E85: Digital Design and Computer Architecture

Problem Set 1

1) Number system finger exercise. Don't use a calculator to automate these parts, though you can use it if you want help with some arithmetic or to check answers. If you find any parts difficult or time-consuming, make up some more problems until number systems feel easy.

   A) Write the powers of 2 from 2^0 to 2^{16}. Commit these numbers to memory because you will use them frequently in digital design.

   B) Base conversions.
      i.   Convert the following numbers to base 2.
           13_{10}, 87_{10}, 1000_{10}, 5_8, 654_8, B_{16}, $FEED_{16}$
      ii.   Convert the following numbers to base 10.
           1001_2, 1100100_2, 5_8, 654_8, B_{16}, $FEED_{16}$
      iii. Convert the following numbers to base 16.
           1001_2, 1100100_2, 5_8, 654_8, 17_{10}, 200_{10}, 1000_{10}

   C) Number systems
      i.   Convert the following numbers to 8-bit 2's complement and sign-magnitude format:
           69_{10}, -2_{10}, -37_{10}
      ii.   Convert the following 6-bit 2's complement numbers to base 10:
           100100_2, 011111_2
      iii.   Convert the following 6-bit sign-magnitude numbers to base 10:
           100100_2, 011111_2
      iv.   Write the most positive and most negative 8-bit numbers in binary and decimal for each of the following formats: unsigned, 2's complement, sign-magnitude.

   D) Arithmetic:
      i.   Assuming unsigned format:
           a) Compute $1010_2 + 0111_2$. Convert the addends and the sum to decimal and check your results.
           b) Extend 101111_2 to 8 bits properly. Convert the input and result to decimal and check your result.
      ii. Repeat the question above assuming 2's complement format.

2) Logic gates
      Write the symbol, Boolean equation, truth table, and Verilog code for a 3-input NAND gate.

3) Impact on Society
      Research and write a paragraph about how digital systems have transformed another discipline of engineering within your lifetime. Provide quantitative data about at least one specific impact, such as cost, reliability, etc. Cite your sources.

4) How long did you spend on this problem set? This will not count toward your grade but will help calibrate the workload.