



Figure 1: A diagram for a pipelined datapath.

Question 3 (15 points): Figure ?? contains a block diagram for a possible implementation of a five-stage pipeline similar to the one that we studied in class.

Assume that the following sequence of instructions execute in this pipeline:

```

0x000F 4000    lw      t0, 0($1)
0x000F 4004    add    t1, t2, t3
0x000F 4008    sub    t4, t0, t1
0x000F 400C    sll    t5, t4, 4
0x000F 4010    sw     t0, 0($5)
0x000F 4014    sra    t5, t5, 5
0x000F 4018    bne   t5, zero, loop
  
```

1. (4 points) During the execution of the sequence of instructions above, is there a need to insert any delay (“bubble”) in the pipeline for the correct execution of the instructions? Explain

2. **(4 points)** Consider the clock cycle in which the **lw** instruction is in the write-back stage. Is there any forward that is needed in that clock cycle? If yes, state which forwarding is needed.
3. **(4 points)** Assume that during the execution of this sequence of instructions, the value in **s5** is **0x8000 0007**. Would the execution of this sequence generate any exceptions in the pipeline? Explain your answer. If any exception is generated, explain how the exception would be handled in the pipeline. Make sure to specify in which stage of the pipeline exceptions are generated and what will happen with each of the instructions in the sequence.
4. **(3 points)** The Mux on the far left side of the Figure ?? has two inputs. The output of that Mux is sent to the PC. Explain what is the role of these two inputs, There is a third value that may be sent to the PC, but this value is not shown in this diagram. When is this third input used?