1)

(a) $P_L = P_L^{free} + 10$

$$= 10 \log_{10}\left(\left(\frac{4\pi d_0}{\lambda}\right)^2 \frac{1}{G_t G_r} \right) + 10$$

$$= 101$$

$$\frac{P_t}{P_r} = \frac{1}{k}\left(\frac{d}{d_0}\right)^3 = \frac{1}{k}$$

$$\Rightarrow k_{dB} = -101$$

$$\frac{P_t}{P_r} = P_L \Rightarrow 10\,dBm - 101 = -91\,dBm = P_r$$

$$\frac{P_r}{P_t} = k\left(\frac{d_0}{d}\right)^3 \Rightarrow \frac{P_{rA}}{P_{rB}} = \left(\frac{d_B}{d_A}\right)^3 \Rightarrow 2 = \left(\frac{1\,km}{d_A}\right)^3$$

$$\Rightarrow d_A = 793.7\ m$$

(b) $\mu_{\psi_{dB}} = 1 \qquad \sigma_{\psi_{dB}} = 3$

$$\text{outage} = P(P_r < P_{min}) = P(P_r^{PL} + \psi_{dB} < P_{min})$$

$$1 - Q\left(\frac{P_{min} - P_r^{PL} - \mu_{\psi_{dB}}}{\sigma}\right)$$

$$= 0.02$$

$$\sigma Q^{-1}(0.98) = P_{min} - P_r^{PL} - \mu_{\psi_{dB}}$$

$$\Rightarrow P_r^{PL} = P_{min} - \sigma Q^{-1}(0.98) - \mu_{\psi_{dB}}$$

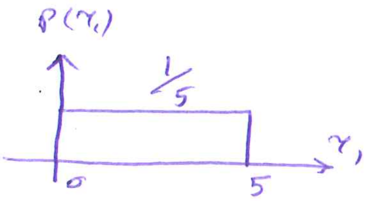
$$= -80 - 3 \times (-2.0537) - 1$$

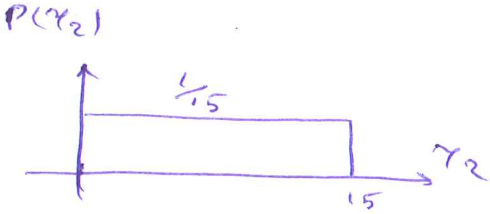
$$= -74.83\,dBm$$

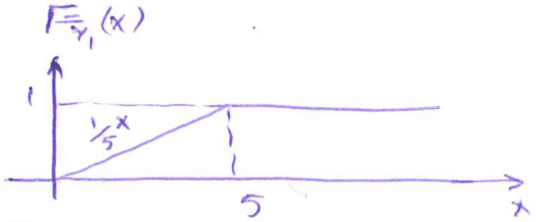
$$\frac{P_r}{P_t} = k\left(\frac{1\,km}{d}\right)^3 \Rightarrow d = 3459.39$$

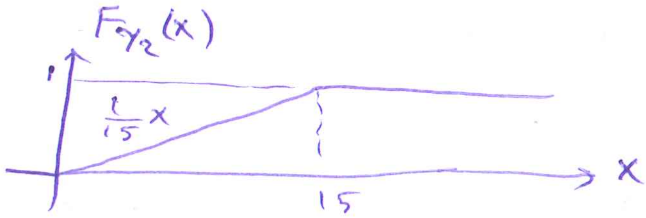
c) SC:

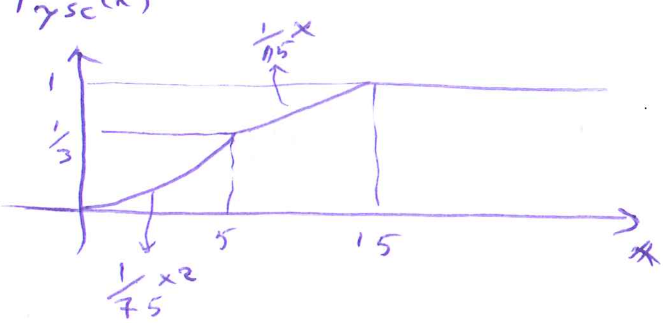
$$F_{\gamma^{sc}}(x) = P(\gamma^{sc} < x) = P(\gamma_1 < x)\, P(\gamma_2 < x)$$
$$= F_{\gamma_1}(x)\, F_{\gamma_2}(x)$$

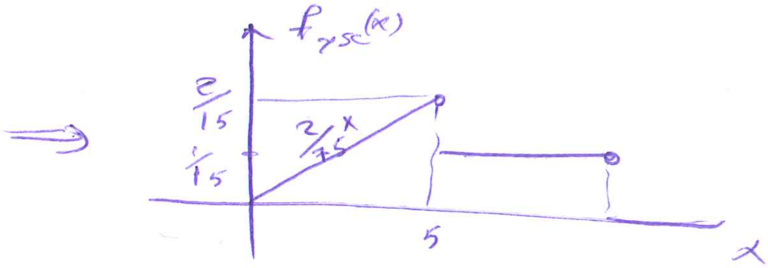




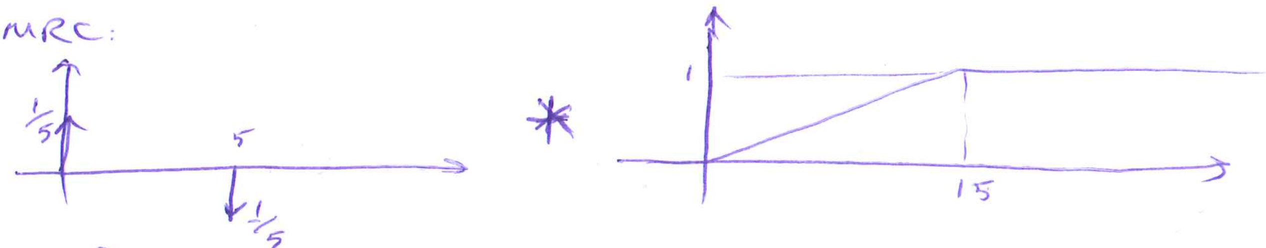


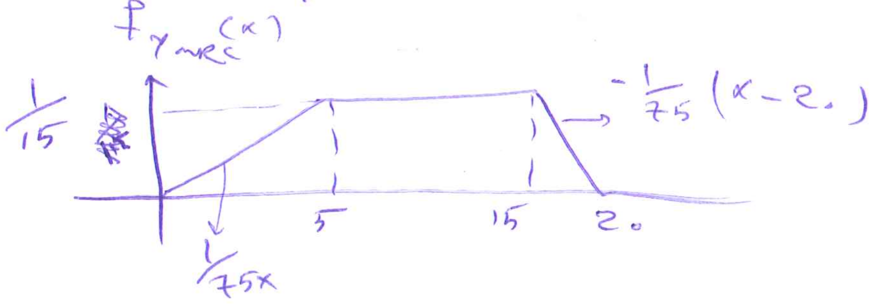






MRC:





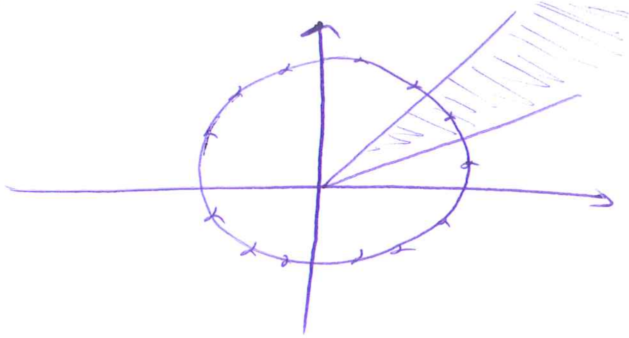
d) $P_{out}^{sc} = P(\gamma^{sc} < 3) = F_{\gamma sc}(3) = \boxed{\frac{9}{75}}$

$P_{out}^{MRC} = P(\gamma^{MRC} < 3) = F_{\gamma^{MRC}}(3) = \int_0^3 f_{\gamma^{MRC}}(x)\,dx$

$= \frac{x^2}{2 \times 75}\Big|_{x=3}$

$= \boxed{\frac{9}{2 \times 75}}$

1- MPSK



Due to phase noise the received signal only rotates on a circle where the radius corresponds to the received SNR. So

$$\bar{P}_s = 1 - \frac{1}{M}$$

2- $f_d^1 = \frac{V\cos\theta}{\lambda} = f_d$

$$f_d^2 = \frac{V\cos(\theta \pm 180)}{\lambda} = -\frac{V\cos\theta}{\lambda}$$

$$\Delta f_d = f_d^2 - f_d^1 = -\frac{2V\cos\theta}{\lambda} = -2f_d$$

3) $h_1, \ldots h_N \sim CN(0;\sigma^2)$

$\underline{h} = [h_1, \ldots h_N]$ $\qquad \underline{h} + c = \underline{h}' \sim$

c: constant $\Rightarrow |h'|^2 \sim$ Ricean

Since the constant "c" means getting a signal from a LOS.