Prelab Assignment 2

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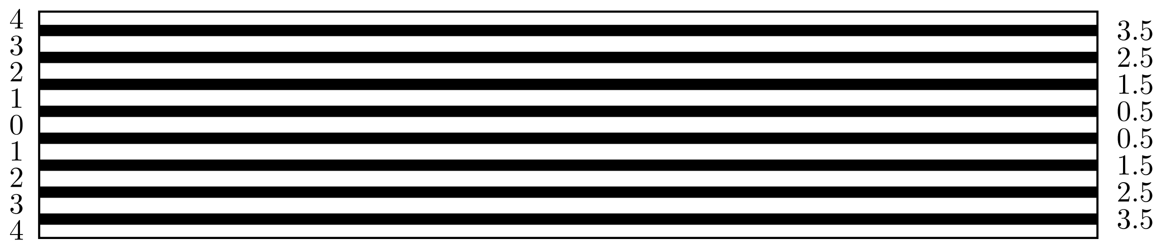
Problem 1

The light-field polariscope is shown below. Assuming a symmetric polariscope, then the fringe number, n, is shown in the figure as well. Right numbers show the dark fringe numbers, while the left shows the light fringe numbers.



The highest fringe number is $n = 4$ for light fringes, and $n = 3.5$ for dark fringes.

Problem 2

First, we need the moment of inertia about the y-axis.

$$I_{yy} = \frac{1}{12} h w^3 = \frac{1}{12} (0.25 \text{ in})(1.5 \text{ in})^3 = 0.07031 \text{ in}^4 \tag{1}$$

Then the stress along the x-axis, σ_{xx}, is given by:

$$\sigma_{xx} = -\frac{M_y z}{I_{yy}} = -\frac{12 \times 0.25}{0.07031} = -42.67 \text{ psi} \tag{2}$$

Then the fringe constant, f_σ is given by:

$$\begin{aligned} f_\sigma &= \frac{t\left(\sigma_1 - \sigma_2\right)}{n + 1/2} \\ &= \frac{0.25(42.67)}{5.5 + 1/2} = 1.778 \end{aligned} \tag{3}$$

Problem 3

A higher fringe constant would give a greater stress resolution. A lower fringe constant would be more applicable for sensitive experimental stress analysis, because increasing the fringe constant would mean the stress would increase, driving the material to failure. So we would prefer a lower fringe constant to remain in the elastic zone, and prevent the material from plastic deformation or yielding.

Problem 4

(a) Derive the relationship between the stress concentration ratio to the number of near and far field fringes.

$$\begin{aligned} \sigma_{max} &= K_t \sigma_{nom} \\ \sigma_{max} - \sigma_{nom} &= (K_t - 1)\,\sigma_{nom} \end{aligned} \tag{4}$$

Then using the equation that relates fringe constant, with the principal stresses:

$$\begin{aligned} \sigma_{max} &= \left(n_{near} + \frac{1}{2}\right)\left(\frac{t}{f_\sigma}\right)^{-1} + \sigma_2 \\ \sigma_{nom} &= \left(n_{far} + \frac{1}{2}\right)\left(\frac{t}{f_\sigma}\right)^{-1} + \sigma_2 \end{aligned} \tag{5}$$

Then subtracting the two:

$$\sigma_{max} - \sigma_{nom} = (n_{near} - n_{far})\left(\frac{t}{f_\sigma}\right)^{-1} = (K_t - 1)\,\sigma_{nom} \tag{6}$$

(b) How many fringe orders will be seen in the near field under this applied stress?

$$\begin{aligned} (K_t - 1)\sigma_{nom} &= (n_{near} - n_{far})\left(\frac{t}{f_\sigma}\right)^{-1} \\ 2\sigma_{nom} &= (n_{near} - 2)\left(\frac{t}{f_\sigma}\right)^{-1} \\ n_{near} &= 2\sigma_{nom}\left(\frac{t}{f_\sigma}\right) + 2 \end{aligned} \tag{7}$$

Problem 5

Quarter-wave plates keep the intensity constant, but converts linearly polarized light into circularly polarized light. They are also used to produce elliptical polarization.