Problem 1.

We would like to take an asorption spectrum of a sample that we believe has its absorption maximum at 200 nm. Which of the following materials should our cuvette be made of: borosilicate glass, polystyrene, or quartz? Explain why your choice is the best option.

Solution

Problem 2.

Why are mirrors preferred over lenses for imaging in many spectroscopic instruments that must cover multiple wavelengths?

Solution

Problem 3.

What performance characteristics of a monochromator are affected when only the grating groove density is changed?

Solution

Problem 4.

A ray in air (n=1.33) is incident on a block of sapphire (n=1.77) at a 40° angle from the normal to the glass surface. At what angle relative to the normal will the ray be transmitted through the glass?

Solution

Problem 5.

What is a birefringent crystal? How does a birefringent crystal work if you send light through it? What is an example of a birefringent crystal?

Solution

Problem 6.

List the four types of lenses and identify them as either converging (C) or diverging (D).

Solution

Problem 7.

A thin biconvex lens of refractive index 1.47 and diameter of 50.8 mm has radii of curvature of R1=1 cm and R2=0.5 cm.

(a) Find the focal point of the lens

(b) If the object is placed 2 cm from the lens, where is the image?

(c) What is the f/# of the lens?

(d) Calculate the NA of the lens

Solution

Problem 8.

What is the definition of an optical aberration? Also name the two types of optical aberrations.

Solution

Problem 9.

A grating has a groove density of 3600 grooves per mm. If the incident beam strikes the grating at an angle of 30°,

(a) What diffraction angle will the first order of 240 nm appear?

(b) What diffraction angle will the first order of 350 nm appear?

(c) What can we conclude about the relationship between diffraction angle and incident wavelength from the answers you calculated in a and b?

(d) What wavelength in the 2^{nd} order overlaps with the 350 nm 1^{st} order beam?

(e) What is the free spectral range for the 1^{st} order at 600 nm?

Solution

Problem 10.

For a fiber optic probe with core and cladding refractive indices of 1.50 and 1.48, respectively, and $\theta_i = 28°$, calculate:

(a) θ_r

(b) NA

Solution

Problem 11.

A monochromator has the following specifications:

- reciprocal linear dispersion = $1.5\,\mathrm{nm\,mm^{-1}}$
- focal length = $320\,\mathrm{mm}$
- f/# = 4.6
- grating size: $68 \times 68\,\mathrm{mm}$
- groove density = $1800\,\mathrm{grooves/mm}$

Calculate the following at $633\,\mathrm{nm}$ assuming the 1^{st} order is used:

(a) Angular dispersion

(b) Linear dispersion

(c) Slit width to obtain a $5\,\mathrm{nm}$ geometric spectral bandpass

Solution