Introduction:

An instrument used to study the spectra with unaided eye is called spectroscope or spectrometer. When it is used to photograph, the spectrum it is called spectrograph. A constant deviation spectrometer got its name due to the fact that it uses constant deviation prism or Pellin-Broca prism.

Objective:

(i) Calibrate the C.D.S using a calibration source

(ii) Determine the weave length of the unknown spectra of the given metals in the arc lamp source.

Apparatus: The constant deviation spectrometer (C.D.S), The calibration source (mercury lamp), D.C.Power supply, the arc stand, the metals (Copper, Brass, etc.), Spirit level.

Theory:

When refraction through a prism takes place in such a manner that the angle of incidence is equal to the angle of emergence, the refracted ray will be parallel to the base of the prism (see Fig. 1). The ray is symmetrical under these conditions. It can be mathematically proved that when the above conditions are satisfied for a particular value of *i*, the deviation suffered by the light ray is minimum and the angle of deviation is known as the angle of minimum deviation δ_m. For any other value of *i*, the value of δ increases.

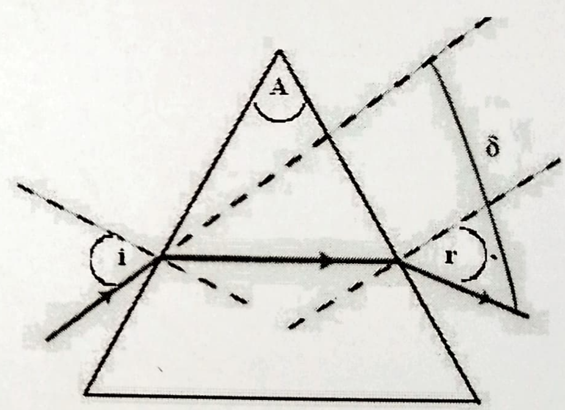

Figure 1: Angle of deviation in ordinary prism

Constant deviation prism

The construction of constant deviation prism is a single piece but can be considered as composed of two *30°* prisms, PQR and QST along with the reflecting prism PRS (see Fig. 2). AB is an incident ray and θ_i is the angle of incidence. For certain θ_i BC is normal to PR and totally reflected at PS and undergoes deviation of *90°*.

Since

$$m\angle PQT = 90° \quad \text{and} \quad m\angle BCD = 90° \tag{1}$$

we have,	$m\angle QBC + m\angle QDC = 180^\circ$	(2)
But, since	$m\angle QBC = 90^\circ + \theta r$ and $m\angle QDC = 90^\circ - \theta_i$,	(3)
Therefore,	$(90^\circ + \theta r) + (90^\circ - \theta_i) = 180^\circ$.	(4)

Thus $\theta_r = \theta_i$ and emergent ray is perpendicular to the incident ray (this can be easily proved from the geometry of the figure). Two prisms PQR and QTS can be considered as a single prism of *60°*. When the angle of incidence is equal to the angle of emergence and the angle of deviation is *90°*, a ray would be passing through a position of minimum deviation. This principle is used in constant deviation spectrometer.

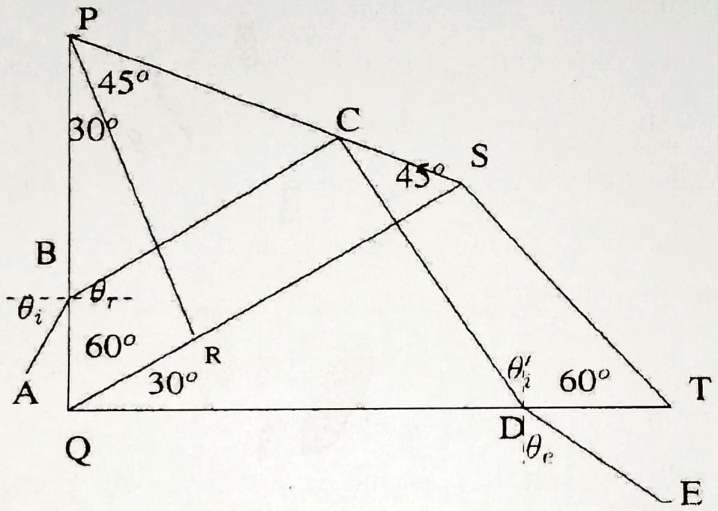

Figure 2: Constant deviation prism

Experimental set up:

The schematic of constant deviation spectrometer set up is shown in Fig.3.

The collimator and the telescope are fixed and the axes are perpendicular to each other. The prism table can be rotated about the vertical axis using a drum which is attached to the table. The head of the drum is calibrated for the wavelength and thus the wavelength can be measured directly. When the light is incident on the prism the prism table can be rotated till the angles of incidence and emergence are equal. The pointer seen in the field of view of telescope can be used for the measurement. After clamping the prism the drumhead is rotated to rotate the prism table and the desired wavelength is measured.

An ordinary prism and a spectrometer can be used for this task, but the process is time consuming. The adjustment of minimum deviation and if it is disturbed, resetting is troublesome. In case of constant deviation spectrometer, if the prism is disturbed it can easily be reset by using a source of known wavelength.

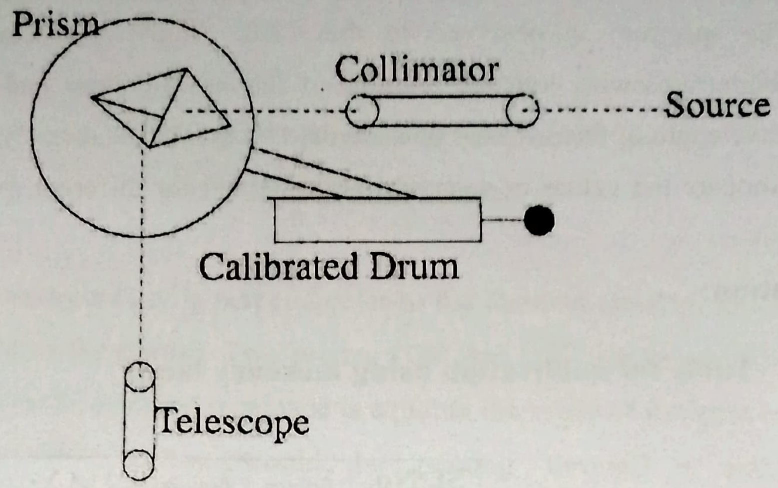

Figure 3: Experimental set up for Constant Deviation Spectrometer

PROCEDURE:

1. Level the constant deviation spectrometer by means of a sprit level and focus the telescope.
2. Place the constant deviation prism on the prism table so that its 90° vertex faces towards the objective of the telescope.
3. **Calibration of the spectrometer:** The drumhead is calibrated using known wavelengths of a calibration source, which is a mercury lamp in this case. The lamp is placed in front of the collimator.
4. The drum is rotated so that it reads a value closest to the value of the single and prominent green line. Now, by slightly rotating the prism and looking through the telescope, the green line is made to coincide on the pointer/crosswire.
5. Once the spectral line coincides with the pointer, clamp the prism. Now, note down the closest values read by the drum ($\lambda_{observed}$) corresponding to the given values (λ_{given}) of different wavelength of mercury. Plot $\lambda_{given} \sim \lambda_{observed}$ and fit it with a straight line to obtain the calibration parameters. Using these parameters any observed unknown wavelength can be calculated to determine the correct wavelength λ_{corr}.
6. Then replace the calibration source by the arc source using a particular metal arc of interest.
7. The D.C.power supply is connected to the arc stand holding the pointed metal arc one over

the other. Switch ON the power supply and observe the arc begins to glow.

8. The spectrum is observed in the CDS. Adjust the drum head to make the pointer/crosswire coincide on each of the spectral lines and read the characteristic wavelength of the different lines emitted by the metals directly.

9. Compare the values of spectral lines obtained for different metals with the literature values.

Observation:

(I) Table for calibration using mercury lamp

Sl. No.	λ_{given}	$\lambda_{observed}$	$\Delta\lambda = (\lambda_{given} - \lambda_{observed})$

(II) Table for emission spectrum of metals

Sl. No.	$\lambda_{observed}$	λ_{corr}	λ_{lit}

PRECAUTION:

1. The arc points or the holders should not be touched as they carry high voltage.
2. To start the glow the two pointer arcs should be brought very close, nearly to touching position and after the glow a minimum gap is maintained to avoid excess load on the power supply.
3. After taking readings, allow the metal rods to cool down before changing to another pair of rods.