# CSE 410 - Computer Systems
# Homework 1

Assigned: Wednesday, October 3, 2001

Due: Wednesday, October 10, 2001
At the start of class

Your name: _____

1. Consider a small microcontroller with byte addressable memory addressing capabilities. The program counter is 16 bits wide.

   a. What is the maximum address (in hex) that can be specified with this program counter?

   b. What is the size of the program instruction address space this defines? Give your answer in K bytes, where $1KB = 1024_{10}$ bytes.

2. As is typical of many small microcontrollers, various parts of the addressable memory space are dedicated to specific functions.

   a. For example, any 16-bit data reference address that contains all zeroes in the upper 10 bits is mapped to a special function register. What is the maximum number of special function registers that can be addressed using this scheme? Give your answer in base 10.

   b. Using this scheme, what is the largest address that refers to a special function register? Give your answer as a 16-bit binary number.

   c. Similarly, any 16-bit data reference address that contains a 1 in both of the top two bits of the address is mapped to Read Only Memory (ROM). How many bytes of ROM can be addressed this way? Give your answer in K bytes, as above.

3.  The following short procedure performs a useful function for C programs.  It takes
    one argument in $a0 (an address) and returns one value in $v0 (an integer).

```
proc:

    lb      $v0,0($a0)          #

    move    $v1,$a0             #  copy the initial address pointer to $v1

    beqz    $v0,done            #

    addu    $v1,$v1,1           #

loop:                           #

    lb      $v0,0($v1)          #

    addu    $v1,$v1,1           #

    bnez    $v0,loop            #

    subu    $v1,$v1,1           #

done:                           #

    subu    $v0,$v1,$a0         #

    j       $ra
```

a.  Add comments to the code, describing the operation of the procedure at each step.
    Don't just translate the instruction into words ("copy $a0 to $v1") but instead try
    to identify the purpose of the instruction ("copy the initial address pointer to
    $v1").

b.  What is the purpose of this procedure?

4. Consider the 32-bit address space of the MIPS processor we have discussed in class. When the most significant bit of a 32-bit address value is set to 0, the address is considered to be referencing the "user" area of memory. When the most significant bit is set to 1, the address is referencing the "kernel" area of memory.

a.      What is the largest address in the user area of memory?  Give your answer in hex.

b.      What is the smallest address in the kernel area of memory?  Give your answer in hex.

c.      A 32-bit address space covers a 4-gigabyte (GB) range.  How big is the user address space, in gigabytes?

---

The following questions require the use of the SPIM simulator.

Start the simulator running.  The last message in the message pane should tell you that the trap.handler was loaded.  Next, open the program argcount.s that is provided on the homework assignment web page.

Don't go any further until you are sure that the files are loaded correctly.

---

5. The program instructions are shown in the second pane of the simulator window.

a.      The trap handler contains a few instructions that are loaded in user space, starting at address 0x00400000. Where is the first instruction in argcount.s loaded?

b.      At address 0x00400014 there is an instruction "jal main" which transfers control to our program.  What is the numeric value in hex of the instruction generated by the assembler for this jal?

c.      Write out the 32-bit numeric value of the instruction in binary, and then identify the fields of the instruction.

6.  The data values for the program are shown in the third pane of the simulator window.

    a.  Look at address 0x10010000, the first address in the heap.  The data that is loaded there is the beginning of the null terminated string from argcount.s.  What is the hex value at this address?

    b.  The first four characters of the string are "The ".  These characters are stored with 1 character per byte, with the first character in byte 0 of the word, the second character in byte 1 of the word, etc.  The hex values for these characters are: T - 0x54, h- 0x68, e-0x65, space - 0x20.  From looking at the hex value at address 0x10010000, is your machine little-endian or big-endian?  Justify your answer.

7.  The register values are shown in the first pane of the simulator window.

    a.  Reload the file argcount.s (Menu->Simulator->Reload) to make sure that you are looking at a fresh copy of memory.  The global pointer is initialized when the program is reloaded.  What is the initial value of $gp in hex?

    b.  What is the value of the data at that address?