EE334 Computer Architecture *Name:*_____
April 10, 2006 Exam 2

Problem 1. **[25 points]**

A program is run on a load and store processor that has a clock cycle time of *0.2nsec*. The instruction mix is given below.

Instruction type	Executed instructions	Multi-cycle CPIi	Pipeline CPIi
ALU	$9.3X10^8$	4	1
Load	$8.1X10^8$	5	1
Store	$4.3 X10^8$	4	1
FP inst.	$1.2 X10^8$	6.8	4.8
Branch	$3.4 X10^8$	3	2

Please determine:

a) The CPI for each implementation.

b) What implementation is faster and by how much.

Problem 2. **[40 points]**

A benchmark in a five-stage pipelined processor has the following characteristics:

26% ALU instructions,
23% load instructions
14% of the loads are followed by instructions that use the data being loaded.
25% of these loads are followed by stores. Let us assume that the destination register for load instruction is Ry, The store instructions that have dependencies on the loads:
- 40% of the stores have the form: `SW Ry, 0(Rx)`
- 60% of the stores have the form: `SW Rx, 0(Ry)`

14% store instructions
19% floating point instructions, and
18% branch instructions (54% of these branches are taken).

This processor's CPI_{int} and CPI_{FP} are equal to 1 and 3.1, respectively (when there are no hazards). Please answer the following questions:

a) Assuming that all the branch instructions cause hazards (the penalty is 1 clock cycle), please compute the overall CPI.

b) If the branch delay slot is scheduled using the three strategies and NO-OP as follows:

Delay Slot	NO-OP	Fall through	Target	Before
%	44%	11%	23%	22%

Please determine the new CPI

Problem 3. **[35 points]**

The code below was complied for a traditional 5-stage RISC pipeline.

```
foo:  LW    R10,0(R1)
      MULT  R4,R3,R10
      LW    R6,0(R2)
      ADD   R6,R4,R6
      SW    R6,0(R2)
      SUBI  R3,R1,#512
      ADDI  R1,R1,#8
      ADDI  R2,R2,#8
      BNZ   R3,foo
```

a) Please determine how many cycles it would take to execute a single iteration; i.e. determine when IF of the loop's first instruction can be performed after one iteration (use the chart provided). If 1000 iterations are executed, please determine the number of cycles.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LW	R10,0(R1)																		
MULT	R4,R3,R10																		
LW	R6,0(R2)																		
ADD	R6,R4,R6																		
SW	R6,0(R2)																		
SUBI	R3,R1,#512																		
ADDI	R1,R1,#8																		
ADDI	R2,R2,#8																		
BNZ	R3,foo																		

b) Without changing the outcome/results of the program, please rearrange the code in order to avoid/eliminate as many stalls as possible. Please determine the number of cycles that would be needed to execute 1000 iterations.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18