PROBLEM 1.1. Consider a channel with an ideal low-pass-filter frequency response, bandlimited to $|f| < 2500$ Hz.

(a) If we are to avoid ISI, what is the maximum symbol rate?

(b) If we are to avoid ISI, and if the transmitter pulse shape $g(t)$ is going to be the raised-cosine pulse shape of (7.62) in the book, with $\alpha = 0.5$ (in other words, 50% excess bandwidth), what is the maximum symbol rate?

PROBLEM 1.2. A 4-ary PAM transmitter is to transmit information with a symbol rate of 2400 symbols/sec, or 2400 baud. What is the minimum channel bandwidth required to avoid ISI?

PROBLEM 1.3. Consider an 8-ary PAM signal $s(t) = \sum_{k=-\infty}^{\infty} a_k g(t - kT)$, where $a_k \in \{\pm 1, \pm 3, \pm 5, \pm 7\}$, where $g(t) = \sin(5\pi t / T) / (5\pi t)$, and where $1 / T = 52$ kbaud.

(a) Is there intersymbol interference?

(b) Is $g(t)$ a Nyquist pulse for this baud rate?

(c) What is the bit rate $R_b$?

(d) How much channel bandwidth does the signal $s(t)$ require?

PROBLEM 1.4. Answer true or false for each question below. If true, explain why. If false, give a counterexample.

(a) True or False: A Nyquist pulse must have a finite bandwidth.

(b) True or False: If $p(t)$ is a Nyquist pulse for symbol rate $1 / T$, then $p(t)$ cannot be a Nyquist pulse for symbol rate $2 / T$.

(c) True or False: If $p(t)$ is a Nyquist pulse for symbol rate $1 / T$, then $p(t)$ is a Nyquist pulse for symbol rate $1 / (2T)$.

(d) Let $b(t)$ be a real received pulse in a PAM system, and let $p(t) = b(t) * b(-t)$ be the overall pulse shape after a matched filter. (The symbol $*$ denotes convolution.) True or False: If $b(t)$ is a Nyquist pulse, then $p(t)$ cannot be a Nyquist pulse.

PROBLEM 1.5. Do the pulse shapes with frequency responses sketched below satisfy the Nyquist criterion? Explain.

![Diagram](a)

![Diagram](b)
PROBLEM 1.6. Consider a binary PAM transmitter transmitting the signal \( s(t) = \sum_{k=\pm} a_k g(t - kT) \), where \( a_k \in \{ \pm 1 \} \), and where the transmitter pulse shape \( g(t) \) is:

\[
g(t) = \cos(\pi t / T), \\
t \in [-T/2, T/2]
\]

The signal \( s(t) \) is transmitted across a channel, as shown below:

\[
s(t) \quad h(t) \quad r(t)
\]

The channel impulse response is \( h(t) = \delta(t) - 0.1 \delta(t - T) \), where \( \delta(t) \) is the Dirac impulse function. Carefully sketch the eye diagram for the noiseless received signal \( r(t) \).

PROBLEM 1.7. Consider the binary PAM signal \( r(t) = \sum_{k=\pm} a_k p(t - kT) \) without noise, where \( a_k \in \{ \pm 1 \} \) and \( p(t) \) is the overall pulse shape. For each of the given following pulse shapes, carefully sketch the eye diagram for this signal.

\[
p(t) = \cos(\pi t / T), \\
t \in [-T/2, T/2]
\]

(a)

(b)

(c)

(d)

(e)