Problem 1 (20 points)

A signal $s(t)$ has a *continuous* probability density function given by

$$p(s) = \begin{cases} \alpha_1 s + \alpha_0, & -4 < s \leq 0 \\ -\alpha_1 s + \alpha_0, & 0 \leq s < 4 \\ 0, & |s| \geq 4 \end{cases}$$

(a) [5pts] Find the constants α_0 and α_1.

(b) [5pts] This signal is quantized to four levels for PCM transmission. Determine the step size Δ and the quantized signal levels.

(c) [5pts] Explain, with suitable diagrams, how a delta modulation system works.

(d) [5pts] If Δ is the step size of quantization and T is the sampling period, determine the maximum amplitude of a sinusoidal signal $s(t) = A \sin \omega t$ such that slope overloading does not occur when the signal is delta-modulated.

Problem 2 (20 points)

A wireline channel of length 1000 km is used to transmit data by means of BPSK modulation. Regenerative repeaters are spaced 50 km apart along the system. Each segment of the channel has an ideal (constant) frequency response over the frequency band $0 \leq f \leq 1200$Hz and an attenuation of 1 dB/km. The channel noise is AWGN.

(a) [6pts] What is the highest bit rate that can be transmitted without ISI?

(b) [6pts] Determine the required E_b/N_0 to achieve a bit error of $P_e = 10^{-7}$ for each repeater. (Your can express your answer in terms of the *erfc* function)

(c) [8pts] Determine the transmitted power at each repeater to achieve the desired E_b/N_0 where $N_0 = 4.1 \times 10^{-21}$ W/Hz.