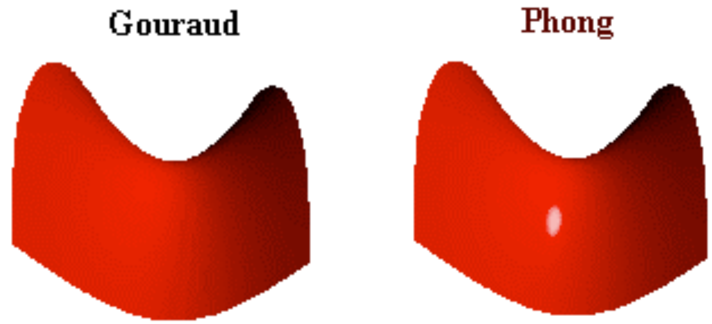
Phong Shading

- Interpolate normals instead of pixel values
  - Shade using normal estimate for each point
  - Advantage
    - high quality, narrow specularities
  - Disadvantage
    - more expensive than Gouraud



from
http://www.geocities.com/SiliconValley/Horizon/6933/shading.html

What about the color of the light?

So far, we have not dealt with the color of the light--the implicit assumption being that it is “white” and thus does not change the color of anything.

This is often not the case!

Naïve (but common) model

Consider the color of the light to be specified by its (R,G,B)--technically the color of a perfect uniform reflector (white surface).

Similarly, now specify the albedo as a triple--one for each channel. The color of a Lambertian surface is then:

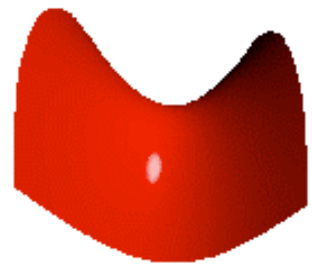
$$(R,G,B) = (\rho_R S_R,\ \rho_G S_G,\ \rho_B S_B)(\mathbf{n} \bullet \mathbf{s})$$

Naïve (but common) model

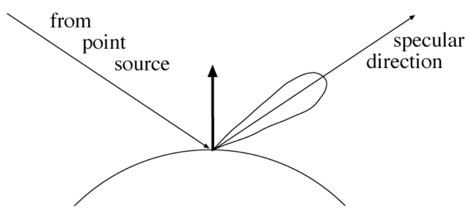
Naïve because we assume that the red part of the light does not interact with green or blue albedos, etc.

(Referred to as the diagonal model)

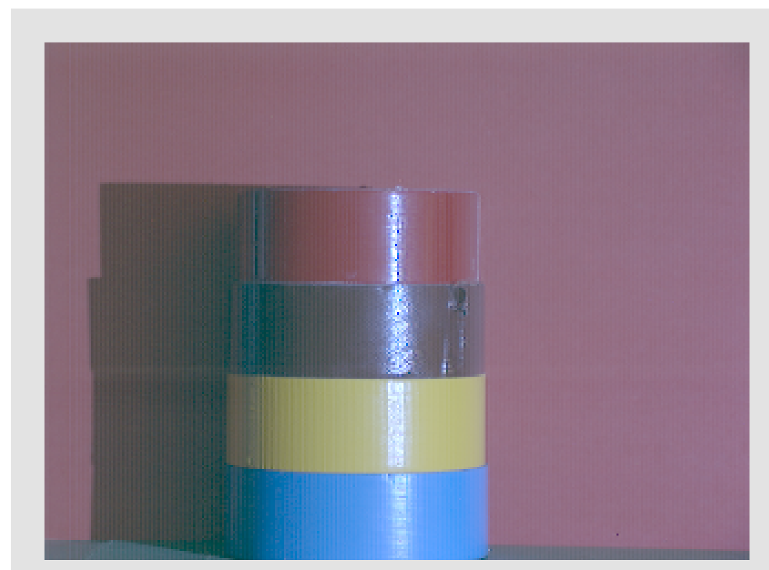
What about specular surfaces?



Specular surfaces

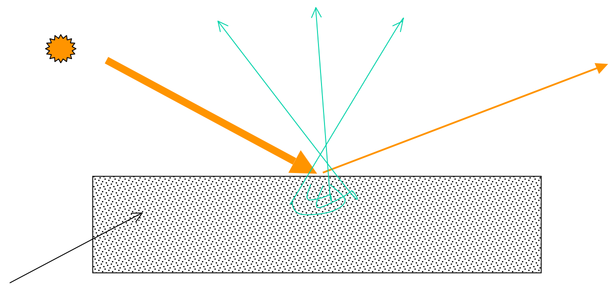


- Important point: The specular part of the reflected light usually carries the color of the **light**
- Technically, this is the case for dielectrics--plastics, paints, glass.
- Important exception is metals (e.g. gold, copper)



Example: Dielectrics

- Examples: Paints, plastics
- Reasonably well approximated by a specular part and a Lambertian body part.

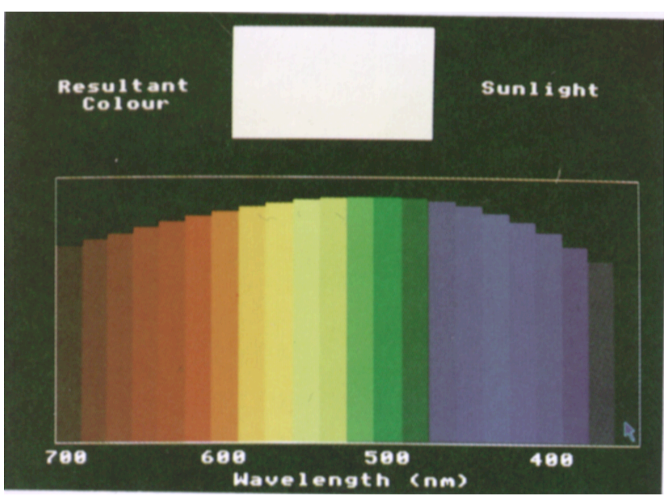


Non conductive matrix with scattering particles of the order of the wavelength of light---note: the same general process explains why the sky is blue.

The colors of the rainbow

- Light is electromagnetic radiation, occurring at different wavelengths (or photon energies)
- The radiation around us is a mix of these
- Visible portion is about 400 to 700 nm
- Certain applications may require modeling some UV also.
- Light is specified by its spectrum recording how much power is at each wavelength.

Sunlight



Two disparate source spectra

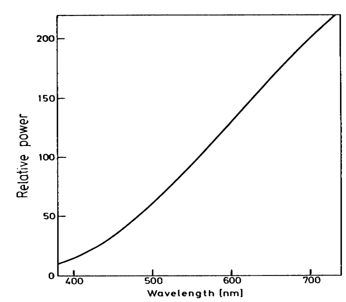


Fig. 4.1. Wavelength composition of light from a tungsten-filament lamp [typified by CIE ILL A (Sect. 4.6)]. Relative spectral power distribution curve. Color temperature: 2856 K

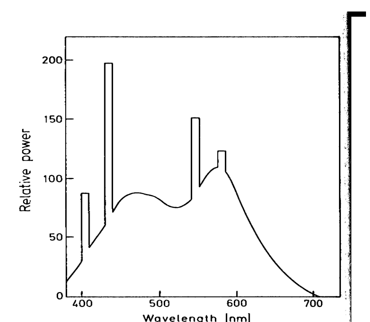
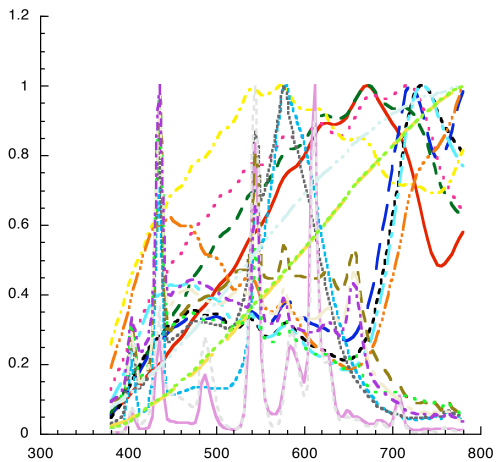


Fig. 4.2. Wavelength composition of light from a daylight fluorescent lamp. Typical relative spectral power distribution curve. Correlated color temperature: 6000 K. (Based on data of Jerome reported in [Ref. 3.14, p. 37])

Energy spectra of 20 other common lights

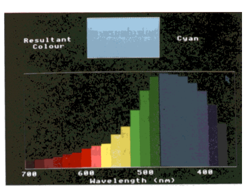


Radiometry for colour

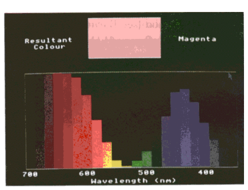
- All definitions are now “per unit wavelength”
- All units are now “per unit wavelength”
- All terms are now “spectral”
- Radiance becomes spectral radiance
  - watts per square meter per steradian per unit wavelength
- Radiosity --- spectral radiosity

Absorption spectra: real pigments

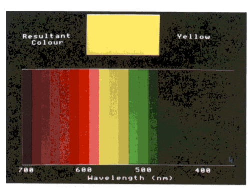
cyan



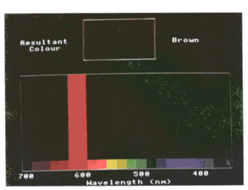
magenta

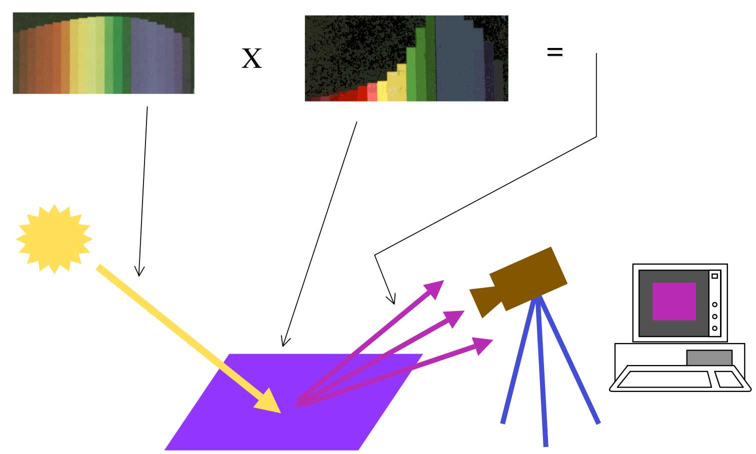


yellow



brown

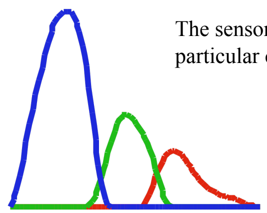




Sensors

Sensors (including those in your eyes) have a varied sensitivity over wavelength

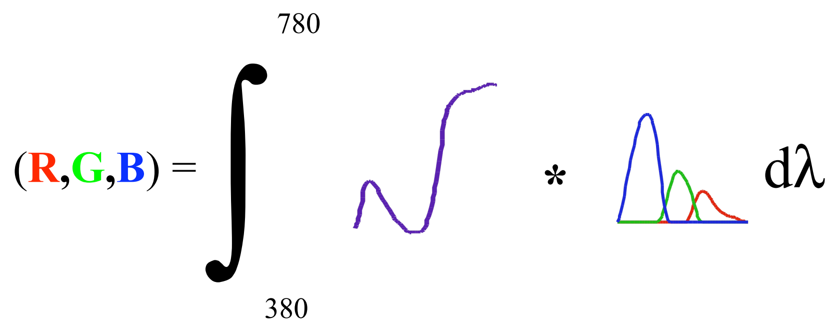
Different variations lead to different kinds of sensor responses ("colors" in a naïve sense)



The sensor sensitivity spectra for a particular color camera (they vary a lot).

<--- wavelength --->

Image Formation (Spectral)



More formally,

The response of an image capture system to a light signal $L(\lambda)$ associated with a given pixels is modeled by

$$\rho^{(k)} = \int L(\lambda) R^{(k)}(\lambda) d\lambda$$

where $R^{(k)}(\lambda)$ is the sensor response function for the kth channel.

Note the usual case of three channels

$$(R, G, B) = \left(\rho^{(1)}, \rho^{(2)}, \rho^{(3)}\right)$$

Discrete Version

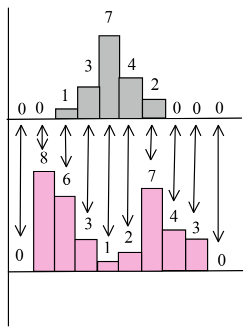
Often we represent functions by vectors. For example, a spectra might be represented by 101 samples in the range of 380 to 780 nm in steps of 4nm.

Then $L(\lambda)$ becomes the vector **L**, $R^{(k)}(\lambda)$ becomes the vector $\mathbf{R^k}$, and the response is given by a dot product:

$$\rho^{(k)} = \mathbf{L} \bullet \mathbf{R^{(k)}}$$

Sensor/light interaction example

R=(0,0,1,3,7,4,2,0,0,0)

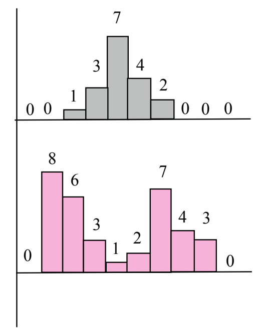


L=(0,8,6,3,1,2,7,4,3,0)

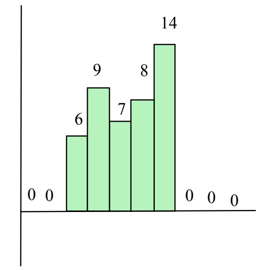
Multiply lined up
pairs of numbers
and then sum up

Sensor/light interaction example

R=(0,0,1,3,7,4,2,0,0,0)



L=(0,8,6,3,1,2,7,4,3,0)



L .* R=
(0*0, 0*8, 1*6, 3*3, 7*1, 4*2, 2*7, 0*4, 0*3, 0*0)
= (0, 0, 6, 9, 7, 8, 14, 0, 0, 0)

L • P = 0 + 0 + 6 + 9 + 7 + 8 + 14
= 44