Instructions

Work on in groups of up to four people (I think three to a group is optimal, but you can have a group of four if you like). Each groups turns in one solution, all members of the group will receive the same grade. Use complete sentences and correct grammar to explain your solution. Make your solution complete and easy for a reader to follow.

The Calculus of Rainbows

6th Edition: page 279-280.
5th Edition: page 288-289.

Use *Mathematica* as much as you like, to take derivatives, solve equations, plot sketches, anything you like. If you use *Mathematica*, include a printout of the *Mathematica* commands you used. You can also do as much as you like by hand, since sometimes it is easier to just take a derivative by hand (for example) than getting *Mathematica* to do it for you.

Note that for Part 3, when considering the secondary rainbow, the light ray travels counterclockwise inside the drop rather than clockwise as the primary rainbow (this is so the light will finally reach an observer on the ground). The clockwise rotation of the angle of deflection is $D(\alpha) = 6\beta - 2\alpha$. I suggest you work with the clockwise expression for $D(\alpha)$ so the 51 degree number the text quotes makes sense.

This Problem is very verbose, so I will include here what I want from each part.

1. Starting from the equation for angle of deviation $D(\alpha)$, show the minimum angle of deviation is $D(\alpha) = 137.97$ degrees and occurs when $\alpha = 59.39$ degrees. Show the rainbow angle is 42.03 degrees.
2. Do Part 1 again for red light ($k = 1.3318$) and violet light ($k = 1.3435$).
3. Starting from the equation for angle of deviation $D(\alpha)$ for the secondary rainbow, show the minimum angle of deviation is $\alpha = \arccos(\sqrt{(k^2-1)/8})$. Using $k = 4/3$, verify the minimum deviation angle is $D(\alpha) = 129.02$ degrees and occurs when $\alpha = 71.83$ degrees. Show you get a rainbow angle of 50.98 degrees.
4. Explain why the rainbows are in opposite order (you don't need any math here).

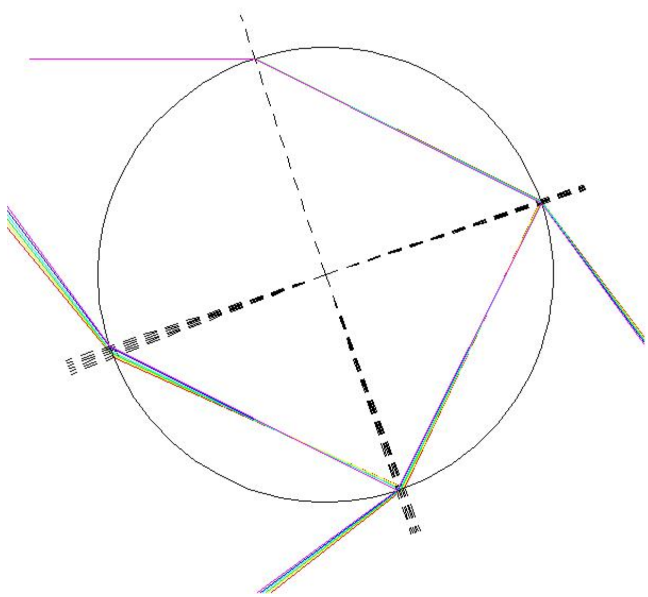

Figure 1: How a single ray of light travels through a spherical water droplet. The different wavelengths contained in the white light from the sun refract different amounts due to Snell's Law, creating a rainbow for the observer below.