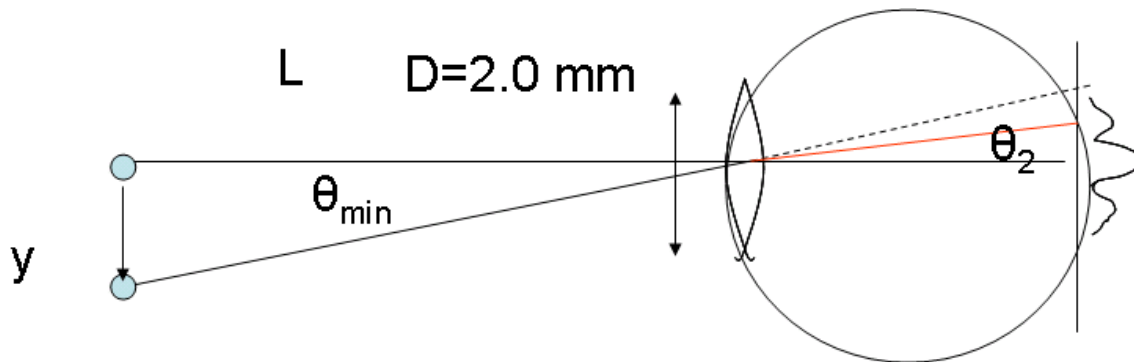Optical Instruments

25.36

Light is refracted as it enters the eye. Because the eye has a refractive index different from that of air light going through the center of the lens is changed from an angle of θ_{min} to θ_2. Note normally the angle would not change since the light would go back into air.

The smaller angle of refraction cancels out the smaller wavelength of light in the eye so that the Rayleigh criterion does not contain the refractive index of the eye.

$n_{eye} \sin \theta_2 = \sin \theta_{min}$ From the small angle approximation $n_{eye} \theta_2 = \theta_{min}$

But $\theta_2 = \dfrac{1.22 \lambda_{eye}}{D} = \dfrac{1.22 \lambda}{D n_{eye}}$

Therefore $\theta_{min} = n_{eye} \left(\dfrac{1.22 \lambda}{D n_{eye}} \right) = \dfrac{1.22 \lambda}{D}$

Part a) The limiting resolution of the eye for an aperture of 2 mm is

$\theta_{min} = \dfrac{1.22 \lambda}{D} = \dfrac{1.22(500 x 10^{-9} m)}{2 x 10^{-3} m} = 3.0 x 10^{-4} radians$

Part b) The diffraction limited distance to resolve two objects 1 cm apart for a diameter of 2 mm is

$L = \dfrac{y}{\theta_{min}} = \dfrac{1 x 10^{-2} m}{3 x 10^{-4}} = 33m$

25.38 If just resolved, the angular separation of the objects is $\theta = \theta_{m\,in} = 1.22\dfrac{\lambda}{D}$

and $s = r\theta = \left(200 \times 10^3 \text{ m}\right)\left[1.22\left(\dfrac{550 \times 10^{-9} \text{ m}}{0.35 \text{ m}}\right)\right] = 0.38 \text{ m} = \boxed{38 \text{ cm}}$