Polariser and Analyser

Polariser:

optic used to polarise the light

Nicol Prism: O-Ray is eliminated using concept of Total Internal Reflection and only E-ray is perfectly polarised and transmitted

Polaroids: O-Ray is eliminated using “ selective absorption”

Tourmaline Crystal and doped **PVA** is also used for Dichroism

Analyser:

Polariser used to detect or analyse polarised light

Huygen's Theory of Double Refraction

"Light Energy propagates interms of wavefront"

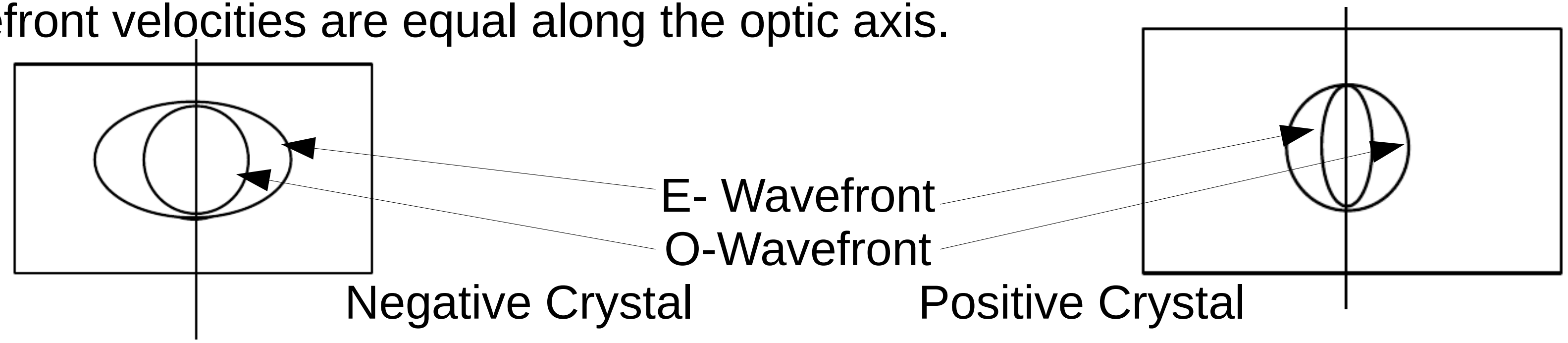
Assumptions:

1. when beam of light strikes a double refacting crystal each point on the refracting surface acts as a source for two secondary wavefronts, which spread out in to the crystal

2. One wavefront obeys the ordinary laws of refraction which travels with the same speed in all the directions. Hence corresponding wave surface is spheroid and called as O-wavefront

3. Second wave front travelswith a diffrent velocities in diffrent directions. Hence wave surface is ellipsoid called E-wavefront. They donot obey Snell's law

4. The rays corresponding to the two wavefronts merge along the optic axis. The O- and E-Wavefront velocities are equal along the optic axis.



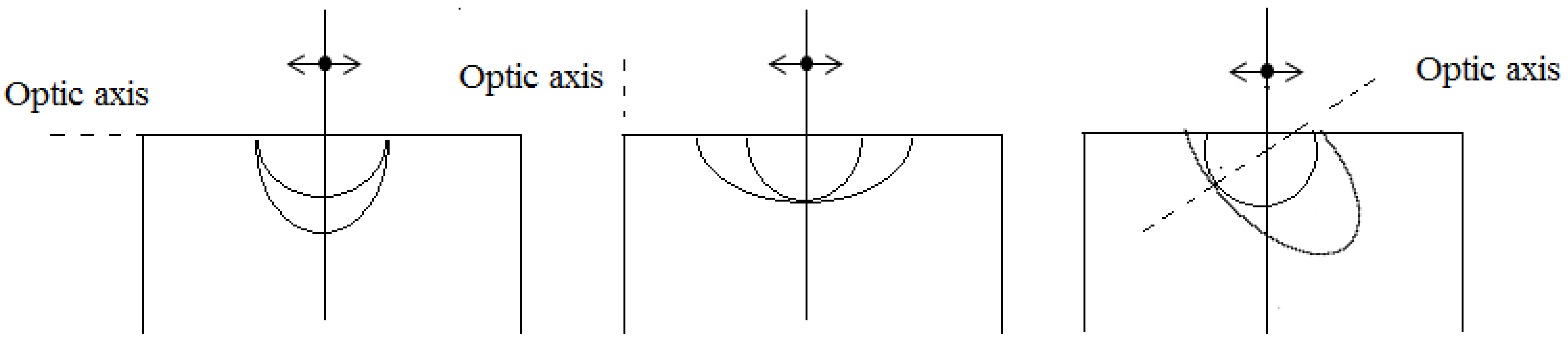
Negative Crystal

Positive Crystal

5. The direction of propogation of E- Wavefront depends on direction of optic axis relative to the refractive surfaces

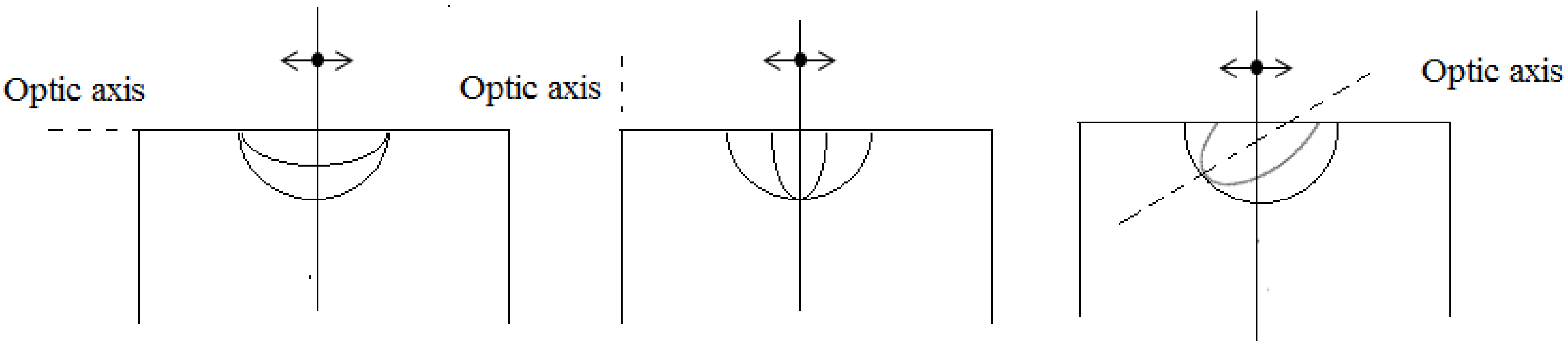
The wavefronts of E and O rays for different orientations of optic axis

For Negative Crystals



The wavefronts of E and O rays for different orientations of optic axis

For Positive Crystals



Theory of Circularly And Elliptically Polarized Light

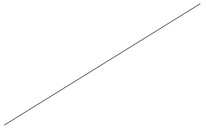
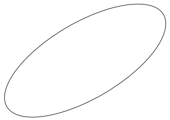
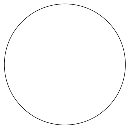
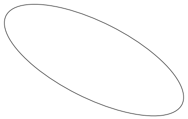
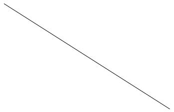
E ray and O ray vibrate in perpendicular directions with phase difference Φ
Then

$$x = a sin\omega t \qquad y = b sin(\omega t + \phi)$$

Superposition of E- Ray and O-Ray results

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - 2\frac{xy}{ab}cos\phi = sin^2\phi$$

Equation of an Ellipse

Φ	**0^{o}** **360^{o}**	**180^{o}-270^{o}** **0^{o}-90^{o}**	**270^{o}** **90^{o}**	**270^{o}-360^{o}** **90^{o}-180^{o}**	**180^{o}**
					

ϕ	Resulting eqn	Resulting vibration	Remark
$0^{o}, 360^{o}$	$y = \frac{b}{a}x$	Straight line	If two PPL is superimposed with zero phase difference then resulting vibration is PPL
180^{o}	$y = -\frac{b}{a}x$	Straight line	If two PPL is superimposed with zero phase difference hen resulting vibration is PPL
$90^{o}, 270^{o}$ $a \neq b$	$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$	Ellipse	If two PPLs with unequal amplitudes are superimposed with a phase difference of 90^{o}, 270^{o}, the resulting vibration is EPL
$90^{o}, 270^{o}$ $a = b$	$x^2 + y^2 = a^2$	Circle	If two PPLs with equal amplitudes are superimposed with a phase difference of 90^{o}, 270^{o}, the resulting vibration is CPL

Retardation Plates

When a light falls normally on a doubly refracting uniaxial crystal plate cut with optic axis parallel to the refracting surfaces, a phase diffrence between the O-ray and E-Ray is introduced. Then the crystal is called as Retardation Plate

The path difference between the two rays is given by

$$\Phi=(\mu_o-\mu_e)t$$

μ_o- Refractive index of O-Ray

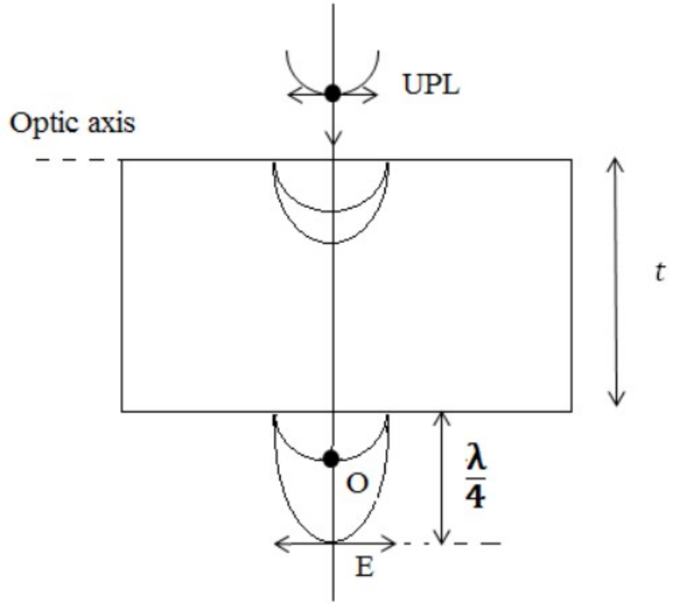
M_e -Refractive index of E-Ray

t- thickness of the plate

Ex: Quarter Wave Plate, Half Wave Plate

Quarter Wave Plate

It is doubly refracting uniaxial crystal plate that introduces a phase diffrence of π/2 or path diffrence of λ/4 between the O-Vibrations and E-vibrations, when light normally incident on it



For Negative Crystal

$$t = \frac{\lambda}{4(\mu_o - \mu_e)}$$

For Positive Crystal

$$t = \frac{\lambda}{4(\mu_e - \mu_o)}$$

Ex: **Mica, Quartz**

Converts PPL in to CPL (or EPL) and conversely it also converts CPL (or EPL) in to PPL

Half Wave Plate

It is doubly refracting uniaxial crystal plate that introduces a phase diffrence of π or path diffrence of λ/2 between the O-Vibrations and E-vibrations, when light normally incident on it

For Negative Crystal

$$t = \frac{\lambda}{2(\mu_o - \mu_e)}$$

For Positive Crystal

$$t = \frac{\lambda}{2(\mu_e - \mu_o)}$$

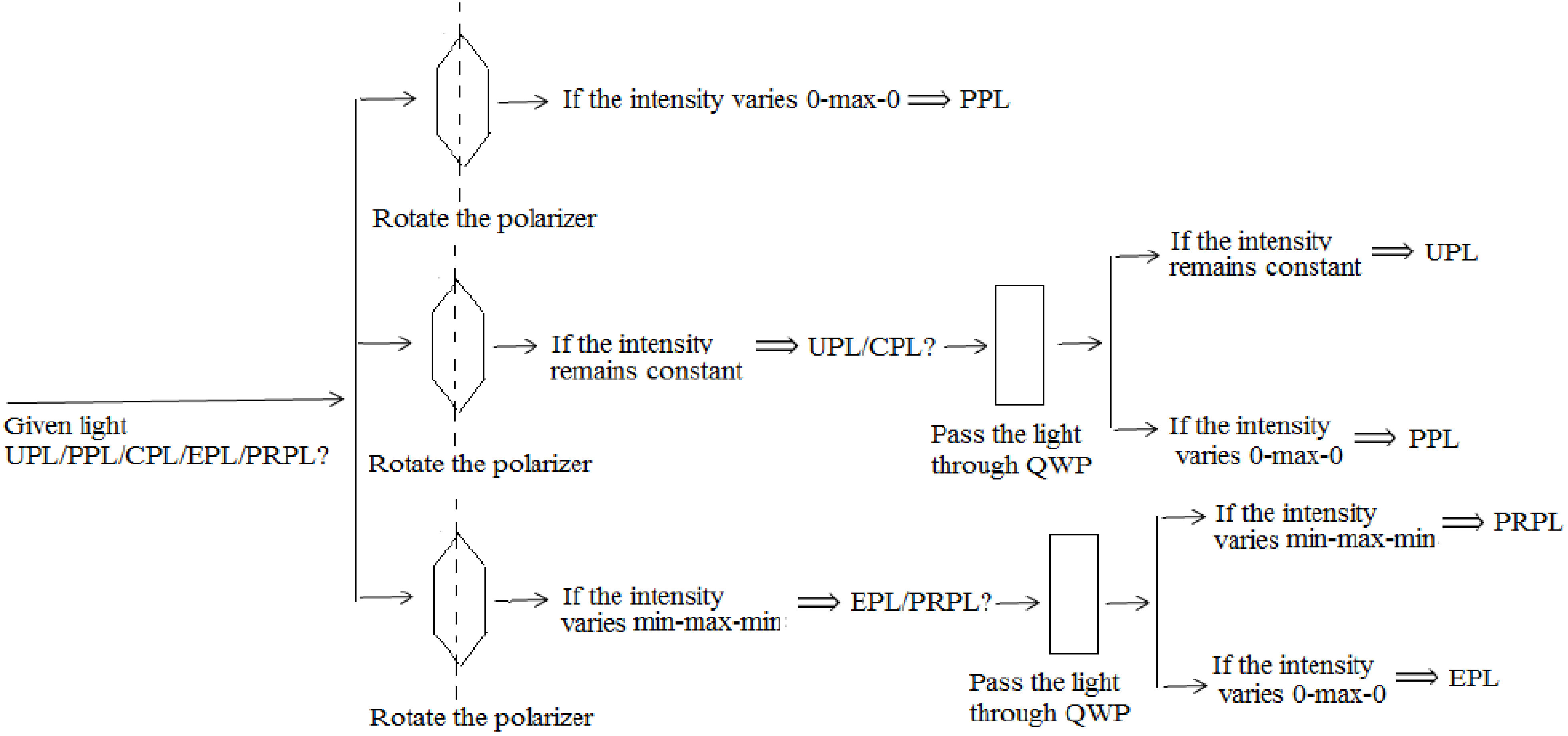
Made from doubly refracting uniaxial crystal, cut with refracting faces parallel to optic axes

Used to ulter the direction of vibration of the linearly polarized light by angle 2θ

θ--- angle between incident vibration and the optic axis

Detection

Allow the light to pass through the analyser



Application

Polarising Sunglass- cuts the glare of light

Optical Activity

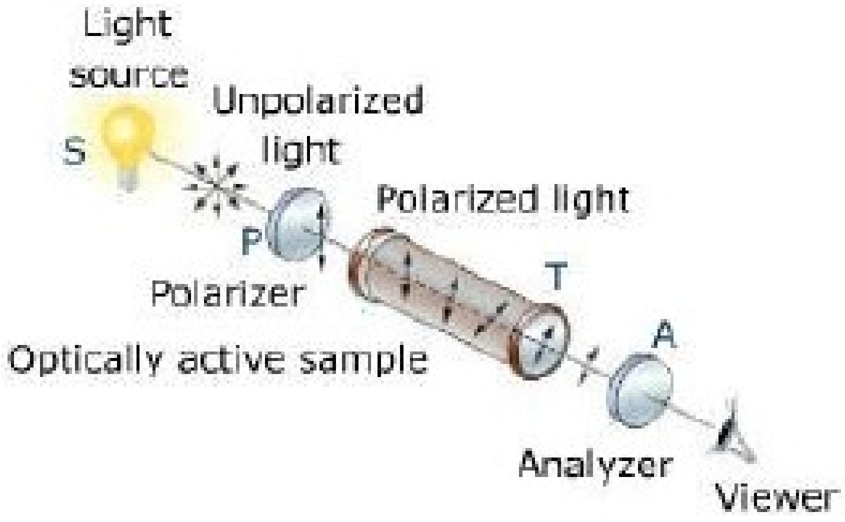
Certain Materials have an ability to rotate the plane of vibration of PPL

Ex: Sugar solution, Turpentine, Liquid Crystals, Tartaric acid, Camphor, Cholestrol

Angle of rotation (θ) depends on

1. Concerntration (c)
2. Length of the Cell (l)
3. Specific Rotation (S)

$$\theta = Slc$$

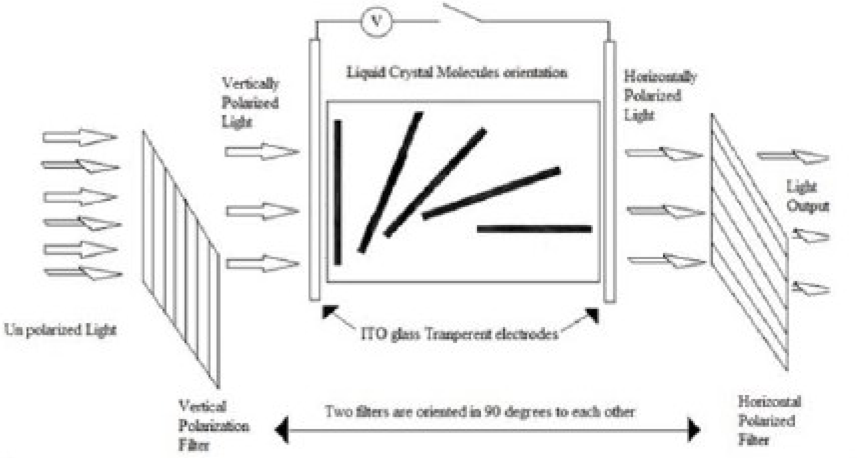


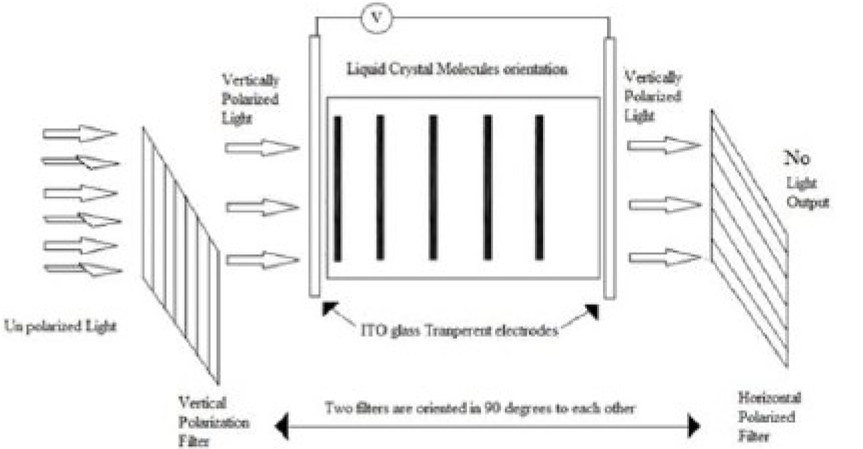
Saccharimeter

Instrument for measuring the concentration of sugar solutions

Liquid Crystal Display

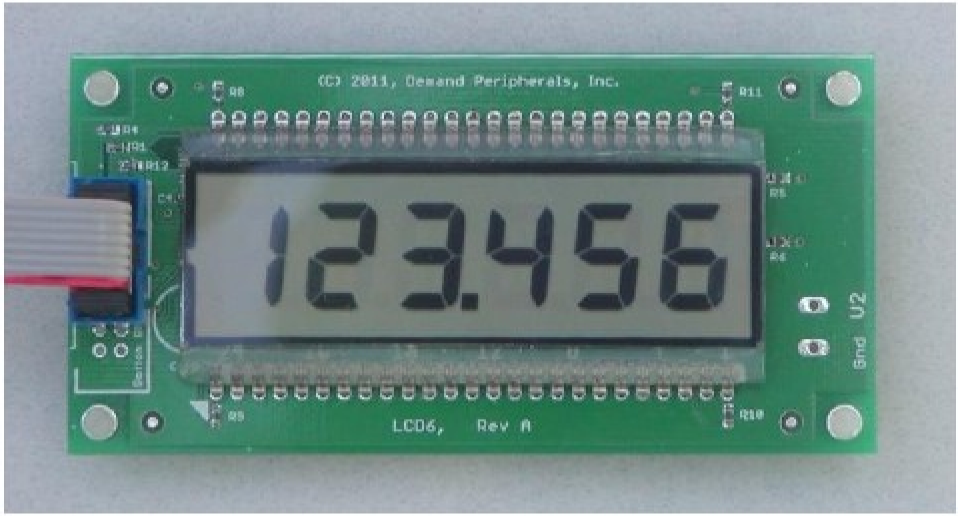
- System of two crossed polarisors do not transmit the light
-Place optically active Liquid crystals between polarisors
- LC's rotate the PPL by 90^o
-Now pass the UPL through thepolarisor, it will allow vertical vibrations
-LC rotate the vertical vibrations into horrizontal vibrations
-these produced horizontal vibrations passed through the analyser
-keep mirror infront of analyser, so that horizontal vibrations reflect back to L.C.through the analyser, rotate again and comes out through the polariser
- System appears bright
- now apply small voltage to L.C., it looses optical activity, vertical components not rotatedin to horizontal, so Ppl is blocked at the analyser
- System appears Dark





Using This Principle Seven segment displays were constructed

Similarly Combination of R.G.B LC's used in Color displays



3-D Movies

- Shot twice through two lenses kept side by side
- These two movies are projecyted on the screen through two projectors mounted with two polarisers, vertical and horizontal
- Viewer looks movie with aspecial goggle mounted with two polarisers, horizontal for one eye and vertical from another
- Thus one eye sees only horizontally polarised movie and another see only vertically polarised movie
- Our brain mixes these two pictures and thus 3D stereo screen version is produced

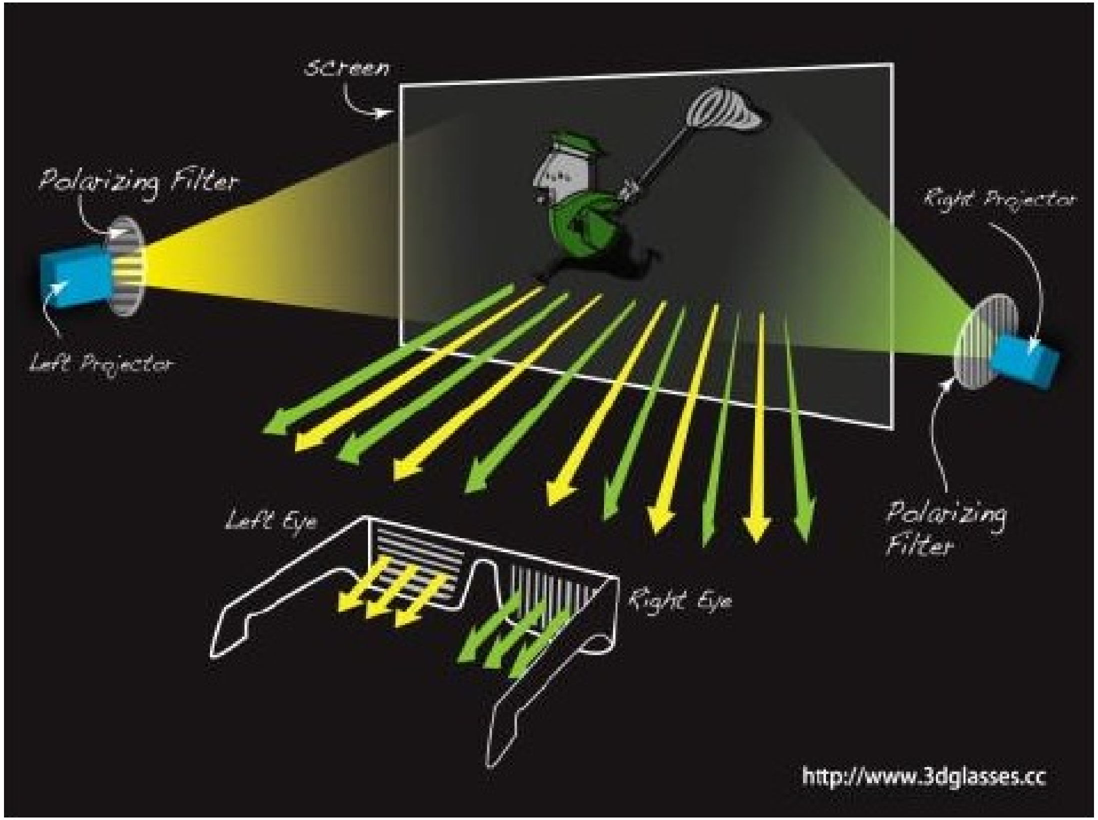
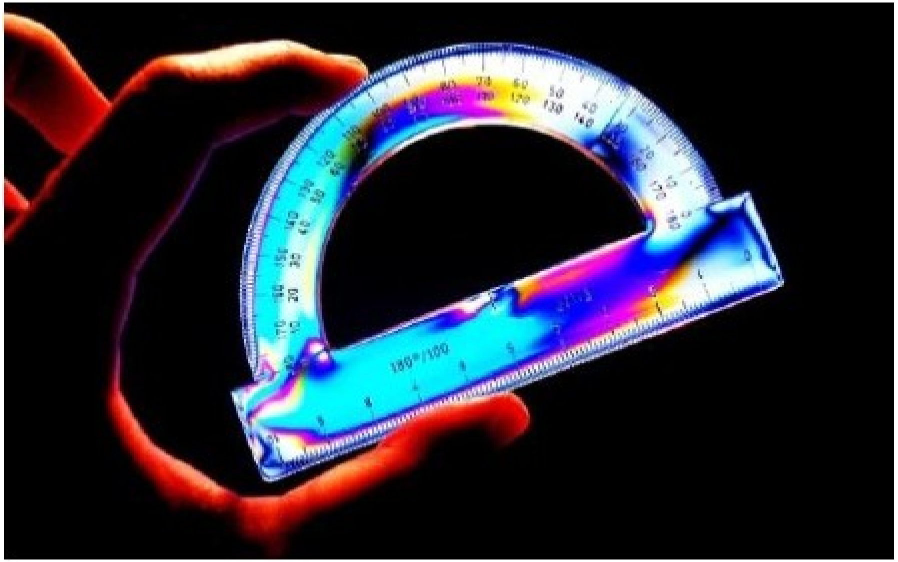


Photo-Elasticity

Due to force, defects or stressed Zones present in the components
These can be made visualised by polarisers
i.e. some material may become double refracting in stressed zone



Reference: Concepts of Engineering Physics, Dr. Narendra Mathakari, MITWPU

Thank you