

# **Colorimetry and Spectrophotometry** **(Technique)**

**Colorimeter and Spectrophotometer**  
**(Instrument)**

# The Photometric Technique

- Spectrophotometer is based on the photometric technique which states that When a beam of incident light of intensity  $I_0$  passes through a solution, a part of the incident light is reflected ( $I_r$ ), a part is absorbed ( $I_a$ ) and rest of the light is transmitted ( $I_t$ )

Thus,

$$I_0 = I_r + I_a + I_t$$

- In photometers (colorimeter & spectrophotometer), ( $I_r$ ) is eliminated because the measurement of ( $I_0$ ) and  $I_t$  is sufficient to determine the ( $I_a$ ). For this purpose, the amount of light reflected ( $I_r$ ) is kept constant by using cells that have identical properties. ( $I_0$ ) & ( $I_t$ ) is then measured

# Working Principle of the Spectrophotometer

- It is based on Beer-Lambert's law which states that the amount of light absorbed by a color solution is directly proportional to the concentration of the solution and the length of a light path through the solution

$$A \propto Cl$$

Where,

**A = Absorbance / Optical density of solution**

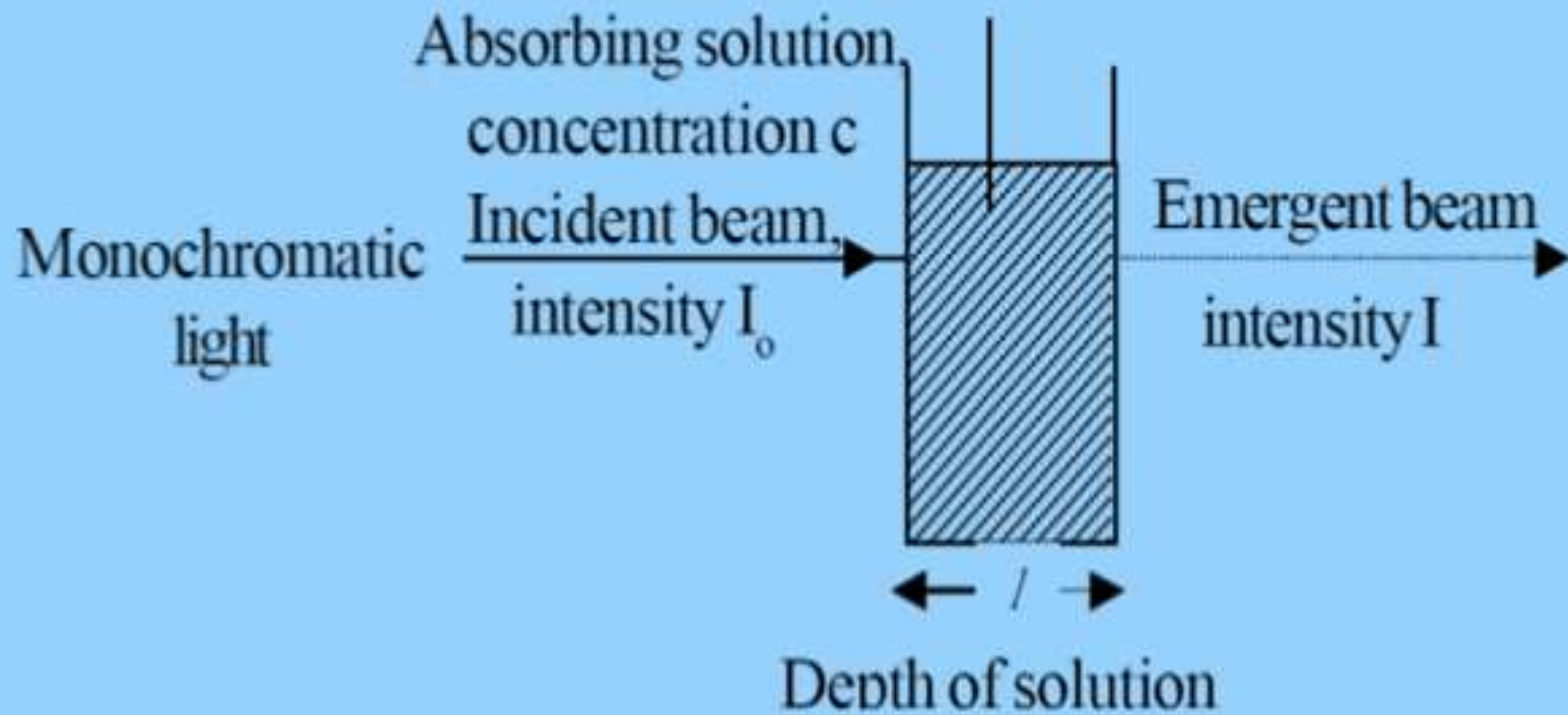
**c = Concentration of solution**

**l = Path length**

**If l is eliminated by using a standard unit sample cell of 1 cm length,**

**Then,**

$$A \propto C$$



# Types of Spectrophotometer

## 1. Single beam spectrophotometer:

- It operates between 325 nm to 1000 nm wavelength using the single beam of light
- The light travels in one direction and the test solution and blank are read in the same

## 2. Double beam spectrophotometer:

- It operates between 185 nm to 1000 nm wavelength. It has two photocells
- This instrument splits the light from the Monochromator into two beams
- One beam is used for reference and the other for sample reading. It eliminates the error which occurs due to fluctuations in the light output and the sensitivity of the detector

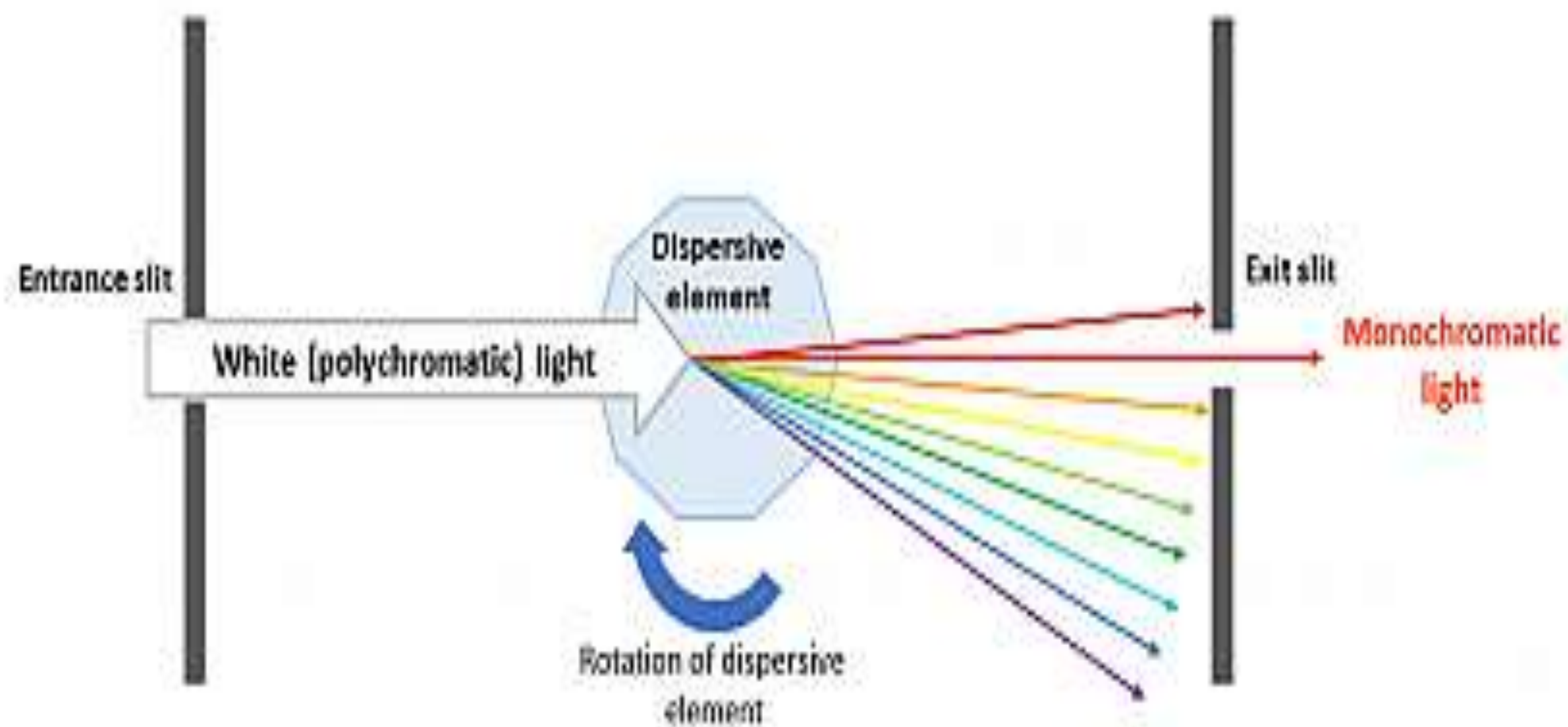
# Parts of Spectrophotometer

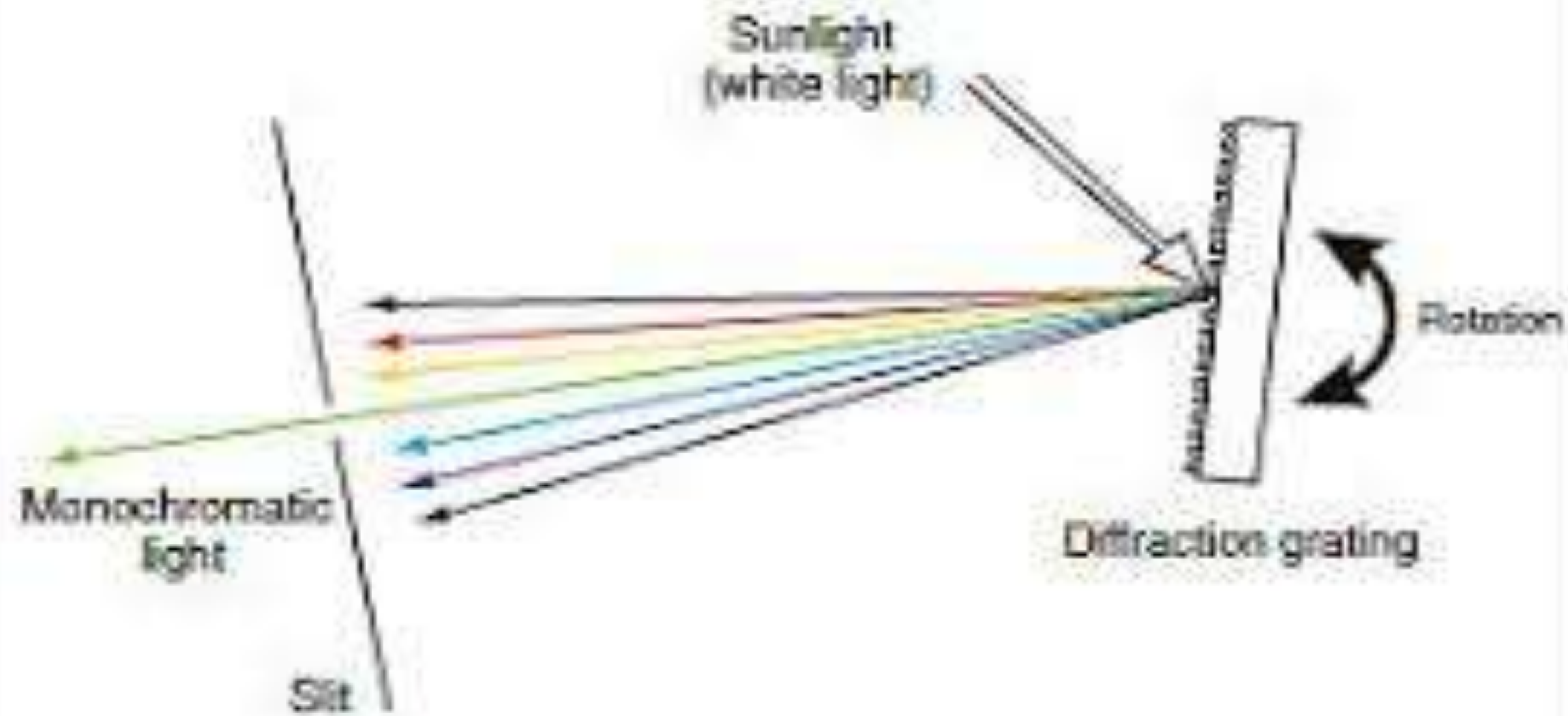
## 1. Light source – To generate light

- Tungsten Halogen lamp for visible light (400- 800 nm)
- Hydrogen or deuterium lamp for Ultraviolet light (200-400 nm)
- Xenon flash lamp for both visible and UV radiations (190-1000 nm)

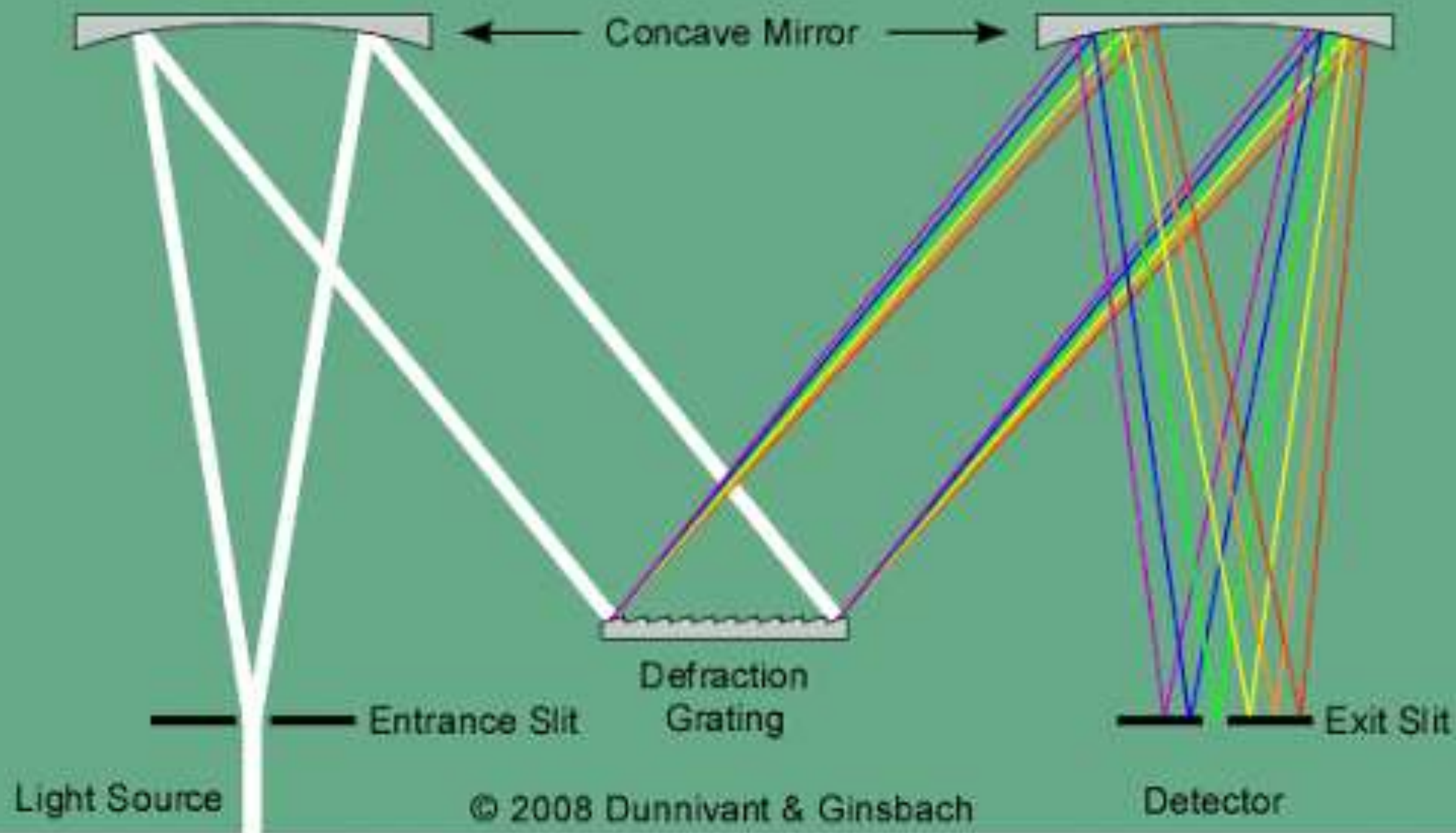
## 2. Monochromator – To select the particular wavelength

- Accept polychromatic input light and outputs monochromatic light
  - Entrance slit
  - Exit slit
  - Dispersion device
    - ✓ Prizm
    - ✓ Absorption filter (Glass)
    - ✓ Interference filter (Metal or thin film)



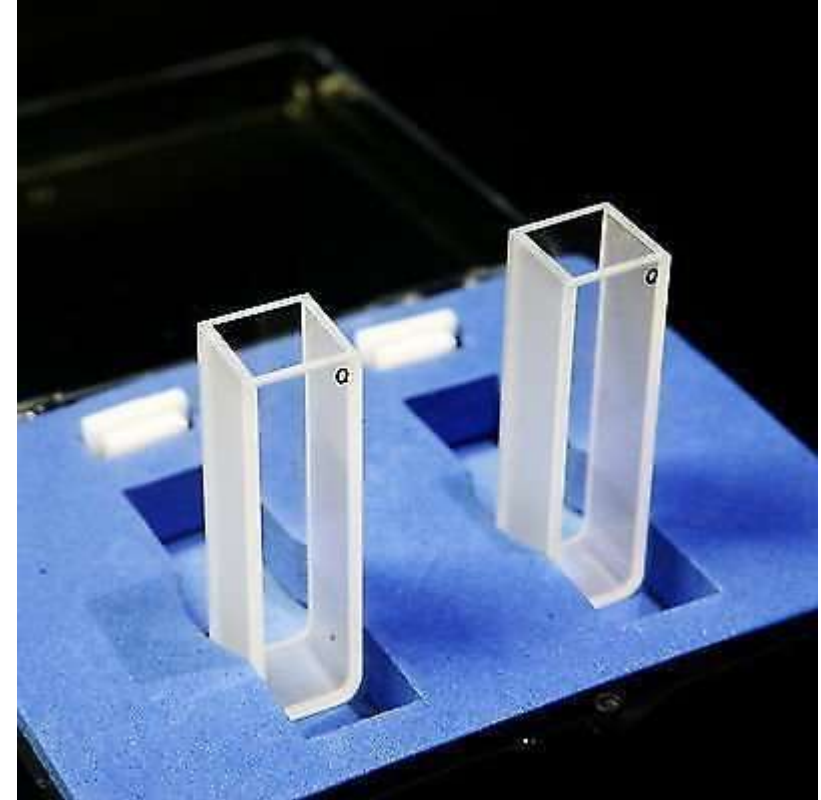






### 3. Sample holder and Sample Cell –

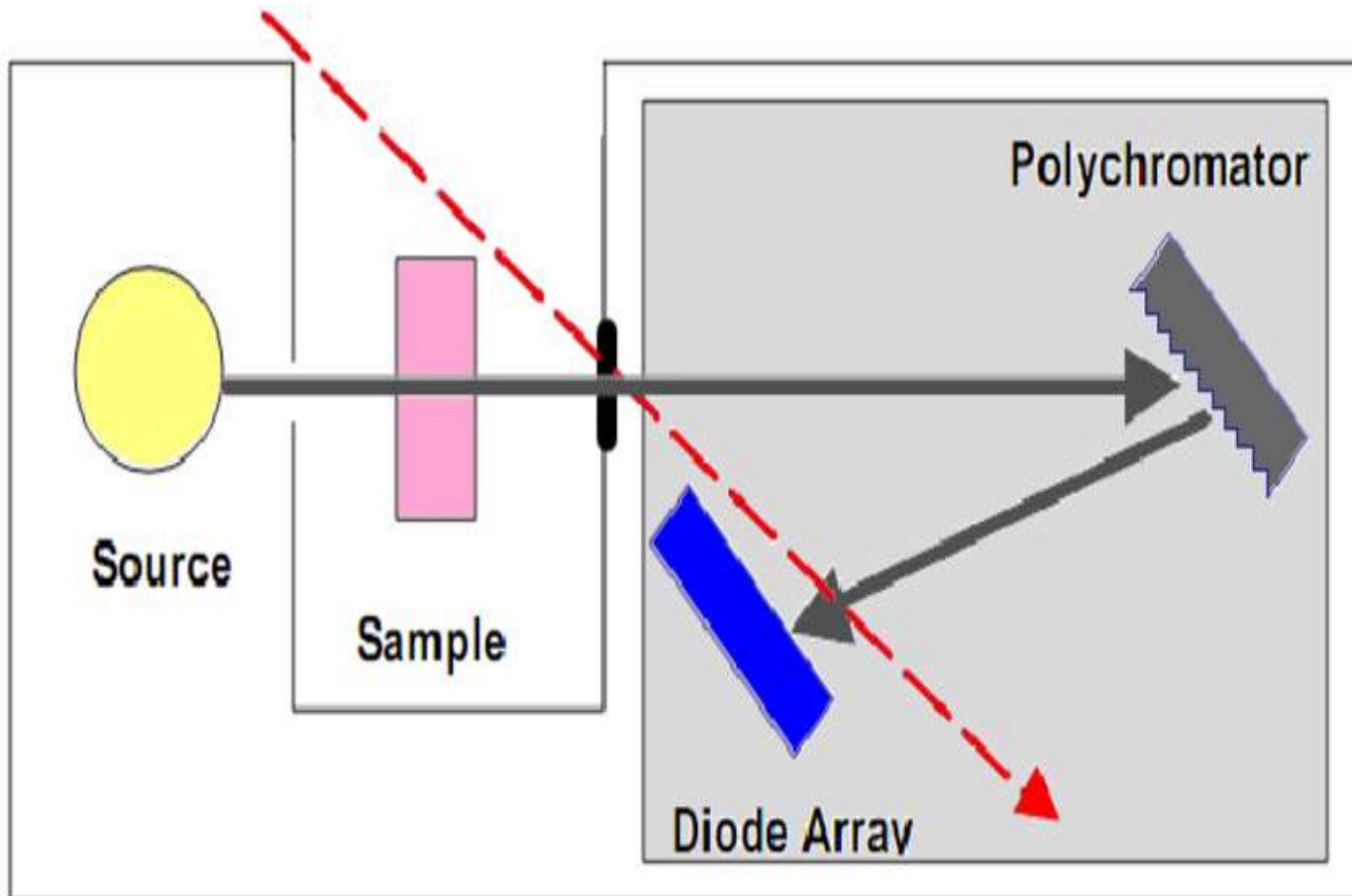
- Test tube or Cuvettes are used to hold the colored solutions
- They are made up of plastic, glass or optical grade quartz

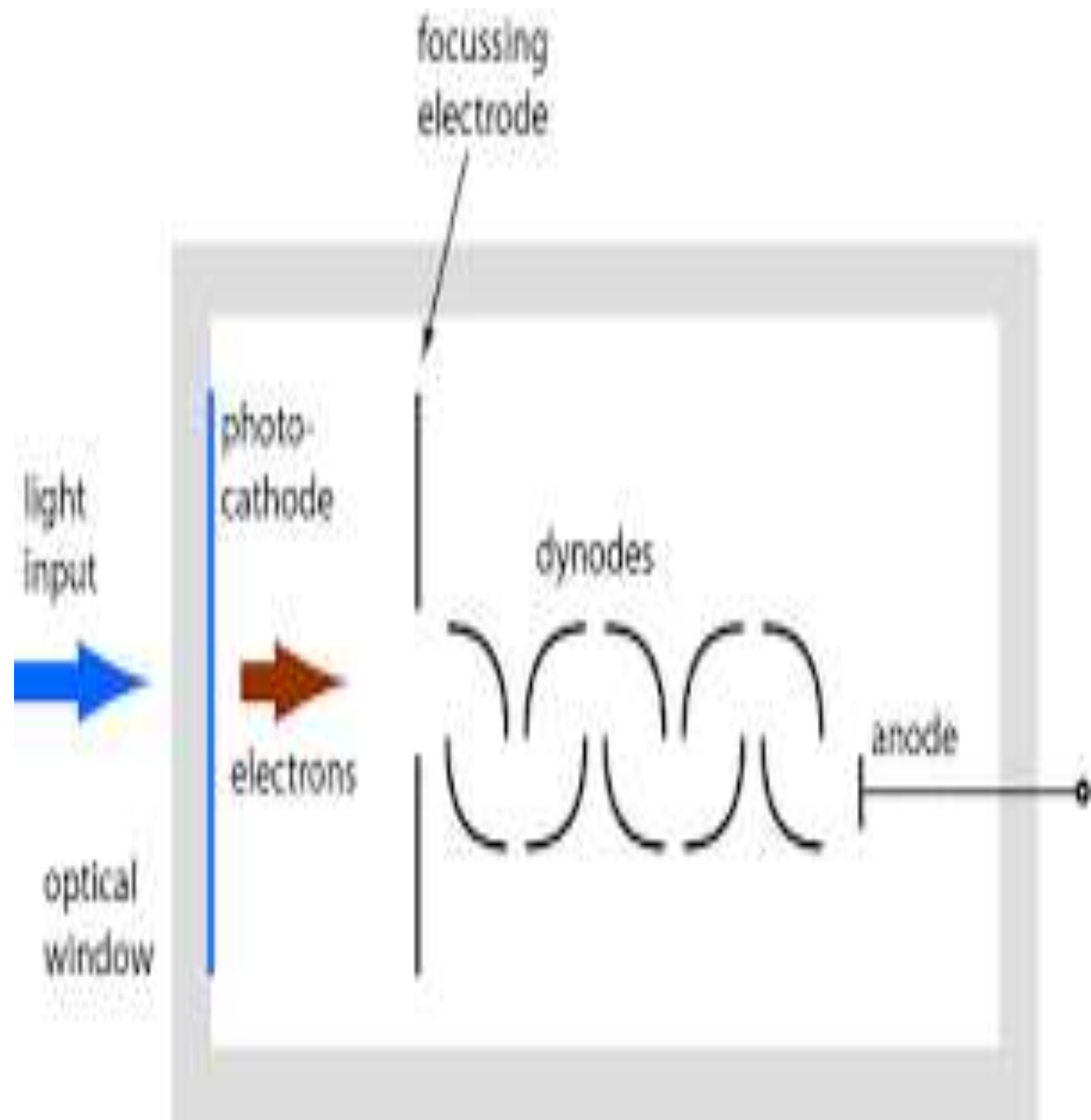
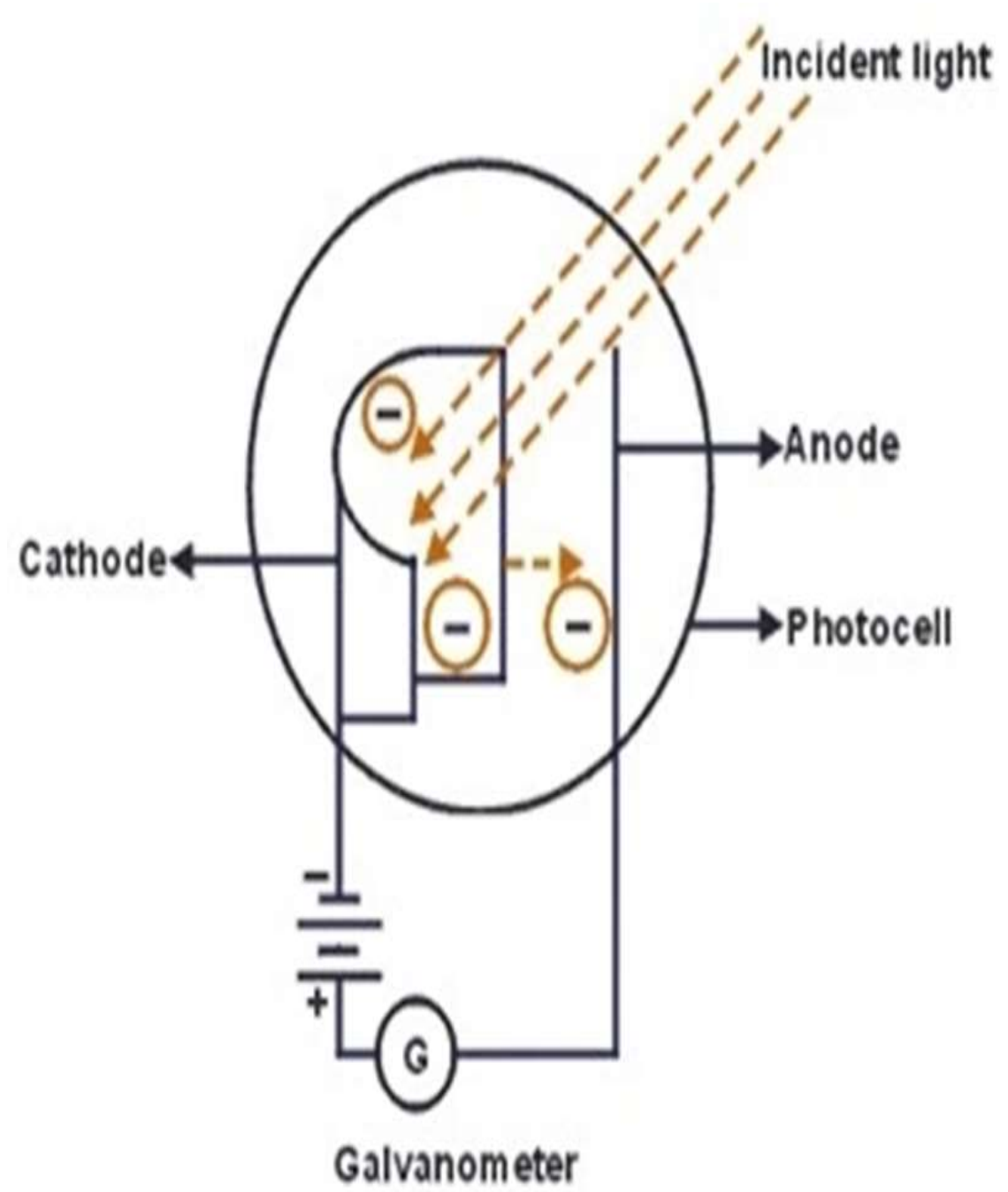


**4. Photodetector system – When light falls on the detector system, an electric current is generated that reflects the galvanometer reading**

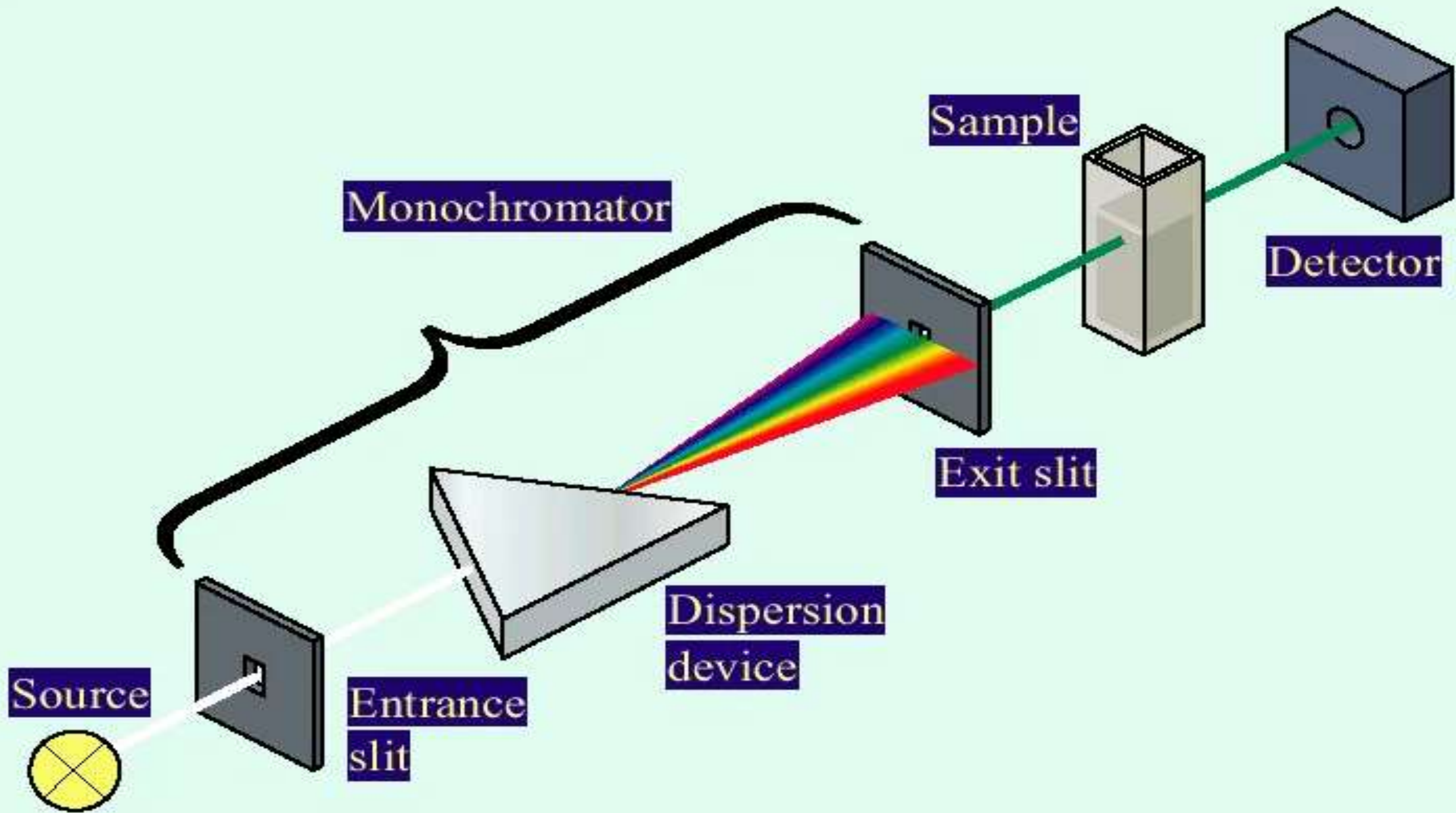
**5. Measuring device – The current from the detector is fed to the measuring device – the galvanometer**

**The meter reading is directly proportional to the intensity of light**

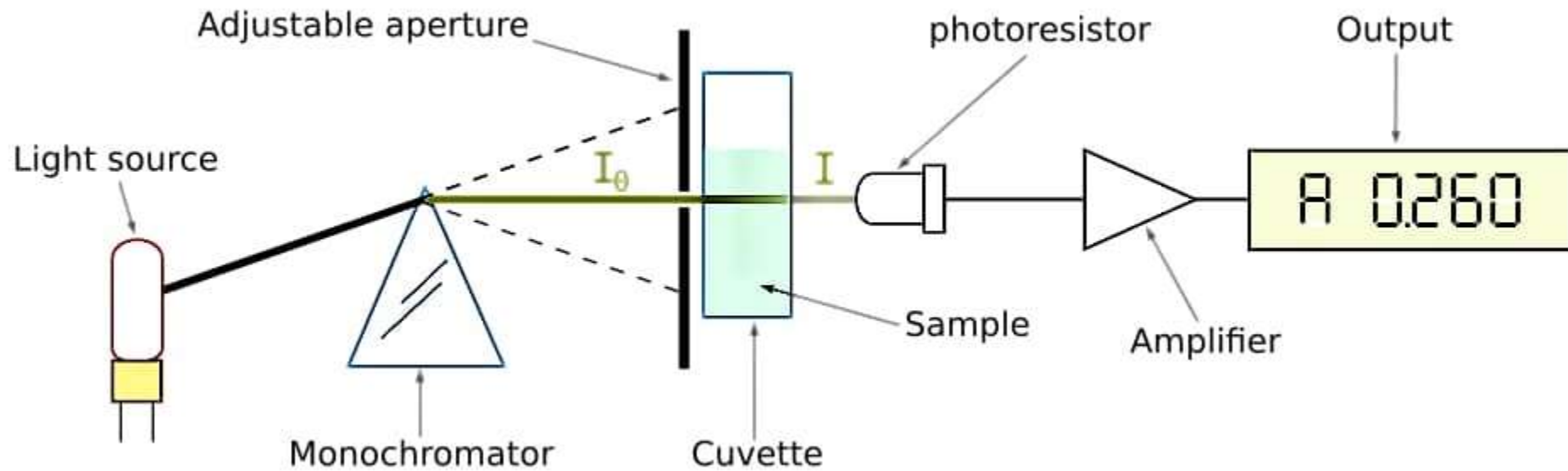








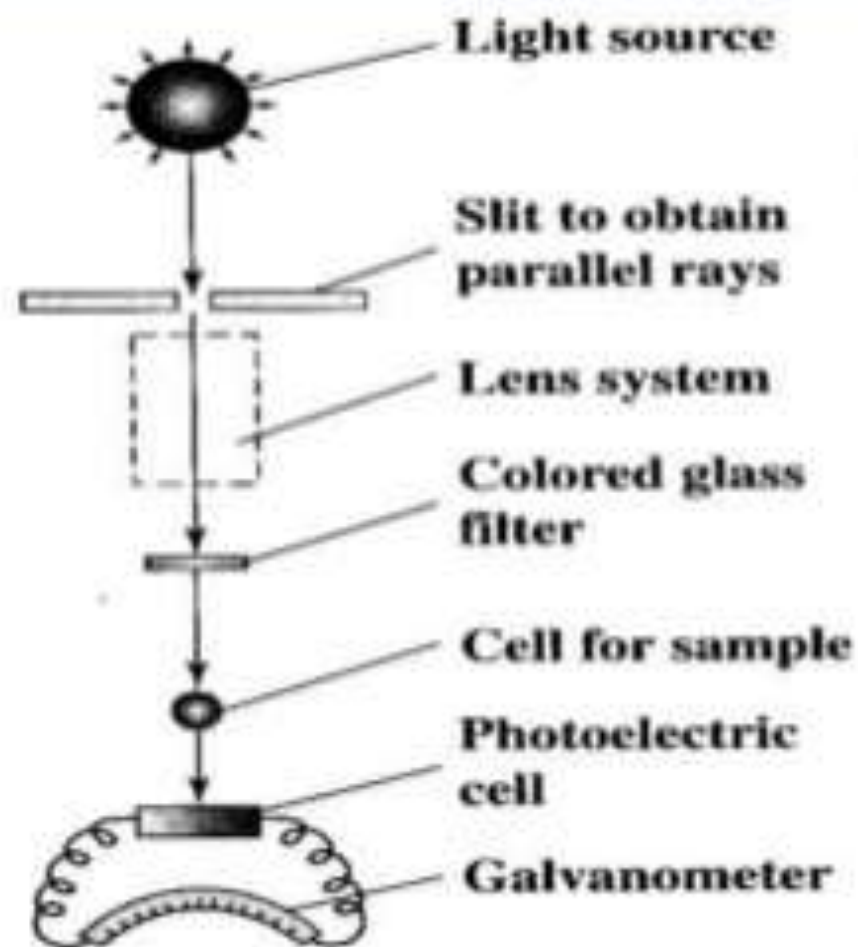
# Spectrophotometer



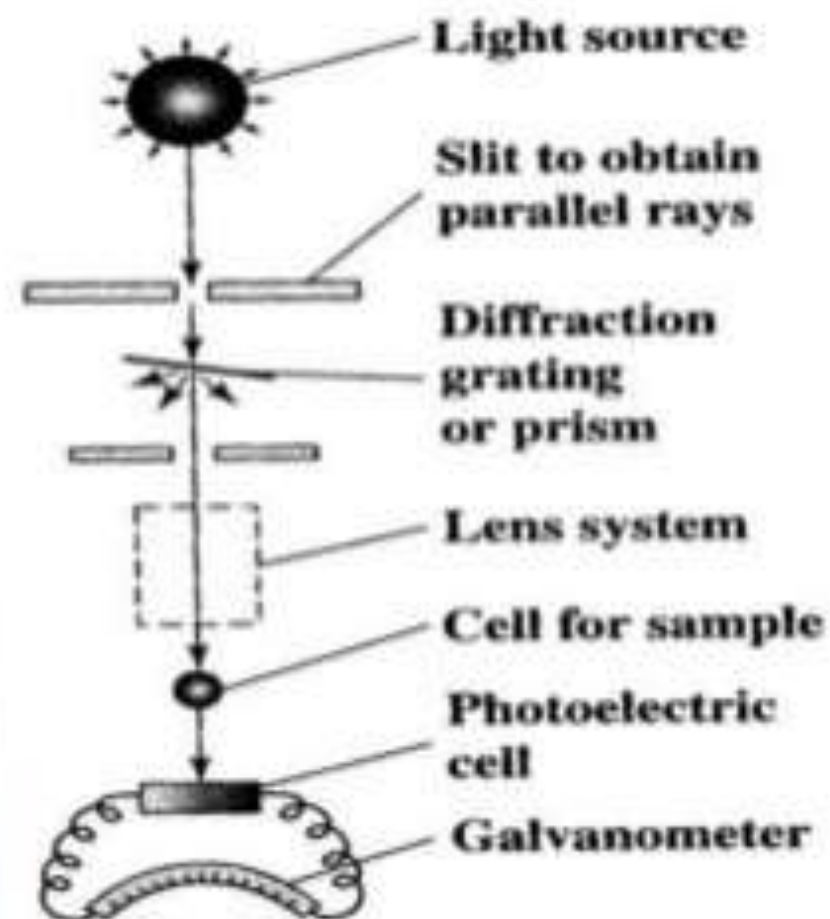
# Difference between colorimeter and spectrophotometer

Colorimeter	Spectrophotometer
Colorimeter is the <b>general</b> type	Spectrophotometer is the <u>specific</u> type.
Both of them measure color and intensity of color through light.	
Basic method of operation is similar for all instruments.	
colorimeter utilizes a <b>three color source</b> (Red, green, and blue) generated by either a <b>color wheel</b> with <b>colored filters</b> or, sets of <b>specially designed LEDs</b> .	Spectrophotometer utilizes either a <b>diffraction grating</b> or <b>prism</b> in the sensor
Colorimeter is <u>limited</u> to the <b>visible light</b> only with WL 400-700 nm	spectrophotometer can be extended to x-ray, UV light, infrared and radiofrequencies

# Colorimeter - Spectrophotometer



**Figure 11.3**  
Schematic diagram of a photoelectric colorimeter.



**Figure 11.5**  
Schematic diagram of a spectrophotometer.



# Applications

- **Concentration Measurement**
- **Detection of Impurities**
- **Chemical Kinetics**
- **Detection of Functional groups**
- **Molecular weight determination**