

24. (a) We note that the cross section area of the beam is $\pi d^2/4$, where d is the diameter of the spot ($d = 2.00\lambda$). The beam intensity is

$$I = \frac{P}{\pi d^2/4} = \frac{5.00 \times 10^{-3} \text{ W}}{\pi[(2.00)(633 \times 10^{-9} \text{ m})]^2/4} = 3.97 \times 10^9 \text{ W/m}^2 .$$

- (b) The radiation pressure is

$$p_r = \frac{I}{c} = \frac{3.97 \times 10^9 \text{ W/m}^2}{2.998 \times 10^8 \text{ m/s}} = 13.2 \text{ Pa} .$$

- (c) In computing the corresponding force, we can use the power and intensity to eliminate the area (mentioned in part (a)). We obtain

$$F_r = \left(\frac{\pi d^2}{4} \right) p_r = \left(\frac{P}{I} \right) p_r = \frac{(5.00 \times 10^{-3} \text{ W})(13.2 \text{ Pa})}{3.97 \times 10^9 \text{ W/m}^2} = 1.67 \times 10^{-11} \text{ N} .$$

- (d) The acceleration of the sphere is

$$\begin{aligned} a &= \frac{F_r}{m} = \frac{F_r}{\rho(\pi d^3/6)} = \frac{6(1.67 \times 10^{-11} \text{ N})}{\pi(5.00 \times 10^3 \text{ kg/m}^3)[(2.00)(633 \times 10^{-9} \text{ m})]^3} \\ &= 3.14 \times 10^3 \text{ m/s}^2 . \end{aligned}$$