

COMP278 FINAL (TAKE HOME)

NAME: _____

Instructions Complete this exam by the due date. Read each question carefully. Please type and email your answers in short, but complete sentences that **demonstrate your thought process**. Please, no more than 3 pages of text. Cite any sources. Happy Holidays!

Pick a computer Shop for a computer, either pre-built or custom made. Be creative! Indicate the name of the computer or the names of the components. Give Tech Specs for each of the following:

- (1) The clock speed of the CPU in megahertz or gigahertz.
- (2) The speed (e.g., average access time, RPM) of the hard drive or primary storage (e.g., magnetic, SSD).
- (3) The average access time of the optical drive (or other removable storage) in milliseconds.

Answer the following questions for the machine you selected or customized.

(1) **Memory organization**

- (a) Assuming a CPU instruction completes in 1 clock cycle, how many nanoseconds are necessary to execute 1 instruction?
- (b) RAM typically responds to memory access requests within 200 nanoseconds. How many instructions can the CPU execute in the time it takes to access RAM?
- (c) How many nanoseconds are necessary for the hard disk to spin in one revolution? Or, how many nanoseconds are necessary to randomly access data from the hard drive?
- (d) In the time it takes to randomly access data from the hard drive, how many instructions can the CPU execute?
- (e) How many instructions can the CPU execute in the time necessary for the optical drive (or other removable storage) to access data?
- (f) Explain how memory and storage are organized. Give an example pseudocode that uses memory or storage inefficiently, and describe how to correct the problem.

(2) **Input and output**

- (a) List two input/output devices that are a part of (or can be connected to) the machine above, other than the keyboard, mouse, and display. Estimate how much data is input/output for these two devices in terms of bytes per second.

- (b) Incidentally, `joeylawrance.com` is hosted at a facility in St. Louis. It took 63 milliseconds on average for an Internet packet to travel from Dobbs 105 to the server and back. In that time, how many instructions can the CPU execute?
- (3) **RISC vs. CISC**
- What are the main differences between RISC and CISC?
 - Is the CPU of the machine you selected earlier RISC or CISC?
 - RISC machines typically interact with RAM only via dedicated **LOAD** and **STORE** instructions (and all other instructions work with registers only), whereas CISC machines may address RAM in load and store instructions, as well as in other, unrelated instructions. What are the advantages and disadvantages of each approach?
- (4) **Microarchitecture** Typically, CPUs fetch & decode instructions, fetch operands, execute, and write back results using pipelining. Explain why.
- (5) **Parallelism** Multi-core CPUs can help speed up programs, if the program takes advantage of parallelism. Amdahl's law (below) indicates the maximum performance improvement on an n -core CPU, given that f is the fraction of the program that is inherently sequential:

$$Speedup = \frac{n}{1 + (n - 1)f}$$

- How many cores are on the computer you selected?
 - Suppose a program is completely sequential. What is the speed up of this program on your computer versus a single core machine? What if your computer had twice the number of cores, what is the speedup?
 - Suppose half of a program is sequential, and the other half can run simultaneously on multiple cores. What is the speed up of this program on your computer versus a single core machine? What if your computer had twice the number of cores, what is the speedup?
- (6) **Computer architecture.** Answer the following using complete sentences.
- What is a flip-flop? List different types of flip-flops and explain how they work.
 - What is a register? How are registers and flip flops related?
 - What is a cache, and what is its purpose?
 - What is a bus? List examples. What is the benefit of having multiple buses, instead of a single bus?
 - How are interrupts used to implement input/output? What is DMA?