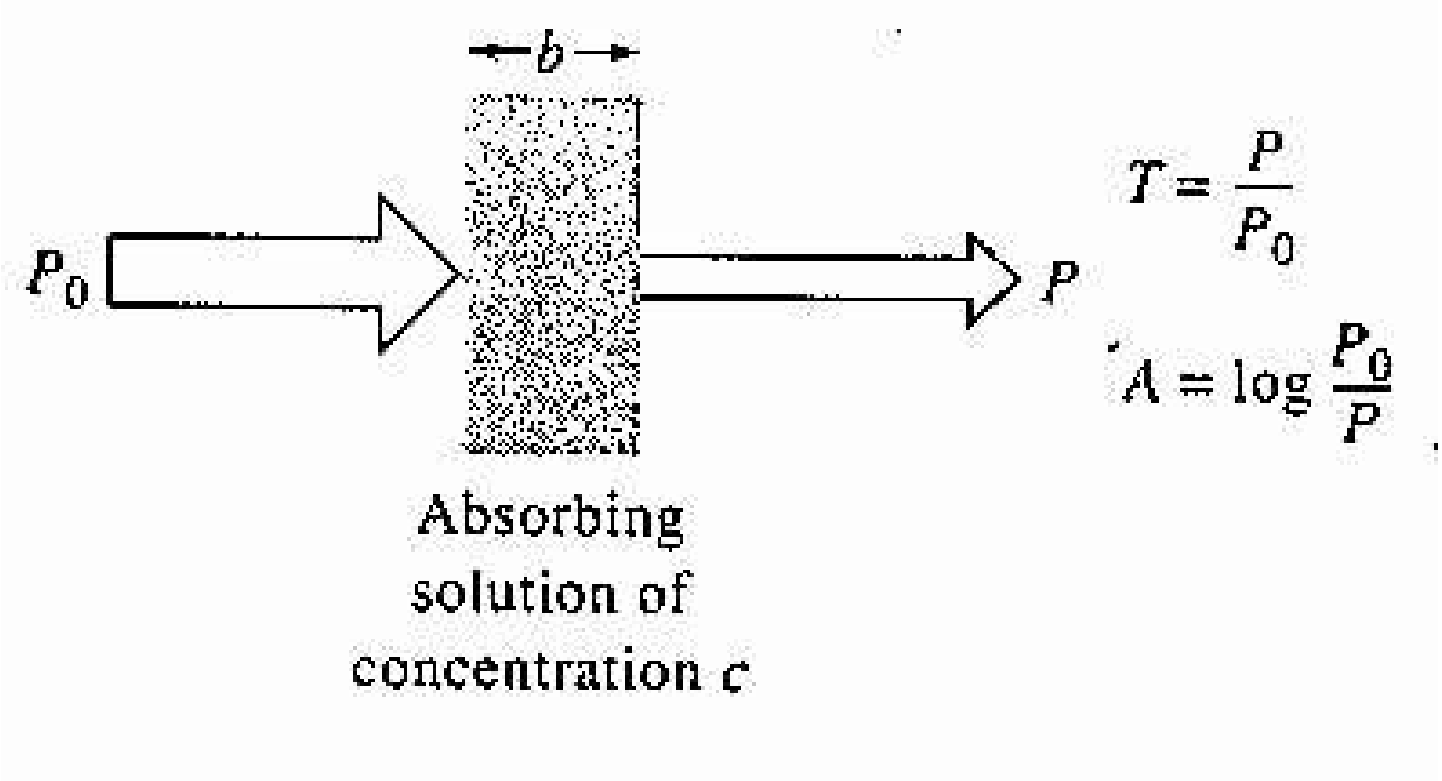
Chapter 18 – Fundamentals of Spectrophotometry (cont'd) AND Chapter 20 - Spectrophotometers

Homework for Chapter 20 –
Due Friday, April 19

Problems 20-1, 20-3, 20-4, 20-6, 20-26

Note: We will talk about some applications of spectrophotometry in class, but will not have any homework assigned from Chapt. 19.

Absorption of Light



Absorption Methods, Transmittance

$T = P/P_o$

where T => transmittance

P => power of transmitted radiation

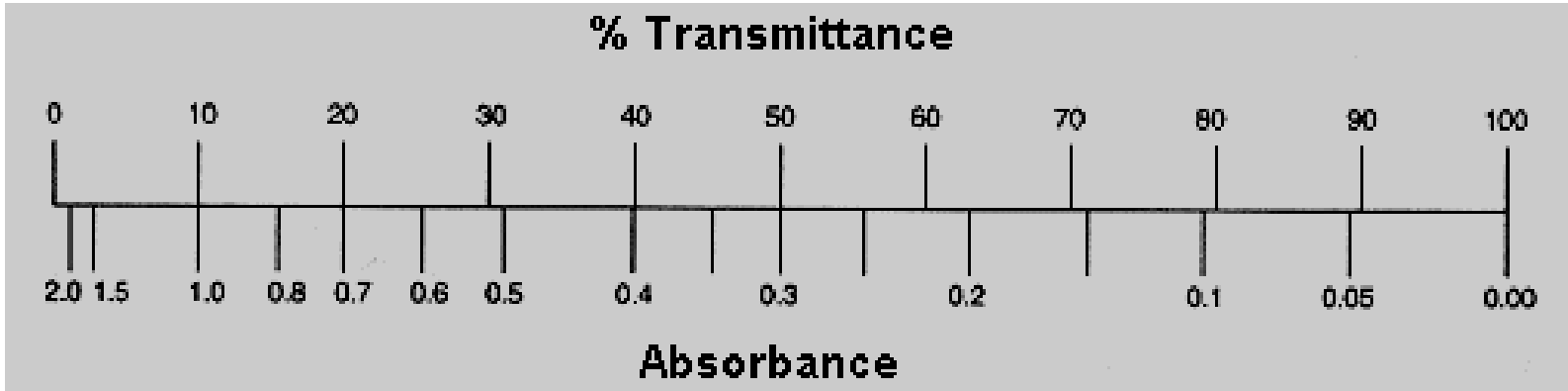
P_o => power of incident radiation

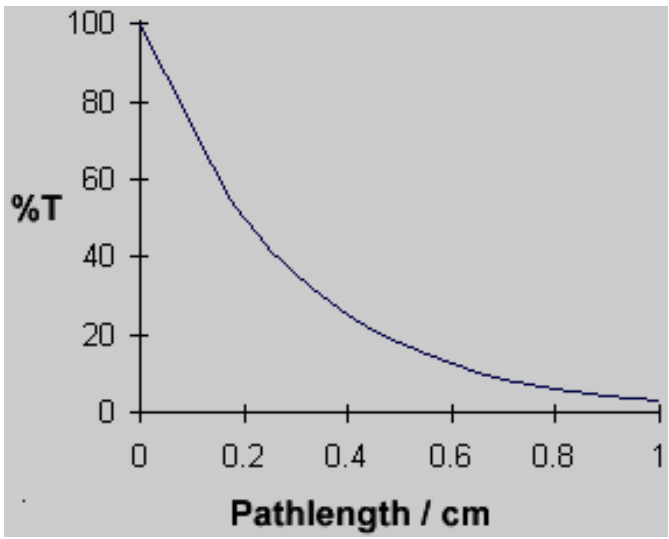
$\%T = (P/P_o)*100$

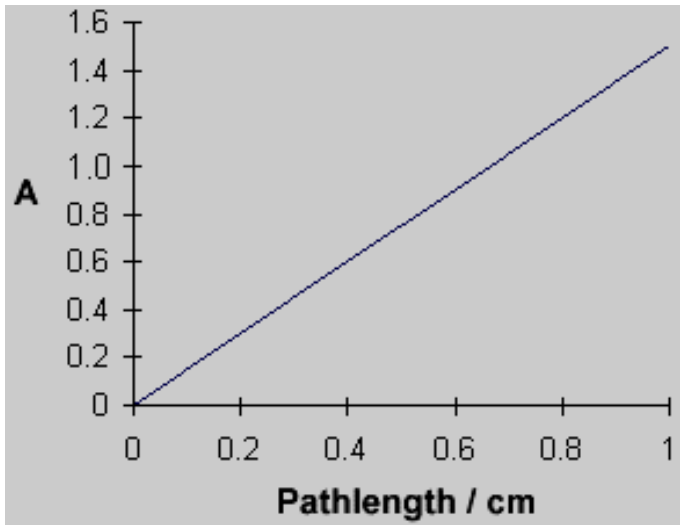
where %T => percent transmittance

Absorbance and transmittance

Absorbance => $A = -\log_{10} T = -\log_{10} (P/P_o)$







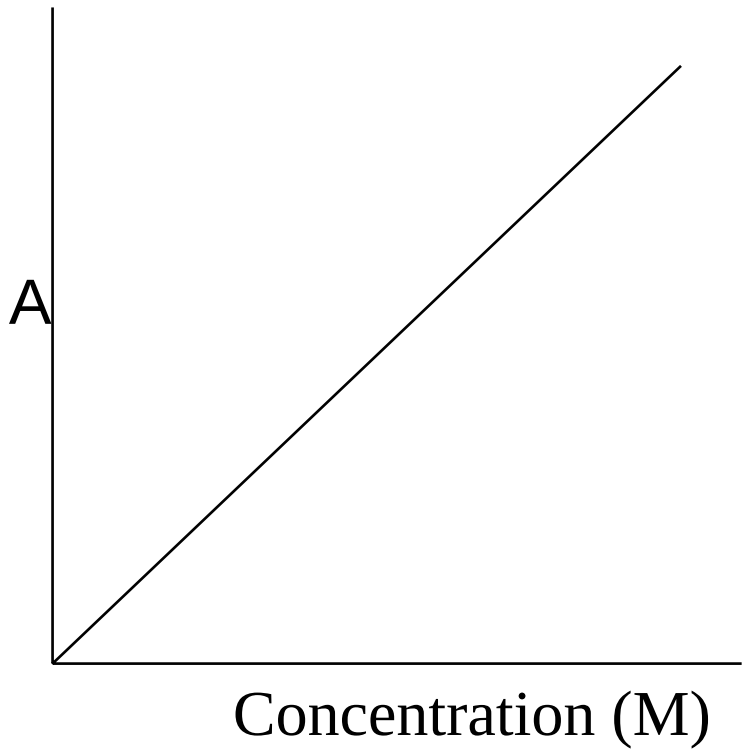
Absorption Methods, Beer's Law

$$A = \varepsilon bc$$

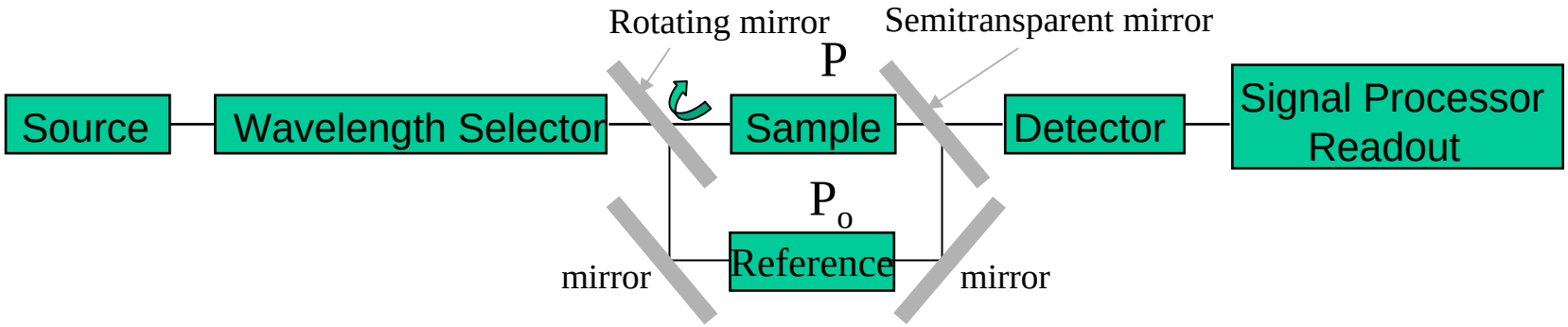
b => path length (cm)

c => concentration (M)

ε => molar absorptivity ($M^{-1}cm^{-1}$)



Components of Optical Instruments



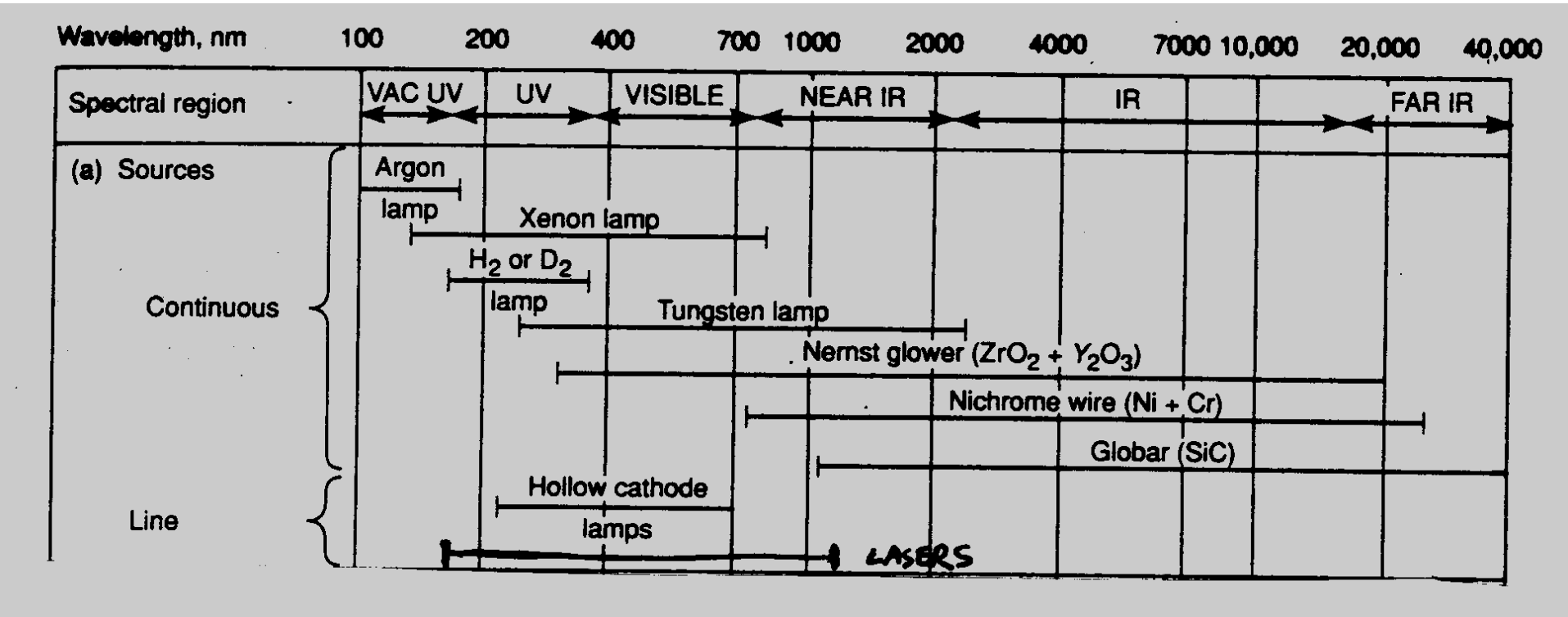
Absorption Spectrometer

Emission Flame Photometer

Flame Atomic Absorption Spectrometer

Fluorescence and/or Scattering Spectrometer

Light sources

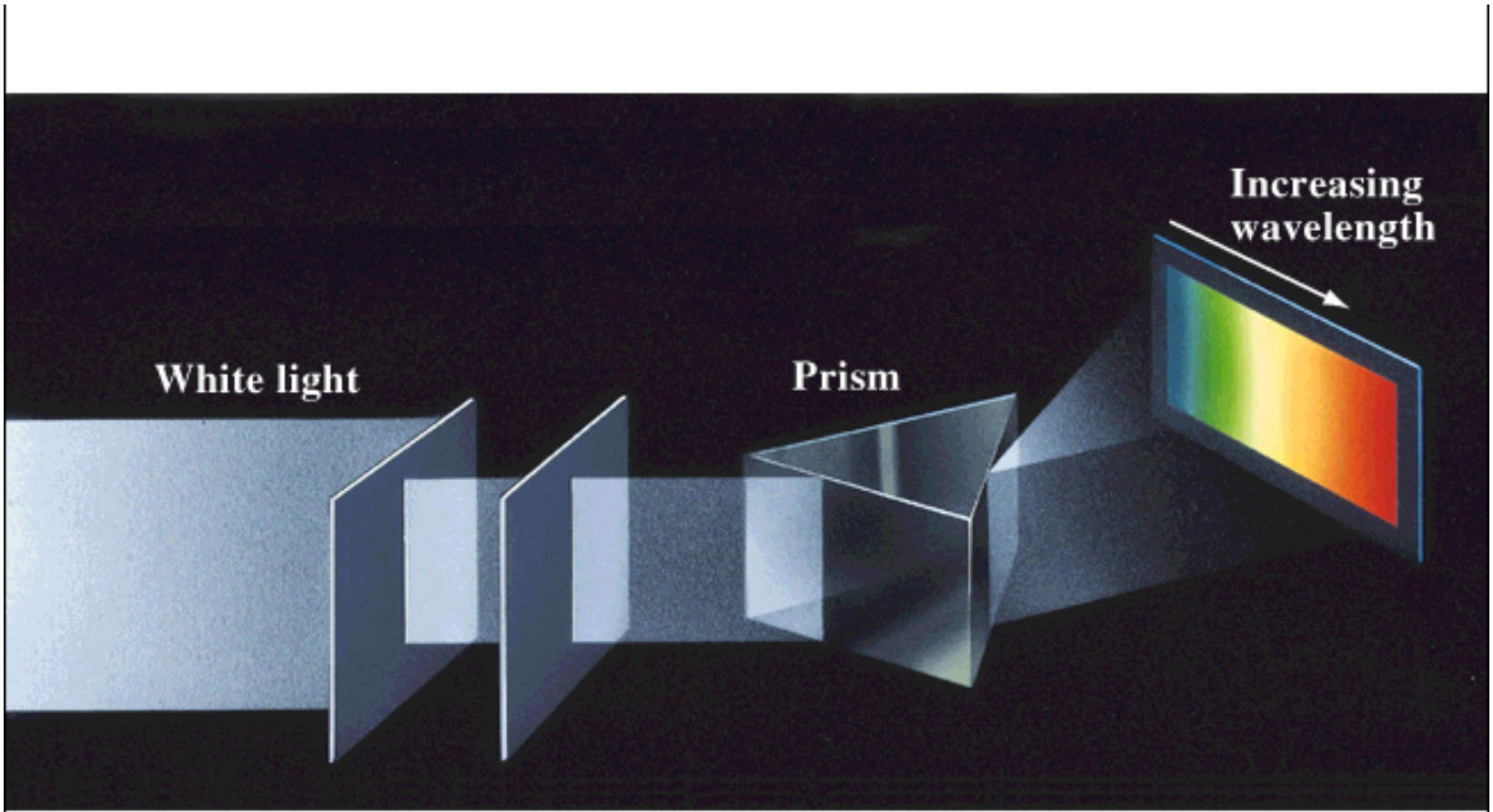


Examples of Sources

- Deuterium lamp - good source for UV continuum radiation - widely used in UV spectrophotometers
- Tungsten filament lamp - Good source of continuum radiation in the 330- 2000 nm range; common in visible, near-IR colorimeters, spectrophotometers. Stable light output with regulated power supply. Similar to regular light-bulb but run at 3000 K.
- Heated metal and ceramic filaments used for the "mid-IR", which is ~ 500-4000 cm^{-1} (A warm object is an efficient IR source). Common source for IR spectroscopy is called a Nernst Glower, globar, or a nichrome wire.

Purpose of monochromator:

Separation of multi-λ light into individual λ's



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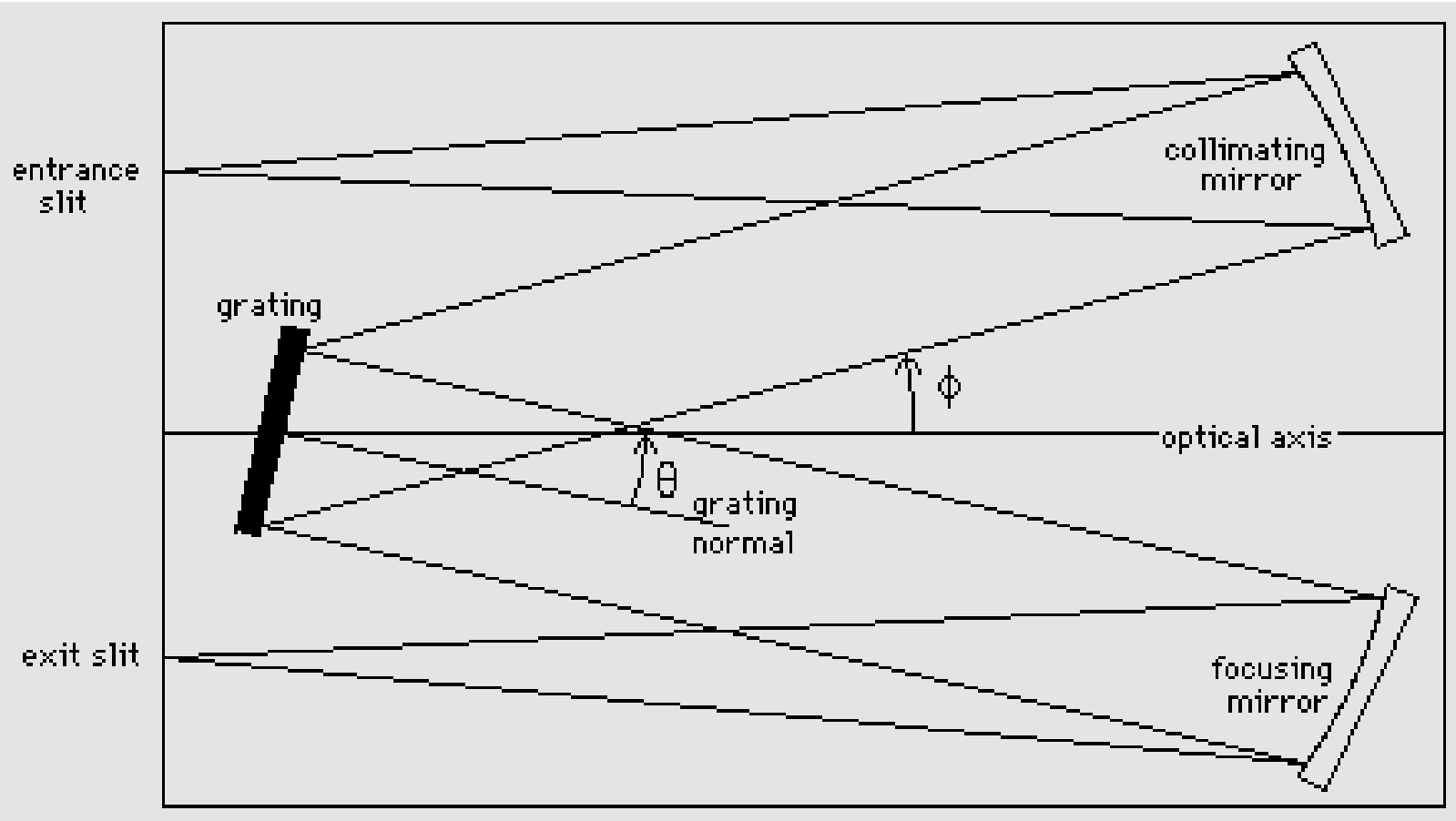
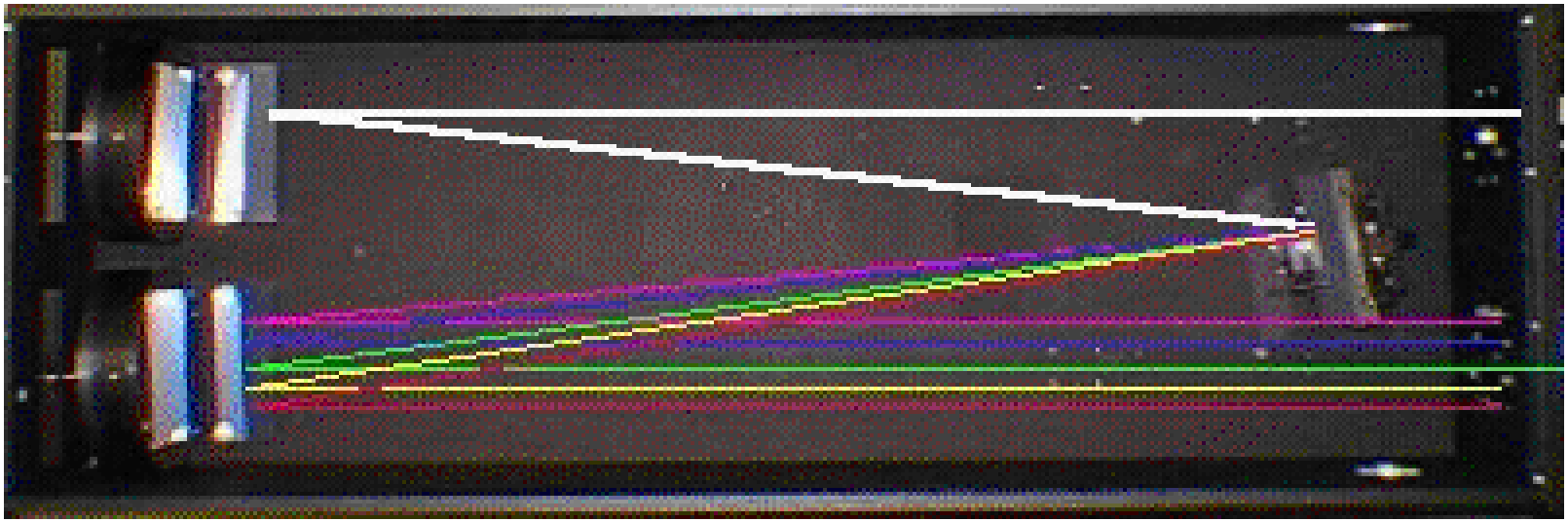
Monochromators

Components:

entrance slit, collimating element (lens or mirror), prism or grating as dispersing element, focusing element (lens or mirror), exit slit

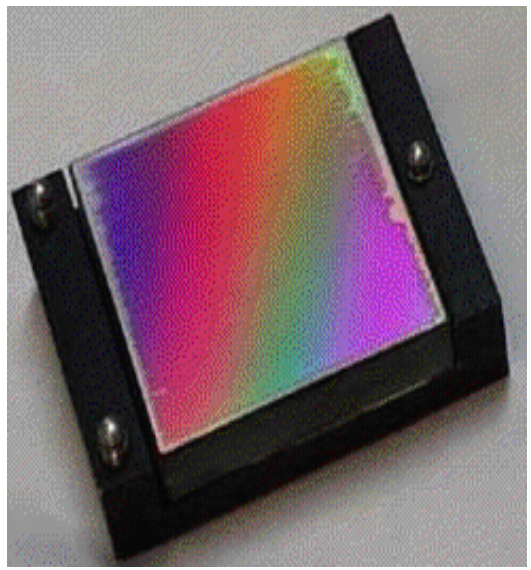


monochromator



http://www.chem.hope.edu/~polik/labtour/monochromator-inside.html

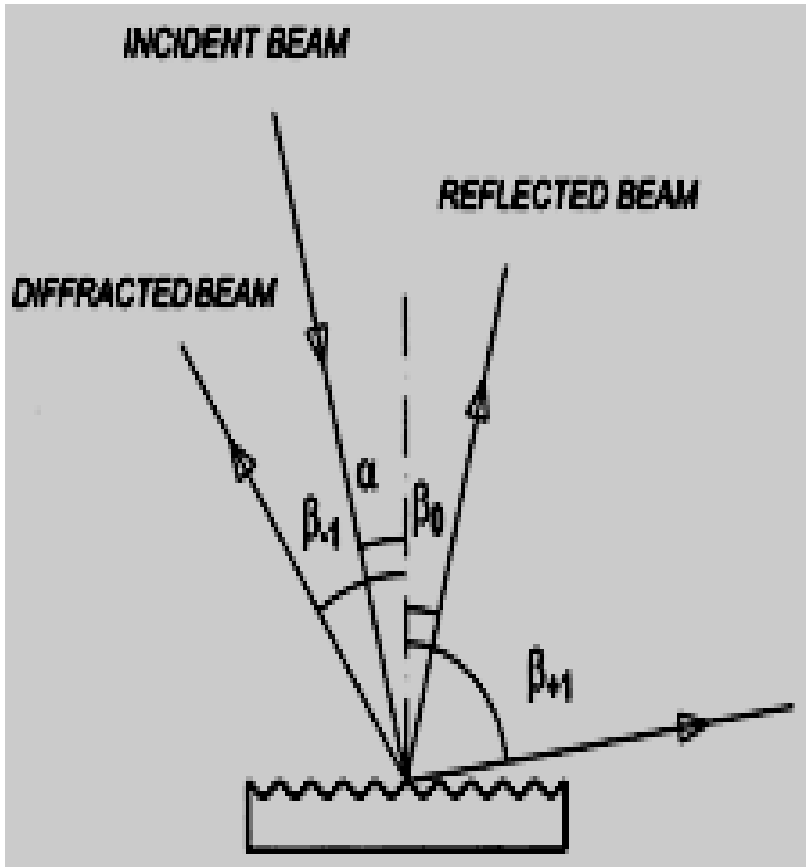
An important use of diffraction is in produci ng monochromatic light from “white” light sources



How do gratings work?

$$\sin\alpha + \sin\beta_m = -m\lambda/d \qquad (1)$$

- The incident beam is diffracted in a manner given by Equation (1)
- The term “m” is referred to as the **order** of the diffraction
- Dispersion increases with order but intensity diminishes



http://www.optics.org/spectrogon/holograt/specprop.html

Sample Containers

Ultra-Violet

- quartz

Visible

- quartz
- glass

Infrared

- NaCl
- AgCl
- KBr

Criteria for Sample Containers

- **Transparent to excitation light**
- **Compatible with samples**
- **Rugged**

Types of Detectors

UV-Visible

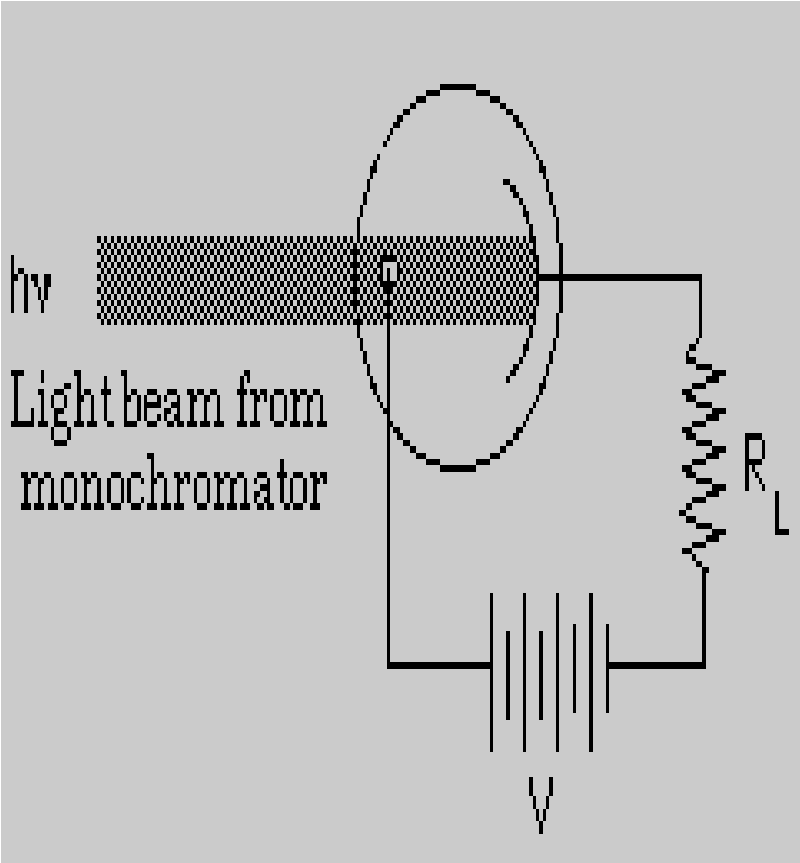
- Photon Detectors
- Vacuum Phototubes
- Photomultiplier Tubes
- Photodiodes
- Linear Photodiode arrays
- Charge-Transfer (Charge Coupled Device, CCD)

Infrared

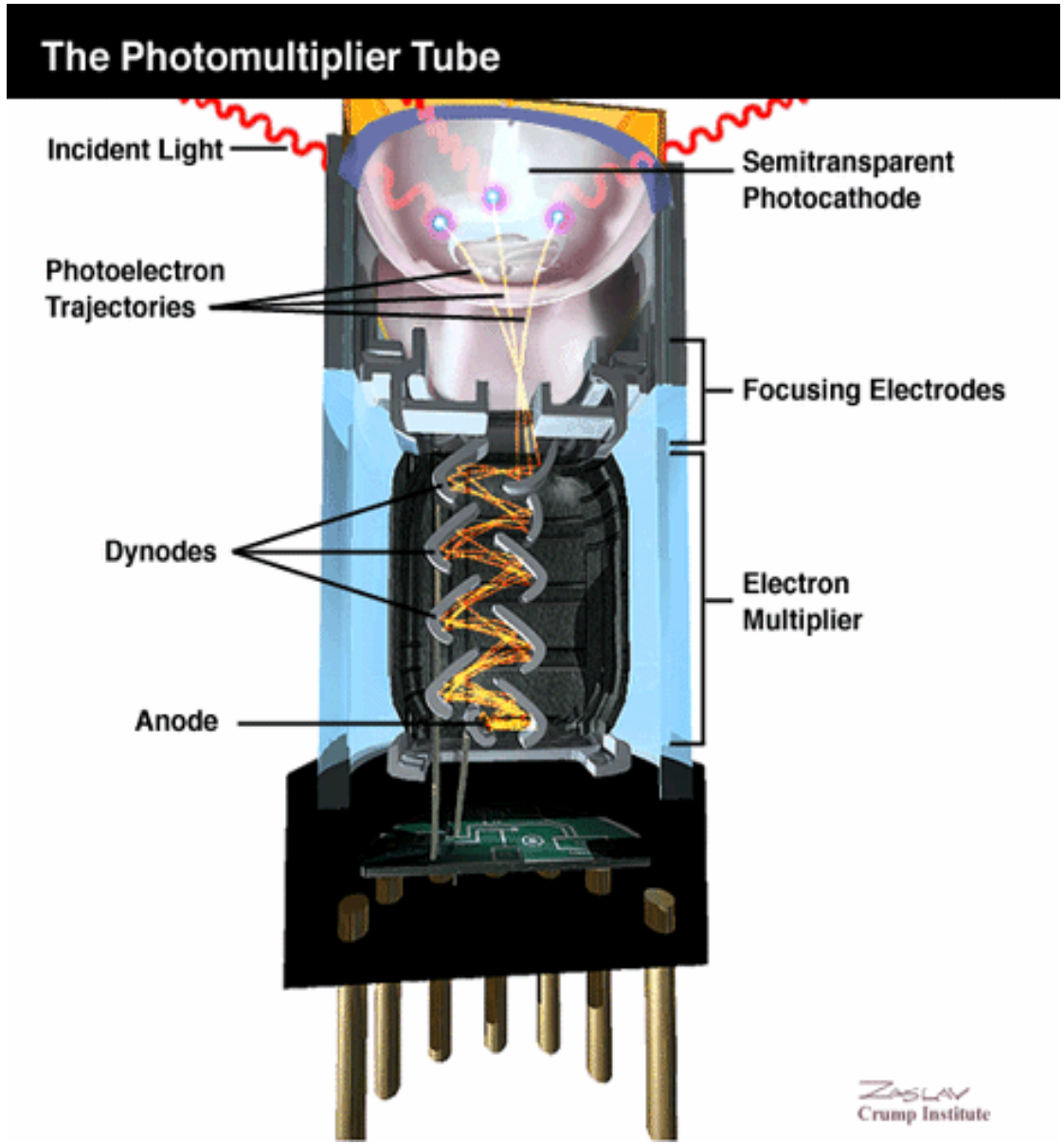
- Heat Detectors

Photoelectric effect based detectors: phototubes

- Phototubes are used for high light intensity applications
- Photons produce photoelectrons; the "photocurrent" is proportional to intensity

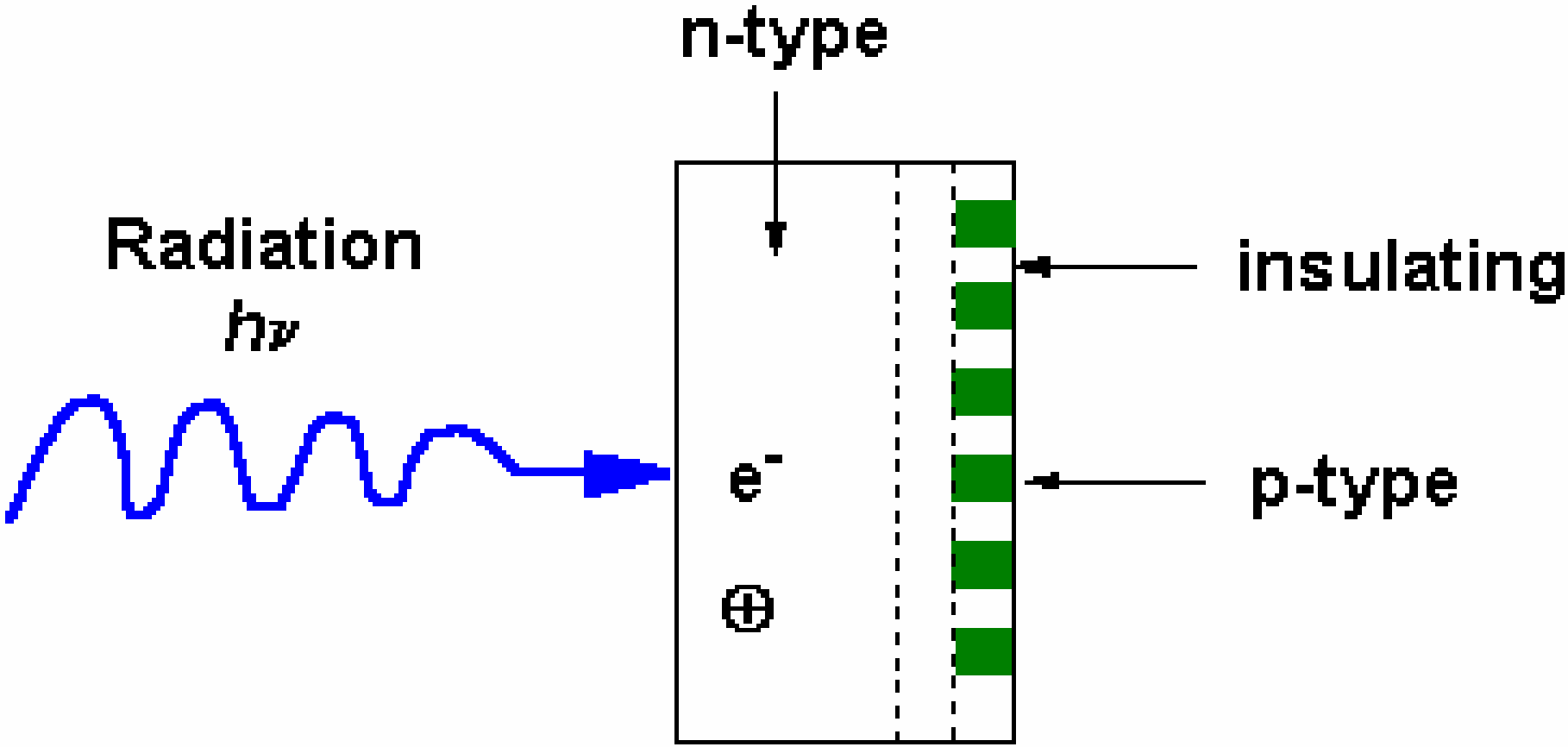


- **Photomultiplier tubes** are used for low light intensity and “photon counting” applications
- Photons strike primary electrode, emits e-; these electrons strike successive secondary surfaces, finally producing a large “pulse” of electrons



http://laxmi.nuc.ucla.edu:8248/M248_99/autorad/Scint/pmt.html

Semiconductor-base Detectors (Photodiodes and CCD's)



Detectors for IR

- Heat detectors
  - thermocouple
  - Ferroelectric
- Semiconductor-based detectors (like HgCdTe)
  - Low bandgap semiconductors
  - Must be cooled for good quantum efficiency, low noise