2.94 A communication satellite is in stationary (synchronous) orbit about the earth (assume altitude of 22,300 statute miles). Its transmitter generates 8.0 W. Assume the transmitting antenna is isotropic. Its signal is received by the 210-ft diameter tracking paraboloidal antenna on the earth at the NASA tracking station at Goldstone, California. Also assume no resistive losses in either antenna, perfect polarization match, and perfect impedance match at both antennas. At a frequency of 2 GHz, determine the:

(a) power density (*in watts/m²*) incident on the receiving antenna.

(b) power received by the ground-based antenna whose gain is 60 dB.

a) Per (2-102), $W_t = W_0 D_t = \frac{P_t D_t}{4\pi R^2}$

Here, $P_t = 8\,W$, $D_t = 1$ (isotropic), and

$$R = 22{,}300 \text{ miles} \left(\frac{1609.344\,m}{\text{mile}}\right) = 35{,}888{,}371.2\,m$$

$$W_t = \frac{8(1)}{4\pi(35{,}888{,}371.2)^2} \Rightarrow \underline{\underline{W_t = 4.9428 \times 10^{-16}\ \frac{W}{m^2}}}$$

b) Per (2-103), $P_r = W_t A_r$ and

per (2-110), $A_r = A_{em} = \frac{\lambda^2}{4\pi} D_0$

where $\lambda = \frac{c}{f} = \frac{2.9979 \times 10^8}{2 \times 10^9} = 0.149895\,m$ and

$$D_0 = 60\,dB_i = 10^{60/10} = 10^6$$

$$P_r = W_t A_r = W_t \frac{\lambda^2 D_0}{4\pi} = 4.9428 \times 10^{-16} \frac{0.149895^2\, 10^6}{4\pi}$$

$$P_r = 8.838 \times 10^{-13}\,W$$

$$\underline{\underline{P_r = 0.8838\,pW}}$$