-3. Consider a time-invariant indoor wireless channel with LOS component at delay 23 ns, multipath component at delay 48 ns, and another multipath component at delay 67 ns. Find ne dela~~y spread assum~~ing that the demodulator synchronizes to the LOS component. Re-eat assuming that the demodulator synchronizes to the first ~~multipath component~~.

① To the LoS component: $T_m = \max \tau_n - \tau_0 = 44\,nm$

② To the first multipath component: $T_m = \max \tau_n - \tau_1 = 19\,ns$

3-4. Show that the minimum value of $f_c \tau_n$ for a system at $f_c = 1$ GHz with a fixed transmitter and a receiver separated by more than 10 m from the transmitter is much greater than 1.

$$\because \tau_{n\,min} = \frac{10\,m}{3\times 10^8\,m/s} = \frac{10}{3}\times 10^{-8}\,s$$

$$\therefore \text{min of } f_c\tau_n = 1\times 10^9 \times \frac{10}{3} \times 10^{-8} = 33 >> 1$$

3-5. Prove, for X and Y independent zero-mean Gaussian random variables with variance σ^2, that the distribution of $Z = \sqrt{X^2 + Y^2}$ is Rayleigh distributed and that the distribution of Z^2 is exponentially distributed.

$$F_z(z) = P[x^2 + y^2 \le z^2] = \iint_{x^2+y^2\le z^2} \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}}\,dxdy = \int_0^{2\pi}\int_0^{x} \frac{1}{2\pi\sigma^2} e^{\frac{-r^2}{2\sigma^2}}\,dr\,d\theta$$

$$= 1 - e^{-\frac{z^2}{2\sigma^2}} \quad (z \ge 0).$$

$$\because \frac{dF_z(z)}{dz} = \frac{z}{\sigma^2} e^{-\frac{z^2}{2\sigma^2}}$$

$\therefore$ z is Rayleigh distributed.

$$F_{z^2}(z) = P[Z \le \sqrt{z}] = 1 - e^{-\frac{z^2}{2\sigma^2}}$$

$$\frac{dF_{z^2}(z)}{dz} = \frac{1}{2\sigma^2} e^{-\frac{z^2}{2\sigma^2}}$$

$\therefore z^2$ is exponentially distributed.