1) It is required to design an equivalent analog filter using a digital filter and other appropriate components. The sampling frequency is \( f_{\text{samp}} = 20 \text{ kHz} \) and the attenuation (\( \alpha \)) specifications of the filter are as follows:

- \( \alpha \geq 42 \text{ dB} \) for \( 0 \leq f \leq 600 \text{ Hz} \) and \( f \geq 4000 \text{ Hz} \).
- \( \alpha \leq 0.5 \text{ dB} \) for \( 1000 \text{ Hz} \leq f \leq 2000 \text{ Hz} \)

a) Determine the equivalent requirements of the digital filter.

b) Design a filter to meet the requirements specified in part a) with the minimum possible order. Give the transfer function and hence the difference equation.

c) Determine the poles and zeros.

d) Give the direct (canonical) and cascade (product of first and second order systems) structures for implementing the digital filter.

e) Investigate the effect of coefficient quantization on the stability and frequency response (magnitude, phase and group delay) for the two structures.

f) Determine the minimum number of bits needed to meet the given requirements (attenuation) within a tolerance of 1 dB.

Verify your results through simulation.