EE119 Homework 4

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Due Friday, February 20, 2009

1. Hecht 6.28. Make sure to justify your answer.
2. Hecht 6.29. Make sure to justify your answer.
3. You have a shiny broadband blue laser whose center wavelength is 486 nm (this is 'F' color, see p. 34 of notes). You want to focus this laser to a point with a 12.5 cm converging lens that will minimize chromatic aberration in the region between G' and D light. So you decide to make an achromat from SPC-1 and DF-4 glasses. Refer to table 1 for the refractive indices of the materials. The lens made out of DF-4 glass should have its outer face flat, and the two lenses should be cemented, which means that the distance between them is zero and their inner radii are the same.
   (a) Find the power of the lens in diopters.
   (b) Find the dispersive power of the two lenses.
   (c) Find the powers of the two lenses.
   (d) Find the radii of the three curved surfaces.
   (e) Now you figure out a way to make the bandwidth of you laser even broader, and you still want to focus it. Repeat part (d) (and whatever is needed of the previous parts) for a lens that is to be corrected for G' and C light. Is the radius of the combined lens (i.e. the outer radius of the crown) bigger or smaller than in part (d)?
4. The rays incident on the outer edge of a lens (outside of the paraxial regime) suffer from spherical aberration. This is because the nonparaxial rays are too strongly bent. Consider the plano-convex lens as we see in Fig. 1-(a) and (b). Depending on which surface faces the incident rays, the amount of spherical aberration can be reduced. In this problem, you will decide which lens configuration is better in terms of spherical aberration.
   (a) Find the focal length of the lens in the paraxial regime.
   (b) Lets assume we have a ray parallel to the optical axis incident on the lens as shown above. Calculate where the ray crosses the optical axis (L). Neglect the thickness of the lens. (Hint: You will use Snell's law twice)
   (c) Now flip the lens around so light is incident on the planar side. Repeat parts (a) and (b). (Hint: You will use Snell's law only once)
   (d) Which lens geometry is better for minimizing spherical aberration?

Table : REFRACTIVE INDICES OF TYPICAL OPTICAL MEDIA FOR FOUR COLORS

Medium	Designation	ICT type	ν	n_C	n_D	n_F	$n_{G'}$
Borosilicate crown	BSC	500/664	66.4	1.49776	1.50000	1.50529	1.50937
Borosilicate crown	BSC-2	517/645	64.5	1.51462	1.51700	1.52264	1.52708
Spectacle crown	SPC-1	523/587	58.7	1.52042	1.52300	1.52933	1.53435
Light barium crown	LBC-1	541/599	59.7	1.53828	1.54100	1.54735	1.55249
Telescope flint	TF	530/516	51.6	1.52762	1.53050	1.53790	1.54379
Dense barium flint	DBF	670/475	47.5	1.66650	1.67050	1.68059	1.68882
Light flint	LF	576/412	41.2	1.57208	1.57600	1.58606	1.59441
Dense flint	DF-2	617/366	36.6	1.61216	1.61700	1.62901	1.63923
Dense flint	DF-4	649/338	33.9	1.64357	1.64900	1.66270	1.67456
Extra dense flint	EDF-3	720/291	29.1	1.71303	1.72000	1.73780	1.75324
Fused quartz	SiO_2		67.9		1.4585		
Crystal quartz (*O* ray)	SiO_2		70.0		1.5443		
Fluorite	CaF_2		95.4		1.4338		

Figure 1: diagram for problem 3

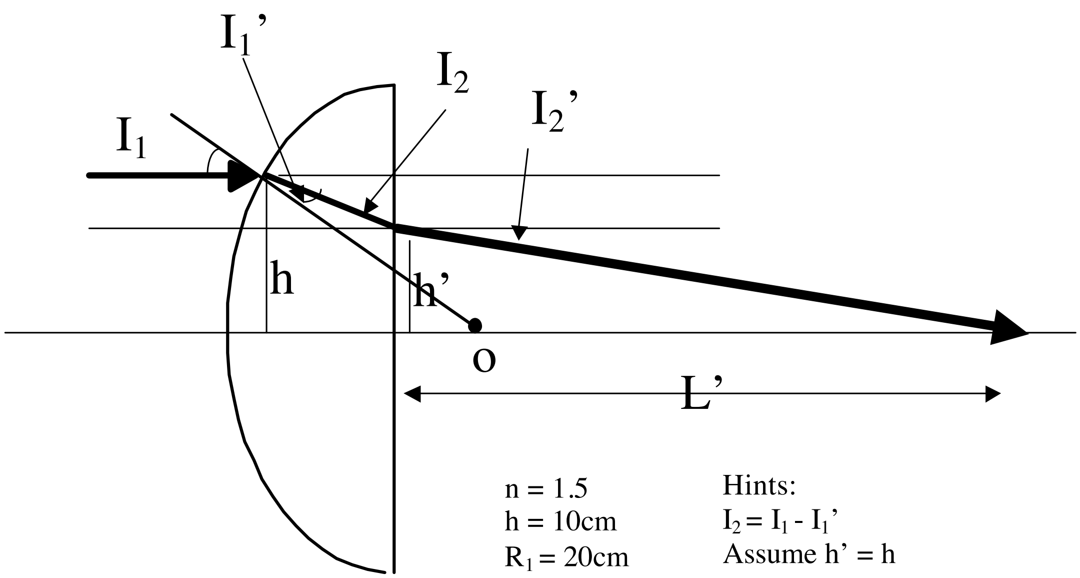

Figure 2: diagram for problem 4