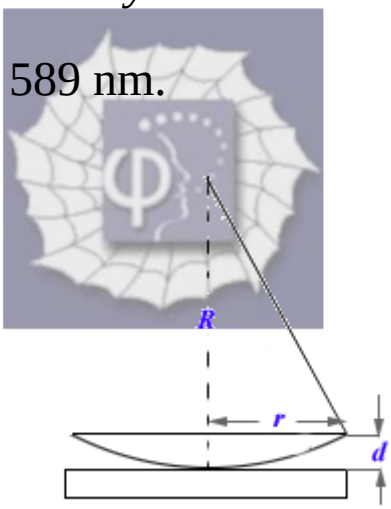
645.

Problem 45.43 (RHK)

In a Newton's ring experiment the radius of curvature R of the lens is 5.0 m *and its diameter is* 20 mm. (a) *We have to find the number of rings that are produced*; (b) *and estimate the number of rings that would be seen if the arrangement were immersed in water* $(n=1.33)$. *We may assume that the wavelength of the light used* λ *is* 589 nm.



Solution:

(a)

In the Newton's ring experimental set up, fringes are formed because of interference of light waves reflected from the top surface of the glass plate on which the lens is resting and those reflected from the curved surface of

the lens in contact with the air or other medium filling the gap. The waves that get reflected from the top of the glass plate undergo an additional phase change of π as the refractive index of the incident side is less than that of the transmitted side. Let the width of the gap between the lens and the plate be *d*. The condition for fringe formation is

$2d = \left(m + \frac{1}{2}\right)\lambda,\ m = 0,1,2,3.....$

It is given that the radius of curvature of the lens *R* is

$R = 5.0$ m,

and that the radius of the lens *r* is

$r = 1.0 \times 10^{-2}$ m.

Therefore, the maximum gap between the lens and the plate will be

$$d_{\max} = R - \sqrt{R^2 - r^2}\ ;\ R - \left(R - \frac{r^2}{2R}\right) = \frac{r^2}{2R}.$$

The total number of Newton's rings formed can be found from the condition for constructive interference when the width of the gap is $d_{\max}$.

We calculate

$$\frac{2d_{\max}}{\lambda} - \frac{1}{2}.$$

Using $\lambda = 589$ nm and the data of the problem, we find

$$\frac{\left(1.0\times10^{-2}\right)^2}{5.0\times589\times10^{-9}} - \frac{1}{2} = 33.9 - 0.5 = 33.4.$$

As the first ring corresponds to $m = 0$, and the last ring corresponds to $m = 33$, the total number of rings that will be seen in the experimental arrangement when the gap between the lens and the plate contains air will be 34.

(b)

We note that the refractive index of water $(n = 1.33)$ is less than the refractive index of glass, which is 1,50. Therefore, when the experimental set up is immersed in water, the mathematical conditions for the fringe formation will be the same as that given in the first part of the problem with the change that λ is replaced by λ_{water}. We calculate

$$\frac{2d_{\max}}{\lambda_{water}} - \frac{1}{2} = 33.9\times1.33 - 0.5 = 44.6.$$

The total number of Newton's rings seen when the set up is immersed in water will be 45.