Hardware & Architecture HW #8 – 100 Points

1. (2 Pts) State Amdahl's Law in words.

2. (4 Pts) Calculate the overall speedup of a system that spends 65% of its time on I/O with a disk upgrade that provides for 50% greater throughput.

3. (8 Pts – 4 Pts Each) Suppose your company has decided that it needs to make certain busy servers 30% faster. Processes in the workload spend 70% of their time using the CPU and 30% on I/O. In order to achieve an overall system speedup of 30%:
    a. How much faster does the CPU need to be?

    b. How much faster does the disk need to be?

4. (4 Pts) Suppose that you are designing an electronic musical instrument. The prototype system occasionally produces off-key notes, causing listeners to wince and grimace. You have determined that the cause of the problem is that the system becomes overwhelmed in processing the complicated input. You are thinking that if you could boost overall system performance by 12% (making it 12% faster than it is now), you could eliminate the problem. One option is to use a faster processor. If the processor accounts for 25% of the workload of this system, and you need to boost performance by 12%, how much faster does the new processor need to be?

5. (16 Pts – 4 Pts Each) Suppose the daytime processing load consists of 60% CPU activity and 40% disk activity. Your customers are complaining that the system is slow. After doing some research, you learn that you can upgrade your disks for $8,000 to make them 2.5 times as fast as they are currently. You have also learned that you can upgrade your CPU to make it 1.4 times as fast for $5,000.
    a. Which would you choose to yield the best performance improvement for the least amount of money?

    b. Which option would you choose if you don't care about the money, but want a faster system?

    c. What is the break-even point for the upgrades? That is, what price would we need to charge for the CPU (or the disk—change only one) so the result was the same cost per 1% increase for both?

    d. How would you answer change if the system activity consists of 55% processor time and 45% disk activity?

6. (8 Pts – 4 Pts Each) Suppose a disk drive has the following characteristics: • 6 surfaces • 16,383 tracks per surface • 63 sectors per track • 512 bytes/sector • Average Track-to-track seek time of 8.5ms • Rotational speed of 7,200 rpm
    a. What is the capacity of the drive?

    b. What is the access time?

7. (12 Pts – 4 Pts Each) Suppose a disk drive has the following characteristics: • 6 surfaces • 953 tracks per surface • 256 sectors per track • 512 bytes/sector • Average track-to-track seek time of 6.5ms • Rotational speed of 5,400 rpm

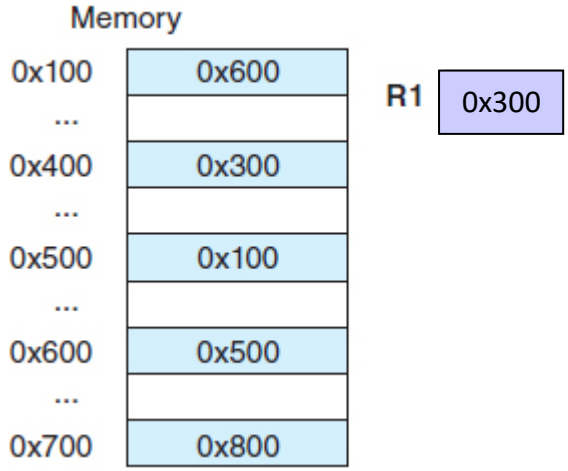
a. What is the capacity of the drive?

b. What is the access time?

c. Is this disk faster than the one described the previous problem? Explain.

8. (4 Pts) A computer has 32-bit instructions and 12-bit addresses. Suppose there are 250 two-address instructions. How many one-address instructions can be formulated? Explain your answer.

9. (4 Pts) Suppose we have the instruction Load 100. Given that memory and register R1 contain the values below, and assuming that R1 is implied in the indexed addressing mode, determine the actual value loaded into the accumulator and fill in the table:



Mode	Value loaded into the AC
Immediate	
Direct	
Indirect	
Indexed	

10. (6 Pts) Given 16-bit instructions, is it possible to use expanding opcodes to allow the following to be encoded assuming we have a total of 32 registers? If so, show the encoding. If not, explain why it is not possible.

60 instructions with two register operands
30 instructions with one register operand
3 instructions with one 10-bit address
26 instructions with zero operands

11. (8 Pts – 4 Pts Each) A non-pipelined system takes 200ns to process a task. The same task can be processed in a five-segment pipeline with a clock cycle of 40ns.

a) Determine the speedup ratio of the pipeline for 200 tasks.

b) What is the theoretical maximum speedup that could be achieved with the pipeline unit over the non-pipelined unit?

12. (8 Pts – 4 Pts Each) A non-pipelined system takes 100ns to process a task. The same task can be processed in a five-stage pipeline with a clock cycle of 20ns.

a. Determine the speedup ratio of the pipeline for 100 tasks.

b. What is the theoretical maximum speedup that could be achieved with the pipeline system over a non-pipelined system?

13. (8 Pts – 2 Pts Each) A digital computer has a memory unit with 24 bits per word. The instruction set consists of 150 different operations. All instructions have an operation code part (opcode) and an address part (allowing for only one address). Each instruction is stored in one word of memory.

a. How many bits are needed for the opcode?

b. How many bits are left for the address part of the instruction?

c. What is the maximum allowable size for memory?

d. What is the largest unsigned binary number that can be accommodated in one word of memory?

14. (8 Pts – 2 Pts Each) The memory unit of a computer has 256K words of 32 bits each. The computer has an instruction format with four fields: an opcode field; a mode field to specify one of seven addressing modes; a register address field to specify one of 60 registers; and a memory address field. Assume an instruction is 32 bits long. Answer the following:

a. How large must the mode field be?

b. How large must the register field be?

c. How large must the address field be?

d. How large is the opcode field?