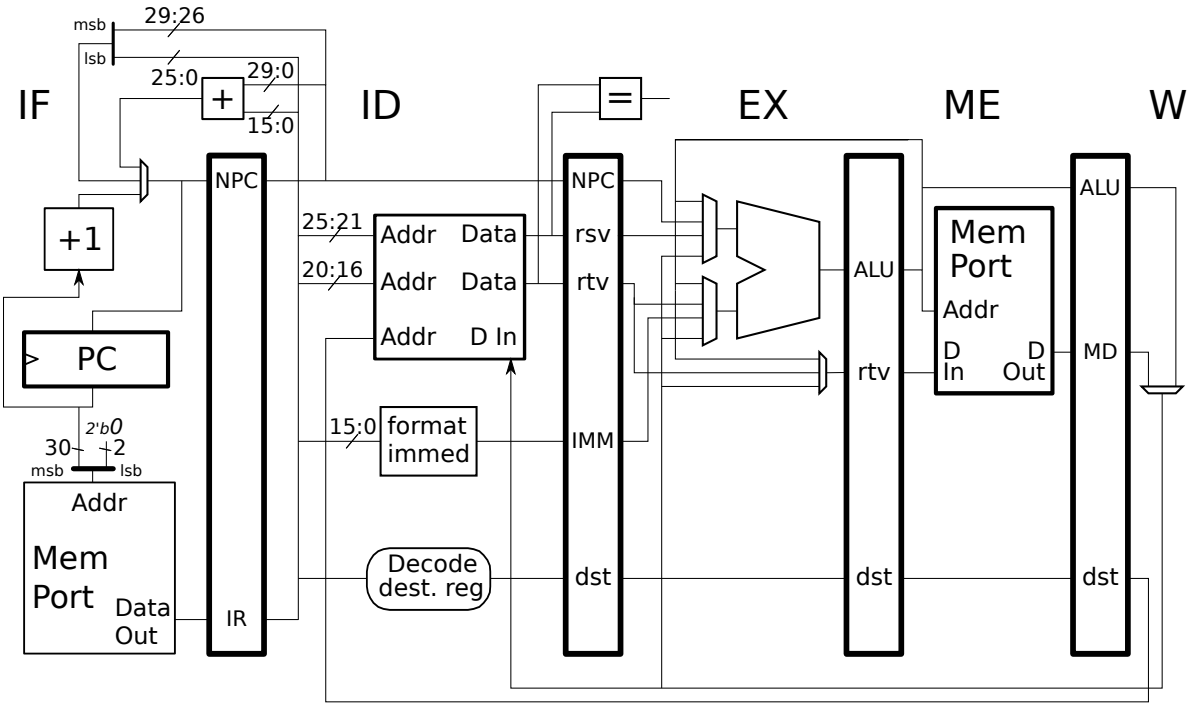
**LSU EE 4720** **Homework 4** **Due: 22 February 2019**

**Problem 1:** The three loops below (probably on the next page) copy an area of memory starting at the address in `r2` to an area of memory starting at the address in `r3`. The number of bytes to copy is in `r5`.




(*a*) Show a pipeline execution diagram for each loop on the illustrated implementation.

(*b*) Compute the rate that each loop copies data in units of bytes per cycle. Base this on your execution diagrams.

(*c*) Loop A has a wasted delay slot and should suffer stalls. Schedule the code (re-arrange instructions) to fill the delay slot and minimize the number of stalls. Feel free to change instructions and to add new ones, though the loop should still copy one byte per iteration and should copy the data as described above.

(*d*) Loop A can be safely substituted for Loop C. That is, if a program calls Loop C then that call can be changed to a call of Loop A or B and the program will still work correctly. However, if a program calls Loop A, substituting B will not work. Explain why and show sample values for `r2`, `r3`, and `r5` for which this is true.

(*e*) If a program calls Loop B substituting C will not work. Explain why and show sample values for `r2`, `r3`, and `r5` for which this is true.

*Code on next page.*

```
# Loop A
add r4, r3, r5
LOOP:
 lb r1, 0(r2)
 sb r1, 0(r3)
 addi r2, r2, 1
 addi r3, r3, 1
 bne r3, r4, LOOP
 nop

# Loop B
add r4, r3, r5
LOOP:
 lw r1, 0(r2)
 sw r1, 0(r3)
 addi r2, r2, 4
 addi r3, r3, 4
 bne r3, r4, LOOP
 nop

# Loop C
add r4, r3, r5
addi r4, r4, -8
LOOP:
 lw r1, 0(r2)
 lw r10, 4(r2)
 sw r1, 0(r3)
 sw r10, 4(r3)
 addi r2, r2, 8
 bne r3, r4, LOOP
 addi r3, r3, 8
```