# Digital Communications
## *Practical Lecture*

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### Question 1

Write a function that takes as an input a parameter `nb_symbols`, a parameter `modulation` and a parameter `modulation_length` which returns a vector `x` of `nb_symbols` symbols identically distributed from the modulation of type `modulation` and order `modulation_length`. The vector `x` is required to have mean power `Es`, such that the energy per bit `Eb` is 1. The modulation types `modulation` are `'pam'` (PAM modulation) and `'qam'` (QAM modulation), and the orders can be taken to be 4, 16 or 64.

### Question 2

Simulate the data transmission of a large vector `x` with additional noise `z` complex Gaussian with variance `N0`. The resulting received signal vector is called `y`. Simulate such transmitted symbols for different modulation types, different `N0`, and plot the resulting constellations `y`.

**Question 3**

Generate a vector `hat_x` which contains at each position the maximum likelihood decision for `x` given `y`. Generate such an `hat_x` vector for all modulation types, and for different modulation orders.

# Symbol Error

### Question 4

Evaluate the probability of symbol error `SER` obtained from the maximum likelihood rule above. Compare to the theoretic `SER_theory`.

# Symbol Error Curve

**Question 5**

Turn `SER` and `SER_theory` into vectors containing the empirical and theoretic symbol errors, respectively, for different ratios `Eb/N0`. The ratios `Eb/N0` will span from $-10$ dB to 20 dB.

### Question 6

A usual rule for the energy decay in a wireless urban channel is to assume that, for a user at distance $d$ (in meters) from the base station, the received symbol energy $E_s$ (degraded by the distance) is of order $-(31.5 + 35 \log_1 0d)$ dB. Which constellation orders can be used 100 m, 200 m, 500 m and 1 km away from the base station if we wish to transmit video/voice (i.e. non-sensitive data) or very sensitive data? What is the expected data rate? How can that be further improved?