Test Bank—Chapter One (Data Representation)

Multiple Choice Questions

1. Which of the following Boolean operations produces the output 1 for the fewest number of input patterns?
   A. AND  B. OR  C. XOR
   ANSWER: A

2. Which of the following best describes the NOR operation?
   A. An XOR followed by a NOT  B. An OR followed by a NOT  C. A NOT followed by an OR
   ANSWER: B

3. Which of the following bit patterns cannot be expressed in hexadecimal notation?
   A. 11111111  B. 1001  C. 110011  D. 100000000001
   ANSWER: C

4. Which of the following is the binary representation of 6 5/8?
   A. 110.11  B. 10.011  C. 110.101  D. 100.101
   ANSWER: C

5. Which of the following bit patterns represents the value 9 in two’s complement notation?
   A. 00011010  B. 11111011  C. 00001001  D. 11111011
   ANSWER: C

6. Which of the following bit patterns represents the value -9 in two’s complement notation?
   A. 00011010  B. 11111011  C. 10001001  D. 11111011
   ANSWER: B

7. What is the result of the following addition problem (using two’s complement notation)?
   00001111
   + 10101010
   A. 011000101  B. 10111001  C. 01010101  D. 10110101
   ANSWER: B

8. What is the result of the following subtraction problem (using two’s complement notation)?
   00001111
   - 10101010
   A. 011000101  B. 10111001  C. 01010101  D. 10110101
A. 01100010  B. 10111001  C. 01010101  D. 10110101

ANSWER: A

9. In which of the following addition problems (using two’s complement notation) does an overflow error occur?

A. 0011  B. 1100  C. 1100  D. 0100

+ 1010  + 0100  + 1100  + 0100

ANSWER: D

10. Which of the following representations in two’s complement notation represents the largest value?

A. 00000010  B. 11110000  C. 00000001  D. 11111111

ANSWER: A

11. Which of the following representations in two’s complement notation represents the smallest value?

A. 00000010  B. 11110000  C. 00000001  D. 11111111

ANSWER: D

12. Which of the following bit patterns (represented in hexadecimal notation) represents a negative number in two’s complement notation?

A. 3F  B. 55  C. A6  D. 7E

ANSWER: C

13. Which of the following bit patterns (represented in hexadecimal notation) represents a positive number in two’s complement notation?

A. 9F  B. F7  C. A8  D. 7E

ANSWER: D

14. What value is represented by the bit pattern 01011100 when interpreted using floating-point format in which the most significant bit is the sign bit, the next three bits represent the exponent field in excess notation, and the last four bits represent the mantissa?

A. -1 1/2  B. 1 1/2  C. -3/8  D. 3/8

ANSWER: B

15. Which of the following values cannot be stored accurately using a floating-point format in which the most significant bit is the sign bit, the next three bits represent the exponent field in excess notation, and the last four bits represent the mantissa?

A. 2 1/2  B. 3/16  C. 7  D. 6 1/4

ANSWER: D
16. Which of the following bit-patterns represents the smallest value using the floating-point format in which the most significant bit is the sign bit, the next three bits represent the exponent field in excess notation, and the last four bits represent the mantissa?

A. 01001000   B. 01011000   C. 00101000   D. 01111000

ANSWER: C

17. Which of the following data storage systems provides the most efficient random access to individual data items?

A. Main memory   B. Magnetic disk   C. CDs/DVDs   D. Flash drives

ANSWER: A

18. Which of the following storage systems is best suited for storing and retrieving long strings of data that are processed in their sequential order?

A. Main memory   B. Magnetic disk   C. CDs/DVDs

ANSWER: C

19. Which of the following mass storage system does not require physical motion?

A. Magnetic tape   B. Magnetic disk   C. CDs/DVDs   D. Flash drives

ANSWER: D

20. Assuming that each of the following bit patterns originally had even parity, which one contains an error?

A. 10101100   B. 11000011   C. 01001100   D. 10001100

ANSWER: C

21. How many errors per pattern could be corrected when using an error-correcting code in which any two code patterns differ by a Hamming distance of 8?

A. 3   B. 4   C. 5   D. 6

ANSWER: A

22. Which of the following is a possible LZW compression of the message “xyz xyz xyz”?

A. 1234   B. 1234545   C. 232   D. 12

ANSWER: B

23. Which of the following systems is least efficient when encoding numeric values?

A. Two’s complement notation   B. Excess notation
C. ASCII   D. Floating-point notation

ANSWER: C
24. Which of the following is a means of encoding music?

   A. ASCII  B. MIDI  C. JPEG  D. GIF

ANSWER: B

25. Which of the following provides a compressed representation of an image by limiting the number of different pixel colors to 256, thereby enabling each pixel in an image to be represented by a single byte whose value indicates which of a palette of entries represents the pixel’s color?

   A. ASCII  B. MPEG  C. JPEG  D. GIF

ANSWER: D

**Fill-in-the-blank/Short-answer Questions**

1. A computer’s main memory consists of numerous memory cells, each of which contains ________ bits. Each memory cell is identified by a numeric value called the cell’s ________.

   ANSWER: eight, address

2. Represent the bit pattern 1111010010011011 in hexadecimal notation.

   ________

   ANSWER: F49B

3. A7DF is the hexadecimal representation for what bit pattern?

   __________

   ANSWER: 1010 0111 1101 1111

4. How many different bit patterns can be formed if each must consist of exactly 6 bits?

   __________

   ANSWER: 64

5. How many bits are needed to represent 1024 different bit patterns?

   __________

   ANSWER: 10

6. Translate each of the following binary representations into its equivalent base ten representation.

   A. 1100 ________
   B. 10.011 ________
   C. 0.01 ________
D. 10001

ANSWER: A. 12   B. 2 3/8   C. 1/4    D. 17

7. Rewrite each of the following values (represented in base ten notation) in binary notation.

A. 7

B. 23

C. 2 1/4

D. 5/8

ANSWER: A. 111    B. 10111    C. 10.01     D. 0.101

8. If the patterns 101.11 and 1.011 represent values in binary notation, what is the binary representation of their sum?

ANSWER: 111.001

9. Using a two’s complement notation system in which each value is represented by a pattern of six bits, represent the value 5.

ANSWER: 000101

10. Using a two’s complement notation system in which each value is represented by a pattern of six bits, represent the value -5.

ANSWER: 111011

11. What is the largest positive integer that can be represented in a two’s complement system in which each value is represented by eight bits?

ANSWER: 127 (represented by 01111111)

12. What is the smallest negative integer that can be represented in a two’s complement system in which each value is represented by eight bits?

ANSWER: -128 (represented by 10000000)

13. In a two’s complement system, what value is represented by the pattern 1111111111111101?

ANSWER: -7
14. When using two’s complement notation, what bit pattern represents the negation of 01001010?

____________

ANSWER: 10110110

15. What value is represented by each of the following patterns in excess notation?

   A. 10000   ____   B. 0110   ____   C. 1100   ____

ANSWER: A. 0, B. -2, C. 4

16. Using an 8-bit floating-point format in which the most significant bit is the sign bit, the next three bits represent the exponent field in excess notation, and the last four bits represent the mantissa, write the bit pattern that represents the value 1 3/4. (Use normalized form.)

____________

ANSWER: 01011110

17. What is the largest value that can be represented in a floating-point system in which each value is encoded by a byte whose most significant bit is the sign bit, the next three bits represent the exponent field in excess notation, and the last four bits represent the mantissa?

____________

ANSWER: 7 1/2 (represented as 01111111)

18. Which of the following addition problems cannot be solved accurately when using a floating-point system in which each value is encoded by a byte whose most significant bit is the sign bit, the next three bits represent the exponent field in excess notation, and the last four bits represent the mantissa?

   A. 2 1/2 + 1 3/8   B. 3 1/2 + 4 1/2   C. 7 + 3/4

____________

ANSWER: A, B, and C

19. The following is an error-correcting code in which any two patterns differ by a Hamming distance of at least three.

   Symbol | Representation
   ------ | ---------------
   A      | 000000          
   B      | 001111          
   C      | 010011          
   D      | 011100          
   E      | 100110          
   F      | 101001          
   G      | 110101          
   H      | 111010          

Decode each of the following patterns

010011 _______ 101010 _______ 011000 _______ 101101 _______

ANSWER: C, H, D, F
20. How many errors in a single code pattern could be corrected when using an error-correcting code in which each code pattern is a Hamming distance of at least seven from any other code pattern?

____________

ANSWER: 3

21. The following is a message that was originally encoded so that each pattern had odd parity. Circle the patterns in which an error has definitely occurred.

10 11 10 10 1 11 11 00 0 10 0 0 0 0 0 0
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1
0 1 0 0 0 1 0 1 0 0 1 0 0 0
1 0 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1
0 1 0 0 1 0 0 1 0 0 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

ANSWER: First, fourth, sixth, and seventh

22. Data compression techniques apply various principles to reduce the size of data. One, called ________________, avoids repeating long strings of the same data item. Another, called ________________, encodes the difference between consecutive blocks of data rather than encoding each block in its entirety. Still another, called ________________, uses short bit patterns to encode frequently occurring items and longer patterns to encode less frequent items.

ANSWER: Run-length encoding, relative encoding, and frequency-dependent encoding.

Vocabulary (Matching) Questions

The following is a list of terms from the chapter along with descriptive phrases that can be used to produce questions (depending on the topics covered in your course) in which the students are asked to match phrases and terms. An example would be a question of the form, “In the blank next to each phrase, write the term from the following list that is best described by the phrase.”

<table>
<thead>
<tr>
<th>Term</th>
<th>Descriptive Phrase</th>
</tr>
</thead>
<tbody>
<tr>
<td>bit</td>
<td>Binary digit</td>
</tr>
<tr>
<td>Boolean operation</td>
<td>AND, OR, XOR, NOT</td>
</tr>
<tr>
<td>address</td>
<td>A numeric value used to identify a memory cell</td>
</tr>
<tr>
<td>hexadecimal notation</td>
<td>An efficient way of representing bit patterns</td>
</tr>
<tr>
<td>track</td>
<td>A circle on the surface of disk platter on which data is written/read</td>
</tr>
<tr>
<td>sector</td>
<td>A segment of a track in a mass storage system</td>
</tr>
<tr>
<td>cylinder</td>
<td>A set of tracks at a given position of the read/write heads</td>
</tr>
<tr>
<td>seek time</td>
<td>The time required to move the read/write heads from one track to another</td>
</tr>
<tr>
<td>latency time</td>
<td>The average amount of time required for the desired data to rotate around to the read/write head</td>
</tr>
<tr>
<td>transfer rate</td>
<td>The rate at which data can be written to or read from a device</td>
</tr>
<tr>
<td>zoned-bit recording</td>
<td>A means of increasing the storage capacity of a magnetic disk system</td>
</tr>
<tr>
<td>ISO</td>
<td>An international organization for establishing standards</td>
</tr>
<tr>
<td>ANSI</td>
<td>A major standardization organization within the United States</td>
</tr>
<tr>
<td>ASCII</td>
<td>A system developed by the American Standards Institute for encoding text</td>
</tr>
<tr>
<td>flip-flop</td>
<td>A digital circuit capable of holding a single digit</td>
</tr>
<tr>
<td>two’s complement notation</td>
<td>A means of encoding whole numbers</td>
</tr>
<tr>
<td>floating-point notation</td>
<td>A means of encoding numeric values that may involve fractions</td>
</tr>
<tr>
<td>truncation</td>
<td>An error that may occur when using floating-point notation</td>
</tr>
<tr>
<td>pixel</td>
<td>A small part of an image</td>
</tr>
</tbody>
</table>
GIF  A means of compressing an image file by restricting the number of colors available
JPEG  A means of compressing images by blurring the boundaries between different colors while maintaining all brightness information
Unicode  A means of encoding text in which each symbol is represented by 21 bits which may be encoded in UTF-8, UTF-16, or UTF-32 formats.
SD card  An application of flash technology
Flash memory  A mass storage device that traps electrons in tiny chambers of silicon dioxide
LZW  An example of adaptive dictionary encoding
MIDI  A means of encoding music in terms of notes and instruments rather than actual audio
VLSI  A means of constructing complex circuitry in a very small space.

General Format Questions

1. Describe how a computer can produce an incorrect answer when performing numerical computations even though it has not malfunctioned.

   ANSWER: Most students will probably refer to overflow and truncation errors.

2. Describe how the concept of Hamming distance is used to produce an error-correcting code.

   ANSWER: By designing a code in which each pattern has a Hamming distance of $n$ from any other pattern, patterns with fewer than $n/2$ errors can be corrected by replacing them with the code pattern that is closest.

3. a. What is the output of the circuit below?

   Input Pattern
   
   \[
   \begin{array}{c}
   1 \\
   0 \\
   1
   \end{array}
   \]

   b. In general, how does the three-bit input pattern across the top of the diagram relate to the circuit’s output?

   ANSWER: a. 0  b. The output is 0 if the input parity is odd; the output is 1 if the input parity is even.

4. If the input and output bit patterns in the circuit below are interpreted as binary representations of numeric values, what operation does the circuit perform?
ANSWER: The circuit subtracts one (except for the case of the input being 000).

5. Explain why such terms as kilo, mega, and giga have acquired double meanings.

ANSWER: The prefixes kilo, mega, and giga are used traditionally to refer to units measured in powers of thousand. However, in reference to memory capacities these prefixes are used to reference units that are powers of two. For example, one kilobyte is $2^{10}$, which is 1024 bytes.

6. Convert the following addition problem into two’s complement notation (using four bits per value), perform the addition, convert the answer back into base ten notation, and explain the results.

\[
\begin{array}{c}
6 \\
+ 3
\end{array}
\]

ANSWER: In two’s complement notation the problem is to add 0110 and 0011. The sum is 1001 which translates to -7. This answer is incorrect due to overflow.

7. Under what condition is each of the following data compression techniques most effective?

   a. Run-length encoding
   b. Relative encoding

ANSWER: a. Compresses most when data consists of long strings of the same entry.
   b. Compresses most when each block of data differs little from the previous block.

8. What is frequency-dependent encoding?

ANSWER: Frequency-dependent encoding is an encoding system that uses short bit patterns to represent data items that occur most often and longer patterns to represent less frequently occurring items. The result is that entire blocks of data can be represented in less space than would be required if each data item were represented by the same size bit pattern.

9. Construct the entire two’s complement scale in which each value is represented by three bits.

ANSWER:

\[
\begin{array}{c}
3 & 011 \\
2 & 010 \\
1 & 001 \\
0 & 000 \\
-1 & 111 \\
\end{array}
\]
10. To what does the term “normalized form” refer in the context of floating-point notation?

**ANSWER:** Normalized form refers to a standard for positioning the bit pattern within the mantissa field. Many values can be represented in floating-point notation by different bit patterns, only one of which is in normalized form. Hence, restricting representations to normalized form assures that each value is represented by a unique pattern.

11. Explain why the final version of the dictionary need not be transmitted with a message encoded using LZW compression.

**ANSWER:** The dictionary can be constructed during decompression in the same way it was constructed during compression.

12. Among the Boolean operations AND, OR, EXCLUSIVE OR, and NOT, which is least like the others? Explain your answer.

**ANSWER:** There is not really a right or wrong answer. The student’s explanation is the most important part. Most students will probably answer NOT because it has only one input whereas the others have two.

13. If a term paper consisted 42 pages, each containing 40 lines of 100 symbols each (counting each space as a symbol), was to be encoded using Unicode, how many bytes of storage space would be required?

**ANSWER:** 336,000 bytes (168,000 symbols times 2 bytes per symbol)

14. In a two’s complement system, what value can be added to any other value without causing an overflow? How many values in the system have this property? Explain your answer.

**ANSWER:** Adding the value 0 to any other value will not produce an overflow. However, if \( m \) is the largest positive integer that can be represented in the system, then any value in the range 1 to \( m \) will produce an overflow when added to \( m \), and any value in the range -1 to -(\( m + 1 \)) will produce an overflow when added to -(\( m + 1 \)).

15. Why is the rightmost bit in a string of bits considered to be the least significant bit?

**ANSWER:** It is the least significant digit in a number. A change to this bit will have the least effect on the value of the number. A change to any other bit will have a greater effect on the value of the number.

16. Given that 1 foot = .3048 meters, write a Python script that will convert a height given in feet and inches to a height given in meters.

**ANSWER:** One possible answer is:

```python
feet = 5
inches = 7
tot_height_in_feet = feet + inches / 12

tot_height_in_meters = tot_height_in_feet * .3048
print('Height in meters is')
print(tot_height_in_meters)
```

17. Given that 1 foot = .3048 meters, write a Python script that will convert a height given meters to a height given in feet and inches.
ANSWER: One possible answer is:

```python
height_in_meters = 1.8
height_in_feet = height_in_meters / .3048
feet = height_in_feet // 12
inches = height_in_feet % 12
print('Height is ' + str(feet) + ' ft ' + str(inches) + ' in ')
```