13.41 A telemetry transmitter situated on the moon transmits 120 mW at 200 MHz. The gain of the transmitting antenna is 15 dB. Calculate the gain (in dB) of the receiving antenna (situated on earth) in order to receive 4 nW. Assume that the moon is 238,857 miles away from the earth and that 1 mile = 1.609 km.

$$r = 238,857 \text{ miles} \left(\frac{1.609 \text{ km}}{mi} \right) \left(\frac{1000 m}{1 \text{ km}} \right) = 384,320,913 m$$

Per the Friis transmission eqn (13.76)

$$P_r = G_{dr} \, G_{dt} \left[\frac{\lambda}{4\pi r} \right]^2 P_t \qquad \text{where } \lambda = \frac{2.9979 \times 10^8}{200 \times 10^6}$$

$$= 1.49895 m$$

$$4 \times 10^{-9} = G_{dr} \, 10^{15/10} \left[\frac{1.49895}{4\pi \, 384,320,913} \right]^2 120 \times 10^{-3}$$

$$\hookrightarrow G_{dr} = 1.094239 \times 10^{10}$$

$$G_{dr} (dB_i) = 10 \log_{10} 1.09424 \times 10^{10}$$

$$\underline{\underline{G_{dr} = 100.391 \, dB_i}}$$