

# 16.317: Microprocessor Systems Design I

Fall 2015

## Homework 5

Due **2:00 PM, Monday, 11/30/15**

### Notes:

- While typed submissions are preferred, handwritten submissions are acceptable.
- Any electronic submission must be in a single file. Archive files will not be accepted.
- Electronic submissions should be e-mailed to Dr. Geiger at [Michael\\_Geiger@uml.edu](mailto:Michael_Geiger@uml.edu).
- This assignment is worth a total of 100 points.

For each of the following complex operations, write a sequence of PIC 16F1829 instructions that performs an equivalent operation. Assume that X, Y, and Z are 16-bit values split into individual bytes as shown in the following cblock directive, which defines two additional variables you can use:

```
cblock 0x70
    XH, XL    ; High and low bytes of X
    YH, YL    ; High and low bytes of Y
    ZH, ZL    ; High and low bytes of Z
    TEMP      ; Temporary byte, if needed
    COUNT     ; Loop counter, if needed
endc
```

Each question on this assignment is worth 20 points.

1. Perform the 16-bit addition:  $X = Y + Z$ . Do not change Y or Z when performing this operation.
2. Perform the 16-bit subtraction:  $X = Y - Z$ . Do not change Y or Z when performing this operation.
3. Perform a 16-bit arithmetic right shift:  $X = Y \gg ZL$ . (Note that, because the shift amount is no greater than 15, a single byte is sufficient to hold that value.) Do not change Y or ZL when performing this operation.

4. Given an 8-bit variable, YL, perform the multiplication:

$$YL = YL * 10$$

Hint: Note that multiplication by a constant amount can be broken into a series of shift and add operations. For example, in general:

- $X * 2$  can be implemented by shifting  $X$  to the left by 1 ( $X \ll 1$ )
- $X * 5$  can be implemented as  $(X * 4) + X = (X \ll 2) + X$

5. Given two 8-bit variables stored in XL and YL, copy the value of bit position YL within variable XL into the carry flag. For example:

- If  $XL = 0x03$  and  $YL = 0x00$ , set C to the value of bit 0 within XL.
  - Since  $XL = 0x03 = 0000\ 0011_2$ ,  $C = 1$
- If  $XL = 0xC2$  and  $YL = 0x04$ , set C to the value of bit 4 within XL.
  - Since  $XL = 0xC2 = 1100\ 0011_2$ ,  $C = 0$

Note that:

- This operation is very similar to the bit test (BT) instruction in the x86 architecture.
- Since YL is not a constant, you cannot use the value of YL directly in any of the PIC bit test instructions (for example, `btfsc XL, YL` is not a valid instruction).
- Your code should not modify either XL or YL.