9.26 Consider the communication system shown in Fig. P9.26, with all components properly matched. If $P_t = 10$ W and $f = 6$ GHz:

(a) What is the power density at the receiving antenna (assuming proper alignment of antennas)?

(b) What is the received power?

(c) If $T_{sys} = 1{,}000$ K and the receiver bandwidth is 20 MHz, what is the signal-to-noise ratio in decibels?

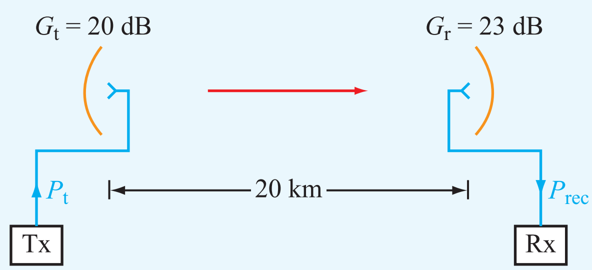

Figure P9.26 Communication system of Problem 9.26.

Solution:

(a) $G_t = 20$ dB $= 100$, $G_r = 23$ dB $= 200$, and $\lambda = c/f = 5$ cm. From Eq. (9.72),

$$S_r = G_t \frac{P_t}{4\pi R^2} = \frac{10^2 \times 10}{4\pi \times (2 \times 10^4)^2} = 2 \times 10^{-7} \qquad (\text{W/m}^2).$$

(b)

$$P_{rec} = P_t G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 = 10 \times 100 \times 200 \times \left(\frac{5 \times 10^{-2}}{4\pi \times 2 \times 10^4}\right)^2 = 7.92 \times 10^{-9} \text{ W}.$$

(c)

$$P_n = KT_{sys}B = 1.38 \times 10^{-23} \times 10^3 \times 2 \times 10^7 = 2.76 \times 10^{-13} \text{ W},$$

$$S_n = \frac{P_{rec}}{P_n} = \frac{7.92 \times 10^{-9}}{2.76 \times 10^{-13}} = 2.87 \times 10^4 = 44.6 \text{ dB}.$$