1. [4 points] Write the decimal number -35 as an 8-bit two’s complement binary number.

\[-35 \text{ is } -64 + 16 + 8 + 4 + 1 = 11011101\]

2. [4 points] What is the largest value that you can represent in 16-bit two's complement. Express your answer in hexadecimal.

\[7FFFFFFF\]

3. [4 points] What is the smallest value that you can represent in 16-bit two's complement. Express your answer in hexadecimal.

\[80000000\]

4. [8 points] Convert the MIPS instruction \texttt{srl $t1,$t1,-1} to machine code. Express your answer in hexadecimal.

\[\text{Bogus question. Sorry. Can't have a right shift of -1. Everyone got full credit for this.}\]

5. [8 points] Rewrite the MIPS pseudo-instruction \texttt{li $t0,305419896} \text{ (where 305419896 is in base-10)} so that it uses two real MIPS instructions. (In other words what two instructions would the assembler generate for the pseudo-instruction above).

\[I \text{ was looking for you to realize that 305419896 cannot be represented in 16 bits. In hexadecimal this number is 12345678.}\]

\[\text{lui } $t0, 0x1234 \\text{ ori } $t0, $t0, 0x5678\]

6. [2 points] How many bits are required to represent a register number in a MIPS instruction?

\[5 \text{ because } 2^5 = 32\]
7. [8 points] Suppose processor $P_1$ has a cycle time of .5 nanoseconds and processor $P_2$ has a cycle time of 0.75 nanoseconds. Furthermore $P_1$ has a CPI of 2 for a program and $P_2$ has a CPI of 1.5 for the same program. Which machine is faster for the program and by how much?

$\text{CPU Time 1} = \text{CPI}(\text{IC})(\text{CT}) = 2(\text{IC})(0.5) = \text{IC} \text{ nanoseconds}$

$\text{CPU Time 2} = 1.5(\text{IC})(0.75) = 1.125(\text{IC}) \text{ nanoseconds}$

$\text{Speedup} = (\text{Time slower})/(\text{Time faster}) = (1.125(\text{IC}))/\text{IC} = 1.125$

So CPU 1 is 1.125 times faster than CPU 2.

8. [4 points] If a computer has a 10 megabit per second network connection how long would it take to send a 20MB file? (Assume 20MB is $2 \times 10^6$ bytes).

There was a typo on this so I allowed two answers. The type was that 20MB is $20 \times 10^6$ bytes not $2 \times 10^6$ bytes.

10 megabits/sec is $10/8$ megabytes/sec = 1.25 megabytes (MB/sec).

So $20\text{MB}/1.25(\text{MB/sec}) = 16 \text{ seconds}$.

9. [8 points] Assume that the execution time of a program $p$ on a processor is 100 seconds. Also assume that $p$ spends 30% of the execution time accessing memory. What would the execution time be if we tripled the performance of memory?

$p$ spends 30 seconds accessing memory (30% of 100). So $p$ must spend 70 seconds in the CPU. Making memory 3 times faster means $p$ would spend 10 seconds in memory but still 70 seconds in the CPU for a total of 80 seconds.

10. [4 points] If the clock cycle time for a processor is $5 \times 10^{-10}$ seconds what is the clock rate? Express your answer in GHz.

$\text{Rate} = 1/\text{Cycle time} = 1/(5 \times 10^{-10}) = 2,000,000,000 = 2\text{GHz}$
11. [8] Simplify the logic expression below as much as possible using the logic laws. Show all work.

\[(\overline{AB})(\overline{AB})\]

There are many ways to do this. Here's one. The original equation is \((\overline{A \cdot B})(\overline{A \cdot B})\) Apply DeMorgan's to each term and we get \((A + B)(A + \overline{B})\). Distribute and we get \(A\overline{A} + A\overline{B} + AB + B\overline{B}\). Recall that \(A\overline{A} = A\) and \(A\overline{B} + AB = A(B + \overline{B}) = A\) and \(B\overline{B} = 0\) so this whole thing just equals \(A\).

12. [30 points] Write a MIPS function `count_fives` that takes an address of a list of 100 integers as a parameter and returns the number of times a 5 appears in the list. Write a complete main program that calls `count_fives` and then prints the count to the console with a nice prompt. For the main program assume there is a label `list` in the data segment that refers to 100 integers.

```mips
.data
list: .word 7, 2, 5, 3, 9, 4, 5, ...
```

The answer to this one is at

http://myslu.stlawu.edu/~ehar/Spring12/220/exam1q11.s

13. Consider a circuit with three inputs \(A\), \(B\), and \(C\) and one output \(Out\) where the \(Out\) is one when none or one of the three inputs are ones.

i. [4] Draw the truth table for this circuit.

<table>
<thead>
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<th>(A)</th>
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<th>(C)</th>
<th>(Out)</th>
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\[Out = \overline{A}BC + \overline{A}BC + \overline{AB}C + AB\overline{C}\]