Phys 402 problem set #9

see https://courses.physics.illinois.edu/phys402/schedule-Sp17.htm for due dates

The following problems are from the 4th edition of Hecht, except for the last one:

8.5* Write an expression for a $\mathcal{P}$-state lightwave of angular frequency $\omega$ and amplitude $E_0$ propagating along a line in the $xy$-plane at 45° to the $x$-axis and having its plane of vibration corresponding to the $xy$-plane. At $t = 0, y = 0$, and $x = 0$ the field is zero.

8.41* Take two ideal Polaroids (the first with its axis vertical and the second, horizontal) and insert between them a stack of 10 half-wave plates, the first with its fast axis rotated $\pi/40$ rad from the vertical, and each subsequent one rotated $\pi/40$ rad from the previous one. Determine the ratio of the emerging to incident irradiance, showing your logic clearly.

8.54* Two incoherent light beams represented by (1, 1, 0, 0) and (3, 0, 0, 3) are superimposed.

(a) Describe in detail the polarization states of each of these.

(b) Determine the resulting Stokes parameters of the combined beam and describe its polarization state.

(c) What is its degree of polarization?

(d) What is the resulting light produced by overlapping the incoherent beams (1, 1, 0, 0) and (1, −1, 0, 0)? Explain.

8.18* Imagine that you have two identical perfect linear polarizers and a source of natural light. Place them one behind the other and position their transmission axes at 0° and 50°, respectively. Now insert between them a third linear polarizer with its transmission axes at 25°. If 1000 W/m² of light is incident, how much will emerge with and without the middle polarizer in place?

8.43* An $\mathcal{S}$-state traverses an eighth-wave plate having a horizontal fast axis. What is its polarization state on emerging?

8.65* If the Pockels cell modulator shown in Fig. 8.57 is illuminated by light of irradiance $I_0$, it will transmit a beam of irradiance $I_\ell$ such that

$$I_\ell = I_0 \sin^2(\lambda \varphi/2)$$

Make a plot of $I_\ell/I_0$ versus applied voltage. What is the significance of the voltage that corresponds to maximum transmission? What is the lowest voltage above zero that will cause $I_\ell$ to be zero for ADP ($\lambda_0 = 546.1$ nm)? How can things be rearranged to yield a maximum value of $I_\ell/I_0$ for zero voltage? In this new configuration what irradiance results when $V = V_\lambda/2$?

9.12* With regard to Young’s Experiment, derive a general expression for the shift in the vertical position of the $n$th maximum as a result of placing a thin parallel sheet of glass of index $n$ and thickness $d$ directly over one of the slits. Identify your assumptions.

9.13* Plane waves of monochromatic light impinge at an angle $\theta_i$ on a screen containing two narrow slits separated by a distance $a$. Derive an equation for the angle measured from the central axis which locates the $n$th maximum.

**Bonus problem:** Watch the following YouTube video of a CNC milling machine: https://www.youtube.com/watch?v=uc5P6Ss3LRE

One application of a Michelson interferometer is calibrating a mill of this type.