Abstract

Calibration of measuring equipment is crucial as it influences the accuracy of all readings obtained from the device. In this experiment, we focused on the calibration of a portable spectrometer constructed using cardboard, two blades, a CD, and masking tape. The spectrometer was employed to capture the known spectra of various light sources. We used a reliable standard sample of the spectrum to ensure accurate calibration. By measuring the pixel distances between peak locations and a reference point (the slit), we plotted wavelength versus pixel distance to establish a correlation. Using this relationship, we determined the peak wavelength of a blue LED light to be 456.38 nm, which is within 8 nm of the actual wavelength (464 nm). Subsequently, we developed a Python code to analyze any spectrum based on this calibration. This process ensured that the spectrometer provided accurate and reliable readings for various light sources.

Methodology

Procedure

1. Select a Light Source:
   - Find a light source with a known spectrum and a standard sample for measurement. Ensure the light source has at least five distinct high-intensity peaks for accurate calibration.

2. Capture the Spectrum:
   - Use the spectrometer to capture a clear image of the light source's spectrum.

3. Image Processing:
   - The captured image will contain two spectra (left and right of the slit). Crop the image to include only the slit and one spectrum.

4. Measure Pixel Distances:
   - Insert the cropped image into a paint software and measure the pixel distances between the slit and each peak point. Bright color lines indicate peak points (refer to the figure). Alternatively, use Python software for more precise measurements.

5. Determine Wavelengths:
   - Compare the spectrum of the known light source and the standard sample to determine the wavelengths of the peak points.

6. Plot Wavelength vs. Pixel Distance:
   - Using Microsoft Excel or Octave, plot a graph of the wavelength of each peak point versus the pixel distance from the slit to the peak point.

7. Calculate Gradient:

- The gradient of the graph provides the wavelength per pixel. Use this relationship to implement the Python code for spectrum analysis.

8. Verify Accuracy:
   - If possible, find another light source with a known spectrum to verify the accuracy of the obtained relationship. Capture an image of this new light source, crop it, and insert it into the paint software.

9. Predict Wavelengths:
   - Measure the pixel distance between the slit and peak locations. Use the relationship obtained in steps 6 and 7 to predict the wavelengths of the light source.

10. Python Code Implementation:
    - Utilize the Python code developed in step 7 to obtain the wavelength directly from the pixel distances.

By following these steps, you can calibrate the spectrometer accurately and use it to analyze various light sources.

Figure Panel

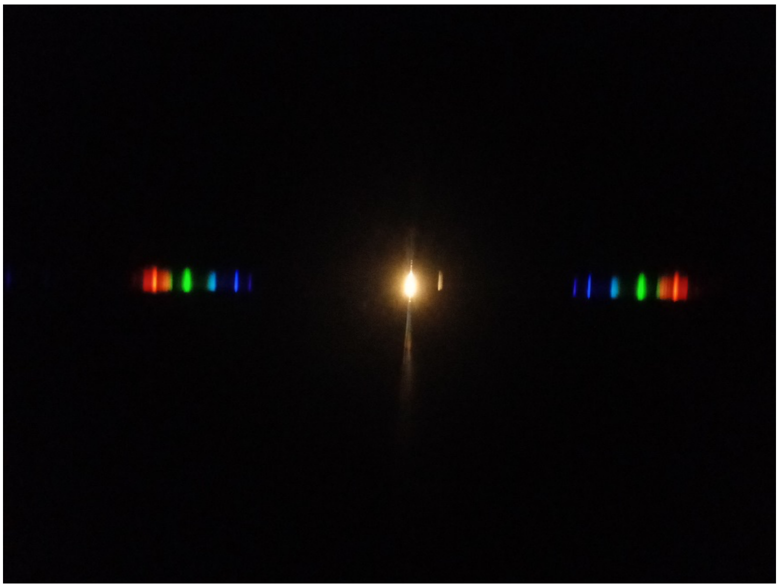

Figure 1: This is an image of the spectrum of a fluorescent bulb. The spectrum is not continuous and contains five distinct peaks, making it suitable for calibrating the spectrometer.

Figure 2: This image is obtained by cropping the above entire image. It is easier to find the pixel distances using the cropped image with paint software as well as Python.

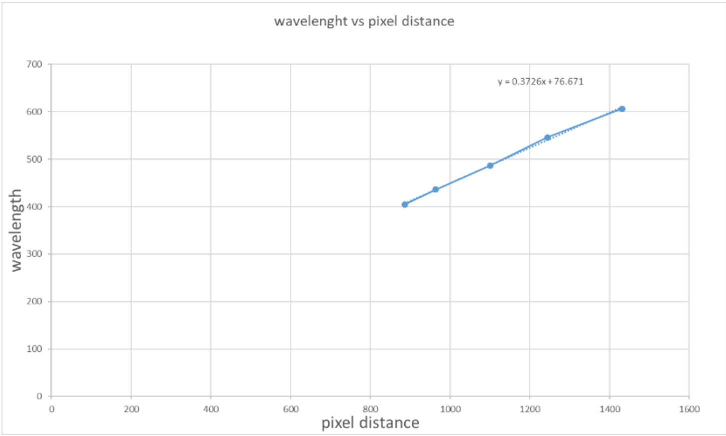

Figure 3: The graph of wavelength of peak point vs. pixel distance. This was obtained using Excel.

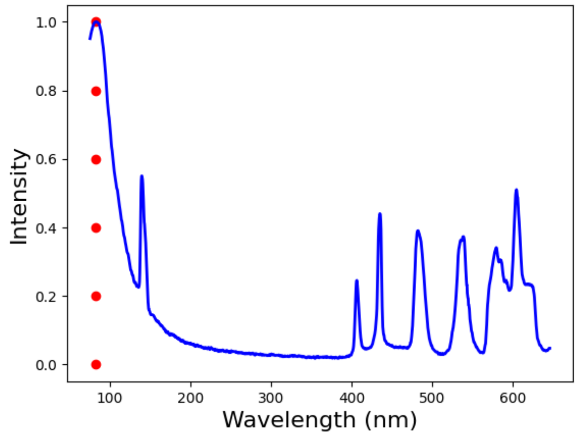

Figure 4: This is the intensity vs. wavelength graph obtained using Python. The maximum peak corresponds to the slit. Peaks in the wavelength range of 400 nm to 650 nm correspond to the spectrum of the light source.

Figure 5: Spectrum of the blue LED light.

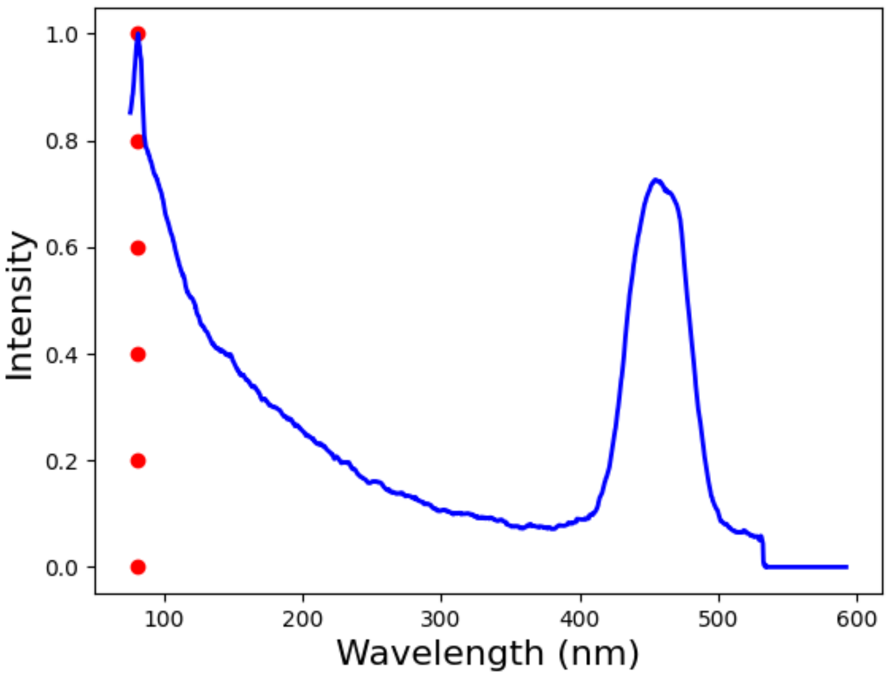

Figure 6: This is the graph of intensity vs. wavelength obtained using Python. The wavelength of the peak point of this graph is 456 nm.

Appendix

Data values for draw the graph.

Pixel distance (x - axis)	Wavelength (nm) (y – axis)
887	405
964	436
1101	487
1244	546
1431	606

Using these date we have obtained relation between X and Y as

$y = 0.3726x + 76.671$

After the calibration we captured a spectrum of a blue LED. And using paint software we measured pixel distance between slit and peak location of the spectrum these data is shown in below. BLUE LED light has only one peak (figure)

Pixel value of the slit = 13

Pixel value of the peak location = (1116 + 950)/2

= 1032

Distance between peak location and slit = 1032-13

= 1019

Wavelength of the peak point = 0.3726 *1019 + 76.671

=<u>456.38 (nm)</u>

Actual wavelength of blue LED is 464 nm. This value is within 8 nm of the experimental value.

Width of the slit should be small as much as possible. If not width of the discrete spectral lines increase. Then the accuracy of the spectrometer decrease and sharpness of the peaks of intensity vs wavelength graph decrease.