

Wein's Law Activity I – Black Box

BACKGROUND

- In physics, Planck's law describes the spectral radiance of electromagnetic radiation at all wavelengths from a black body. Max Planck was a German physicist considered to be the founder of the quantum theory. Planck was awarded the Nobel Prize in Physics in 1918.

MATERIALS

- Small desk lamp
- Bare incandescent light bulb (optional, if available - neon lamp, tungsten lamp, florescent lamp, uv lamp, various colored "party" bulbs)
- black container (box or large can covered inside with black paper or paint)
- IR thermometers
- Stop watch or clock with 2nd hand
- graph paper
- blank or lined paper
- Pencils
- Rulers
- (OPTIONAL) Colored pencils
- (OPTIONAL) Computer with Excel program
- (OPTIONAL) printer

PROCESS

1. Using the IR thermometer, measure the temperature of the inside and outside of the container.
2. Aim the light bulb inside the container. Be sure to place
3. Turn on the bulb. Wait one minute.
4. Remove the bulb and quickly measure the temperature inside and outside the container.
5. Record this data on a piece of paper, recording time and temperature.
6. Return the bulb to the container.
7. Repeat the measurement every minute as the bulb heats up the container, removing the bulb each time to get the temperature of the inside and outside of the container.
8. After 10 minutes, or after the temperature of the box no longer goes any higher, remove and turn off the bulb, allowing the box to cool.
9. Record the temperature of the inside and outside of the container each minute as it cools.

10. Create a graph, plotting time versus temperature, for each lamp. Be sure to use a different color, or different symbol, when plotting the different lamps.
11. Sketch the curve generated by the data points.

QUESTIONS

1. What kind of curve is generated by the plot?
2. What does the curve tell you about the two different light sources?
3. Find the peak of each curve. Next, determine the slope of the curve to the left of the peak, and to the right of the peak.
4. What can you deduce from the relationship between the peak of the curve and the slope of the curve?

DISCUSSION

- These plots give a broad-spectrum (Planck) thermal curve.
- By having one set of students measure the temperatures when the light has been on for 5 minutes, another team after 10 minutes, etc., it shows the relation between peak temperature and slope of curve.
- By using two different types of lamps, it shows the relation between temperature and emission wavelength (e.g., a neon lamp vs. a tungsten lamp, etc.)

GENERATE THE GRAPH USING EXCEL

1. Using the hand-written data table listing versus temperature for each data point
2. Using an Excel spreadsheet, enter the data in columns – time, temperature – for each lamp. Be sure to separate warm up and cool-down data points.
3. Be sure to save your work often.
4. Next, insert a line graph. A blank graph area will appear. Click once in this area.

5. Click “*Select Data*” from the top menu to add data to the graph area. A pop-up window will appear.
6. In “*Chart Data Range*” box, click the small red arrow to the right.
7. Highlight all the cells containing data for Temperature readings only. Ignore the Time # data for now.
8. Click the red arrow again to return to the data source selection window. Notice *Series 1* in the lower left part of the window.
9. Click once on *Series 1*. Click “*Edit*.” In the 2nd pop-up window, rename this series to “Temperature inside box in 1-minute intervals.” Click OK to return to the 1st pop-up window.
10. Click OK again to exit the pop-up.
11. Your graph should appear with a line graph showing the temperature rise during warm-up and temperature fall during cool-down.

ADJUST THE GRAPH

1. Move the generated graph below the data table by clicking and dragging it around the sheet.
2. Click once in the background of the graph to highlight the plot area. Right click in this selected area, and choose “Format Plot Area” to change its fill color, and other options.
3. Once changes are made, click “Close.”
4. Click once on the line graph showing the temperature rise and fall. Right click on this line and choose “Format Data Series” to change fill color, line color, marker color, and other options.
5. Once changes are made, click “Close.”
6. Click on the any corner of the graph to re-size it. Move the graph on the page by clicking and dragging it around.

ADJUST THE PRINTOUT

1. Using *Print Preview*, *Page Break Preview*, and *Page Set-up Options* adjust final printed size of data table and chart.