

Lecture 1: Photometer

BIOEN 302
Autumn 2010

1

Photometry, or colorimetry, is...

Quantitative Analysis of Absorption

Absorption reduces light intensity.

Thickness: δx

$$\frac{dI(x)}{dx} = -\mu_a I(x)$$

Beer-Lambert's Law

$$I(x) = C \exp(-\mu_a x) = I_0 \exp(-\mu_a x)$$

9/30/2009 BIOEN 302 2

Absorption Coefficient

Absorption Coefficient:

$$\mu_a = \epsilon [C]$$

Extinction Coefficient (e-based)

Units: $\text{cm}^{-1}\text{M}^{-1}$

Molar Concentration of Absorbing Molecules

M=Moles/Liter, Molar

9/30/2009 BIOEN 302 3

Transmission and Absorbance

Transmission: $T = \frac{I(d)}{I_0} \times 100\%$

Absorbance: $A = \log \frac{I_0}{I(d)} = \mu_{a,10} d$

Absorbance = Optical Density (OD)

Cuvette (solution)

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And the reason we came here ...

Concentration Measurement

$$\text{OD} = \log \frac{I_0}{I(d)} = \mu_{a,10} d = \epsilon_{10} d [C]$$

Molar Concentration:

$$[C] = \frac{\text{OD}}{\epsilon_{10} d}$$

OD is from measurement
d is given for a given cuvette (e.g. $d=1 \text{ cm}$)
 ϵ_{10} is tabulated (or can be calibrated)

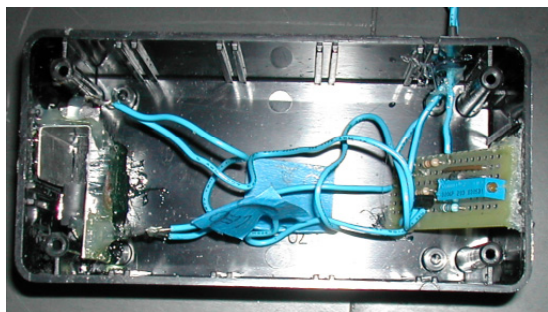
Cuvette (solution)

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Simple photometer

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Simple photometer



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7

LED applications

- Indicator lights
- Automobile tail lights
- Low-power flashlights
- Home lighting?
- Remote controls
- Optical isolation
- Mini fluorescent microscopes

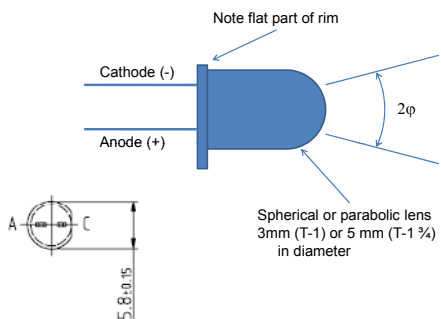


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8

LED properties - mechanical



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9

From the LED catalog pages:

- Light can be broad or narrow spectral range
 - White covers 420-700 nm
 - 428 and 470 nm are common short-λ values
 - Special purpose < 400 nm but > \$5 each
- IR emitters at 880 & 950 nm are common
 - Long lambda: GaP, GaAlAs
 - Mid (500s): GaAsP, InGaAlP
 - Blue : GaN
 - White: InGaN

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10

From the LED catalog pages:

- Output angle varies from 8°– 75°
- Most hemispherical but some tapered/parabolic.
- Package can be clear or colored
- Forward current 15 – 40 mA, fwd voltage 1.7 – 3.9
- Light output from 6 to 9300 mcd (millicandela)

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11

LED properties – optical.1

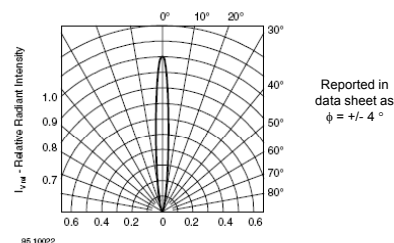


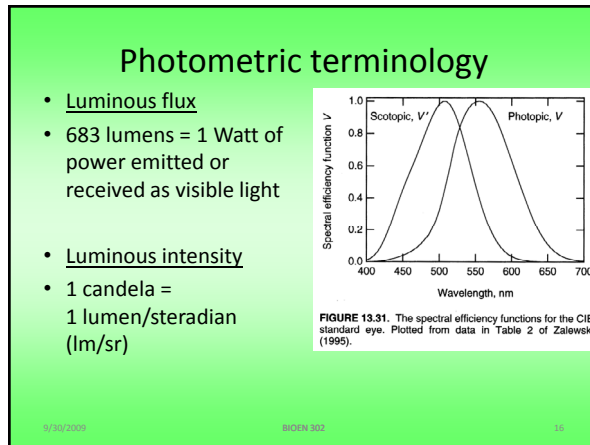
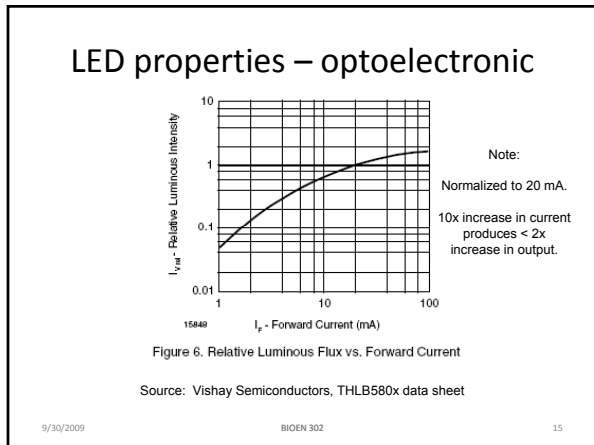
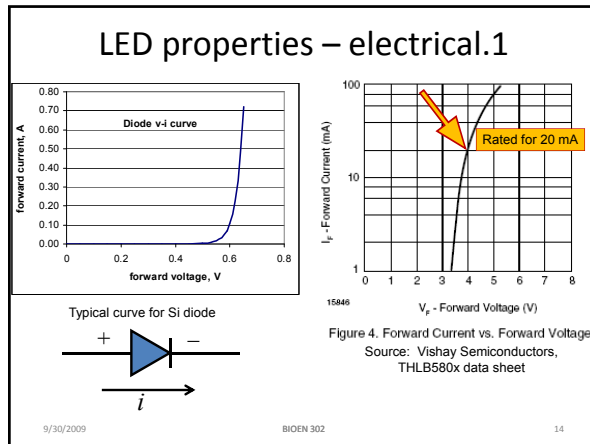
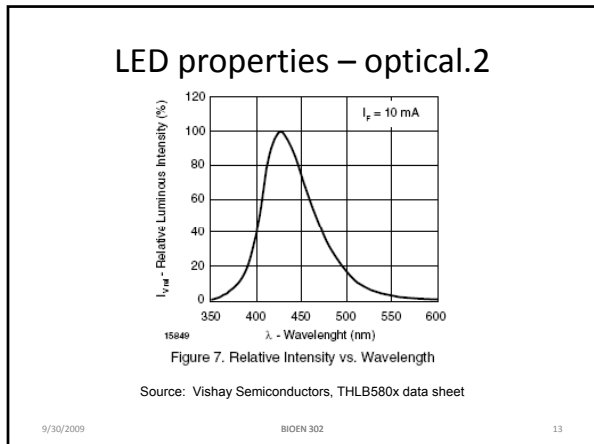
Figure 3. Rel. Luminous Intensity vs. Angular Displacement

Source: Vishay Semiconductors, THLB580x data sheet

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12



Photodetectors

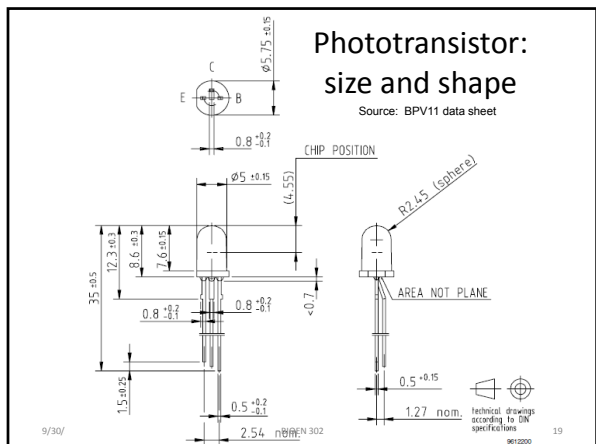
- Photocell (resistance decreases with light)
- Photodiode (current increases with light)
- Phototransistor (composed of two photodiodes)

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Photodetector applications

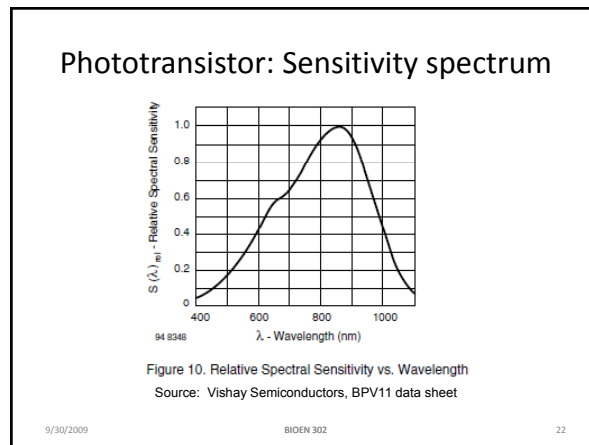
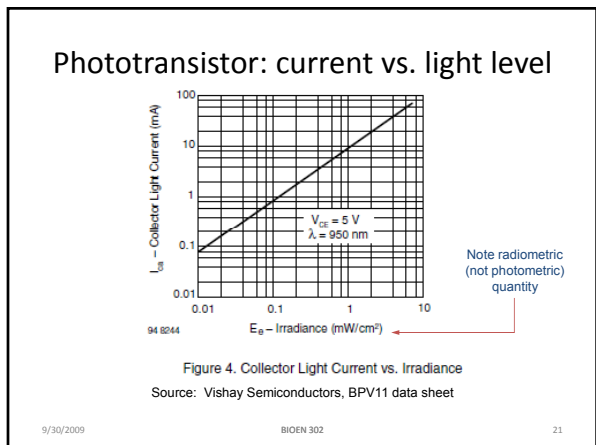
- Motion sensors
- Daylight sensors
- Optoisolation
- Transmittance measurement
- Voltage is applied across leads, light controls the current

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General transistor properties

- $V_C > V_B > V_E$
- $V_B - V_E$ determines current
- In phototransistor, base is not connected and incident light determines current
- C, B, E can appear in any order on the physical component



LED driver: current source

- Voltage-controlled current source using operational amplifier, $I_{LED} = V_1/R_1$
- Voltage regulation with zener diode; current control with potentiometer

Detector circuit

- Similar to voltage divider
- May be buffered or amplified
- Calibrate output vs. concentration

Mechanical considerations

- Maximize the portion of the light that goes through the liquid in the cuvette
- Prevent stray ambient light



→ Design cuvette holder in BIOEN 304

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25

Prelab questions

- What are limits imposed by op-amp or other circuit components?
- How do we test for these limits?
- To be discussed in lab...
 - Derivation of LED current
 - Op-amp limitations

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26