Binary representation:

1. What is the 5-bit binary representation of the decimal number 21?
   
   10101

2. What is the hexadecimal representation for decimal 219 encoded as an 8-bit binary number?
   
   1101_1011 \rightarrow \text{0xDB}

3. What is the hexadecimal representation for decimal 51 encoded as a 6-bit binary number?
   
   110011 \rightarrow \text{0x33}

4. The hexadecimal representation for an 8-bit binary number is 0x9E. What is its decimal representation?
   
   158

5. What is the range of integers that can be represented with a single 8-bit quantity?
   
   0 - 255

6. Since the start of official pitching statistics in 1988, the highest number of pitches in a single game has been 172. Assuming that remains the upper bound on pitch count, how many bits would we need to record the pitch count for each game as a binary number?
   
   $$\text{ceil}(\log_2(172)) = 8$$
7. Compute the sum of these two 4-bit binary numbers. Express the result in hexadecimal.

\[
\begin{array}{c}
1101 \\
+0110 \\
10011 == 0x13
\end{array}
\]
Compile the following expressions to RISC assembly using the instructions above. Assume a is stored at address 0x1000, b is stored at 0x1004, and c is stored at 0x1008.

1. \( a = b + c; \)

\[
\begin{align*}
&\text{li } a1, 0x1000 \quad \text{ // actually lui } a1, 1 \\
&\text{lw } a2, 4(a1) \quad \text{ // } a2 = b \\
&\text{lw } a3, 8(a1) \quad \text{ // } a3 = c \\
&\text{add } a3, a2, a3 \quad \text{ // } a3 = b + c \\
&\text{sw } a3, 0(a1) \quad \text{ // store } a3 \text{ into } a
\end{align*}
\]

2. if \( a > b \) \( c = 17; \)

\[
\begin{align*}
&\text{li } a1, 0x1000 \quad \text{ // actually lui } a1, 1 \\
&\text{lw } a2, 0(a1) \quad \text{ // } a2 = a \\
&\text{lw } a3, 4(a1) \quad \text{ // } a3 = b \\
&\text{bge } a3, a2, \text{end} \quad \text{ // branch to end if } a \leq b \text{ (or } b \geq a) \\
&\text{li } a4, 17 \quad \text{ // actually just addi } a4, x0, 17 \\
&\text{sw } a4, 8(a1) \quad \text{ // } c = 17
\end{align*}
\]

end:

3. \( \text{sum} = 0; \)

for \( i = 0; i < 10; i = i+1 \)

\[
\begin{align*}
&\text{sum} += i; \\
&\text{li } a1, 0 \quad \text{ // } a1 = 0 \text{ (sum) or addi } a1, x0, 0, \text{ since } x0 \text{ is hardwired to } 0 \\
&\text{li } a2, 0 \quad \text{ // } a2 = 0 \text{ (i) or addi } a2, x0, 0 \\
&\text{li } a3, 10 \quad \text{ // } a3 = 10 \text{ or addi } a3, x0, 10
\end{align*}
\]

loop:

\[
\begin{align*}
&\text{add } a1, a1, a2 \quad \text{ // } a1 = a1 + a2 \text{ or sum = sum + i} \\
&\text{addi } a2, a2, 1 \quad \text{ // } i = i+1 \\
&\text{blt } a2, a3, \text{loop} \quad \text{ // if } i < 10, \text{ branch to beginning of loop body}
\end{align*}
\]