The Digital World

A Definition (from Wikipedia)

- A **digital** system is one that uses discrete numbers, especially binary numbers, or non-numeric symbols such as letters or icons, for input, processing, transmission, storage, or display, rather than a continuous spectrum of values (an analog system).

A Digital Clock

- It has digits on it!

A Digital Clock!

- The pendulum generates a discrete sequence of pulses.
- The hands do not move continuously---they change their positions once per minute.

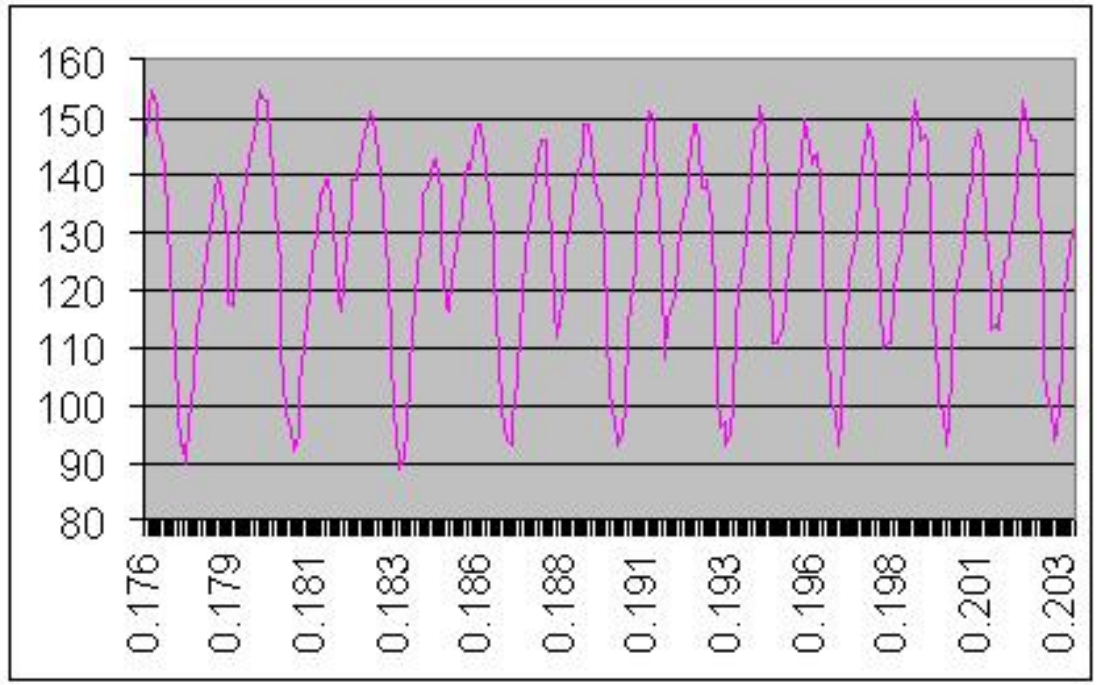
A Real Analog Clock

- The (apparent) motion of the sun, and the corresponding motion of the shadow, are continuous, rather than discrete.

Analog versus Digital Sound Recording

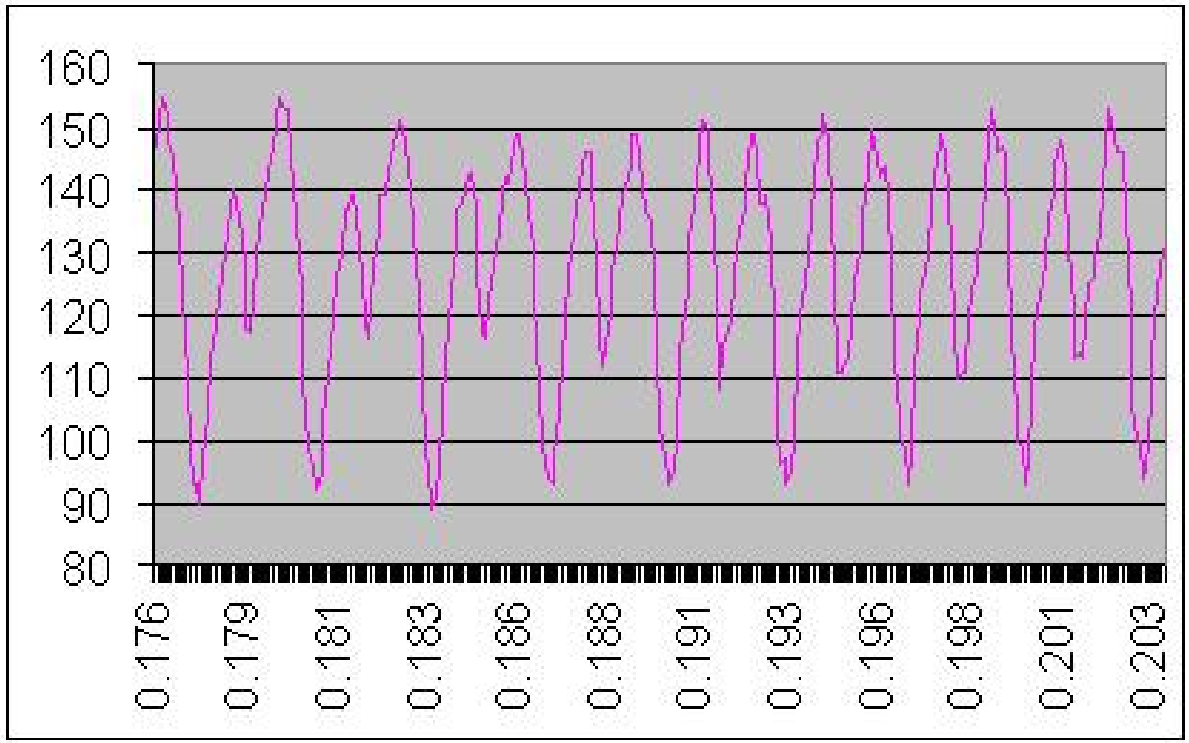
What is Sound?

- Rapid variations in pressure of air near the ear cause the eardrum to vibrate.
- Larger amplitude—louder sound.
- Higher frequency—higher pitch.



Click me-I play music!

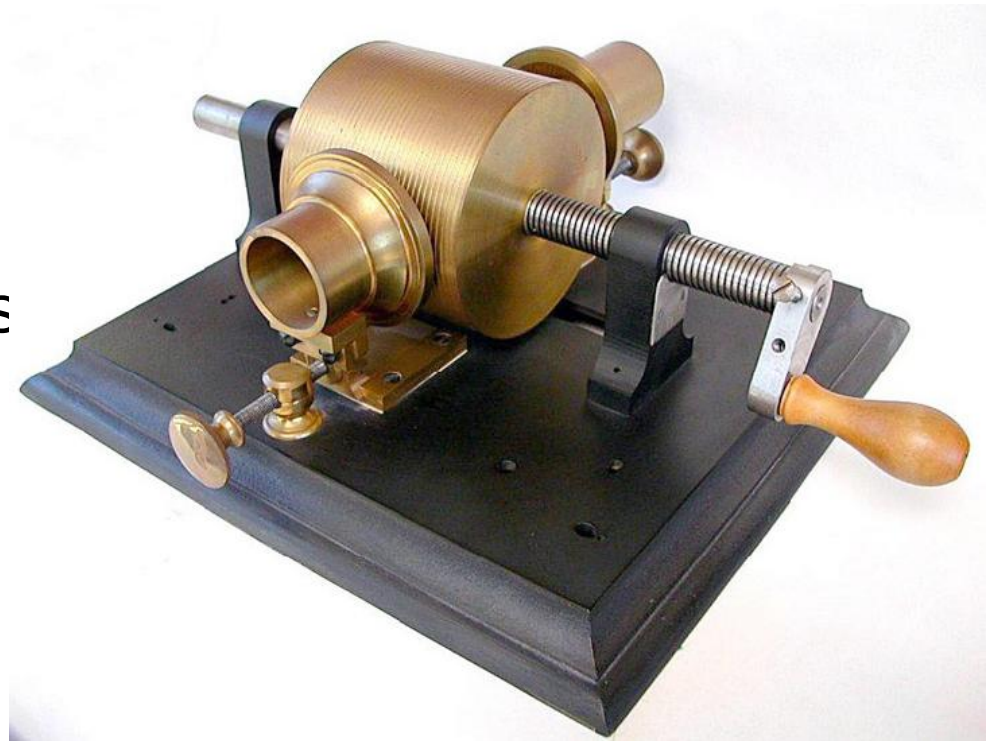
Frequency Measured in Hertz (cyles per second)



Vibrational period is about 0.0035 seconds, roughly 300 hertz (about D above Middle C.)

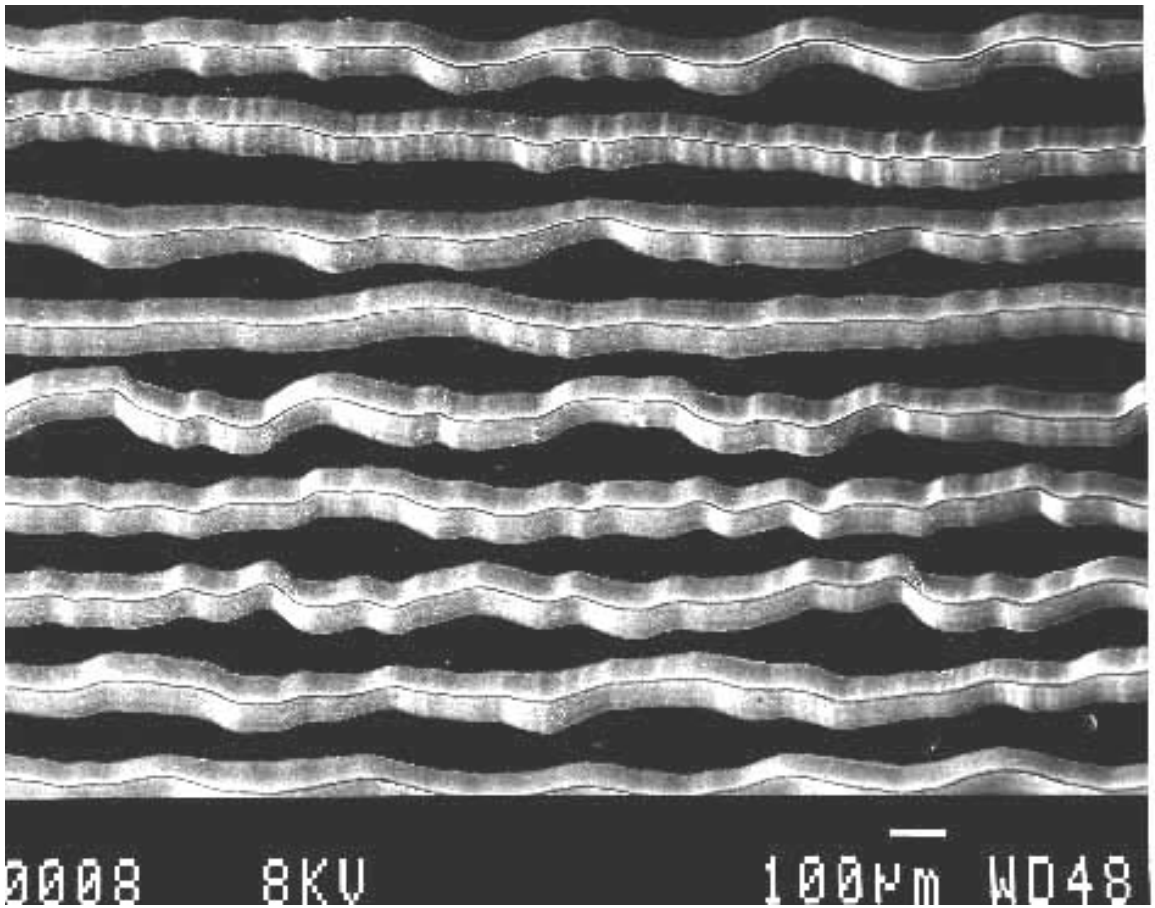
Phonograph—Analog sound recording

- The sound wave is engraved into the surface of the record.
- On playback, the stylus rides in the groove created during the recording and vibrates accordingly.

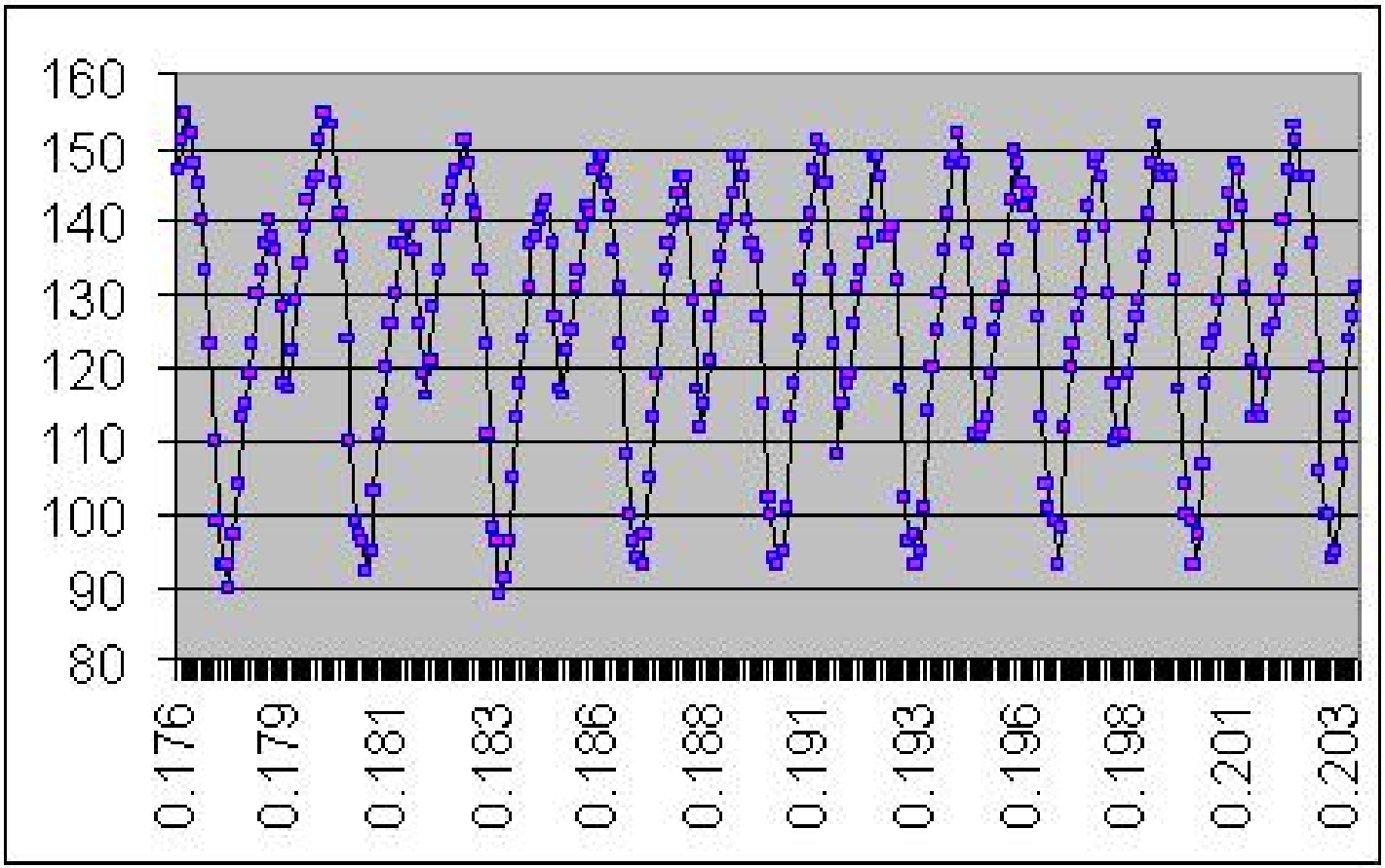


Edison’s 1877 phonograph

Microphotograph of grooves on a modern vinyl phongraph record



Digital Sound Recording



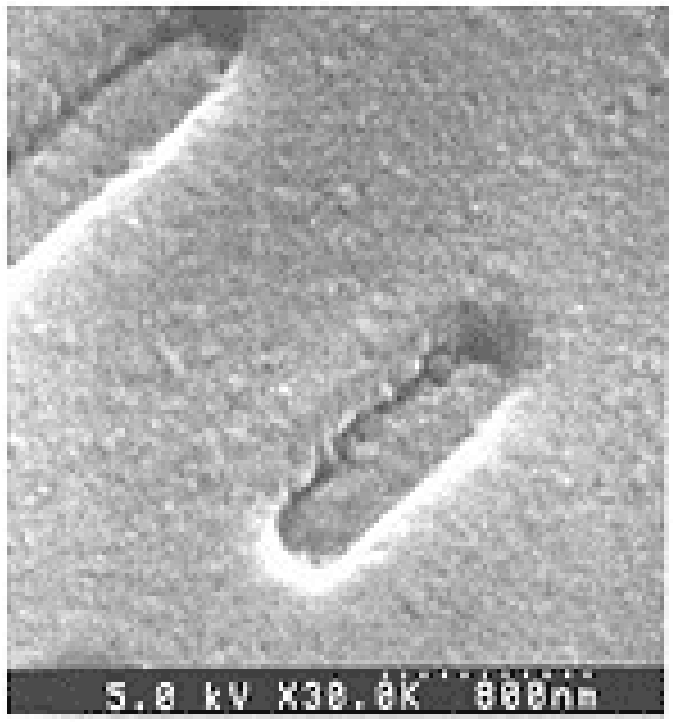
Sound is **sampled-**--its amplitude is measured—at frequent intervals-- and the resulting sequence of numbers is recorded. ***Analog-to-Digital Conversion***.

CD-quality Digital Recording

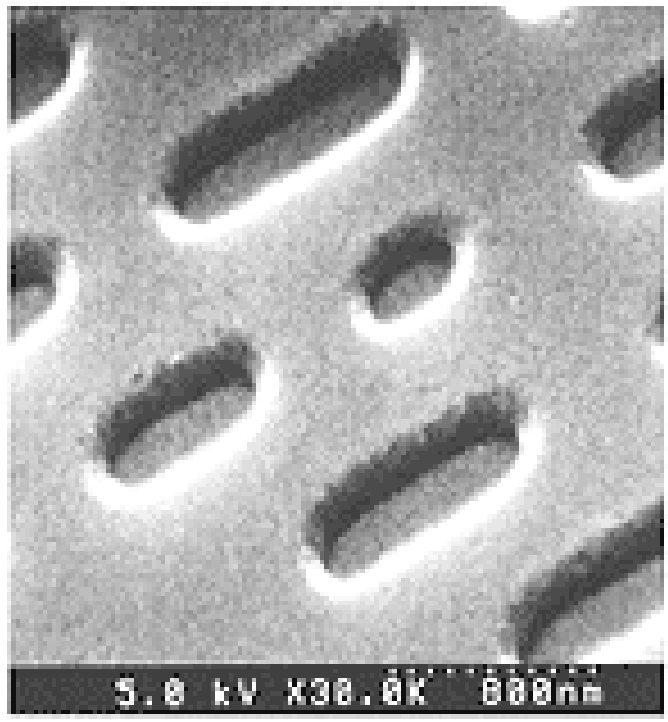
- Recording quality depends on the number of different amplitude levels that can be distinguished and how frequently the samples are measured.
- Music for CDs is sampled at 44100 hz (44100 samples per second).Each sample value is 2 bytes (= 16 bits) so there are 65536 different possible amplitude levels.
- One hour of stereo music takes up about 650MB.

CD-quality Digital Recording

- To make a CD, a laser burns pits in the reflective surface of the disk to represent bits (pit = 1, no pit =0---or is it the other way around?)



CD

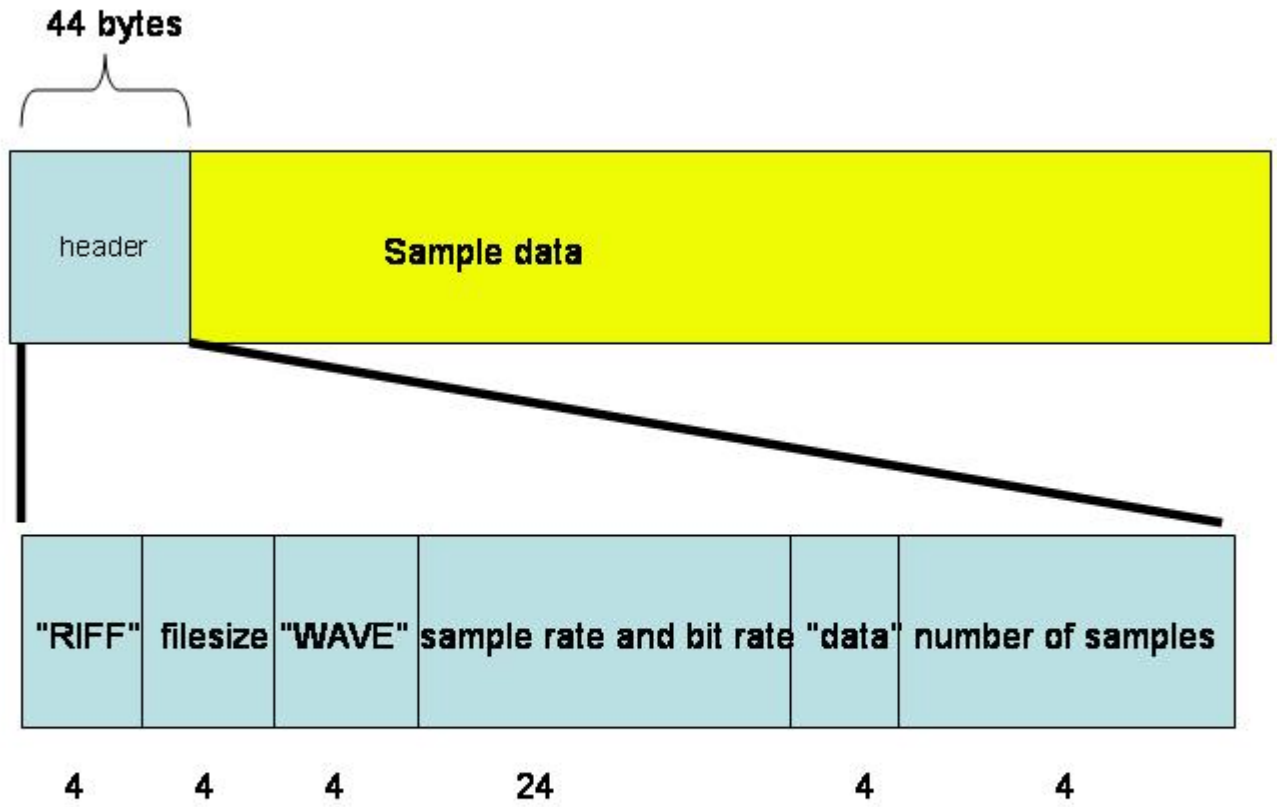


DVD

.wav Files

- The .wav files you experiment with use a sampling frequency of 11025 Hz with one byte per sample. (They are also monaural rather than in stereo!)
- You can *modify the sound* by *manipulating the numbers.*

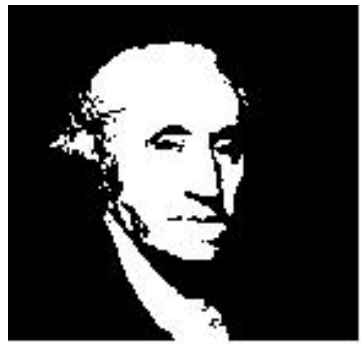
Format of a .wav file



Digital Images

Monochrome Bitmap Image

- In a bitmap image, each pixel in the image is assigned a numerical value or values.
- At right is a *monochrome* bitmap image: each pixel is encoded by one *bit*. (1=white, 0=black).

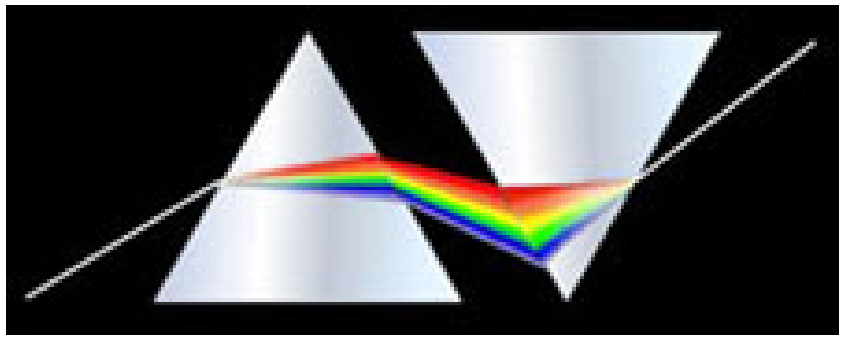


Grayscale Bitmap Image

- Each pixel is encoded by a single byte, that is, a value between 00_{hex} and FF_{hex} (0 and 255). 00 is black and FF is white.

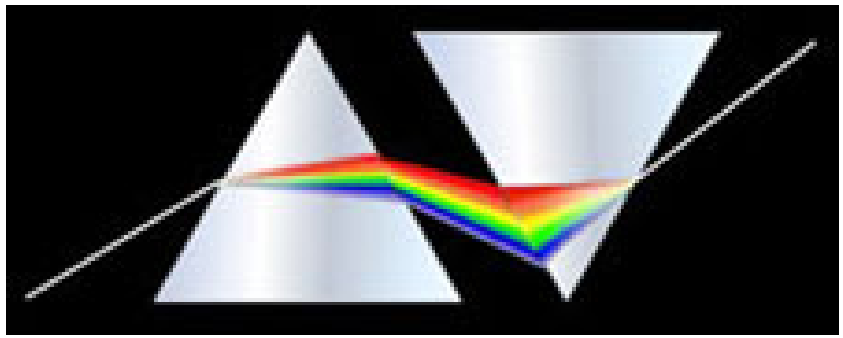
…and color?

- The wavelength of a beam of light determines its color.
- White light is composed of light of many different wavelengths---the prism refracts different wavelengths at different angles.



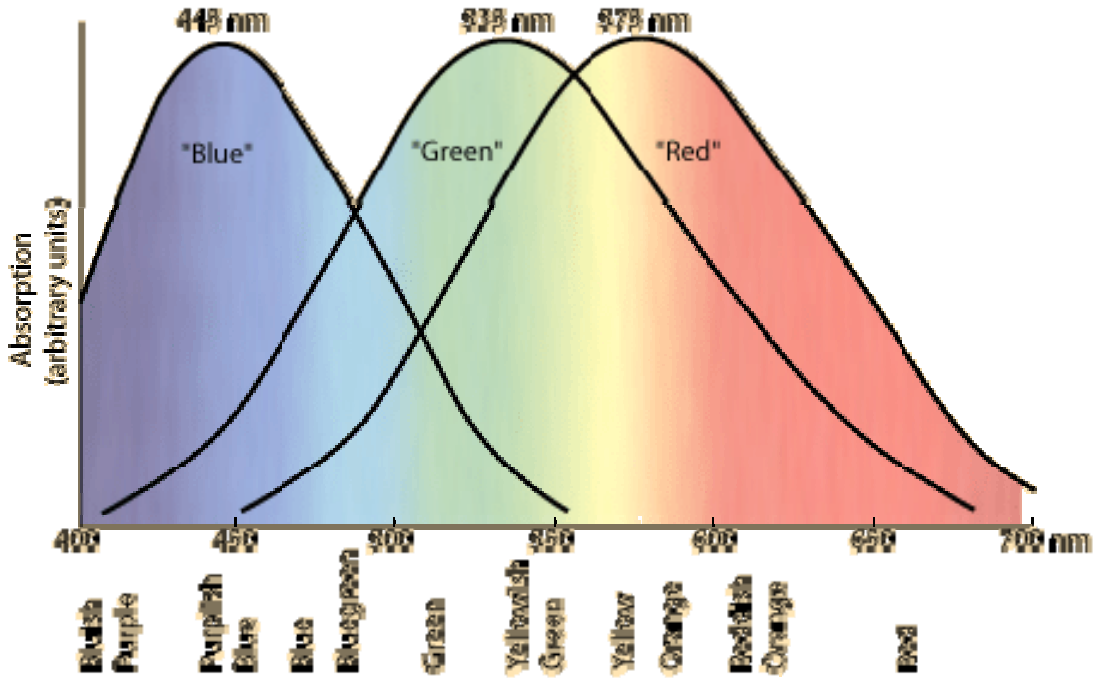
Combining Spectral Colors

- What if you blocked all but the red light and green emerging from the first prism?
- The light emerging from the second prism would appear yellow!
- The reason for this is *physiological!*



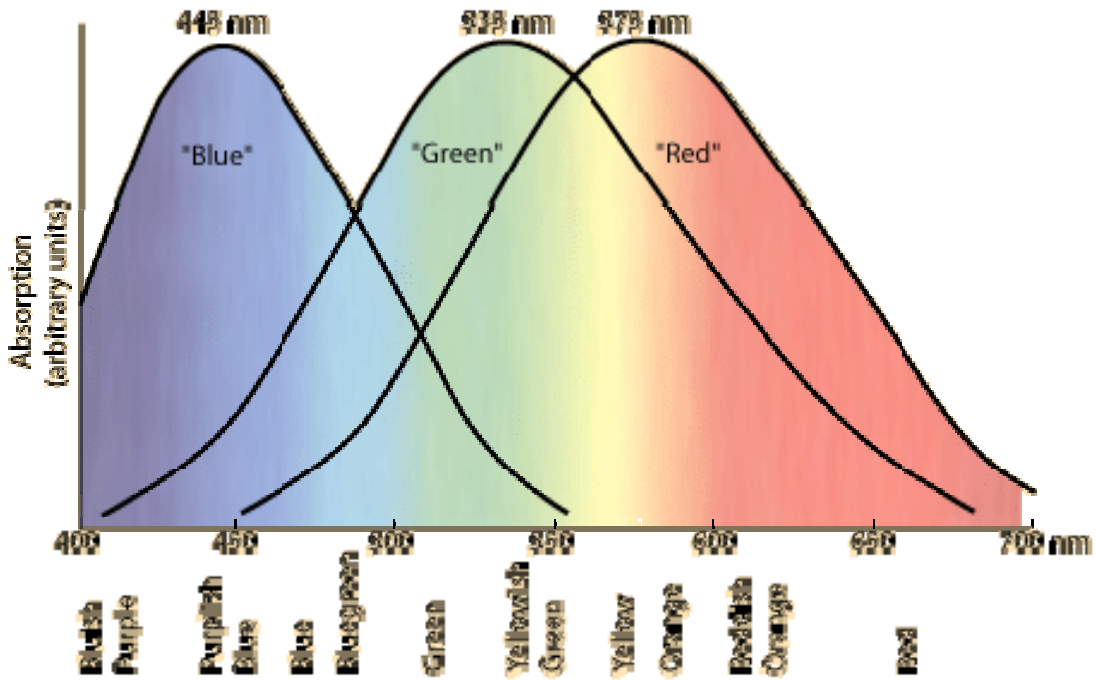
Physiology of Color Vision

- Three types of “cone cells” in the eye have different responses to light of different wavelengths.



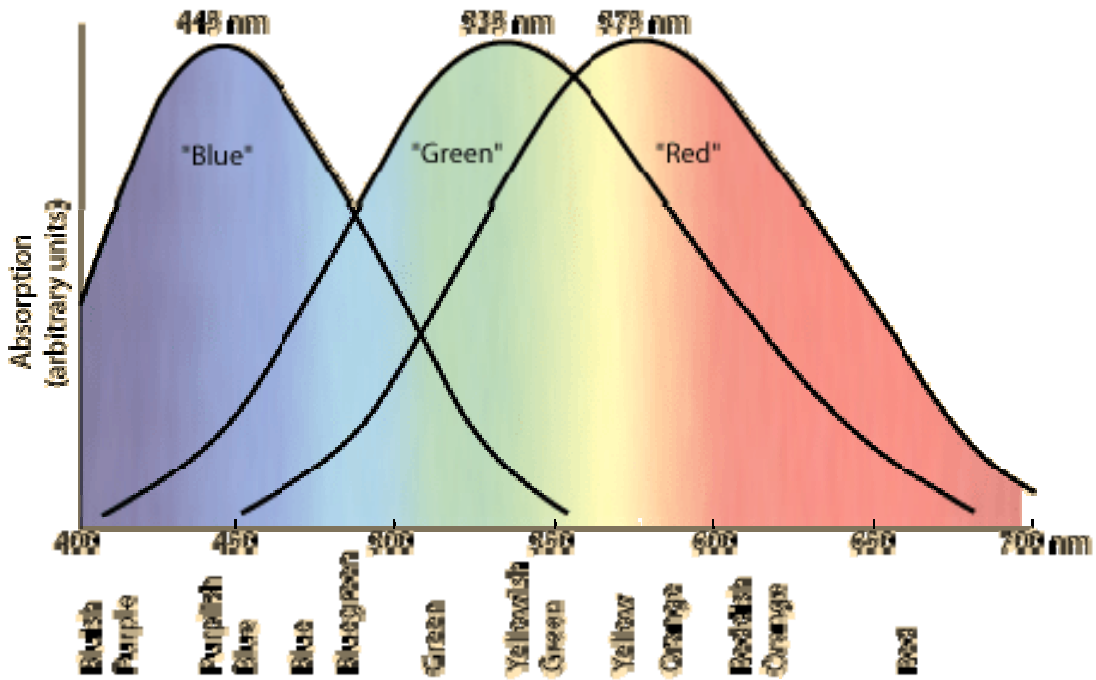
Physiology of Color Vision

- Pure spectral yellow light provokes a large response from the red-sensitive and green-sensitive cells, but almost none from the blue-sensitive cones.



Physiology of Color Vision

- So a mix of red and green will appear yellow.
- Wide range of colors obtained by mixing different proportions of red, green and blue light (“primary colors”).



Bitmap Color Image

- Each pixel encoded by three bytes, giving mix of red, green and blue light.
- If red, green and blue values are all equal, the color is some shade of gray (higher values=lighter color).