

# HOMework SOLUTIONS

This document contains the solutions to all of the assigned homework problems.  
The solutions to each homework assignment will be posted immediately after the class in which it is assigned.

## Chap 1

2.

*In Section 1.3.1, the phonograph was analyzed as a communication system by identifying the following five components: the input transducer, the transmitter, the transmission channel, the receiver, and the output transmitter. Identify the same five components for each of the following communication systems. If you are not sure how something works, you might want to do some research in a library or on the Web.*

### (a) Broadcast radio

- a. input transducer –the microphone.
- b. transmitter –the radio station’s antenna
- c. transmission channel – the radio waves which the antenna puts out.
- d. receiver –the antenna on the home or car radio.
- e. output –the speaker connected to the radio.

### (b) A doorbell

- a. input transducer –a button next to the door.
- b. transmitter –the transformer producing the current flowing between the button and the bell.
- c. transmission channel –the wire between the button and the bell.
- d. receiver –the solenoid that energized the plunger hitting the bell.
- e. output –the bell/speaker that puts out the bell noise.

### (c) Cable TV

- a. input transducer –the television camera and what it is taping.
- b. transmitter –the TV Station.
- c. transmission channel – Hence the “cable” in Cable TV.
- d. receiver – The “Cable” box
- e. output –the home television.

5.

*List as many information systems as you can (at least four) that are found in your home or residence, and identify, as best you can, whether these systems are analog, digital, or both. Briefly explain the analog and/or digital aspects.*

- The Television – connected to cable, the television is analog
- The computer and the Internet – Digital
- The VCR – analog with a digital clock
- The stereo – the CD player is digital and the tape player and radio are analog.
- The coffee maker – analog with a digital clock.
- The thermostat on the air conditioner is analog. Its analog because its always changing and the temperature is always changing.
- The piano is also analog because pitch can differ in infinite amounts of ways.

## Chap 2

6.

*Locate examples of Web pages that feature static, dynamic, active and interactive content. Describe how each such page is an example of one of these content types.*

**6) Dynamic:** <http://weather.noaa.gov/weather/current/KSJC.html>

This is a dynamic Web page because it provides weather information and the like by using each person's computer resources. There is no one unchanging document that a person or others will obtain when a document is downloaded from the URL. Since the information generated from this URL is constantly changing, the Web page is dynamic, not static.

**Active:** <http://play.games.com/playgames/home.jsp>  
<http://www.gameskidsplay.net/>

These are active Web pages because one can play games and move icons on the site. One can move icons on the site by using a mouse or arrows on the computer and each person that comes to the site does not receive the same document, since that would affect another person's game. Rather, each user plays the game with their own copy of it on their computer. When they go to the site, the game program is downloaded to each individual's computer, therefore, the URL is the same, but each person is playing their own game.

**Interactive:** <http://ticketing.ticketmaster.com/cgi/RegMyAccount.asp>  
<http://orders.jcrew.com/includes/MyJCrew.jhtml>

These are interactive Web pages because the user (of the Web browser) can send information back to the site (server) which responds in some way. The user is able to send name, address, credit card information, etc. back to the server in order to purchase an item, for example. The information is analyzed and a response is processed and sent.

**Static:** <http://cseserv.engr.scu.edu/nquinn/COEN001/COEN001syllabus.htm>

This Web page is static because there is one unchanging document that all users will come to when they enter this URL. It is unlike the dynamic web page in that the information will not change on a constant basis, as does the weather information on the dynamic web page does. The document remains constant to all users.

## Chap 3

2.

*How many bits would you need to represent the letters a through z? How many would you need to represent the decimal numbers 1 through 1000?*

Using the mathematical equation that 2 to the N power equals the number of codewords that could possibly be represented, it turns out that five bits are needed to represent 26 different letters. There would be 32 possible combinations with 5 bits, therefore leaving 6 unused combinations. Ten bits would be needed to represent the numbers 1 through 1000, because 2 to the 10th power gives us 1024 possible combinations, leaving 24 unused.

15.

*Assume that you are building a digital system to measure and display the speed of your car. Further assume that the speeds you wish to represent vary from 0 to 120 miles per hour. If you were to use a 4-bit word to represent the speed, how precisely could you measure the speed? Do you think this would provide enough precision for normal purposes?*

So...  $120\text{mph} / 16 = 7.5$

This implies that we could measure our speed in increments of every 7.5mph. However a normal speedometer usually gives you increments of every 2.5mph. So we might be better using a five-bit word which would be more accurate when measuring and reading your speed.

16.

*Identify a favorite piece of music, and calculate the number of bits required to store it on a CD. You may ignore any extra bits that are used for error recovery.*

If my favorite song is four minutes long (240 seconds) and we know that a CD uses 16bits/value \* 44,100values/sec \* 2 channels = 1,411,200 bits/sec → 240 sec. \*(1,411,200 bits) = 338,688,000 bits, to hold my song.

## Chap 4

2.

*Determine a protocol for transmission of stock prices while minimizing the number of bits to be transmitted. Assume that there are 100 stocks whose prices are to be transmitted, and that they are transmitted continuously. You may also assume that an initial list of all the stock names and any other relevant information is sent to the receiver in advance. Explain your protocol with examples, and give illustrations of the functions that a protocol is to perform. Assume that the stock prices range between zero and \$200, and that a precision of one cent is needed. Given that, and your protocol, determine the needed bit rate so that all of the stock prices are transmitted in one second.*

In order to determine a protocol for the transmission of 100 stock prices, we must first determine the number of bits needed to transfer one stock price between \$0.00 and \$200.00. If there are 20,000 possibilities, 15 bits ( $2^{15} = 32768$ ) are needed.

Since our agreed upon protocol will be to transmit the 100 stock's values in sequence, we will need  $100 \times 15$  bits to transmit the all of the stock prices.

In addition, 8 bits are needed to transmit a starting point in order to check for errors and begin transmissions. For all 100 stock prices, therefore, 1508 bits are needed.

Chap 5

5.

Draw a rectangular grid on your paper. On that grid print or write a single alphanumeric character. Generate the transmitted bit string for the binary encoding of that character, assuming black-white encoding, and a left-to-right, top-to-bottom scan.

	1	1	1		
	1				
	1	1			
	1				
	1				
	1	1	1		

(011100)(010000)(011000)(010000)(010000)(011100)

12.

Conventional TV will soon be supplemented by a high-definition television system (HDTV). The standards will be (approximately): 1,000 display lines vertically, and a width-to-height ratio of 3:2, 60 images per second. Aspect ratio is the ratio of screen width to height. For standard TV the width-to-height ratio is 4:3, which is rather narrow compared to the eye's field of view. Given this data, determine the approximate number of picture elements along each line, the time required to scan each line, and the approximate digital data rate (assuming no coding techniques are used to reduce the data rate, which is unrealistic).

1000 display lines vertically → 1500 display lines across, = 1.5 million elements.

The time required to scan a line if HDTV scans 60 images per second would be  $1\text{sec}/(1000\text{lines} * 60\text{images}) = 1.6667 * 10^{-5}$  seconds.

If you take 1.5 million pixels x 24 bits per pixel x 60 frames per second = 2,160,000,000 of bits per second or 270,000,000 bytes/sec (approximate digital rate).

## Chap 6

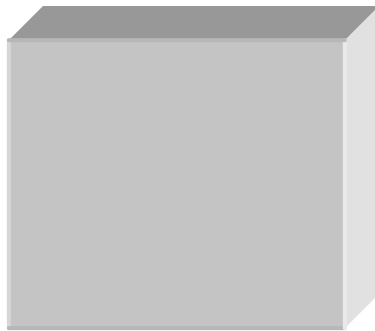
5.

*Explain in your own words the fundamental differences between bit-mapped and vector graphics image storage formats, including the advantages and disadvantages of each.*

The vector graphics approach to storing images involves programming a description of the object or image in order for the computer to be able to redraw the image for viewing. The bit-mapped storage is the actual storage of the points which make up the image. In other words, a bit-mapped storage is the literal image storage, whereas a vector graphic would simply be the dimensions or blueprints used to make this image. The advantage to using vector graphics is that it requires much *less storage space* because it is not storing the individual the “intensity at each point in the image”. Also, vector graphic images often offer a much clearer image because it is based on the instructions for making it rather than the choppy pixel makeup. However, bit-mapped still offer the best option for recreating natural objects (such as a flower), which do not have specific dimensions that can be recreated. Vector images were created initially for mechanical drawings, but have been very successful in computer animations (such as the films “Bugs Life”), and in creating Virtual Reality. Unlike bit-mapping, vector image use allow complete freedom to move around in a seemingly three dimensional world, rather than limited to one point of view in bit-mapped imaging.

7.

*Draw a simple example image and use this to explain the difference in representation between the bit-mapped and vector graphics formats. Determine the number of bits which would be required to store this image in the two formats for good image quality. Explain your reasoning and calculations.*



Using the simple example of a 3D box (or cube), the two types of storage for this image can be compared. Using the vector graphics technique, the dimensions for the figure would be specified in width, height, and depth, and the (x,y) coordinates of one of the corners of the cube. Using these values, the created image would be given a surface or texture with the specified color of gray. To represent this image in bits, the nodes would be represented with the binary codes.

The bit-mapped technique on the other hand, would be created using pixels on vertical and horizontal axis's. To create this representation in bits, it would have to be determined how large the pixels would be. Also, different bits would be needed to specify the different shades of gray that make the box. The bit mapped representation would require many more bits than the vector graphics due to the amount of coding needed to represent the pixels opposed to the dimensions in the vector graphing.

Chap 7

3.

Determine the frequency of occurrence of each of the letters in this sentence. From these results, determine a fixed-length binary code and a variable-length binary code for the letters. Explain your procedure. Recall that variable-length codes must be designed for unique decodability. There are many appropriate codes which you may create.

```

e ~ t c n r f h o i s u a D l m q y .
e ~ t c n r f h o i s u
e ~ t c n r f h o i s
e ~ t c n r f h o
e ~ t c n r
e ~ t c n
e ~ t
e ~
e ~
e ~
e ~
e
e
e
15 12 7 6 6 5 4 4 4 3 3 2 1 1 1 1 1 1 1
      0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1
      1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1
          0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1
          0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0

```

Where ~ → space.

6.

It is possible that in flipping a coin 10 times, the results of the first three flips will all be heads. If this occurs, explain what the probability of heads will be on the fourth flip.

Since the situation is independent of all other situations, it is not dependent on the last three flips, the question only asks what is the probability of the fourth flip, not all of the subsequent flips, hence  $\frac{1}{2}$  is your probability.

## Chap 8

3.

*By hand, run-length encode the following fragment of one line of an image where the numbers in each box represent the intensity value at that pixel:*

15	15	15	205	205	5	8	198	44	44
----	----	----	-----	-----	---	---	-----	----	----

One protocol might be to use a very simple RLE which has an escape character followed by a count followed by the character. That would be:

`\ 3 15 \ 2 205 5 8 198 \ 2 44`

Another slightly smarter protocol would recognize that sequences shorter than 4 characters are not minimized by RLE therefore the encoding would look like:

`15 15 15 205 205 5 8 198 44 44.`

6.

*One Mbit/second is available for a portable video player. Explain what processing and compression would be necessary to display conventional TV video and HDTV video with this data rate. Comment on the amount of compression, the likely type of compression, and image quality.*

### **CONVENTIONAL TV- 720/525 pixels**

#### **BLACK AND WHITE:**

$720 \times 525 \times 1 = 378,000$  pixels (bits) per image needed (black and white). This implies that at 30 images per second would need  $378,000 \times 30 = 11,340,000$  bits/sec data rate. If we have 1Mbit/sec available, our compression would need to be 11.34:1.

#### **COLOR:**

$720 \times 525 = 378,000$  pixels \* 8 (for color) = 3,024,000 bits per image needed (color). This implies that at 30 images per second would need  $3,024,000 \times 30 = 90,720,000$  bits/sec data rate. If we have 1Mbit/sec available, our compression would need to be 90.72:1.

### **HDTV- 1920/1080pixels**

#### **BLACK AND WHITE:**

$1920 \times 1080 \times 1 = 2,073,600$  pixels (bits) per image needed (black and white). This implies that at 60 images per second would need  $2,073,600 \times 60 = 124,416,000$  bits/sec data rate. If we have 1Mbit/sec available, our compression would need to be 124.416:1.

#### **COLOR:**

$1920 \times 1080 = 2,073,600$  pixels \* 24 (for color) = 49,766,400 bits per image needed (color). This implies that at 60 images per second would need  $49,766,400 \times 60 = 2,985,980,000$  bits/sec data rate. If we have 1Mbit/sec available, our compression would need to be 2,985.98:1. (*That is some serious compression!*)

## Chap 9

3.

*In this question you will explore the reason that online home delivery of video selections on demand through the telephone is not available. In Chapter 17 you will discover that the storage capacity of a single-sided, single-layer DVD-Video disc is approximately 4.7 GB (4.7 billion bytes). Using a bit rate of 56 kbps for a high speed telephone modem connection, how long would it take to download this amount of data? If it takes you 10 minutes, round trip, to drive to the local video store, rent a DVD and bring it home, what is the bit rate of your car in this application?*

$4,700,000,000 \times 8 / 56,000 = 671,428.57 \text{ seconds} = 11,190 \text{ minutes} = 186.5 \text{ hours}$ , to download the data.

Your car has a bit rate of  $4,700,000,000 \times 8 / (60 \times 10) = 62,666,666.7 \text{ bits/sec}$ .

## Chap 10

3.

*How is sound different in outer space?*

Sound has no medium to travel in, in space. Thus there is no sound.

10.

*Figures 10.10 and 10.11 display the frequency spectra of two signals with the same fundamental frequency: 440 Hz. What are the approximate bandwidths of the two signals, from the figures?*

Figure 10.10 has a bandwidth of exactly 440 Hz, however the graph seems to indicate a bandwidth of something less than 2000 Hz.

Figure 10.11 indicates a bandwidth of 6400 Hz as the last small blip on the graph.

## Chap 11

2.

*We wish to digitally record (in stereo) high-quality audio with a 20 kHz bandwidth. How many samples must be taken in each second?*

According to the Nyquist sampling theorem:

“IN ORDER TO BE PERFECTLY REPRESENTED BY ITS SAMPLES, A SIGNAL MUST BE SAMPLED AT A SAMPLING RATE EQUAL TO AT LEAST TWICE ITS HIGHEST FREQUENCY COMPONENT.”

Therefore a 20 kHz signal must be sampled at least 40,000 times per second, but since it is to be recorded in stereo we must record 2 channels. Hence our total samples per second is 80,000.

4.

*Use the applet "Sampling and Reconstruction with Sound" with the chirp signal and a sampling rate of 2 kHz. Describe the reconstructed signal and explain why it has the shape that you observe. What part of the reconstructed signal matches the original chirp signal and what part does not? Explain.*

As you begin increasing the sampling rate, you see that the reconstructed wave approximates the original up to a point. Keep in mind that the original wave starts off at 0 Hz on the left of the graph and increases to 2000 Hz on the right hand side of the graph. The reconstructed wave only looks like the original up to the point where the sampling frequency equals twice that of the content of the original.

The shape of the reconstructed signal is a mirror of itself at the midway point of the graph. This is due to the fact that the sampling rate is exactly half of what it needs to be. The sampling is only picking up half of the information it needs and because the sampling is occurring at a fixed rate it exhibits the mirroring effect as the original signal's frequency increases from 0 to 2k Hz.

4.

*Based on what you have learned, determine the amount of storage needed to record a normal telephone call of one hour in duration.*

The answer to Problem 6 tells us that one half of a phone conversation takes 64000 bits of storage per second. There one hour of a full two-way conversation equals:  
 $64000\text{bits} * 2\text{ways} * 60\text{sec} * 60\text{min} = 460,800,000$  bits or 57,600,000 bytes.

This implies that an uncompressed telephone conversation takes about 1 megabyte / minute.

6.

*Determine an appropriate value for the data rate for digitized voice in a telephone system, without data compression. You will need to determine two pieces of information: the rate at which the voice should be sampled, and the number of bits to be used to represent the value of each sample. Each of these values should be no larger than necessary, since any increase beyond the necessary bit rate will raise the transmission cost without significantly improving quality.*

For voice the bandwidth is 4 kHz, the signal must be sampled at 8,000 Hz and quantized to 256 levels at each sample. Eight bits are required to represent 256 levels. Hence the bit rate for the digital telephone call (in each direction) is 8,000 times 8, or 64,000 bits per second.

## Chap 13

4.

*One fundamental way in which a cell phone differs from a wired phone is that it can move around, even around the world. Explain how this makes the connection of a caller to a given cell phone more complex than a connection to a wired phone.*

With a wired phone, the location of the phone is always known, therefore the complexity of connecting to that phone from the central office is rather simple and predictable. The area code determines the general location, the prefix determines more specifically the location within the general area and the final 4 digits determine which physical set of wires to connect to.

With a cellular phone, the location of the phone is not known. It must be determined dynamically by messages received from a cell site antenna and relayed back to the central call connection center. This type of dynamic nature requires **significantly** more complex switching hardware and computational power to manage thousands upon thousands of simultaneous cell phones. A cell phone can potentially come online anywhere in the world and the system must accommodate it.

5.

*What factors do you think are at work that are causing some advancing third world nations to implement only cellular telephone systems instead of wire-based telephone systems?*

The most significant reasons are infrastructure costs, i.e. the cost of land lines and/or telephone poles/wires/etc that are needed to support conventional telephony. Many developing countries are still largely rural in nature and these infrastructure costs could never be justified. Secondly, the ability of cellular technology to provide much more than traditional telephony systems in the way of features, provides the developing countries with a way to get a jump up on the technology curve without a steep cost curve.

## Chap 14

1.

*Given the speed of light, determine the transmission delay for a telephone call from New York to Los Angeles, from one side of Los Angeles to the other side, and from New York to Tokyo. Is this significant for human conversation? Why or why not?*

Light travels at 186,000 miles/sec.

New York to LA is about **2462** miles.  $2462 / 186000 = .0132$  seconds

Across LA is about 100 miles.  $100 / 186000 = .000537$  seconds

New York to Tokyo is about 6760 miles.  $6760 / 186000 = .0363$  seconds

All of these times are negligible to human speech. Anything less than several tenths of a second is barely noticeable.

## Chap 16

7.

*Assume that we desire a position accuracy of +/-100 feet with the Global Positioning system. What accuracy in time measurement is required to accomplish this? For satellites positioned as in the actual system, what is the total time delay from satellite to GPS receiver, and what is the percent accuracy required in this time measurement to achieve the desired position accuracy?*

Light travels at 186000 miles / sec or 982,080,000 ft/sec. This implies that light travels the 200 feet of our desired accuracy in 0.000000203649 seconds. This is about 2 tenths of a millionth of a second. A tiny number, but a computer can execute about 1 billion instructions per sec or 200 instructions in the time it takes light to travel the 200 feet.

The total time delay from the satellite to the GPS receiver is:

11000 miles/186000 or 0.05913978 seconds. The percentage accuracy required is then:

$0.000000203649/0.05913978 = 0.000003443519 = 0.0003443519\%$  About 3 ten thousands of a percent accuracy.

$$200/(11000*5280) = .000003444 = .0003444\%$$

Either method results in the same answer.

## Chap 17

2.

*How many minutes of telephone-quality audio could be stored on a CD?*

From table 17.1, the size of a “74 minute” CD is 681,984,000 bytes.

Since we sample sound as 8000 bytes per second, there are  $681,984,000/8000$  seconds of voice quality sound on a CD or 85248 seconds or 1420.8 minutes or 23.68 hours. About a day’s worth!

Chap 18

6.

*Assume that 10 terminals are generating packets of data, each at a rate of 100 packets per second, and that the packets are 100 bits in length. All of these terminals are connected to a router which has a single data connection to the Internet. What minimum data rate would be required on the Internet connection? Would this minimum data rate be acceptable in practice?*

*Explain.*

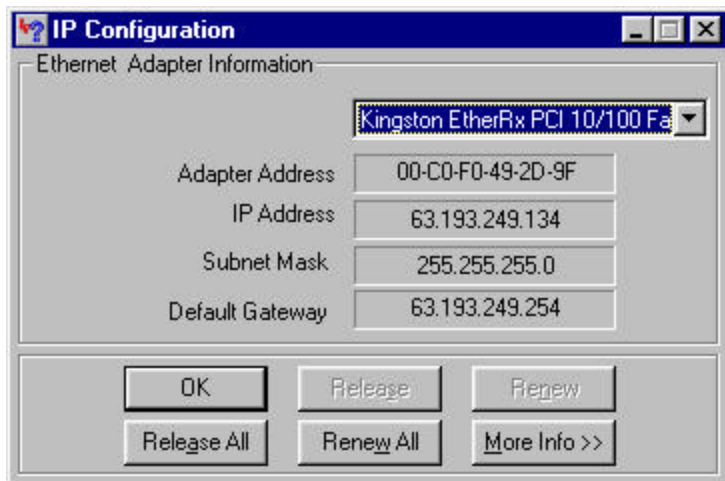
100 bits x 100 packets/sec x 10 terminals → 100000bits/sec = 100kbits/sec

This minimum data rate would not be acceptable in the long run, since there are other overhead packets that need to occur now and then. This would necessitate that the rate be somewhat larger than the minimum. A standard rate of 128kbits/sec would be sufficient.

Chap 19

*Determine the 6 byte unique address (commonly called the MAC address) of the Ethernet card in the computer you most frequently use that is connected to the School's network.*

*Capture the window on your screen containing the address, by using Alt-PrintScreen, and then paste it into a Word document.*



This was taken from my computer at home. I use an Ethernet card to connect to the Internet.