CHAPTER 3

PRACTICE SET

Questions

Q3-1. The period of a signal is the inverse of its frequency and vice versa: T = 1/*f* and *f* = 1/T.

Q3-3. *Fourier series* gives the frequency domain of a periodic signal; *Fourier analysis* gives the frequency domain of a nonperiodic signal.

Q3-5. *Baseband transmission* means sending a digital or an analog signal without modulation using a low-pass channel. *Broadband transmission* means to modulate signal using a band-pass channel.

Q3-7. The *Nyquist theorem* defines the maximum bit rate of a noiseless channel.

Q3-9. A fiber-optic cable uses light (very high frequency). Since *f* is very high, the wavelength, which is $\lambda = c / f$, is very low.

Q3-11. The frequency domain of a voice signal is normally *continuous* because voice is a nonperiodic signal.

Q3-13. This is *baseband transmission* because no modulation is involved.

Q3-15. This is *broadband transmission* because it involves modulation.

Problems

P3-1.

a.	$T = 1/f$	$= 1 / (24\text{ Hz})$	$= 0.0417\text{ s}$	$= 41.7\text{ ms}$
b.	$T = 1/f$	$= 1 / (8\text{ MHz})$	$= 0.000000125\text{ s}$	$= 0.125\text{ ms}$
c.	$T = 1/f$	$= 1 / (140\text{ kHz})$	$= 7.14 \times 10^{-6}\text{ s}$	$= 7.14\text{ ms}$

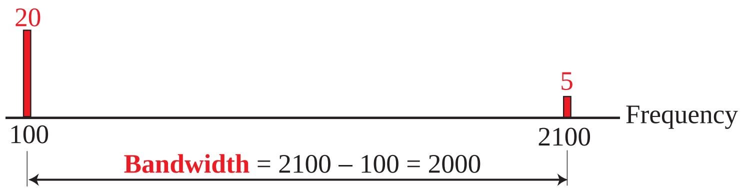
P3-3.

a. 90 degrees ($\pi/2$ radians)

b. 0 degrees (0 radians)

c. 90 degrees ($\pi/2$ radians) (Note that it is the same wave as in part *a*.)

P3-5. We know the bandwidth is 2000. The highest frequency must be 100 + 2000 = 2100 Hz. See below:



P3-7.

a. bit rate = 1/ (bit duration) = 1 / (0.001 s) = 1000 bps = 1 Kbps

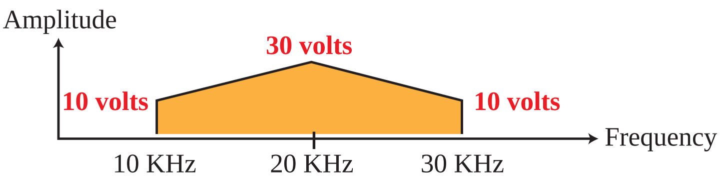
b. bit rate = 1/ (bit duration) = 1 / (2 ms) = 500 bps

c. bit rate = 1/ (bit duration) = 1 / (20 μs/10) = 1 / (2 μs) = 500 Kbps

P3-9. There are 8 bits in 16 ns. Bit rate is $8 / (16 \times 10^{-9}) = 0.5 \times 10^{9} = 500$ Mbps

P3-11. The bandwidth is $5 \times 5 = 25$ Hz.

P3-13. The signal is nonperiodic, so the frequency domain is made of a continuous spectrum of frequencies as shown below:



P3-15. We can calculate the attenuation as shown below:

$$\text{dB} = 10 \log_{10} (90 / 100) = -0.46 \text{ dB}$$

P3-17. The total gain is $3 \times 4 = 12$ dB. To find how much the signal is amplified, we can use the following formula:

$12 = 10 \log (P_2/P_1) \quad \rightarrow \quad \log (P_2/P_1) = 1.2 \quad \rightarrow \quad P_2/P_1 = 10^{1.2} = 15.85$

The signal is amplified almost 16 times.

P3-19. $480 \text{ s} \times 300{,}000 \text{ km/s} = 144{,}000{,}000 \text{ km}$

P3-21. We use the Shannon capacity $C = B \log_2 (1 + SNR)$

$C = 4{,}000 \log_2 (1 + 1{,}000) \approx 40 \text{ Kbps}$

P3-23. The file contains $2{,}000{,}000 \times 8 = 16{,}000{,}000$ bits.

a. With a 56-Kbps channel, it takes $16{,}000{,}000/56{,}000 = 289 \text{ s} \approx 5$ minutes.

b. With a 1-Mbps channel, it takes $16{,}000{,}000/1{,}000{,}000 = 16$ s.

P3-25. We have

$SNR = (200 \text{ mW}) / (10 \times 2 \times \mu\text{W}) = 10{,}000$

$SNR_{dB} = 10 \log_{10} SNR = 10 \log_{10} 10000 = 40$

P3-27. We can approximately calculate the capacity as

a. $C = B \times (SNR_{dB} /3) = 20 \text{ KHz} \times (40 /3) = 267 \text{ Kbps}$

b. $C = B \times (SNR_{dB} /3) = 200 \text{ KHz} \times (4 /3) = 267 \text{ Kbps}$

c. $C = B \times (SNR_{dB} /3) = 1 \text{ MHz} \times (20 /3) = 6.67 \text{ Mbps}$

P3-29. We can use the approximate formula

$$C = B \times (SNR_{dB} /3) \text{ or } SNR_{dB} = (3 \times C) / B$$

We can say that the minimum of SNR_{dB} is

$$SNR_{dB} = 3 \times 100 \text{ Kbps} / 4 \text{ KHz} = 75$$

This means that the minimum

$$SNR = 10\ SNR_{dB}/10 = 107.5 \approx 31{,}622{,}776$$

P3-31. The bit duration is the inverse of the bandwidth.We have

(bit length) = (propagation speed) ´ (bit duration)

a. Bit length = $(2 \times 10^8 \text{ m}) \times [(1 / (1 \text{ Mbps})] = 200$ m. This means a bit occupies 200 meters on a transmission medium.

b. Bit length = $(2 \times 10^8 \text{ m}) \times [(1 / (10 \text{ Mbps})] = 20$ m. This means a bit occupies 20 meters on a transmission medium.

c. Bit length = $(2 \times 10^8 \text{ m}) \times [(1 / (100 \text{ Mbps})] = 2 \text{ m}$. This means a bit occupies 2 meters on a transmission medium.

P3-33. We have Latency = $\text{Delay}_{pr} + \text{Delay}_{qu} + \text{Delay}_{tr} + \text{Delay}_{pg}$

$\text{Delay}_{pr} = 10 \times 1\ \mu s = 10\ \mu s$ **// Processing delay**

$\text{Delay}_{qu} = 10 \times 2\ \mu s = 20\ \mu s$ **// Queuing delay**

$\text{Delay}_{tr} = 5{,}000{,}000 / (5 \text{ Mbps}) = 1 \text{ s}$ **// Transmission delay**

$\text{Delay}_{pg} = (2000 \text{ Km}) / (2 \times 10^8) = 0.01 \text{ s}$ **// Propagation delay**

This means

Latency = $10\ \mu s + 20\ \mu s + 1s + 0.01\ s \approx 1.01\ s$

The transmission time is dominant here because the packet size is huge.