

**Readings:** Riley, Hobson and Pence - Chapter - 8,10,11  
(selected topics)

[http://chaos.swarthmore.edu/courses/Physics50\\_2010/000\\_Review.pdf](http://chaos.swarthmore.edu/courses/Physics50_2010/000_Review.pdf)

[http://chaos.swarthmore.edu/courses/Physics50\\_2010/003\\_PolarizationMatrices.pdf](http://chaos.swarthmore.edu/courses/Physics50_2010/003_PolarizationMatrices.pdf)

**Some More review Problems:**

8.10 Pauli Matrices

8.13 Gram-Schmidt

8.21 Eigenvectors

8.34 Simultaneous Equations

10.13 Vector Identity (use  $\epsilon_{ijk}$ )

11.01 Vector Field

**Polarization Problems:**

**1. Two Polarizers:** A beam of light, having intensity  $I_1=1$ , and moving along the z-axis is incident on a first polarizer  $P_1$  (in the xy plane) and whose pass-direction is parallel to the x-axis. The beam emerging from  $P_1$  is incident on a second parallel polarizer  $P_2$ , rotating around the z-axis.

Plot the intensity  $I_2$  emerging from  $P_2$  when the angle  $\theta$  between its pass-direction and the x-axis increases from  $0^\circ$  to  $180^\circ$ .

Assume that the polarizers do not absorb any light.

**2. Three Polarizers:** A beam of light, having intensity  $I_1=1$ , and moving along the z-axis is incident on a first polarizer  $P_1$  (in the xy plane) and whose pass-direction is parallel to the x-axis. The beam emerging from  $P_1$  is incident on a second parallel polarizer  $P_2$ , rotating around the z-axis. The beam emerging from  $P_2$  is incident on a third parallel polarizer  $P_3$ , whose pass-direction is perpendicular to the x-axis.

Plot the intensity  $I_2$  emerging from  $P_2$  when the angle  $\theta$  between its pass-direction and the x-axis increases from  $0^\circ$  to  $360^\circ$  and the intensity  $I_3$  of the beam emerging from the third polarizer.

Assume that the polarizers do not absorb any light.

**3. Retarders:** A beam of monochromatic light ( $\lambda = 0.5893\mu$ ), of intensity  $I_1$ , is moving along the z-axis and reaches a polarizer  $P_1$  whose plane is perpendicular to the z-axis (in the x-y plane). The beam emerging from  $P_1$  reaches a retarder that has its plane parallel to the x-y plane. The optic (fast) axis of the retarder subtends an angle  $\beta = 45^\circ$  with the x-axis. The beam emerging from the retarder reaches another polarizer  $P_2$ , whose transmission axis has the same direction as  $P_1$ .

- (a) Find the intensity of the beam emerging from polarizer  $P_2$  when the retarder is half-wave  $R_{h-w}$  and when it is quarter-wave  $R_{q-w}$ .
- (b) If another half-wave plate  $R_{h-w}$ , whose optic axis is at  $45^\circ$  from the x-axis takes the place of the polarizer  $P_2$ , after the half-wave  $R_{h-w}$  or the quarter-wave  $R_{q-w}$ , find the polarization of the final beams and their intensities.

Assume that the polarizers and retarders do not absorb any light.

**4. A Half-Wave Plate:** A beam of light, having intensity  $I_1 = 1$ , and moving along the z-axis is incident on a first polarizer  $P_1$  (in the xy plane) and whose pass-direction (transmission axis) subtends angle  $\theta = 45^\circ$  with the x-axis. The beam emerging from  $P_1$  is incident on a half-wave plate  $R_{h-w}$ , parallel to  $P_1$  and whose optic axis is parallel to the x-axis. Emerging from the half-wave plate the beam is incident on a second polarizer  $P_2$ , parallel to  $P_1$  and  $R_{h-w}$ , rotating on the z-axis.

Plot the intensity  $I_2$  of the beam emerging from  $P_2$  when the angle  $\theta$  between its pass-direction and the x-axis is increasing from  $0^\circ$  to  $360^\circ$ .

Assume that the polarizers and retarders do not absorb any light.

**5. A Quarter-Wave Plate:** A beam of light, having intensity  $I_1=1$ , and moving along the z-axis is incident on a first polarizer  $P_1$  (in the xy plane) and whose pass-direction is parallel to the x-axis. The beam emerging from  $P_1$  is incident on a quarter-wave plate  $R_{q-w}$ , parallel to  $P_1$ . The optic axis of  $R_{q-w}$  is parallel to the x-axis. Emerging from the quarter-wave plate the beam is incident on a second polarizer  $P_2$  parallel to  $P_1$  and  $R_{q-w}$ .

Plot the intensity  $I_2$  of the beam emerging from  $P_2$  when the angle  $\theta$  between its pass-direction and the x-axis is increasing from  $0^\circ$  to  $360^\circ$ .

Next the direction of the pass-direction of the first polarizer  $P_1$ , changes from  $0^\circ$  to  $45^\circ$  leaving unchanged the direction of the optic axis of  $R_{q-w}$ .

Plot the intensity  $I_2$  of the beam emerging from  $P_2$  when the angle  $\theta$  between its pass-direction and the x-axis is increasing from  $0^\circ$  to  $360^\circ$ .

Assume that the polarizers and retarders do not absorb any light.

**NOTE: Optics Experiment #2 involves calculated intensities similar to these problems.**