CS433: Computer Architecture – Fall 2020
Homework 1
Total Points: 21 points
All students should solve all problems
Due Date: September 10, 2020 at 10:00 pm CT (see course information slides for more details)

Directions:
- **All students must write and sign the following statement at the end of their homework submission. "I have read the honor code for this class in the course information handout and have done this homework in conformance with that code. I understand fully the penalty for violating the honor code policies for this class." No credit will be given for a submission that does not contain this signed statement.**
- **On top of the first page of your homework solution, please write your name and NETID, your partner's name and NETID, and whether you are an undergrad or grad student.**
- **Please show all work that you used to arrive at your answer. Answers without justification will not receive credit.**
- **See course information slides for more details**

Problem 0 [4 points]

Choose the correct answer for the following multiple-choice questions:

0.0) You are offered old homework solutions by a student who formerly took this class. You should:
   a. Accept the solutions because no one will ever know.
   b. Not even look at the solutions because that is the honor code set for this class.
   c. Accept the solutions because you don't really want to learn anything in this class. You are simply taking it to fulfill a requirement.

0.1) While working with a partner on a homework assignment, one of your classmates asks if he/she can also work with you. You should:
   a. Tell the other student that you already have a partner for this homework assignment.
   b. Agree to work with the other student, but only on the portion of the homework you have not yet completed.
   c. Apologize for having found a partner too early and offer to send the other student a completed copy of your homework.

0.2) Suppose you and your partner are overwhelmed with work at the time the homework is due. You should:
   a. Have your partner do half the problems, you do the other half, and combine your solutions.
   b. Complain about your course load to everyone you meet.
   c. Think ahead and email Professor Adve for an extension within 48 hours of when the homework is handed out.

0.3) You and your partner have discussed all the problems and their solutions. You then independently finish writing up your solutions for submission. Your partner texts you that s/he is running out of time to write up her/his solutions because there is a midterm the next day and asks you for your writeup as an aid. You should:

a. Give your partner your writeup. After all, you already discussed the solutions with her/him earlier.
b. Not give your writeup because the honor code requires both partners to independently write the solutions.
c. Not give your writeup, but be available to help your partner as she/he writes up her/his submission.

Problem 1 [5 points]:

Part (A) [2 points]

Assume a new execution mode called "enhanced mode" provides a 2.5x speedup to the sections of programs where it applies. What percentage of a program (measured by original execution time) must run in enhanced mode for an overall speedup of 10%?

Part (B) [1 point]

For the program identified in Part (A), what is the maximum possible speedup with an ideal enhanced mode (i.e. the identified percentage of the program is sped up infinitely)?

Part (C) [2 points]

Two enhancements are proposed: one that can enhance 40% of execution time with a speedup of 1.5, and another that can enhance a different 25% of execution time with some greater speedup value. Only one of these two can be implemented. How much of a speedup is necessary in the second enhancement to give a better enhancement than the first?

Problem 2 [3 points]

Several researchers have suggested that adding a register-memory addressing mode to a load-store machine might be useful. The idea is to replace sequences of

    ld x1, 0(x8)

    add x2, x2, x1

with

add x2, 0(x8)

Assume that the new instruction will cause the clock cycle time to increase by 5% and will not affect the CPI. Also, assume loads constitute 25.1% of all instructions. What percentage of the loads must be eliminated for the machine with the new instruction to have at least the same performance?

Problem 3 [3 points]

Consider a 2.4 cm^2 die for a 64-bit processor manufactured from a 42 cm-diameter wafer costing $9,000. Assume a wafer yield of 99%. Use the defect model from the lecture notes with 0.016 defects per cm^2 and $\alpha=10$. What is the expected cost per die (before testing)? Ignore edge effect correction.

Problem 4 [3 points]

Suppose a processor uses 105W of power while operating at 2.7 GHz, of which 3/4 is dynamic power. Suppose we want to run the same processor at a higher frequency which requires increasing the operating voltage proportionally as well. If a dynamic power consumption increase of up to 130W can be tolerated, by how much can the processor frequency be sped up?

Problem 5 [3 points]

Consider a server farm of 1,200 identical components where a single failure causes the entire system to crash. If each component has an MTTF of 150 days, what is the MTTF of the entire farm? Assume an exponential distribution for component time to failure.