Homework 1 Solutions

1. [Computer Systems]
   a) An embedded system is a computer system designed to perform one or more dedicated functions often with real-time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts.
   b) Texas Instruments
      National Instruments
      Motorola/ Freescale
      Analog Devices
      ARM (see below)
   c) Processors used in embedded systems generally consume less power.
      Processors used in desktops and laptops are more expensive.
      Processors used in desktops and laptops are architecturally more complex.
      Clock frequencies for desktop and laptop processors are faster.
      Code for embedded processors must be compact due to memory limitations.
   d) Cellular
      Automotive
      Television
      Appliances
      Industrial Automation
      Aerospace
      Military
      Entertainment
      Security
      Medical
   e) ARM makes microprocessor cores for embedded systems. But, ARM only creates and licenses its technology as intellectual property (IP), rather than manufacturing and selling its own physical microprocessors.

2. [Microprocessor attributes]
   a) Car brakes: real-time performance, reliability, durability
   b) Cell phone: cost, power consumption
   c) Data center: reliability, security, processing power
   d) Weather forecasting:
      for simulation: processing power,
      for measurement: cost, power consumption, heat dissipation, durability
   e) Video games: processing power, cost, integrated peripherals

3. Number of transistors on a chip – scale up
   Process/transistor size – scale down
   Clock frequency – scale up
   Power consumption – scale up
   Source voltage – scale down
   Number of engineers involved in the design – scale up

Word size – scale up
Number of processor cores – scale up
Levels of cache – scale up

4. [Digital Logic Review]
   a) 1 gate delay
   b) 8 gate delays

5. [Digital Logic Review]
   a) Flip-flops are edge-triggered, so are easier to work with.
   b) D-FFs are commonly used flip-flops, with simple logic.
   c) The input is captured at the edge of the clock, and the output does not change until the next cycle, making the circuit easier to control and less sensitive to glitches.
   d) This is just convention.

6. [Digital Logic Review]
   a) A+B=D5B3 (base 16)
   b) A-B= AECF (base 16)
   c) A=1100 0010 0100 0001 (base 16)

7. [Digital Logic Review]
   a) A+B=1000 (2's complement), which is an overflow, since it is a negative number, and we added two positive numbers.
   b) -B = 1010 + 1 = 1011, so A-B = 0011 + 1011 = 1110 (2's complement)
      In decimal: A = 3, B = 5, A-B = -2
      Checking: 1110 (2's complement) = $-1*2^3 + 1*2^2 + 1*2^1 + 0*2^0 = -8 + 4 + 2 = -2$
   c) -A = 1100 + 1 = 1101, so B-A = 0101 + 1101 = 0010 (ignoring the carry out)
      In decimal: B-A = 2
      Checking: 0010 (2's complement) is indeed 2 (decimal)