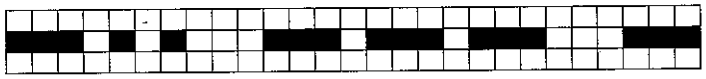
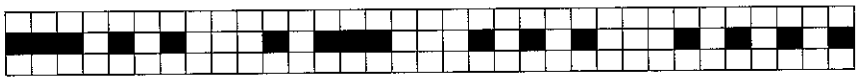
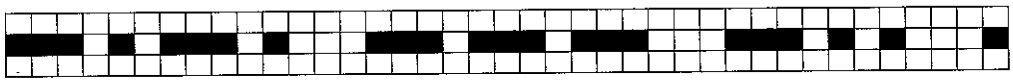
PROBLEM SET 1.3

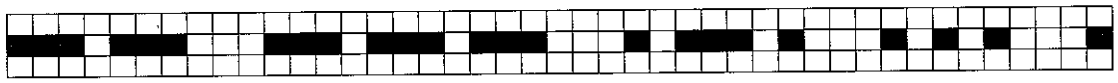
Problems 1 and 2

Each of the following patterns is a Morse code representation of a single word. If ON is represented by a black square, and OFF is represented by a white square, decode each message.

1. **a.** 

   b. 

2. **a.** 

   b. 

3. Use grid paper or a spreadsheet program and Morse code to create the pattern that represents the word DIGIT.

4. Use grid paper or a spreadsheet program and Morse code to create the pattern that represents the word BINARY.

5. Suppose the message THE TRAIN IS ON TIME is transmitted by Morse code, but the sender accidentally separates characters by leaving the circuit off for only one time unit rather than for three. The receiver has no idea what message will be sent. At what point during the transmission would the receiver realize that an error has been made? Explain.

6. Suppose the message ME AND YOU is transmitted by Morse code, but the sender accidentally separates words by leaving the circuit off for three time units rather than for six. The receiver has no idea what message will be sent. At what point during the transmission would the receiver realize that an error has been made? Explain.

7. **a.** Translate the following one-word message from Morse code into English. In this case, 1 represents ON and 0 represents OFF:

   10111011100010101010001110101110111

   b. Convert the following message from English to Morse code using 1 to represent ON and 0 to represent OFF: CHECK

8. **a.** Translate the following message from Morse code into English. In this case, 1 represents ON and 0 represents OFF:

   1010100011100010101110001110101000111010111011 1

   b. Convert the following message from English to Morse code using 1 to represent ON and 0 to represent OFF: GO PLAY

9. **a.** Convert the number 194 into a sequence of 0s and 1s using the UPC manufacturer number code.

   b. Use grid paper or a spreadsheet program and convert the sequence of 0s and 1s from part (a) into a bar code with 0 represented by a white strip and 1 represented by a black strip.

10. **a.** Convert the number 628 into a sequence of 0s and 1s using the UPC manufacturer number code.

    b. Use grid paper or a spreadsheet program and convert the sequence of 0s and 1s from part (a) into a bar code with 0 represented by a white strip and 1 represented by a black strip.

11. Convert the sequence of 0s and 1s into the UPC product number.

    a. 101110010001001110010

    b. 100111011011001001000

12. Convert the sequence of 0s and 1s into the UPC product number.

    a. 110011010100001110100

    b. 100100011100101110010

13. Kraft Foods uses a manufacturer number 21000. A box of macaroni and cheese is a general grocery item, so the item number is 0. The product number is 65833.

    a. Calculate the check digit for the UPC.

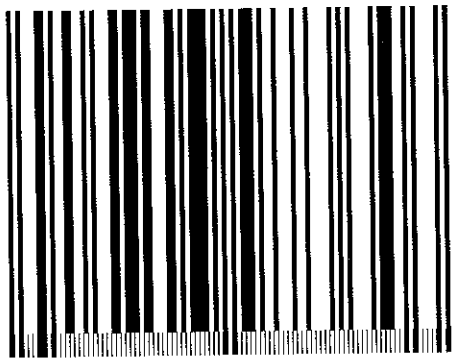
    b. Construct the UPC bar code for Kraft Macaroni & Cheese.

14. The Kellogg Company uses a manufacturer number 38000. A box of Kellogg's Corn Pops is a general grocery item, so the item number is 0. The product number is 01011.

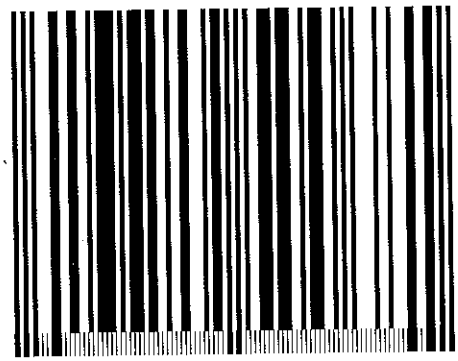
    a. Calculate the check digit for the UPC.

    b. Construct the UPC bar code for Kellogg's Corn Pops.

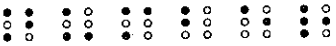
15. For the following bar code, give the Universal Product Code. A grid along the bottom has been retained to clarify the spacing.

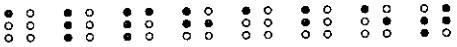


16. For the following bar code, give the Universal Product Code. A grid along the bottom has been retained to clarify the spacing.

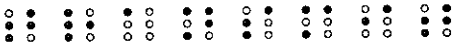


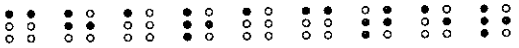
17. Decode each of the following words coded in Braille.

a. 

b. 

18. Decode each of the following words coded in Braille.

a. 

b. 

19. Encode each of the following words or phrases into Braille.

a. BITS **b.** GO TO SLEEP

20. Encode each of the following words or phrases into Braille.

a. INTEGER

b. DO YOUR HOMEWORK

21. Convert each of the following words from ASCII to characters in the English language.

a. 0111 0010 0110 1001 0110 0111 0110 1000 0111 0100

b. 0110 1110 0110 1001 0110 0010 0110 0010 0110 1100 0110 0101

22. Convert each of the following words from ASCII to characters in the English language.

a. 0110 1101 0110 0101 0111 0011 0111 0011 0110 0001 0110 0111 0110 0101

b. 0111 0011 0110 0011 0110 0001 0110 1110 0110 1110 0110 0101 0111 0010

23. Convert the following words from characters in the English language to ASCII.

a. pattern **b.** circuit

24. Convert the following words from characters in the English language to ASCII.

a. signal **b.** guard

25. Draw the Postnet code that represents each of the following numbers.

a. 32 **b.** 905 **c.** 2437

26. Draw the Postnet code that represents each of the following numbers.

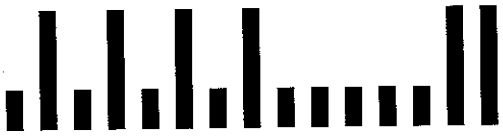
a. 51 **b.** 680 **c.** 7129

27. **a.** A single digit is given in the form of a Postnet code, but it contains one mistake. Correct the mistake in as many ways as possible.

b. Identify the number represented by the following Postnet codes.

28. **a.** A single digit is given in the form of a Postnet code, but it contains one mistake. Correct the mistake in as many ways as possible.

b. Identify the number represented by the following Postnet codes.



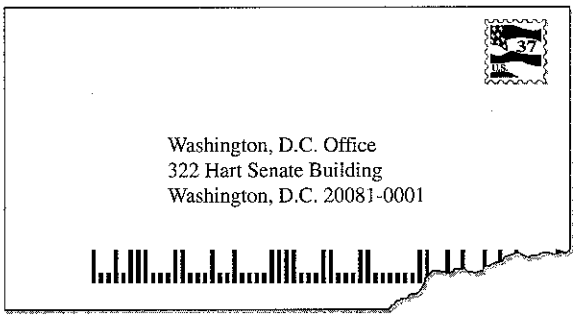
29. Decode the following ZIP + 4 Postnet code.

30. Decode the following ZIP + 4 Postnet code.

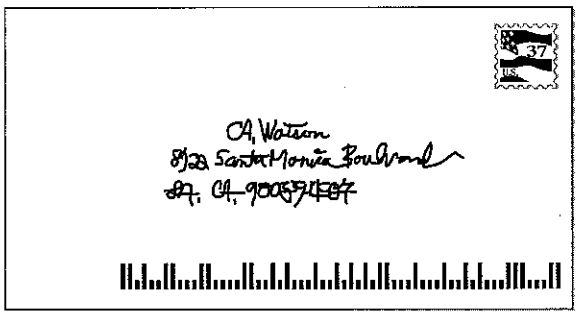
31. A ZIP + 4 code for Wilmington, Delaware, is 19804-0001. Calculate the check digit and construct the Postnet code.

32. A ZIP + 4 code for Concord, California, is 94520-1412. Calculate the check digit and construct the Postnet code.

33. The following letter has been damaged. Reconstruct the ZIP + 4 + delivery-point code.



34. The handwriting on the following letter is difficult to read. Use the ZIP + 4 + delivery-point code to reconstruct the address.



35. The following ZIP + 4 Postnet code contains an error. Find and correct the error.

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37. Manufacturers store music on a CD digitally as 0s and 1s. Music is sampled 44,100 times per second. Each sample is 2 bytes (16 bits). Separate samples are taken for the left and right speakers. For a 4-minute song, how many bits are sampled?

38. Using the information in problem 37, how many bits are sampled in a 6-minute song?

39. Use the information from problem 37 and the fact that a 56K modem will download at a rate of 56 kilobits per section under ideal conditions to answer the following questions. (Note: A kilobit is 1024 bits.)

a. Suppose music is downloaded under ideal conditions via a 56K modem. How long will it take a 4-minute song to download?

b. MP3 is a compression system for music. It reduces the number of bytes in a song without reducing the quality significantly. If the number of bytes is reduced by a factor of 10, then how long will it take a 56K modem to download a 4-minute song in MP3 format?

c. You may be able to connect to the Internet using a Digital Subscriber Line (DSL). DSL is a high-speed connection that uses the existing telephone line. Assume that DSL can download at a maximum rate of 512 kilobits per second. How long would it take a DSL to download a 4-minute song?

40. Use the information from problem 37 and the fact that a 56K modem will download at a rate of 56 kilobits per section under ideal conditions to answer the following questions (Note: A kilobit is 1024 bits.)

a. Suppose music is downloaded under ideal conditions via a 56K modem. How long will it take a 6-minute song to download?

b. MP3 is a compression system for music. It reduces the number of bytes in a song without reducing the quality significantly. If the number of bytes is reduced by a factor of 10, then how long will it take a 56K modem to download a 6-minute song in MP3 format?

c. You may be able to connect to the Internet using a Digital Subscribe Line (DSL). DSL is a high-speed connection that uses the existing telephone line. Assume that DSL can download at a maximum rate of 512 kilobits per second. How long would it take a DSL to download a 6-minute song?

Extended Problems

41. In this section, we have translated messages from Morse code to English and from English to Morse code using 1s and 0s or dark and light squares. You can also learn to transmit Morse code messages by using things such as a flashlight, a buzzer, or tapping. The dot and dash or on and off patterns for Morse code were presented in Table 1.9. Once you become familiar with the patterns for each letter, you can practice sending and receiving Morse code. On the Internet, locate a Morse code applet by using search keywords "Morse code applet" or go to a site such as www.soton.ac.uk/~scp93ch/morse/. Morse code applets allow you to convert messages to Morse code. You can also type in your encoded message, and the site will translate it back into English. Many sites allow you to hear the Morse code message as a series of beeps. Encode and listen to several simple messages. Use a flashlight or tapping to practice sending messages in Morse code, and be prepared to present your message to your class.

42. Research the Braille system of encoding. On the Internet use search keyword "Braille" or go to www.nbp.org/alph.html or www.nyise.org/braille.htm#history for more information. Write a report of your findings. Be sure to include answers to the following questions in your report: When was Braille developed? Have there been any updates or improvements to the system since its original design? Does the system incorporate any error-detection strategies?

43. Research the history of the ZIP code. For information about ZIP codes on the Internet, go to the U.S. Postal Service website at www.usps.com. Summarize your findings in a report and be sure to include answers to the following questions: What does "ZIP" stand for? When was the code created and why? What do the digits in the ZIP code stand for? When was the ZIP code expanded to the ZIP + 4 format? How is the new delivery-point code determined from the ZIP + 4 code? Pick one state and sketch a map showing the ZIP code delivery areas.

Problems 44 through 47

Binary codes that use multiple check digits, called **parity bits**, to detect and correct single digit transmission errors are called Hamming codes. Suppose we want to encode four bits: $b_1\ b_2\ b_3\ b_4$. Three parity bits will be added at the end of the code, each calculated by using a different set of bits so the new code will contain the original four-bit code and three parity bits. It will now look like $b_1\ b_2\ b_3\ b_4\ P_1\ P_2\ P_3$. We will use congruence modulo 2 to define the three parity bits as follows: $P_1 \equiv (b_1 + b_2 + b_3) \bmod 2$, $P_2 \equiv (b_2 + b_3 + b_4) \bmod 2$, and $P_3 \equiv (b_1 + b_3 + b_4) \bmod 2$.

For example, to the four bit code 1100, we would add the following three parity bits:

$$P_1 \equiv (1 + 1 + 0) \bmod 2, \text{ so } P_1 = 0.$$
$$P_2 \equiv (1 + 0 + 0) \bmod 2, \text{ so } P_2 = 1.$$
$$P_3 \equiv (1 + 0 + 0) \bmod 2, \text{ so } P_3 = 1.$$

The transmission would look like 1100011. However, if there is interference in the transmission, and the receiver picks up the code as 0100011, how will the error be detected and corrected?

Because each of the original four bits shows up in at least two parity bit calculations, a single-bit error will show up in at least two parity bits, as the following table shows.

Four-Bit Code	$P_1 = 0$	$P_2 = 1$	$P_3 = 1$
0 1 0 0	Error detected because $1 \equiv (0 + 1 + 0) \bmod 2$. The parity bit should have been 1.	No error detected because $1 \equiv (1 + 0 + 0) \bmod 2$. The parity bit is correct.	Error detected because $0 \equiv (0 + 0 + 0) \bmod 2$. The parity bit should have been 0.

There was an error detected in parity bit 1, which involved b_1, b_2, and b_3. An error was also detected in parity bit 3 which involved b_1, b_3, and b_4. Notice that the parity bits that detected errors involved b_1 and b_3. Because no error was detected in parity bit 2, which also involved b_3, we conclude that b_3 must not be the source of the error. The error must be in b_1, and the code can be corrected by replacing the 0 with a 1 for the first bit in the four-bit code.

44. For each of the following 4-bit codes, add the three parity bits as defined above.

a. 0100 **b.** 0110

c. 1110 **d.** 0000

45. Each of the following 4-bit codes contains a single-digit error. Determine the incorrect digit and correct the error.

a. 1011100 **b.** 1110111

46. The transmission 1111011 has a single-digit error. Explain how you can detect and correct the error.

47. The transmission 1111111 was received as 1001111 with two single-digit errors. Will this type of error be detected? Can it be corrected? Explain.

48. In the 1970s, Rivest, Shamir, and Adelman created the RSA public key system. It is an encryption algorithm that is currently used to maintain secure transmissions over the Internet. It allows the user to encode a message that only the intended recipient may decode. The method uses prime numbers and modular arithmetic. Research the RSA public key system. What is a public key? What is a private key? Describe the encryption and decryption processes and give an example. What makes this system so secure? For more information use search keywords "RSA public key system" on the Internet. Write a report that summarizes your findings.