TLT-6206 Radio propagation in wireless networks
Final examination
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Calculators allowed! You can answer in Finnish or English. You have to answer to all five (5) questions.

1. Answer or explain shortly the following (1 point each, totally 6p):

   a) Diffraction
   b) Coherence time
   c) EIRP
   d) Fast fading
   e) Slow fading
   f) Channel rank

2. A broadcast system is targeted to provide coverage over a 4 km range. The minimum reception level of a receiver is -110 dBm with 7 dBi antenna gain at the TX and 0 dBi at the RX.

   a) What would be the required transmit power (P_t) when the path loss is modeled with Okumura-Hata model given as

   $$L_{OH} = 135 + 35\log_{10}(R) \quad \text{[dB]}$$

   where R is the distance in [km]. (2p)

   b) Provided that you have to take into account also slow fading such that

   $$L_{TOT} = L_{OH} + L_S \quad \text{[dB]}$$

   where L_s is a Gaussian random variable with zero-mean and standard deviation σ=10 dB. Determine the required transmit power P_t for 95% time availability. (3p)

   c) What is the impact of frequency on the propagation loss for the above system? (1p)

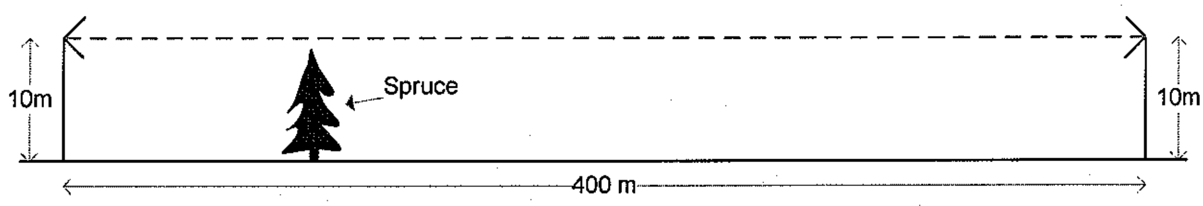
3. Calculate the total excess delay, mean delay, and RMS delay spread for a channel whose power delay profile is specified in the table below.

Relative delay [μs]	Average relative power [dB]
0.0	-3.0
0.5	0.0
0.6	-2.0
1.6	-6.0
2.3	-8.0
10.0	-10.0
12.0	-11.0

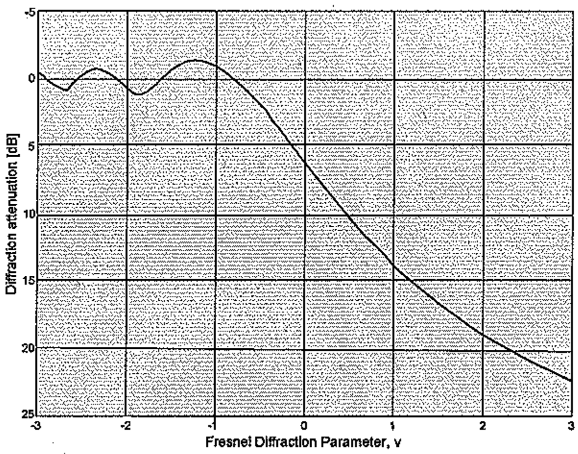
Would the channel be regarded as a wideband channel if the symbol period is 10 μs?

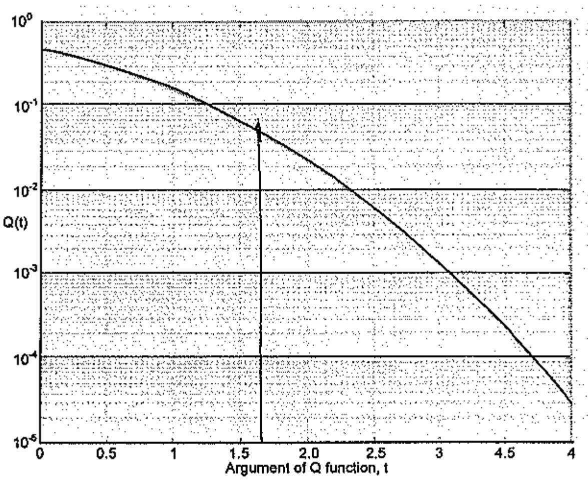
4. Compare different propagation models. What advantages and disadvantages they have? Describe shortly one from each model type.

5. Two 10m stationary transceivers are located 400 m apart from each other operating at 400MHz band. Moreover, there is a perfect Xmas-spruce located 100 m away from one of the transceivers. How tall can the spruce be until it blocks the radio line-of-sight connection between transceivers?



Some useful stuff





$$\text{Fresnel coefficient } v \approx \pm h\sqrt{\frac{2(d_1+d_2)}{\lambda d_1 d_2}} = \frac{\pm h}{r_n}\sqrt{2n},$$

$$\tau_0 = \frac{1}{P_T}\sum_{i=1}^{n} P_i \tau_i \qquad P_T = \sum_{i=1}^{n} P_i \qquad r_n \approx \sqrt{\frac{n\lambda d_1 d_2}{d_1+d_2}} \qquad \tau_{RMS} = \sqrt{\frac{1}{P_T}\sum_{i=1}^{n} P_i {\tau^2}_i - {\tau^2}_0}$$

$$\text{Rms Doppler spread } v_{rms} = \sqrt{\frac{\sum_{i=1}^{N}(v_i - v_0)^2 \phi_H(v)}{\sum_{i=1}^{N}\phi_H(v)}}, \text{ where } v_0 = \frac{\sum_{i=1}^{N} v_i \phi_H(v)}{\sum_{i=1}^{N}\phi_H(v)}$$

Q(-t)=1-Q(t)
Q(0)=0.5
Pr{X>t}=Q(t/σ), where X is Gaussian random variable and σ its standard deviation.