EE 4720 **Homework 8** **Due: 2 May 1997**

The following code fragment is used in several problems below.

```
add r1, r2, r3
sub r6, r7, r8
lw  r10, 0(r20)
add r11, r10, r12
sub r14, r1, r9
add r1, r14, r15
sub r16, r17, r18
add r19, r21, r22
sw  0(r20), r6
```

Problem 1: A 3-way VLIW version of the DLX ISA, 3VDLX, packs three DLX instructions into a single 3VDLX instruction. The values of source registers in a 3VDLX instruction are based on the execution of the previous instructions, not the current one.

An implementation of 3VDLX must be fully pipelined and bypassed. Like the DLX implementations, integer arithmetic values are available in the next cycle, but loads are available to instructions fetched two cycles later (than the 3VDLX instruction containing the load instruction).

Show how the DLX code fragment above can be re-written for 3VDLX, showing one 3VDLX instruction as three DLX instructions on a line separated by semicolons. Show a timing diagram for the execution of the code fragment. The fragment should be written to execute quickly.

Problem 2: Show how the code fragment would execute on a static-issue, 3-way superscalar machine. The superscalar machine is similar to the DLX implementations but has three complete pipelines, it is fully bypassed.

Problem 3: Show how the code fragment would execute on a dynamic-issue, 3-way superscalar machine using Tomasulo's Approach, similar to the DLX implementations. There are three integer execution units, three load/store units, and two reservation stations for each functional unit. The memory stage is used only by load and store instructions.

Problem 4: Using 2^{18}-entry by 16-bit memory devices, design a memory system that will provide $16.777216\,\mathrm{MB} = 2^{24}$ bytes of memory[1] in 32-bit words. (This is only slightly more complicated than the simple case given in class.)

[1] "M" is a combining form meaning 1,000,000. Unfortunately, in certain contexts it is used for 1,048,576, and it's not always clear which of the two interpretations is intended. In this class "M" will always mean 1,000,000.