

Physics Research - Fall 2011

W Processing Information Between a Spectrophotometer and an Arduino

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W Project Goal and Outline

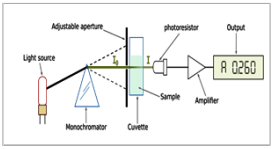
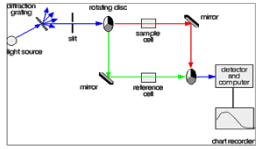
- Connect old analogue spectrophotometer to modern computer
- Needed for completion:
 - Understand how to a spectrophotometer works
- Design hardware to interface a computer and the spectrophotometer
- Implement computer code to:
 - Control the hardware
 - Process the data

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W Basics of a Spectrophotometer

- A spectrophotometer measures transmission of various wavelengths of light through a test sample.
- Two different types of spectrophotometers
 - Single Beam Spectrophotometer
 - Double Beam Spectrophotometer

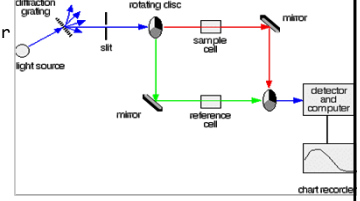



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W How a Spectrophotometer Works

- There are 4 key portions to the spectrophotometer:
 - The light source
 - The monochromator containing a diffraction grating
 - Sample chamber
 - The detector




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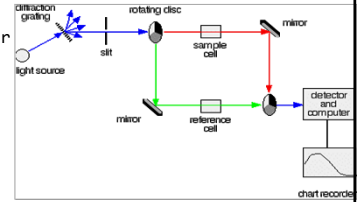


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W How a Spectrophotometer Works

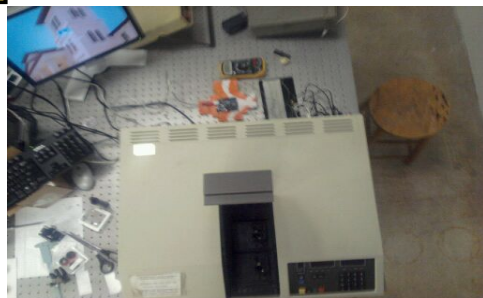
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W The Lambda 3A Spectrophotometer



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W Interface hardware

ARDUINO Uno:

- ATmega328 microprocessor
- Clock Speed: 16 Mhz
- Flash Memory: 32 KB
- Operating Voltage: 5V
- Simplified version of C++
- 6 Analog input pins and 14 digital I/O pins with a ADC.



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W Why we chose the Arduino

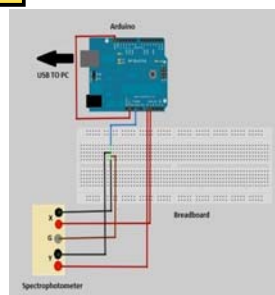
- Ease of Use
- Free Software
- Readily available
- Requires a USB connection
- Support numerous extensions (*Shields*): Bluetooth/WiFi antenna, motor, data-logger, touchscreen,...



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W Circuit Schematic



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W Data Collection and Calibration

- Data Collection rate : ≈ 110 readings/sec
- Scanning speed: 120 nm/min
- Python script: serial, math and time libraries
- Period of Integration: 1 sec
- Uncertainty: ≈ 1.0 nm and ≈ 0.201 %T
- Calibration equations:

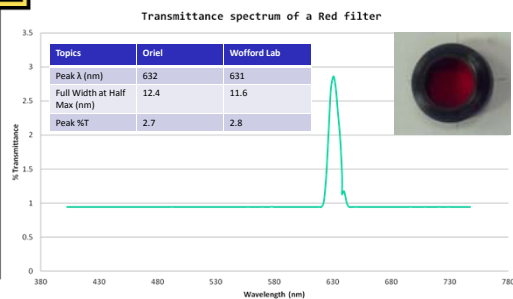
$$\lambda = ax^2 + bx + c$$

$$\%T = ax^2 + bx + c$$

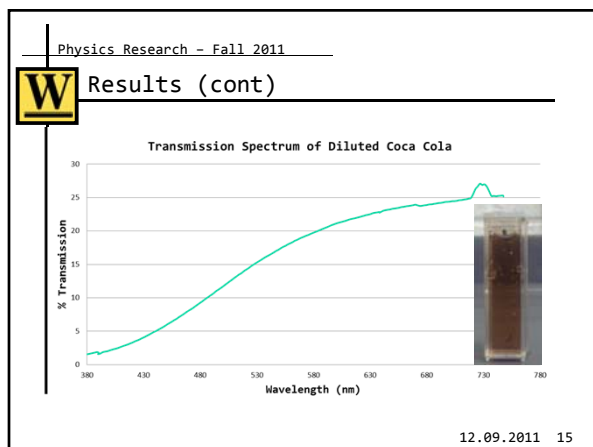
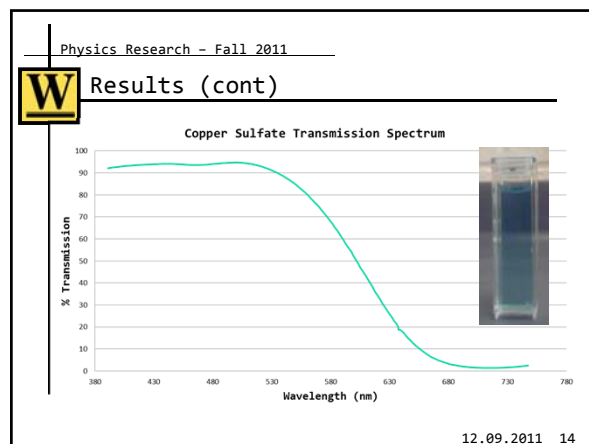
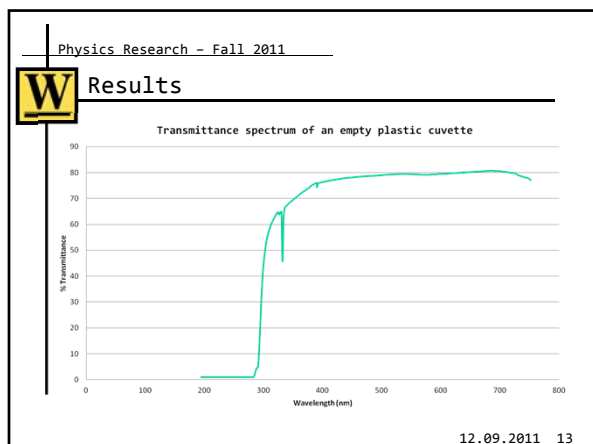
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W First Experiment



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- ## Conclusion
- Successfully interfaced an older model spectrophotometer to a computer.
 - Created computer code to automate the collection and process of data.
 - Calibrate the output voltage from the spectrophotometer to usable data.
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- ## Future Work
- Add a stepper-motor for total wavelength control from the spectrophotometer
 - Implement a handshaking protocol to synchronize the serial communication and handle the speed of the incoming data.
 - Create an enclosure for the Arduino for temperature stabilization and electrical noise suppression
 - Follow on experiments studying photoelectricity and photoexcitation of various materials such as solar panels.
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- ## Sources
- <http://www.microspectra.com/component/content/article/35-technical-support/248-spectrophotometer-design>
 - <http://www.nist.gov/pml/div685/grp03/spectrophotometry.cfm>
 - Csele, Mark and Brown, Jeff. Perkin-Elmer Lambda 3B Spectrophotometer.
 - Margolis, Michael. Arduino Cookbook. Beijing Farnham Dorset, England: O'Reilly, 2011.
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Data Used

- $\lambda = 4.54x^2 + 451.12x + 194.22$
- $\%T = 0.8921y^2 + 98.608y + 0.942$
- Light source:
 - UV = Deuterium Lamp
 - Visible = Tungsten lamp
- Coke dilution = 50% coke, 50 % water
- Red filter code = L-BPF-1-MR