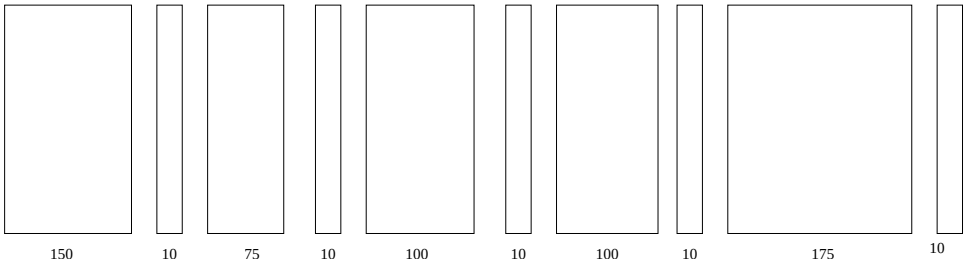
CPSC 313, Winter 2006 - Term 2
Pipelining

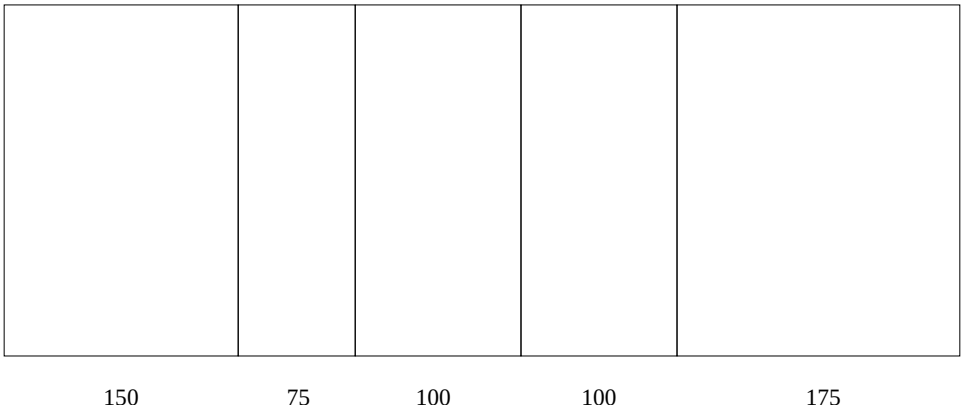
Assigned: March 9, Due: Sunday, March 18, 11:59PM

All of these questions are to be handed in on paper.

1. Consider a five-stage pipeline with stage gate delays of 150 ps, 75 ps, 100 ps, 100 ps and 175 ps and a memory delay of 10 ps, as shown below. Signals flow from left to right.



   (a) What is the maximum clock frequency this circuit could tolerate, measured in cycles per second?
   (b) What is best throughput this circuit could produce, measured in instructions-completed per second?
   (c) What is the execution latency of a single instruction, measured in seconds per instruction?
   (d) Answer questions a-c for a similar circuit that is not pipelined (i.e., where each stage is connected back-to-back with no intervening memory, as shown below)?



(e) Suppose that in order to improve the throughput of the pipeline you could split a single stage into two equal sized stages. Which stage would you split to maximize the throughput improvement?

(f) What if you could split 2 stages in half, which 2 stages would you split?

(g) Answer questions a-c for your resulting seven-stage pipeline.

2. For each of the following code fragments indicate whether a data or control dependency exists and explain by giving the type of the dependency (i.e., control, causal, anti, or output) and indicating the registers involved.

(a)
```
addl %eax, %ebx
addl %ebx, %ecx
```

(b)
```
irmovl $10, %ebx
addl %ebx, %ecx
```

(c)
```
mrmovl 10(%eax), %ebx
addl %ebx, %ecx
```

(d)
```
rmmovl %ecx, 10(%eax)
irmovl $10, %ecx
```

(e)
```
rmmovl %ebx, (%eax)
rmmovl %ecx, (%eax)
```

(f)
```
jmp target
```

(g)
```
jle less-equal
```

(h)
```
ret
```

3. Can any of the dependencies listed in problem 2 be eliminated simply by re-writing the assembly code? List all that can, explaining why and giving the revised code. (NOTE: you may assume that the remainder of the code that isn't shown in the problem can be changed in a similar manner.)

4. For each of the code fragments in problem 2, indicate whether a hazard exists in the y86 pipeline. Briefly explain why or why not.