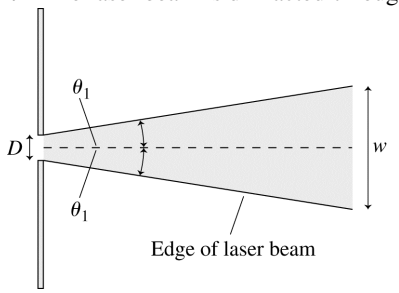
22.57. Model: The laser beam is diffracted through a circular aperture.

Visualize:



Solve: **(a)** No. The laser light emerges through a circular aperture at the end of the laser. This aperture causes diffraction, hence the laser beam must gradually spread out. The diffraction angle is small enough that the laser beam *appears* to be parallel over short distances. But if you observe the laser beam at a large distance it is easy to see that the diameter of the beam is slowly increasing.

(b) The position of the first minimum in the diffraction pattern is more or less the "edge" of the laser beam. For diffraction through a circular aperture, the first minimum is at an angle

$$\theta_1 = \frac{1.22\lambda}{D} = \frac{1.22\left(633\times10^{-9}\text{ m}\right)}{0.0015\text{ m}} = 5.15\times10^{-4}\text{ rad} = 0.0295°$$

(c) The diameter of the laser beam is the width of the diffraction pattern:

$$w = \frac{2.44\lambda L}{D} = \frac{2.44\left(633\times10^{-9}\text{ m}\right)(3\text{ m})}{0.0015\text{ m}} = 0.00309\text{ m} = 0.31\text{ cm}$$

(d) At $L = 1$ km $= 1000$ m, the diameter is

$$w = \frac{2.44\lambda L}{D} = \frac{2.44\left(633\times10^{-9}\text{ m}\right)(1000\text{ m})}{0.0015\text{ m}} = 1.03\text{ m} = 103\text{ cm}$$