Write your answers in legible and separate letters or I will not grade them.

Use only given space for your answers.
1. The following figures depict the original Tomasulo and speculative Tomasulo algorithms. Compare and contrast them in terms of their register renaming and write results. (30 points)
2.  a. ____________ can reduce traffic to the main memory by coalescing multiple writes into single writes. (5 points)

    b. In ______________ indexed and ______________ tagged caches, caches and TLBs can be accessed in parallel. (5 points)

3.  (a)____________________ is a key data structure for implementing virtual memory in operating systems. (b)____________ is a hardware structure to assist virtual memory to eliminate most accesses to (a). Misses in (a) are called (c)_______________ and misses in (b) require accesses to (a). (15 points)

4.  Explain SIMD thread scheduler, a multithreaded SIMD processor, and thread block scheduler. (15 points)

5.  What is snooping? Explain what will occur if there is a write miss and the corresponding memory block is in the shared state in the snooping-based MSI multiprocessor system? (15 points)
6. For the following MIPS assembly code, identify all data dependences by type. List the two instructions involved. Draw the data dependence graph for this code (15pts).

```
add $1, $5, $3
sw $1, 0($2)
lw $1, 4($2)
add $5, $5, $1
sw $1, 0($2)
```