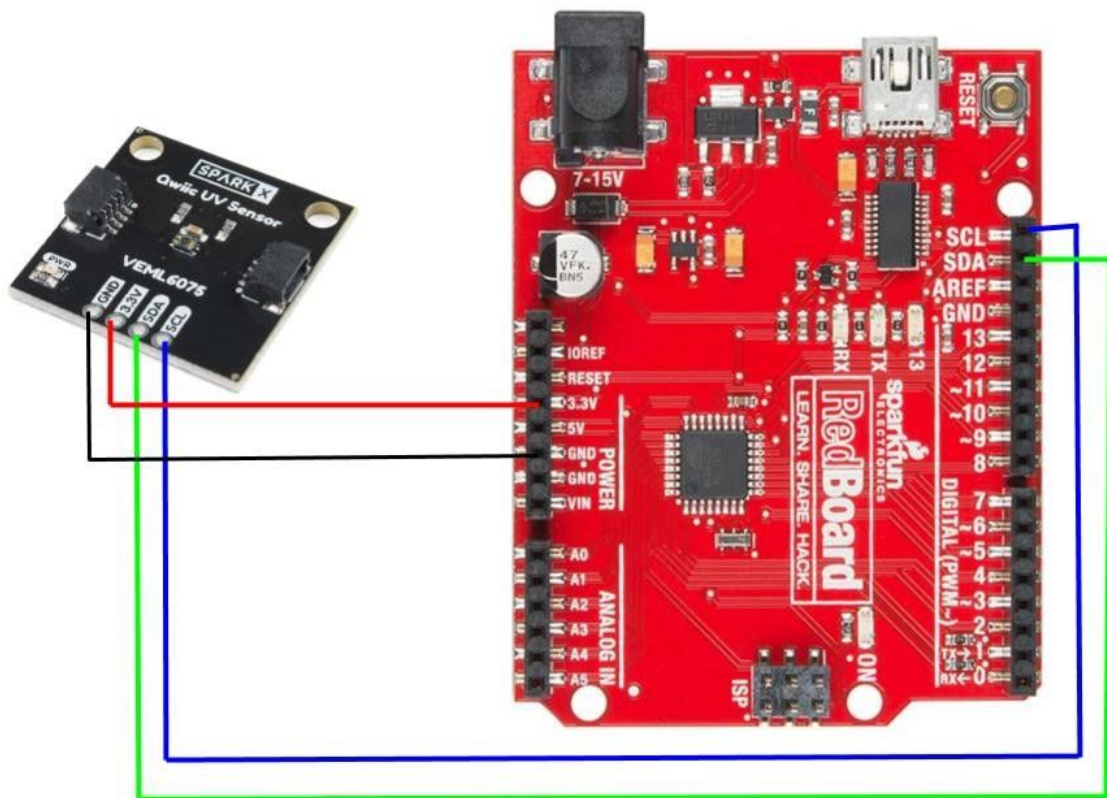
Light is an electromagnetic radiation within a certain portion of the electromagnetic spectrum. It is composed of the visible light which can be perceived by the human eye and the non-visible light which cannot be perceived by the human eyes. The light becomes invisible when the wavelength is above 700 nm. The ultraviolet is among invisible. It has a bad effect on the materials. Therefore a measurement of the UV was also made.



The measurement was made in term of the UV index. It is a unit to measure the degree of energy brought by the light.

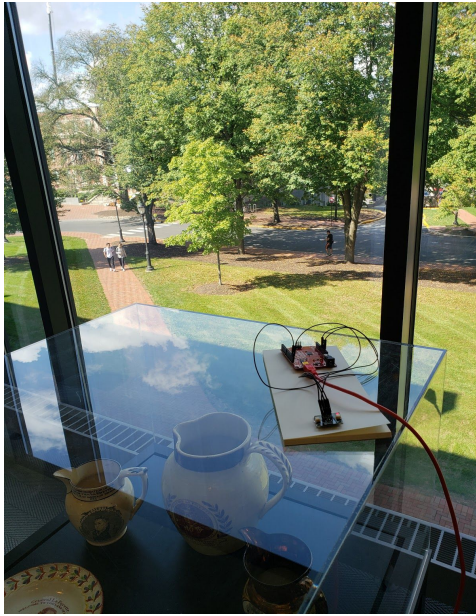
UV index	0-2	3-5	6-7	8-10	<11
Level	Low	Moderate	High	Very High	Extreme

A sensor called 'VEML 6075' was used to proceed that measurement. The Arduino library that runs this sensor was found on the official site of sparkFun. The representation of the circuit is the following



The reading was made in term in real time. The real time data were printed in the serial monitor. These last were copied from the serial monitor to spreadsheet.

A measurement of the outside door and the inside door was realized to compare the index values .



Indoor measurement



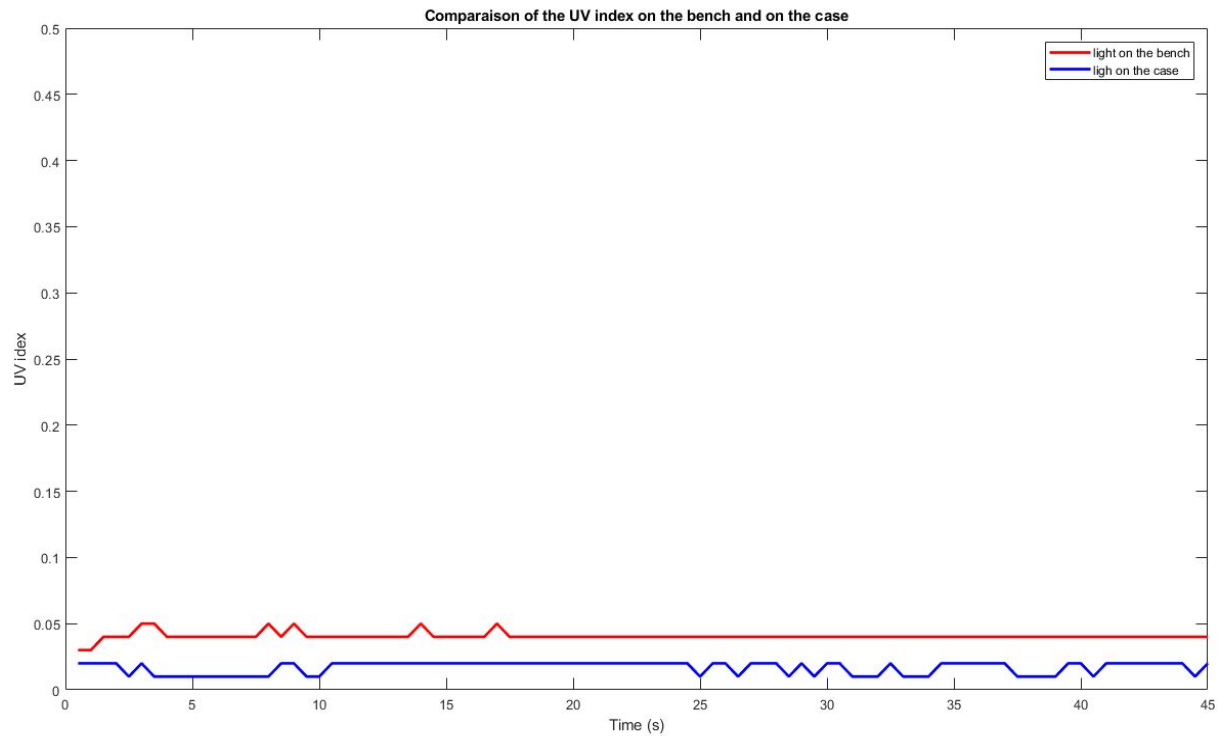
Outdoor measurement

RESULTS

The result of the measurement is shown in the graph below:



The graph above shows UV index outside is significantly higher than inside the collection room. The graph below shows just the UV index of the light at the bench at the entrance of the reading room and the UV index of the light at the case near the wall of windows in the reading room:



From the data, it appears that the UV index on the collection room is slightly low. It is almost next to 0. This result means that the UV has no potential effect on the collection. It is because the Special Collection uses UV light protection that is still functional.

V. Conclusion.

Because of the high illuminance levels that were measured with the photoresistor, actions should be taken to decrease the lux levels inside the reading room or the items that are on display in the reading room should only be placed on display for short periods of time. Visible light has a large role in fading prints and artworks that hang on the walls of the reading rooms and these artworks should be hung on display for only a couple months at a time. One option to decreasing the light levels would be using a dimmer on the fluorescent bulbs that are used as overhead lighting. Another option would be the use of curtains on the large wall of windows closest to the desks in the reading room and near the front entrance. The data collected in these experiments may need further testing in order to get more accurate results but with the data at present, the reading room does not currently hold up to museum standards and a solution to this problem should be found before any unrepairable permanent damage occurs. However, the items are protected from the UV because the light bulb used by the special collection possess a UV protector which is still in a good state.

References.

- [1] All about circuit, 'Design lux meter':<https://www.allaboutcircuits.com/projects/design-a-luxmeter-using-a-light-dependent-resistor/>
- [2] NEDCC, 'Protection from Light Damage',<https://www.nedcc.org/free-resources/preservation-leaflets/2.-the-environment/2.4-protection-from-light-damage#nomobile>
- [2] Archival Methods, "Light Damage, Protecting Your Collections from Harm":
<https://www.archivalmethods.com/blog/light-damage/>
- [3] Philadelphia Museum of Art, "What effect does exposure to light have on a museums collections? ": <http://www.philamuseum.org/conservation/10.html?page=2>
- [4] Canadian Centre for Occupational Health and Safety, "Ultraviolet Radiation":https://www.ccohs.ca/oshanswers/phys_agents/ultravioletradiation.html
- [5] Texas Historical Commission, "Recommended Light Levels":
<http://www.thc.texas.gov/public/upload/publications/Light%20Level%20Recommendations%202013.pdf>
- [6] Github, "SparkFun Arduino Library Examples":https://github.com/sparkfun/SparkFun_VEML6075_Arduino_Library/blob/master/examples/Example4_Calculate_UVI/Example4_Calculate_UVI.ino
- [7] National Optical Astronomy Observation, "Recommended illuminance value":
https://www.noao.edu/education/QLTkit/ACTIVITY_Documents/Safety/LightLevels_outdoor+indoor.pdf
- [8] Wikipedia, "Daylight": <https://en.wikipedia.org/wiki/Daylight>

Appendix A: Arduino Code

```

#include <EEPROM.h>
int addr = 0; // address of the current EEPROM location
int light = 0; //light value read by the sensor
int LED=12;// the LED is connected to the pin 12
int button=4;//the button is connected to the button
void setup() {
  Serial.begin(9600);
  pinMode(LED,OUTPUT);//the mode of the LED is OUTPUT
  pinMode(button,INPUT); //the mode of the button is INPUT
}

void saving () // this is a function that will allow the collection of data
{
  if (digitalRead(button)==HIGH) //if the button is pressed (that means the
current flows)
  {
    for (int i = 0 ; i < 100 ; i++) { // a loop will start and turns 100
times
    light = analogRead(A0);//read the value of A0 where the sensor is
connected
    Serial.println(light);
    EEPROM.write(addr, light); // write present value to EEPROM which
can be extracted by another script and cleared later
    digitalWrite(LED,LOW);//the LED turns off
    delay(9000); //wait 9 seconds
    addr = addr + 1; // move to the next address in EEPROM
  }
}

void loop() {
  digitalWrite(LED,HIGH);// the LED turns on
  saving();// the function saving is running

} // end for loop

```

```
// This a program that allows to see the UVA,UVB and UV index value
// The library used in this sensor is found in Sparkfun website
#include <SparkFun_VEML6075_Arduino_Library.h>

VEML6075 uv; // Create a VEML6075 object

void setup() {
  Serial.begin(9600);
  // set the beginning of the serial
  // It will inform the user if it is unable to connect with the sensor
  if (uv.begin() == false) {
    Serial.println("Unable to communicate with VEML6075.");
    while (1) ;
  }
  Serial.println("UVA, UVB, UV Index");
}

void loop() {
  // Use the uva, uvb, and index functions to read calibrated UVA and UVB
  values and a
  // calculated UV index value between 0-11.
  Serial.println(String(uv.uva()) + ", " + String(uv.uvb()) + ", " +
String(uv.index()));
  delay(250);
}
```

Appendix B: Matlab

Expected Illuminance code matlab

```
%{
    Plot the graph
%}
h=plot(t,maxi,'green',t,luxGlass,'red',t,luxBench,'blue');
%{
    Set the label,legend,title, the width of the line and min and max axis
%}
xlabel('Time (s)')
ylabel('Illuminance (lux)')
legend('expected maximum illuminance in a collection','illuminance
glass','illuminance bench')
title('Illuminances in the bench and the glass compared to the required one')
set(h(1),'linewidth',2);
set(h(2),'linewidth',2);
set(h(3),'linewidth',2);
xlim([0 900])
ylim([0 800])
```

Sunlight matlab code

```
>> illuminance = luxl(:,1);
>> time = luxl(:,2);
>> plot(time ,illuminance)
>> title('Illuminance outdoor')
>> xlabel('time [s]')
>> ylabel('illuminance [lux]')
>> grid on
>>
```

Glass matlab code

```
>> lux = glass(:,1);
>> time = glass(:,2);
>> plot(time, lux)
>> title('Glass lux')
>> xlabel('time [s]')
>> ylabel('lux')
>> grid on
>> |
```

Bench matlab code

```
>> bench = lux2(:,1);
>> time = lux2(:,2);
>> plot(time,bench)
>> title('Bench vs time')
>> xlabel('time [s]')
>> ylabel('bench_lux')
>> grid on
>>
```

Comparison of the UV index of the sun and light indoor Matlab Code

```
%{
    Plot the graph
%}
h=plot(time,uvSun,'green',time,uvCase,'red',time,uvBench,'blue');
%{
    Set the label,legend,title, the width of the line and min and max axis
%}
xlabel('Time (s)')
ylabel('UV idex')
legend('sun','light on the bench','light on the case')
title('Comparaison of the UV index of the sun to the indoor light')
set(h(1),'linewidth',2);
set(h(2),'linewidth',2);
set(h(3),'linewidth',2);
xlim([0 45])
ylim([0 4])
```

Comparison of the UV index indoor and outdoor Matlab code

```
%{  
    Plot the graph  
%}  
h=plot(time,uvCase,'red',time,uvBench,'blue');  
  
%{  
    Set the label,legend,title, the width of the line and min and max axis  
%}  
xlabel('Time (s)')  
ylabel('UV index')  
legend('light on the bench','light on the case')  
title('Comparison of the UV index on the bench and on the case')  
set(h(1),'linewidth',2);  
set(h(2),'linewidth',2);  
xlim([0 45])  
ylim([0 0.5])
```


Appendix C: List of Team Member Contributions

Harrison: Wrote the outline of the original code. Created the project folder and a document for ideas and notes. Reformatted research into the background section of the paper. Wrote the first half of the Methods section and corrected the other half. Created citations to go along with already used sourced. Moved previous Final Report draft into the proper template. Worked on presentation creating some of the slides.

Cecelia: Provided most of the research. Created the first model of the photoresistor sensor. Created documents for our research. Contributed to the results and conclusion sections of the paper. Collected data at the library in special collections. Helped troubleshoot aspects of the code. Analyzed raw data and converted it into lux.

Tafita: Updated Harrison's code. Looked the code for the UV sensor and the library. Designed the circuit. Collected data with Miriam in the library. Did the outdoor measurement. Looked for the final conversion code of the lux. Completed the method description of the report. Finalized the presentation slide.

Miriam: Set up another model of the photoresistor sensor. Collected the data from the library. Proofread and made some changes in the report. Made the graphing in Matlab and wrote the code in the report.