Assignment 2: Propagation

Problem 2.1

A mobile phone is located 5 km away from a base station. It uses a vertical $\lambda/4$ monopole antenna with a gain of 2.55 dB to receive cellular radio signals. The free space E-field at 1 km from the transmitter is measured to be 10^{-3} V/m. The carrier frequency used for this system is $f = 900\,$MHz.

a) Find the length and effective aperture of the receiving antenna.

b) Find the received power at the mobile using the 2-ray ground reflection model assuming the height of the transmitting antenna is 50 m, and the receiving antenna is 1.5 m above ground.

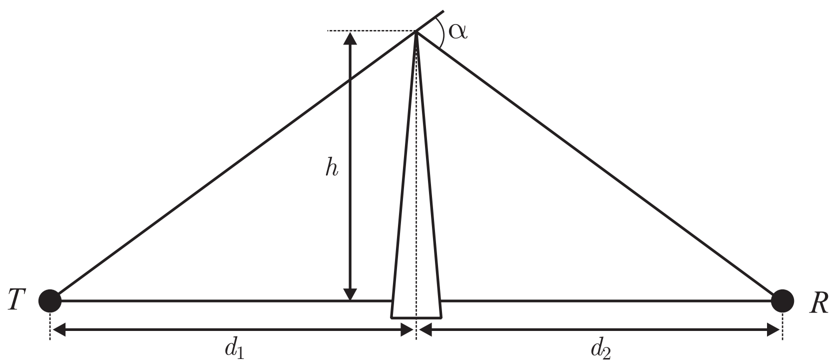
Problem 2.2

Compute the diffraction loss for the three cases shown in the figure below. Assume $\lambda = 1/3\,$m, $d_1 = 1\,$km, $d_2 = 1\,$km, and

a) $h = 25$ m,

b) $h = 0$ m,

c) $h = -25$ m.



Compare your answers using values from the graph showing the knife-edge diffraction in function of the diffraction parameter υ, as well as the approximate solution given by the equation on slide 3.65. For each of these cases identify the Fresnel zone within which the tip of the obstruction lies.

Problem 2.3

A base station transmits a power of 10 W into a feeder cable with a loss of 10 dB. The transmit antenna has a gain of 12 dBd (dBd refers to a $\lambda/2$ dipole) in the direction of a mobile receiver, with antenna gain 0 dBd and feeder loss 2 dB. The mobile receiver has a sensitivity of –104 dBm.

a) Determine the maximum acceptable path loss.

b) Calculate the maximum range of the communication system, assuming $h_1 = 1.5\,\text{m}$, $h_2 = 30\,\text{m}$, $f = 900\,\text{MHz}$ and that propagation takes place over a plane earth.

How does this range change if the base station height is doubled?

Problem 2.4

At one time, a system for global mobile telephony was suggested where the users communicate to and from different satellites. In this case, 66 satellites were to be placed 180 km over the earth and have a maximum dimension of 12 m × 12 m × 6 m. Assume that the mobile telephone antenna is linearly polarized and with a maximum gain of 1.5 dB, the mobile transmit power is 1 W, the attenuation in the atmosphere is 3 dB and the frequency 1.8 GHz.

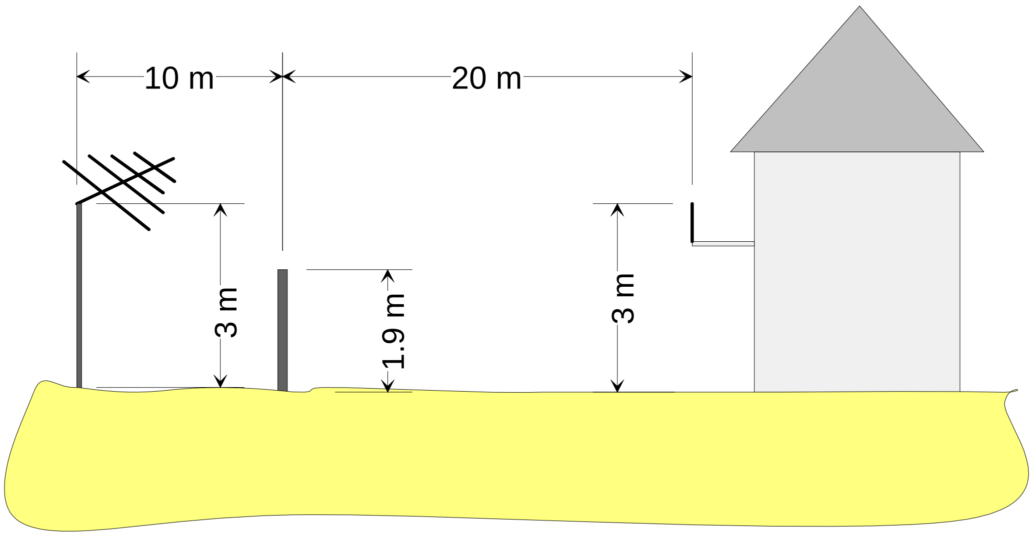
a) Determine the required antenna gain of a circularly polarized satellite antenna if the received power at the satellite must be at least 100 pW.

b) What approximate area does this gain correspond to?

c) Is the suggested system possible to build?

Problem 2.5

A microwave link working at 6 GHz is installed in the vicinity of an apartment house. The antenna is installed at a height of 3 m and at a distance of 30 m from the house. The tenant (Mieter) of the house measures on his balcony (3 m above ground) an electrical field strength which is 3 times higher than allowed by health regulations. A wall with a height of 1.9 m stands between the house and the antenna at a distance of 10 m from the antenna. Assume that there are no ground reflections and that the wall is thin and completely absorbing.



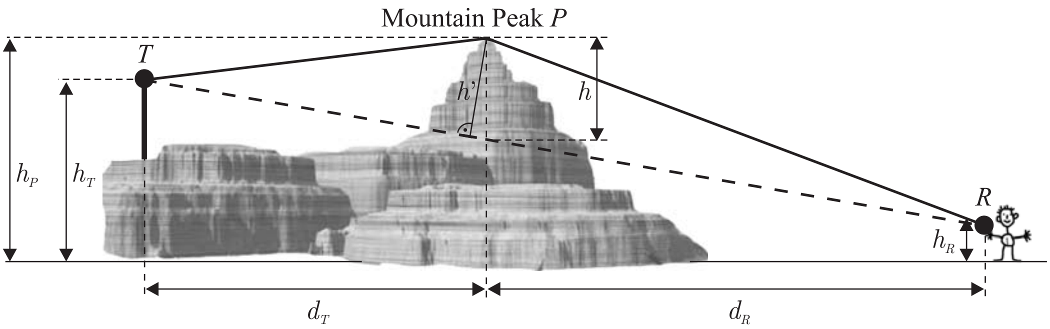
a) How much higher (approximate result $\pm 10\%$) would be the field strength without the wall standing there?

b) By how much has the wall to be heightened (approximate result $\pm 10\%$) in order to reduce the field strength on the balcony below the maximum value allowed by health regulations?

c) During the heightening of the wall a slight increase of the field strength was noticed. For approximately which height could this be possible?

Problem 2.6

The peak of a mountain (P) is located between a radio station (transmitter T) and a listener (receiver R), holding a portable radio at a height of $h_R = 2\,\text{m}$. The radio station transmits on a frequency of $f = 100\,\text{MHz}$, and is positioned at a height $h_T = 90\,\text{m}$. The height of the mountain is $h_P = 100\,\text{m}$. The ground distance between T and the mountain is $d_T = 300\,\text{m}$, and between R and the mountain $d_R = 500\,\text{m}$.
Note: The mountain can be assumed to be thin and completely absorbing. There are no ground reflections.



a) Perform a geometrical simplification of the knife-edge problem. Calculate the height h' of the triangle $\triangle_{TPR}$. Assume that $h' = h$.

b) Which would be the maximum height $h_{P,\max}$ of peak P in order to have no significant effect on the transmission (according to the Fresnel zone clearance rule of thumb).

c) Calculate approximately the fraction of power that R is receiving in case a) compared to b).