CMPSCI 145 MIDTERM #1
Solution Key
SPRING 2019
March 6, 2019
Professor William T. Verts
A. (5 points) What is the output voltage of the circuit if the input voltage was 100 volts?

The output voltage will be \( \frac{1}{4} \) of the input voltage, so 25 volts.

B. (5 points) How many teeth must gear \( G_2 \) have so that the division ratio of the gears matches the division ratio of the resistors? (Ignoring differences in sign.)

80 teeth.

A. (5 points) Convert 67 (decimal) to unsigned binary.

\[
\begin{align*}
67 & \div 2 = 33 \text{ R } 1 \\
33 & \div 2 = 16 \text{ R } 1 \\
16 & \div 2 = 8 \text{ R } 0 \\
8 & \div 2 = 4 \text{ R } 0 \\
4 & \div 2 = 2 \text{ R } 0 \\
2 & \div 2 = 1 \text{ R } 0 \\
1 & \div 2 = 0 \text{ R } 1
\end{align*}
\]

So, the final answer is 1000011

B. (5 points) Convert 10011111 (binary) to hexadecimal (base 16).

Partition number into groups of 4 bits, convert each one separately.

\[
\begin{align*}
1001 & = 9 \\
1111 & = 15 = \text{ F}
\end{align*}
\]

So, the final answer is 9F
15 Points (1 point each box) – Solve each sum below, and then tell me, yes or no, if it exhibits unsigned overflow or signed overflow. For problems that use four-digit decimal arithmetic (base 10), the left-most digit is the sign digit, and you are to write down only the right-most four digits of the sum even if a carry to a fifth digit is generated. For problems that use eight-bit binary arithmetic (base 2), the left-most bit is the sign bit, and you are to write down only the right-most eight bits of the sum, even if a carry to a ninth bit is generated.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Sum (in four decimal digits or eight binary bits)</th>
<th>Unsigned Overflow?</th>
<th>Signed Overflow?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decimal: 4972 + 1974</td>
<td>6946</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Decimal: 7259 + 2022</td>
<td>9281</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Decimal: 8416 + 8980</td>
<td>7396</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Binary: 11100001 + 01101011</td>
<td>01001100</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Binary: 11110000 + 11011010</td>
<td>11001010</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>

18 Points (1 point each box) – Show the decimal (base 10) value of the eight-bit binary numbers interpreted in each of the following ways. For signed interpretations, the left-most bit is the sign bit.

<table>
<thead>
<tr>
<th>The Number</th>
<th>01000101</th>
<th>11111111</th>
<th>10010010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsigned Binary</td>
<td>69</td>
<td>255</td>
<td>146</td>
</tr>
<tr>
<td>Sign &amp; Magnitude Signed Binary</td>
<td>+69</td>
<td>-127</td>
<td>-18</td>
</tr>
<tr>
<td>One’s Complement Signed Binary</td>
<td>+69</td>
<td>-0</td>
<td>-109</td>
</tr>
<tr>
<td>Two’s Complement Signed Binary</td>
<td>+69</td>
<td>-1</td>
<td>-110</td>
</tr>
<tr>
<td>BCD (if illegal answer ERROR)</td>
<td>45</td>
<td>ERROR</td>
<td>92</td>
</tr>
<tr>
<td>Excess-3 (if illegal answer ERROR)</td>
<td>12</td>
<td>ERROR</td>
<td>ERROR</td>
</tr>
</tbody>
</table>
<5> 10 Points – (5 points each) An analog computation system can continuously represent any number between 0 and 10 (inclusive), but the scale markings are only good to one digit to the right of the decimal point (that is, 0.0, 0.1, 0.2, …, 9.9, 10.0).

A. What happens when the computation 1.5×2.3 is attempted?

The result, 3.45 is between scale markings 3.4 and 3.5, so the exact answer can’t be computed.

B. What happens when the computation 6.9×7.2 is attempted?

The result is larger than 10.0, so there is an overflow.

<6> 10 Points – (2 points each) Which of the following are analog and which are digital?

- A. A mechanical cam to compute logarithms Analog
- B. Magnetic core memory Digital
- C. A NOR-gate Digital
- D. A hydraulic press Analog
- E. A flip-flop Digital

<7> 16 Points – (2 points each) Trace the following circuit and show the outputs for all given inputs.

5 Points Extra Credit: What function does this circuit perform?

2:1 multiplexer. When Select = 0, the DATA 0 input is passed to the output; when Select = 1 the DATA 1 input is passed to the output. See page 101 of the Companion.
11 Points – SHORT ANSWER – In radio A, a knob controls a variable resistor used as the volume control. In radio B, a switch is used to select low volume versus high volume. Which is analog and which is digital? What are the advantages and disadvantages of each system? Use the back of the page for your answer.

Radio A is controlled by an **analog** volume control,

Radio B is controlled by a **digital** volume control.

The analog version has an **infinite number of legal positions**, and can smoothly control the volume from minimum to maximum, but **returning to an exact previous setting is nearly impossible**.

The digital version has only two settings, so **cannot have as many possible volumes** as the analog system, but **those two settings are absolutely repeatable**.