1. A wireless receiver with an effective diameter of 250 cm is receiving signals at 20 GHz from a transmitter that transmits at a power of 30 mW and a gain of 30 dB.

   (a) What is the gain of the receiver antenna?

   (b) What is the received power if the receiver is 5 km away from the transmitter?

   [Solution]

   Given

   d_e = Effective diameter = 250 cm.

   f_c = Carrier frequency = 20 GHz.

   P_t = Transmitter power = 30 mW

   G_t = Transmitter gain = 30 dB = 1000.

   d = Distance of receiver = 5 km.

   A_e = Effective area = $(\frac{\pi d_e^2}{4}) = 4.91$ m^2

   λ = Wavelength = $\frac{\text{c (speed of light)}}{f_c} = 0.015$ m

   (a) G_r = Receiver antenna gain = $\frac{4\pi A_e}{\lambda^2} = 2.74 * 10^5 = 54.38$ dB.

   (b) P_r = Received power at distance of 5 km = $\frac{A_e G_t P_t}{4\pi d^2} = 4.69 * 10^{-7}$ Watts.

2. Consider an antenna transmitting a power of 5 W at 900 MHz. Calculate the received power at a distance of 2 km if propagation is taking place in free space.

   [***Solution***]

   Transmitted power = $P_t = 5$ W

   Carrier frequency = 900 MHz $\Longrightarrow \lambda = \frac{c}{f} = 0.33$ m

   $d = 2$ km

   Assuming unit gain in free space model, i.e., $G_t = G_r = 1$

   Received power can be calculated by the formula

$$P_r = \frac{G_t G_r P_t}{\left(\frac{4\pi d}{\lambda}\right)^2}$$
$$= 8.8 \times 10^{-10} \text{ W}$$

4. The transmission power is 40 W, under a free space propagation model,

   (a) What is the transmission power in unit of dBm?

   (b) The receiver is in a distance of 1000 m, what is the received power, assuming that the carrier frequency $f_c = 900$ MHz and $G_t = G_r = 1$ dB?

   (c) Express the free space path loss in dB.

[Solution]

(a) $10 \times \log(40 \times 1000) = 46$ dBm.

(b)

$$\begin{aligned} P_r &= \frac{G_t G_r P_t}{\left(\frac{4\pi d}{\lambda}\right)^2} \\ &= \frac{40 \times 1 \times 1 \times \left(\frac{1}{3}\right)^2}{(4 \times \pi \times 1000)^2} \\ &= 2.82 \times 10^{-8} \text{ W}. \end{aligned}$$

(c) $\Pr(\text{dB}) = 10 \times \log\left(2.82 \times 10^{-8}\right) = -75$ dB.

5. A receiver is tuned to 1 GHz transmission and receives signals with Doppler frequencies ranging from 10 Hz to 50 Hz when moving at a speed of 80 km/hr. What is the fading rate?

[Solution]

Moving speed $v = 80$ km/hr. $= 22.22$ m/sec

$v = 1$ GHz

Thus, $\lambda = c/v$,

where c is free space propagation speed and equals to 3×10^8 m/sec.

$\lambda = 0.1$ m

Therefore, the fading rate

$$\begin{aligned} N(rm) &= \frac{2v}{\lambda} \\ &= \frac{2 \times 22.22}{0.1} \\ &= 444.4 \text{ Hz.} \end{aligned}$$

Here we are not considering the Doppler shift because the θ is not given.