CS 250P   **Name (Print):** _____

Winter 2019
Midterm
02/11/2019
Time Limit: 3:30pm - 4:50pm

- **Don't forget to write your name on this exam.**

- **This is an open book, open notes exam. But no online or in-class chatting.**

- **Ask us if something is confusing in the questions.**

- **Organize your work**, in a reasonably neat and coherent way, in the space provided. Work scattered all over the page without a clear ordering will receive very little credit.

- **Mysterious or unsupported answers will not receive full credit**. A correct answer, unsupported by explanation will receive no credit; an incorrect answer supported by substantially correct explanations might still receive partial credit.

- If you need more space, use the back of the pages; clearly indicate when you have done this.

Problem	Points	Score
1	15	
2	10	
3	30	
4	20	
5	5	
6	10	
Total:	90	

1. Understanding performance

   Processor A consumes 1.3x the power of processor B, but finishes the task in 30% less time, which processor should you pick:

   (a) (5 points) If you were constrained by power delivery constraints?

   (b) (5 points) If you were trying to minimize energy per operation?

   (c) (5 points) If you were trying to minimize response times?

2. DFS and DVFS

   Processor-A at 3 GHz consumes 80 W of dynamic powerand 20 W of static power. It completes a program in 20seconds.

   (a) (5 points) What is the energy consumption if I scale frequency downby 50%?

   (b) (5 points) What is the energy consumption if I scale frequency and voltage down by 40%?

3. Basic pipelining

   An unpipelined processor takes 6 ns to work on one instruction. It then takes 0.2 ns to latch its results into latches. I was able to convert the circuits into 5 sequential pipeline stages. The stages have the following lengths: 1ns; 0.8ns; 1.3ns; 1.3ns; 0.9ns. Answer the following, assuming that there are no stalls in the pipeline.

   (a) (5 points) What is the cycle time in the new processor?

   (b) (5 points) What is the clock speed?

   (c) (5 points) What is the IPC?

   (d) (5 points) How long does it take to finish one instr?

   (e) (5 points) What is the speedup from pipelining?

   (f) (5 points) What is the max speedup from pipelining?

4. Five-stage RISC pipeline

   For the 5-stage pipeline that we've discussed in class (note that Register Read and Register Write take half a cycle) answer the following question: How many stalls will the second instruction experience with and without bypassing

   (a) (5 points) Integer addition followed by a dependent integer addition

   (b) (5 points) Load, providing the address for a store

(c) (5 points) Load, providing the data for a store

(d) (5 points) Integer addition providing the address for the store

5. Static ILP techniques

   (a) (5 points) Illustrate the loop unrolling technique by converting the following C loop in a semantically equivalent loop unrolled 4 times. You can use C or any other programming language.

```
for (i = 0; i < 100; i++) {
    a[i] = b[i] * c[i];
}
```

6. Branch prediction

The following "for" loop executes inside an infinite while loop. The inner "for" loop executesfive iterations and has a branch inside.

```
int a[] = {1, 0, 1, 0, 0};

while (1) {

    for (i = 0; i < 5; i++) {

        if (a[i] == 0) {
            ...
        }
    }
    ...
}
```

(a) (5 points) Assume that your CPU is using a 2-bit saturating counter predictor. Provide the pattern of branch prediction decisions by the predictor (assume that the external while loop ran for 100 iterations already, and the counters are in the steady state). What is the prediction success rate? I.e., out of 10 branches executed in one iteration of the inner "for" loop, what fraction is predicted correctly?

(b) (5 points) Can you suggest a technique to improve accuracy of branch prediction?