Today’s topics

**Computer Hardware**
- Electric Circuits
- Designing an Adder

**Upcoming**
- Computer Communications
  *(Great Ideas Chapter 10)*

**Reading**
*(not in text)*
Binary Addition (Z = X + Y)

- Like Decimal, but---
  - Have only two symbols: 0, 1
- At first, seems like two “inputs” will do
  
  x: 10010
  y: +01001
  z: 11011

- Looking at it
  - From right: 0+1 = 1; 1+0 = 1; 0+0 = 0; 0+1 = 1; 1+0 = 1
  - However, example not realistic
  - Must deal with possible carries
  - Need better example
Binary Addition \( (Z = X + Y) \) (+carry)

- Let’s try
  
  \[
  \begin{array}{c}
  C: & 001100100 \\
  X: & 100110011 \\
  Y: & +000110010 \\
  Z: & 101100101 \\
  \end{array}
  \]

- Must add a top row for carries to get whole picture

- To add two number (by columns) takes *three* inputs
  
  - X, Y and C (for carry)
  - So, *from right*: 0+0+1 = 1(carry 0); 0+1+1 = 0(carry1);
    1+0+0 = 1(carry 0); 0+1+1 = 0(carry 1); 0+0+0 = 0(carry0);
    0+1+1 = 0(carry 1); 1+1+1 = 1(carry 1); 1+0+0 = 1(carry0);
    0+0+0 = 0 (carry 0); 0+1+0 = 1 (carry 0)
Truth Tables for Addition

- We need two 3-input truth tables
  - One for the resulting Sum bit
  - One for the resulting Carry bit

Sum:

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>C</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
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</table>

\[ S = X'Y'C + X'YC' + XY'C' + XYZ \]
Truth Tables for Addition

Carry:

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>C_in</th>
<th>Carry</th>
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<tbody>
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<td>0</td>
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The 3 bit Adder

- Now have the building-blocks to put together an Adder of arbitrary size
- Design in several steps (illustrated by drawings on web page)
  1. Block Diagram
  2. Simple Adder
  3. Control Section
  4. Putting it all together: The 3 Bit Adder
- Will be on quizzes and/or Final Exam
- Learn how to go through circuits and mark them
- May encounter different circuits
  - E.g., a Subtracter
  - Same marking methods will apply