Problem 7.3

(a) \( g(t) = \text{sinc}(200t) \)

This sinc pulse corresponds to a bandwidth \( W = 100 \text{ Hz} \). Hence, the Nyquist rate is 200 Hz, and the Nyquist interval is 1/200 seconds.

(b) \( g(t) = \text{sinc}^2(200t) \)

This signal may be viewed as the product of the sinc pulse \( \text{sinc}(200t) \) with itself. Since multiplication in the time domain corresponds to convolution in the frequency domain, we find that the signal \( g(t) \) has a bandwidth equal to twice that of the sinc pulse \( \text{sinc}(200t) \), that is, 200 Hz. The Nyquist rate of \( g(t) \) is therefore 400 Hz, and the Nyquist interval is 1/400 seconds.

(c) \( g(t) = \text{sinc}(200t) + \text{sinc}^2(200t) \)

The bandwidth of \( g(t) \) is determined by the highest frequency component of \( \text{sinc}(200t) \) or \( \text{sinc}^2(200t) \), whichever one is the largest. With the bandwidth (i.e., highest frequency component of) the sinc pulse \( \text{sinc}(200t) \) equal to 100 Hz and that of the squared sinc pulse \( \text{sinc}^2(200t) \) equal to 200 Hz, it follows that the bandwidth of \( g(t) \) is 200 Hz. Correspondingly, the Nyquist rate of \( g(t) \) is 400 Hz, and its Nyquist interval is 1/400 seconds.
Problem 7.7

(a) The sampling interval is $T_x = 125 \mu s$. There are 24 channels and 1 sync pulse, so the time allotted to each channel is $T_c = T_x/25 = 5 \mu s$. The pulse duration is 1 $\mu s$, so the time between pulses is 4 $\mu s$.

(b) If sampled at the Nyquist rate, 6.8 kHz, then $T_x = 147 \mu s$, $T_c = 6.68 \mu s$, and the time between pulses is 5.68 $\mu s$. 
Problem 7.17

(a) Let the message bandwidth be $W$. Then, sampling the message signal at its Nyquist rate, and using an $R$-bit code to represent each sample of the message signal, we find that the bit duration is

$$T_b = \frac{T_s}{R} = \frac{1}{2WR}$$

The bit rate is

$$\frac{1}{T_b} = 2WR$$

The maximum value of message bandwidth is therefore

$$W_{\text{max}} = \frac{50 \times 10^6}{2 \times 7}$$

$$= 3.57 \times 10^6 \text{ Hz}$$

(b) The output signal-to-quantizing noise ratio is given by (see Example 2):

$$10\log_{10}(\text{SNR})_0 = 1.8 + 6R$$

$$= 1.8 + 6 \times 7$$

$$= 43.8 \text{ dB}$$
Problem 7.21

The modulating wave is

\[ m(t) = A_m \cos(2\pi f_m t) \]

The slope of \( m(t) \) is

\[ \frac{dm(t)}{dt} = -2\pi f_m A_m \sin(2\pi f_m t) \]

The maximum slope of \( m(t) \) is equal to \( 2\pi f_m A_m \).

The maximum average slope of the approximating signal \( m_d(t) \) produced by the delta modulator is \( \delta/T_s \), where \( \delta \) is the step size and \( T_s \) is the sampling period. The limiting value of \( A_m \) is therefore given by

\[ 2\pi f_m A_m > \frac{\delta}{T_s} \]

or

\[ A_m > \frac{\delta}{2\pi f_m T_s} \]

Assuming a load of 1 ohm, the transmitted power is \( A_m^2/2 \). Therefore, the maximum power that may be transmitted without slope-overload distortion is equal to \( \delta^2 / 8\pi^2 f_m^2 T_s^2 \). 
Problem 7.22

\[ f_s = 10f_{\text{Nyquist}} \]

\[ f_{\text{Nyquist}} = 6.8 \, \text{kHz} \]

\[ f_s = 10 \times 6.8 \times 10^3 = 6.8 \times 10^4 \, \text{Hz} \]

\[ \frac{\Delta}{T_s} \geq \max \left| \frac{dm(t)}{dt} \right| \]

For the sinusoidal signal \( m(t) = A_m \sin(2\pi f_m t) \), we have

\[ \frac{dm(t)}{dt} = 2\pi f_m A_m \cos(2\pi f_m t) \]

Hence,

\[ \left| \frac{dm(t)}{dt} \right|_{\text{max}} = \left| 2\pi f_m A_m \right|_{\text{max}} \]

or, equivalently,

\[ \frac{\Delta}{T_s} \geq \left| 2\pi f_m A_m \right|_{\text{max}} \]

Therefore,

\[ |A_m|_{\text{max}} = \frac{\Delta}{T_s \times 2\pi \times f_m} \]

\[ = \frac{\Delta f_s}{2\pi f_m} \]

\[ = \frac{0.1 \times 6.8 \times 10^4}{2\pi \times 10^3} \]

\[ = 1.08 \, \text{V} \]