ECE 331 Spring 2012 **Homework 4 -Solution**

Due Mon Feb 6 at the beginning of class.
Show all your work and please try to be neat. Refer to Handouts 3 and 4 as necessary.

1. Which component of microcontroller architecture best fits the blanks below.
   a. Accumulators A and B and index registers X and Y compose the Resister File in the 68HC12 microcontroller.
   b. The memory address of the next instruction to be executed is stored in the Program Counter
   c. Instruction bytes for the current instruction stored in the Instruction Register
   d. Data exchanged between Memory and the CPU must pass through Data Bus.
   e. After decoding instruction bytes, function/control bits are sent to the data path (or ALU) for instruction execution.
   f. Memory stores data and instruction bytes.
   g. I/O Devices provide a microcontroller with interfaces to the outside world.
   h. A memory address operand must pass from the CPU to the memory through the Memory Bus.

2. Arithmetic Instructions
   a) If accA holds $16 and accB holds $2A, what values will be in the each accumulators after executing the ABA instruction?

      ABA adds accA to accB and stores result in accA. accB remains unchanged
      $16 + $2A = $40, thus
      accA holds $40 and **accB holds $2A**

   b) What series of instructions would achieve the 16-bit subtraction of $1234 from $8ABC (i.e., $8ABC-$1234)? Write the instructions and state what the result would be and where it would be stored.

      This can be done with 8-bit instructions but it's more tricky (have to account for possible borrow from the lower byte). The best solution is

      ```
      LDD   #$8ABC
      SUBD  #$1234
      ```

      This would result in $7888 being stored in accD, **$78 in accA** and **$88 in accB**.

3. Data Transfer/Manipulation Instructions
   a) If accA holds $16 and accB holds $2A, what memory locations will change value after executing the STD $637F instruction? Identify the new value in any changed memory locations.

      STD $637F would store accA,accB to memory at $637F,6380
      <$637F> holds $16 and **<$6380> holds $2A**

   b) What is the difference between a logical shift right and an arithmetic shift right?

      logical shift right inserts a '0' value into the MSB while arithmetic shift right rolls the old MSB value back into the MSB bit.

4. Logic and Bit Operations

Assuming Accumulator B holds $FF:

   a) What value is in accB after the instruction BITB #$00?

      BITB does not affect the value in accB → **accB holds $FF**

   b) What values is in accB after the instruction ANDB #$00?

      $FF AND $00 = $00 → **$00 is stored in accB**

   c) What CCR flags are set or cleared by the instructions in a) and b)?

      BITB does the same, so here, **V=0, N=0, Z=1**
      ANDB clears V and adjusts N and Z. Here, **V=0, N=0, Z=1**

Assuming accD holds $B5A4, IX holds $833C, and memory location $833C holds $0F:

   d) What is the result of the instruction BCLR $833C %01100110? Specify the resulting value in hex and the location it is stored.

This instruction will clear to 0 all bit positions in address $833C where the mask has a '1' value. It does not affect bit positions where the mask holds a '0'. Here the mask has a '1' for bits 6, 5, 2, and 1. So,
$0F = %00001111 will become %00001001 = **$09**.

This is functionally the same as ANDing the memory contents with the inverse of the mask. %00001111 AND %10011001 = 00001001.

$09 will be stored in memory at $833C.

e) Write an instruction that will force high (1) the 5th, 3rd and 1st bits of memory location $00D7 (assuming bits are 7 through 0).

BSET $D7 %00101010

5. Data Test Instructions
Using a data test instruction, how could you determine if an 8-bit values stored in memory address $E207 was negative. Write the required assembly code and explain what happens after the code is executed to let you know if the value is negative or not.

We could load the value in to accA or accB and use CMPA, CMPB, TSTA, or TSTB, but the easiest way is to use TST.

TST $E207

This instruction will clear V and C and adjust N and Z. If N is 1, the value at $E207 is negative. Otherwise, it is not.

6. Identify the address mode associated with each of the following statements:
   a. Instruction data is stored in memory at an address relative to the value in an index register.

   Indexed

   b. Executes without any operands.

   Inherent

   c. Contains all necessary data within its op-code and operand bytes.

   Immediate

   d. Provides access to all data within the full memory structure.

   Extended

   e. Permits the fastest execution of instructions that use data stored in memory.

   Direct