Question 1 (10 points) For each of the following, answer True or False as appropriate:

1. The basic electronic device used to build logic gates is called a transistor.  
   **TRUE**

2. 8-bits have 255 unique binary patterns.  
   **FALSE**

3. Faster computers can compute more things than slower ones.  
   **FALSE**

4. A voltage of 0 volts represents a binary digit 1 in the CPU.  
   **FALSE**

5. A voltage of 1.2 volts represents a binary digit 0 in the CPU.  
   **FALSE**

6. The idea of a universal computing device was developed by John von Neumann  
   **FALSE**

7. The Difference Engine was developed at the University of Pennsylvania in the 1940s.  
   **FALSE**

8. The hexadecimal number system is a positional number system.  
   **TRUE**

9. The Roman number system is a positional number system.  
   **FALSE**

10. The XOR gate is logically complete.  
    **FALSE**
Question 2 (20 points) Convert the following numbers as specified.

1. \((77)_{10}\) to base-2 (8-bits) \[0100\ 1101\]

2. \((-77)_{10}\) to base-2 (8-bits 2’s complement representation) \[1011\ 0011\]

3. \((77)_{10}\) to base-16 \[4D\]

4. \((77)_{8}\) to base-10 \[63\]

5. \((77)_{16}\) to base-10 \[119\]

6. \((-34)_{10}\) to base-2 (8-bits 2’s complement representation) \[11011110\]

7. \((-34)_{10}\) to base-2 (16-bits 2’s complement representation) \[1111\ 1111\ 1101\ 1110\]

8. \((01011111)_{2}\) to base-16 \[5F\]

9. \((01011111)_{2}\) to base-10 \[95\]

10. 8-bit, 2’s complement \((11011111)_{2}\) to base-10 \[-33\]
Question 3 (25 points) Below, use the latest value in each variable from the previous question (Note: In C/Java both int and float in Java use 32-bits to represent values):

(a) Consider the C/Java statement:

```
int x = 4230;
```

Show the precise representation (in bits) that will be used to store the value of x.

```
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 1 1 0
```

(b) Next, consider the statement:

```
int y = -x * 2; // y = -8460
```

Show the precise representation (in bits) that will be used to store the value of y.

```
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 0 1 0 0
```

(c) Next, consider the statement:

```
int a = x + y;  // a = -4230
```

Show the precise representation (in bits) that will be used to store the value of a.

```
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 0 1 0
```

(d) Next, consider the statement:

```
float w = x/2.0; // w = 2115.0 (2115 = 100 0010 0011)
```

Show the precise representation (in bits) that will be used to store the value of w.

```
0 1 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0
```

(e) Next, consider the statement:

```
float z = -w * 3; // z = -6345.0 (6345 = 1 100 0010 0011)
```

Show the precise representation (in bits) that will be used to store the value of z.

```
1 1 0 0 0 1 0 1 1 1 0 0 0 1 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
```
Question 4 (10 points)

(a) For what values of ABCDEF will the output of the six-input AND gate be 1? 001 110

Also, what decimal value does that represent? Assume that A is the leftmost bit. 14

(b) How many rows will there be in the Truth Table for the function above? 64 (2^6)

(c) How many output lines will a five-input decoder have? 32 (2^5)

(c) How many output lines will a 16-input MUX have? 1

How many Select lines will this MUX have? 4

(d) If the code for the letter ‘A’ is 65 and for ‘a’ is 97 and, you are given the following in C/Java:

```c
char upper = <some uppercase letter>;
char lower;
```

Write the C/Java expression you can use to convert a letter in `upper` to the corresponding lowercase letter and store it in `lower`. `lower = upper + 32;`
Question 5 (10 points) (A) Complete the Truth Table for the following circuit diagram:

![Circuit Diagram]

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>out</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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(B) How many total transistors does the circuit shown above use? \(20\)
**Question 6 (10 points)** A comparator circuit has two 1-bit inputs A and B and three 1-bit outputs G (greater), E (equal), and L (less than). Here is how the outputs are described:

- **G** is 1 if A > B
- **E** is 1 if A = B
- **L** is 1 if A < B

0 otherwise 0 otherwise 0 otherwise

Here is a functional block diagram of a comparator:

![Comparator Diagram](image)

Complete the truth table for the 1-bit comparator described above.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>G</th>
<th>E</th>
<th>L</th>
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<tbody>
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</table>
**Question 7 (15 points)** The following logic circuit consists of two XOR gates. Fill in the Output truth table below.

```
<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Output</th>
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</thead>
<tbody>
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