COMP 311 Written Assignment 1 Name: ____________________

Question 1: 211 Review

1.1. How many bits are in a byte?

1.2. How many bytes are in an integer?

1.3. If the size of a word is 32 bits, how many bytes are in two words?

1.4. How many distinct value can be represented with 7 bits?

1.5. What is the most negative number I can represent in 2's complement with 4 bits? Answer in decimal.

1.6. What is the most positive number I can represent in 2's complement with 4 bits? Answer in decimal.

1.7. What is the least significant bit of the number 0b0100_1101_0101_1001? Prepend your answer with 0b.

1.8. What is the most significant bit of the number 0b0100_1101_0101_1001? Prepend your answer with 0b.

1.9. What is the least significant byte of the number 0b0100_1101_0101_1001? Prepend your answer with 0b. Place an underscore between groups of 4 bits as shown in the question.

1.10. What is the most significant byte of the number 0b0100_1101_0101_1001? Prepend your answer with 0b. Place an underscore between groups of 4 bits as shown in the question.

1.11. What is the value of bit 1 of the number 0b0100_1101_0101_1001? Prepend your answer with 0b.

1.12. What is the value of bit 2 of the number 0b0100_1101_0101_1001? Prepend your answer with 0b.

Question 2: Decimal to Binary and Hex Convert each of the following decimal numbers into (a) binary and (b) hex. Your final answer should have 8 bits. The autograder expects the following formatting: binary numbers are preceded by "0b", hex numbers are preceded by "0x", and there are underscores between groups of four digits. For example: $0b0001\_1001$ or $0xABCA\_BBCD$.

2.1. 44 in binary

2.2. 44 in hex

2.3. 65 in binary

2.4. 65 in hex

Question 3: Binary to Hex and Decimal Convert each of the following binary numbers into (a) hex and (b) decimal. For question 2.1 your final hex answer should be 2 nibbles. For question 2.2 your final hex answer should be 3 nibbles. The autograder expects the following formatting: hex numbers are preceded by "0x".

3.1. $0b1001\_1100$ in Hex

3.2. $0b1001\_1100$ in Decimal

3.3. $0b1001\_0101\_0011$ in Hex

3.4. $0b1001\_0101\_0011$ in Decimal

Question 4: Hex to binary and decimal Convert each of the following unsigned hex numbers into (a) binary and (b) decimal. For question 3.1 your final binary answer should be 8 bits. For question 3.2 your final binary answer should be 12 bits. The autograder expects the following formatting: binary numbers are preceded by "0b" and there are underscores between groups of four digits. For example: $0b0001\_1001$.

4.1. $0x90$ in Binary

4.2. $0x90$ in Decimal

4.3. $0x12A$ in Binary

4.4. $0x12A$ in Decimal

Question 5: Unsigned integers and 2's complement For each of the following questions, interpret the 6 bit binary number in the following representations: (a) unsigned, (b) 2's complement. Answers should be written in decimal.

5.1. $0b00\_1111$ as an unsigned integer

5.2. $0b00\_1111$ in 2's complement

5.3. $0b10\_0001$ as an unsigned integer

5.4. $0b10\_0001$ in 2's complement

Question 6: Max Values On the left-hand side, choose the bit pattern whose two's complement base-10 integer interpretation is the maximum of the choices available. On the right-hand side, choose the bit pattern whose unsigned base-10 integer interpretation is the maximum of the choices available.

- ○ $0b1111\_1111$
- ○ $0b1000\_0000$
- ○ $0b0111\_1111$
- ○ $0b0000\_0001$
- ○ $0b0000\_0000$

- ○ $0b1111\_1111$
- ○ $0b1000\_0000$
- ○ $0b0111\_1111$
- ○ $0b0000\_0001$
- ○ $0b0000\_0000$

Question 7: Overflow Our machines have a fixed number of bits to work with. When machines perform addition and subtraction, they will output an incorrect answer if the result does not fit into the given number of bits. This is known as overflow. Later on in this course, we'll design a circuit that can add and subtract numbers. As circuit designers, we need to understand when these errors can occur.

7.1. Let's say we want to add together the numbers 10 and 12. We know the decimal result of this addition is 22.

Now, let's say we have a machine that can add together 5-bit numbers and produces a 5-bit result. What binary number would the machine output? Remember your 0b and underscore.

7.2. What is the decimal value of the result if we interpret it as an unsigned value?

7.3. Did overflow occur? (yes/no?)

7.4. What is the decimal value of the result if we interpret it as a 2's complement value?

7.5. Did overflow occur? (yes/no?)

Question 8: Unsigned Binary Addition For each problem, add together the unsigned binary numbers using the rules of addition and indicate whether over occurs assuming all numbers are expressed using a five bit, unsigned binary representation. All binary answers should be preceded with a "0b".

8.1. 0*b*0_1101 +
0*b*0_0111

8.2. Overflow? (yes/no)

8.3. 0*b*1_1010 +
0*b*1_0101

8.4. Overflow? (yes/no)

Question 9: 2's Complement Binary Addition For each problem, add together the 2's complement binary numbers using the rules of addition and indicate whether overflow occurs assuming all numbers are expressed using a six bit, 2's complement binary representation. All binary answers should be preceded with a "0b".

9.1. 0*b*01_0000 +
0*b*11_1111

9.2. Overflow? (yes/no)

9.3. 0*b*01_1111 +
0*b*00_0001

9.4. Overflow? (yes/no)

Question 10: 2's Complement Subtraction For each problem, subtract the second operand from the first by negating the second operand and then adding the binary operands. All binary answers should be preceded with a "0b".

10.1. 0*b*01_1001 −
0*b*00_1111

10.2. 0*b*01_0110 −
0*b*01_0101

Question 11: Bitwise Operations Apply the different bitwise operations to the binary numbers:
$0b01\_0110$
$0b11\_1000$

11.1. OR

11.2. AND

11.3. XOR

Question 12: Sign and Zero Extension Sign extension always preserves the value of signed numbers (e.g. sign extending the number -7 will produce the number -7). Zero extension does not (e.g. zero-extending -7 will not produce -7). Let's look at a couple of examples.

12.1. What is the decimal interpretation of the following 2's complement number? $0b111$

12.2. Let's say that we need to extend this number to 8-bits to make it compatible with our system. Provide the sign-extended 8-bit value of the original number.

12.3. What is the decimal interpretation of the following 2's complement number? $0b1111\_1111$

12.4. Is this the same value as our original number? (yes/no)

12.5. What if we had zero-extended this number instead? Provide the zero-extended 8-bit value of the original number.

12.6. What is the decimal interpretation of the above 2's complement number?

12.7. Is this the same value as our original number? (yes/no)

12.8. Let's take a look at a positive number now. What is the decimal interpretation of the following 2's complement number? $0b0110$

12.9. Let's say that we need to extend this number to 7-bits to make it compatible with our system. Provide the sign-extended 7-bit value of the number.

12.10. What is the decimal value of the above number (part 9) if we interpret it in 2's complement?

12.11. Is this the same value as our original number (part 8)? (yes/no)

12.12. Zero-extend the original number (from part 8) to 7-bits.

12.13. What is the decimal value of the above number (part 12) if we interpret it in 2's complement?

12.14. Is this the same value as our original number (part 8)? (yes/no)

Question 13: Memory I have a 20-element integer array whose base address is $0x$0000_0003_0010.
Recall: sizeof(int) = 4 bytes

13.1. What is the address of element 0?

13.2. What is the address of element 2?

13.3. What is the address of element 9?

13.4. Which addresses does element 3 occupy?

- ◯ 0x0000_0003_0010
- ◯ 0x0000_0003_0011
- ◯ 0x0000_0003_0012
- ◯ 0x0000_0003_0013
- ◯ 0x0000_0003_0014
- ◯ 0x0000_0003_0015
- ◯ 0x0000_0003_0016
- ◯ 0x0000_0003_0017
- ◯ 0x0000_0003_0018
- ◯ 0x0000_0003_0019
- ◯ 0x0000_0003_001A
- ◯ 0x0000_0003_001B
- ◯ 0x0000_0003_001C
- ◯ 0x0000_0003_001D
- ◯ 0x0000_0003_001E
- ◯ 0x0000_0003_001F
- ◯ 0x0000_0003_0020
- ◯ 0x0000_0003_0021

Question 14: More Memory The following integer array is stored in memory starting at address $0xFFFF\_7FFF\_0000$.

```
arr = [42185 100492 252475]
```

Fill in the memory contents below. Feel free to use a decimal to binary calculator for this problem. Provide your answers in binary.

Formatting: Prepend your answers with $0b$. Place an underscore between groups of 4 bits.

Address	**Data**
0xFFFF_7FFF_0000	______________________
0xFFFF_7FFF_0001	______________________
0xFFFF_7FFF_0002	______________________
0xFFFF_7FFF_0003	______________________
0xFFFF_7FFF_0004	______________________
0xFFFF_7FFF_0005	______________________
0xFFFF_7FFF_0006	______________________
0xFFFF_7FFF_0007	______________________
0xFFFF_7FFF_0008	______________________
0xFFFF_7FFF_0008	______________________
0xFFFF_7FFF_000A	______________________
0xFFFF_7FFF_000B	______________________

Question 15: A Little More Memory Answer the following questions based on the memory contents below.

Address	**Data**
0x0000_0004_0000	0x12345678
0x0000_0004_0004	0x55555555
0x0000_0004_0008	0x00000000
0x0000_0004_000C	0x45454545
0x0000_0004_0010	0x98765432
0x0000_0004_0014	0xAB1234CD
0x0000_0004_0018	0xEF729641
0x0000_0004_001C	0xAC528BED
0x0000_0004_0020	0x5629ABCD

15.1. What is the hex value of the byte stored at address 0x00040010?

15.2. What is the hex value of the byte stored at address 0x0004001E?

Question 16: Transistors T/F

16.1. A pMOS transistor behaves as a closed switch when V_g is high.

◯ True
◯ False

16.2. nMOS transistors are part of the pull-up network.

◯ True
◯ False

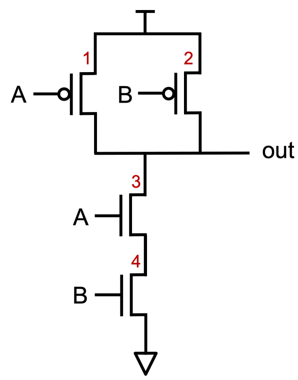
16.3. An nMOS transistor behaves as an open switch when V_g is high.

◯ True
◯ False

16.4. In an nMOS transistor, current can flow between source and drain when V_g is low.

◯ True
◯ False

Question 17: CMOS Gates Use the transistor diagram below to answer the following questions. Each transistor is numbered in order to make answering the following questions more clear.



17.1. Which transistors are on when A = 0 and B = 0?

◯ 1
◯ 2
◯ 3
◯ 4

17.2. What is the output when A = 0 and B = 0?

17.3. Which network is driving the output when A = 0 and B = 0?

◯ Pull-up
◯ Pull-down

17.4. Which transistors are on when A = 1 and B = 0?

◯ 1
◯ 2
◯ 3
◯ 4

17.5. What is the output when A = 1 and B = 0?

17.6. Which network is driving the output when A = 1 and B = 0?

◯ Pull-up
◯ Pull-down

17.7. Which transistors are on when A = 1 and B = 1?

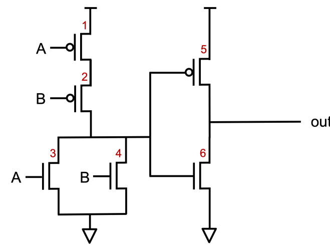
◯ 1
◯ 2
◯ 3
◯ 4

17.8. What is the output when A = 1 and B = 1?

17.9. Which network is driving the output when A = 1 and B = 1?

◯ Pull-up
◯ Pull-down

Question 18: More CMOS Use the transistor diagram below to answer the following questions. Each transistor is numbered in order to make answering the following questions more clear.



18.1. Which transistors are on when A = 0 and B = 0?

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6

18.2. What is the output when A = 0 and B = 0?

18.3. Which network is driving the output when A = 0 and B = 0?

- ◯ Pull-up
- ◯ Pull-down

18.4. Which transistors are on when A = 1 and B = 0?

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6

18.5. What is the output when A = 1 and B = 0?

18.6. Which network is driving the output when A = 1 and B = 0?

- ◯ Pull-up
- ◯ Pull-down