# Exercise 9

## Problem 1

a) Use the Bilinear transformation and construct a 3. order digital Butterworth low pass filter with cut-off frequency 1 kHz and sampling frequency 5 kHz. Find $H(z)$ as a cascade connection of a second order and a first-order filter.

b) Sketch the magnitude frequency response in the same figure for the analog 3. order LP Butterworth filter with cut off frequency 1kHz and the digital filter from 1a). (Use the formula for the attenuation of the Butterworth filters or the attenuation graphs for normalized, analog, Butterworth filters).

c) A digital Butterworth filter with cut-off frequency 500Hz and at least 60dB attenuation at 2 kHz shall be constructed. The sampling frequency should be 5 kHz. What order should the filter be?

d) What filter order is necessary, if the sampling rate was changed to 10 kHz and the specification of 1c) otherwise still apply?

e) The sequence $x(n) = cos(\pi n/5) + cos(2\pi n/5)$ is sent into the filter from 1c). What are the magnitudes of the two frequency components out of the filter after the output has stabilized? (The sampling rate is 5 kHz).