Optical Microscopy – Homework Assignment

1. Chromatic aberration.

Use the lensmaker’s equation to calculate the focal length for three different wavelengths: 400nm, 500nm and 700nm, for a thick lens.

The lensmaker’s equation is given by:

\[ \frac{1}{f} = (n - 1) \left[ \frac{1}{R_1} - \frac{1}{R_2} + \frac{(n - 1)d}{n R_1 R_2} \right], \]

where:
- \( f \) is the focal length of the lens (to be found).
- \( n \) is the index of refraction.
- \( R_1 = 25 \text{ cm} \) is the radius of curvature for the lens surface closest to the light source.
- \( R_2 = 15 \text{ cm} \) is the radius of curvature for the lens surface farthest from the light source.
- \( d = 45 \text{ mm} \) is the thickness of the lens.

To find the index of refraction \( n \) for each one of the wavelengths use the Sellmeier equation given by:

\[ n^2(\lambda) = 1 + \frac{B_1 \lambda^2}{\lambda^2 - C_1} + \frac{B_2 \lambda^2}{\lambda^2 - C_2} + \frac{B_3 \lambda^2}{\lambda^2 - C_3}, \]

where:
- \( \lambda \) is the wavelength,
- \( B_1, B_2, B_3 \) and \( C_1, C_2, C_3 \) are experimental parameters for glass given by:

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( B_1 )</td>
<td>1.03961212</td>
</tr>
<tr>
<td>( B_2 )</td>
<td>0.231792344</td>
</tr>
<tr>
<td>( B_3 )</td>
<td>1.01046945</td>
</tr>
<tr>
<td>( C_1 )</td>
<td>6.00069867 \times 10^{-3} \text{ ( \mu m^2 )}</td>
</tr>
<tr>
<td>( C_2 )</td>
<td>2.00179144 \times 10^{-2} \text{ ( \mu m^2 )}</td>
</tr>
<tr>
<td>( C_3 )</td>
<td>1.03560653 \times 10^2 \text{ ( \mu m^2 )}</td>
</tr>
</tbody>
</table>
2. **Total Internal Diffraction (TIR).**

Use Snell’s law to find the critical angle for orange light (590nm) propagating from one medium to another for the following refraction indexes:

- Air to water.
- Water to air
- Glass to water
- Glass to air
- Water to glass
- Diamond to water

3. **Numerical aperture and diffraction limit.**

Calculate the diffraction limit for each one of the following wavelengths 400nm, 500nm 700nm for objectives with the following numerical apertures:

NA=0.6, 0.9, 1.2, 1.45, 1.68

4. **FRET**


- Alexa Fluor 488
- GFP
- Cy3 dye
- Rhodamin 123
- Texas Red