CODE: AL-E215

BSC PHYSICS

Aim: To verify law of Malus

Apparatus: (1) Monochromatic source of light lamp house with 100/60w lamp or Diode Laser
(2) Two polarizers with angular scale from 0-360°
(3) Current meter with connected photo sensor
(4) Optical bench with stand for mounting polarizer and analyzer

Theory: An unpolarized light consists of the vibrations which are istropically distributed in all 360° directions transverse to direction of propagation. Since vibrations exist in all the directions, their net X and Y components are equal i.e. 50%. If such light is passed through a polarizer, the components parallel to optic axis are transmitted and components perpendicular to optic axis are eliminated. Thus when the light is polarized once, its intensity decreases by 50%. Consider a system of two polarizers having an angle θ between their optic axes. Let the amplitude and intensity of the light incident on the first polarizer be *Eo*and*Io* respectively. When the light passes through first polarizer, its amplitude and intensity reduces. Let these reduced amplitude and intensity be $E_1$and I_1 respectively. (We have $I_1 \cong I_o/2$). As the angle between the optic axes of the polarizers is θ, the light polarized by the first polarizer (E_1) is incident on the second polarizer at θ itself (refer Fig 3.1). Second polarizer transmits the cosine component of *E1* as it is along its optic axis. If the E_2 and I_2 are the amplitude and intensity of the light transmitted by the second polarizer, then we have

$$E_2=E_1\cos\theta \Rightarrow I2=I_1\cos^2\theta \quad \text{.....(3.1)}$$

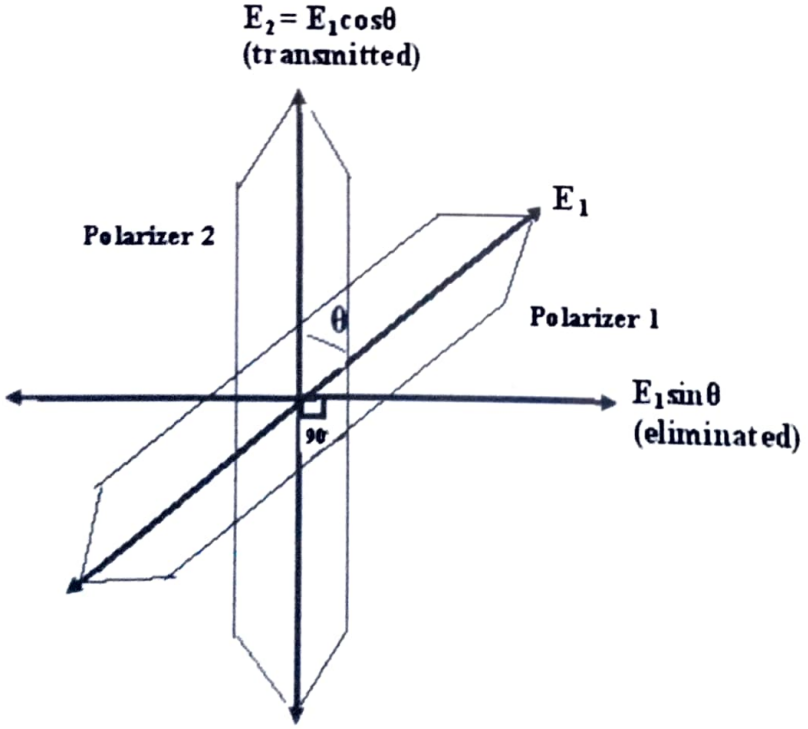
Eqn (3.1) signifies that *I2* is the function of θ and I_1 is the maximum value of I_2. Thus, by choosing appropriate notations,

$$I_\theta=I_m\cos^2\theta \quad \text{.....(3.2)}$$

Eqn (3.1) and (3.2) represent law of Malus. The law states that the intensity transmitted by a pair of polarizers is a cosine square function of the angle between their optic axes.

Procedure

- The polarizer towards the light source is called polarizer and that towards the observer is called analyzer.
- Arrange the accessories of the optical bench, first connect the lamp on the optical bench , followed by polarizer, analyzer then photo detector.
- Connect the photo sensor cable to the intensity meter
- Level the optical bench using spirit level. And keep the light straight so it falls on the detector.
- Perform the experiment in dark room so that no other light except that from only lamp light will fall on to the detector (photo meter).
- Make the intensity photometer ON and set it at appropriate range (0-200 Ma)
- Rotate the analyzer through 360° while looking through it. The intensity will maximize three times at θ equal to 0° , 180° and 360°, while intensity will be extinguished at θ equal to 90° and 270°.
- Adjust the analyzer so that it transmits maximum intensity. This corresponds to θ= 0^{o} condition. Confirm this position by using a photo detector measurement display. Hold the photo detector sensor on the analyzer and move the analyzer slightly back and forth and detect the exact



maximum
intensity position. Note the corresponding angular position of the analyzer. Let this be θ'. As this is maximum intensity condition, it corresponds to θ = 0^{o}. θ' is the angular position of the analyzer and θ is the angle between the

optic axes of polarizer and analyzer. θ' and θ need not be same. Also record the maximum intensity shown by the photo detector. This is I_m

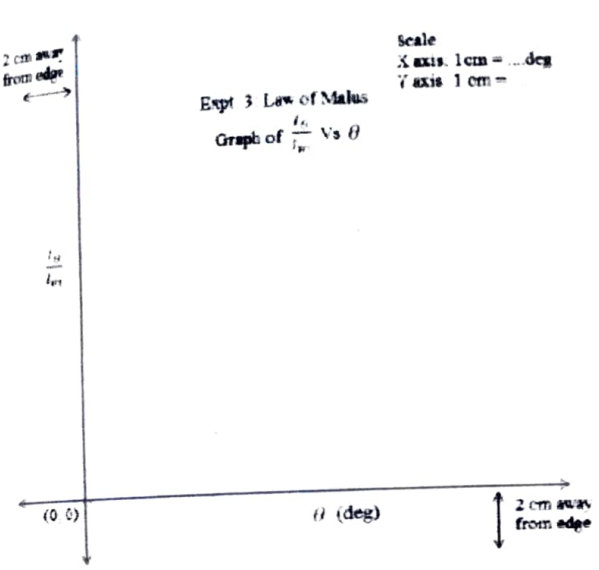
- Now rotate the analyzer by 30° each time and record both θ'' and θ.
- Also record the corresponding intensities using the photo detector and meter. These intensities are denoted by I_θ.
- Continue the observations till θ reaches 360°. Record all your readings in the observation table below
- Calculate I_θ/I_m and $cos^2\theta$.for each θ readings.
- Plot the graph of I_θ/I vs θ for all 13 values of θ , It will show cosine square nature.
- Also plot the graph of I_θ/I_m Vs $cos^2\theta$ only for first four values. It will be a straight line.
- Both these graphs signify law of Malus

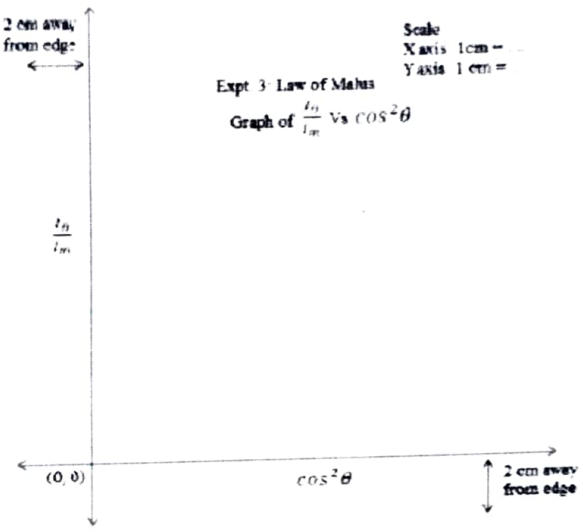
Observation, calculations and results.

1) The least count of the angular scale on the analyzer = 1 deg

2) The maximum intensity (for θ = 0°), I_m=..... mA

Sr. No.	The reading on the angular scale on the analyzer θ' deg	The angle between polarizer & analyzer θ deg	Intensity through the analyzer (I_θ), lux	Relative intensity $\frac{I_\theta}{I_m}$	$cos^2\theta$
1		0	$I_\theta = I_m$=..	1	1
2		30			
3		60			
4		90			
5		120			
6		150			
7		180			
8		210			
9		240			
10		270			
11		300			
12		330			
13		360			


2 cm away from edge
Scale
X axis 1 cm = ...deg
Y axis 1 cm =
Expt 3 Law of Malus
Graph of $\frac{I_{tr}}{I_{in}}$ Vs θ
$\frac{I_{tr}}{I_{in}}$
(0, 0)
θ (deg)
2 cm away from edge


2 cm away from edge
Scale
X axis 1cm =
Y axis 1 cm =
Expt 3 Law of Malus
Graph of $\frac{I_{tr}}{I_{in}}$ Vs $COS^2\theta$
$\frac{I_{tr}}{I_{in}}$
(0, 0)
$COS^2\theta$
2 cm away from edge