**Problem 1:** The MIPS program below copies a region of memory and runs on the illustrated implementation. In the sub-problems below use only the bypass connections shown in the illustration.

(a) Show a pipeline execution diagram for the code running on the illustrated implementation for two iterations.

(b) Compute the CPI and the rate at which memory is copied in bytes per cycle assuming a large number of iterations.

- Don’t forget, when computing the number of cycles per iteration be sure not to count a cycle more, or less, than once.

```
LOOP:
 lw $t0, 0($a0)
 sw 0($a1), $t0
 addi $a0, $a0, 4
 bne $a0, $a2 LOOP
 addi $a1, $a1, 4
```

**Problem 2:** Execution should be inefficient in the problem above.

(a) Add exactly the bypass connections needed so that the program above executes as fast as possible.

- Don’t forget that branch uses ID-stage comparison units.
- Don’t forget the store.

(b) Show a pipeline execution diagram of the code on the improved implementation.

(c) For each bypass path that you’ve added show the cycles in which it will be used by writing the cycle number near the bypass path. If a bypass path goes to several places (for example, both ALU muxen) put the cycle number at the place(s) that use the signal.

(d) Re-compute the CPI and the rate at which memory is copied.