

**Problem 1:** Two VAX instructions appear below. VAX documentation can be found via <http://www.ece.lsu.edu/ee4720/doc/vax.pdf>. Don't print it, it's 544 pages. Take advantage of the extensive bookmarking of the manual to find things quickly. Chapter 5 describes the addressing modes and assembler syntax, Chapter 8 summarizes the VAX ISA, and Chapter 9 lists the instructions. For the instructions look up `ext` and `add` then find the mnemonics used below. Pay attention to operand order.

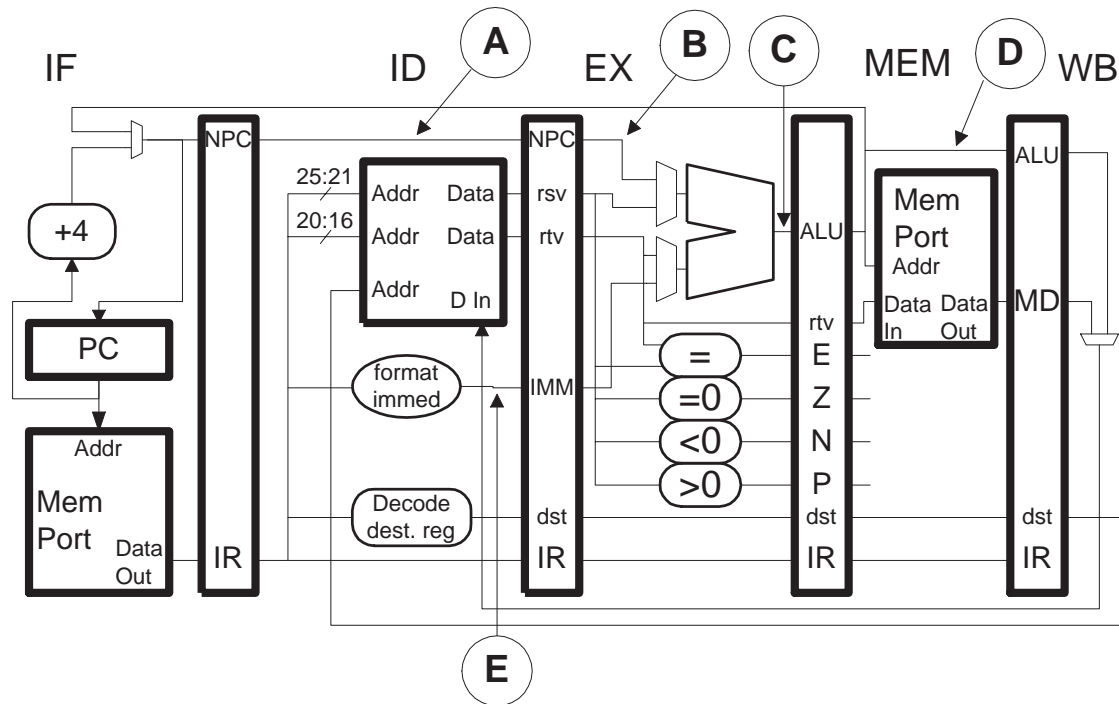
(a) Translate the VAX code below to MIPS (without changing what it does, of course). Ignore overflows and the setting of condition codes.

```
extzv    #10, #5, r1, r2
```

```
addl2    @0x12034060(r3), (r4)+ # Don't overlook the "@" and "+".
```

(b) (Extra Credit) Show how the instructions above are coded.

**Problem 2:** A pipelined MIPS implementation and some MIPS code appear below. The results computed by the MIPS instructions are shown in the comments.



```

LOOP: # LOOP = 0x1000
  addi $1, $2, 4      # 0x24
  sub  $3, $0, $3     # 0x30
  and  $1, $1, $6     # 0x20
  or   $4, $1, $5     # 0x70
  bne  $4, $3, LOOP  # Taken
  sw   $4, 7($8)     # $8 = 0x801
  add  $10, $11, $12 # 0x230
  add  $13, $11, $12 # 0x230
  add  $14, $11, $12 # 0x230
  
```

(a) Draw a pipeline execution diagram showing the execution of the code on the implementation. Base your pipeline execution diagram on the illustrated pipeline, do not depend solely on memorized execution timing rules, since they depend on details of the hardware which vary from problem to problem. Show execution until the second fetch of the first instruction.

(b) Determine the CPI for a large number of iterations.

(c) Certain wires in the implementation diagram are labeled with letters. (The circled letters with arrows.) Beneath the pipeline execution diagram show the value on those wires at near the end of each cycle. (Write sideways if necessary.) Do not show values if the corresponding stage holds a bubble or a squashed instruction. Only show immediate values if the corresponding instruction uses one. *Hint: Three instructions above use an immediate.*

(d) This is a special bonus question that did not appear in the original assignment! For those students who have taken EE 3755 in Fall 2001, identify the Verilog code in <http://www.ece.lsu.edu/ee4720/v/mipspipe.html> corresponding to each labeled wire.

**Problem 3:** Add **exactly** the bypass paths needed so that the code in the previous problem will run on the implementation below (the same as the one above) with the minimum number of stalls. Indicate the cycles in which the bypass paths will be used and the values bypassed on them.