1. **A beam of sunlight encounters a plate of crown glass at an angle of 45.00°. If the index of refraction for red light in crown glass is $n_r = 1.520$ and for violet light is $n_v = 1.538$, find the angle between the violet ray and the red ray in the glass.**

SOLUTION:

The angle that the light is refracted or bent is given by the Law of Refraction,

$$n_1 sin(q_1) = n_2 sin(q_2) .$$

Assuming that n_1 and q_1 refer to the air, the refracted angle in the glass is

$$q_2 = arcsin(n_1 sin(q_1)/n_2) .$$

For the each colour of light we get,

$$q_{red} = arcsin(1 \times sin(45.00°) / 1.520) = 27.7233° ,$$
$$q_{violet} = arcsin(1 \times sin(45.00°) / 1.538) = 27.3714° .$$

The difference is $Dq = 0.35°$.

This phenomenon where different colours of light refract at different angles is called *Dispersion* and leads to the rainbow of light formed by prisms.

2. The convex lens of a magnifying glass has a focal length of 20 cm. At what distance from the postage stamp must you hold this lens if the image of the stamp is to be twice as large as the stamp and
(a) the image is inverted, or
(b) the image is erect?

SOLUTION:

For a convex lens, f = +20 cm.

(a) Given that the image is inverted and twice as large, we have M = -2. Now our definition of magnification is M = -i/o, therefore i = 2o. Using the lens formula

$$1/o + 1/i = 1/f .$$

Substituting i = 2o , this becomes

$$1/o + 1/2o = 1/f ,$$

or

$$o = 3f/2 = 3(20 \text{ cm})/2 = 30 \text{ cm} .$$

Thus i = 2(30 cm) = 60 cm.

(b) Since the image is erect and twice as large, then M = +2. Therefore i = -2o. Substituting this into the lens equation

$$1/o - 1/2o = 1/f ,$$

yields

$$o = ½f = ½(20\ cm) = 10\ cm .$$

Thus i = -2(10 cm) = -20 cm.

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3. A lens forms an image of an object. The object is 20.0 cm from the lens. The image is 5.00 cm from the lens on the same side as the object.
(a) What is the focal length of the lens? Is the lens converging or diverging?
(b) If the object is 2.00 cm tall, how tall is the image? Is it erect or inverted?

SOLUTION:

(a) We are given that o = 20.0 cm and that i = -5.00 cm. The minus sign for i indicates that the image is on the same side of the lens as the object. Using the lens equation

$$1/f = 1/o + 1/i = 1/20 + 1/(-5) = -3/20 .$$

The focal length of the lens is thus -20/3 = -6.67 cm. The minus sign indicates that the lens is diverging or concave.

The magnification is given by

$$M = -i/o = -(-5)/20 = ¼ .$$

As well, the size of the image is given by

$$H_{image} = Mh_{object} = ¼(2.00\ cm) = 0.50\ cm .$$

The magnification is positive so the image is erect. As well the image is on the same side as the object, so it is virtual and virtual images are erect.

4. T/F- - As The Index Of Refraction Value Increases, The Optical Density Increases, And The Speed Of Light In That Material Decreases.

>> TRUE.