Your name: \_Lake Summers\_

This is an open-book, open-note exam. You may use a calculator, and you may use a browser to look up background material on the internet. Do not use another person to provide you an answer or explain a question. Do not post questions and/or answers to chat, discord, text, etc. Do not discuss the questions and/or answers with anyone over Zoom, cell call, etc. **Do your work individually and submit your completed exam on Canvas before the 4:45 pm deadline.**

While you can choose to give only simple answers, you should show your work to allow for partial credit when your answers or units are incorrect. **For full credit, you must simplify your answers to simple fractions or whole numbers and show the correct units.** Decimal numbers are also acceptable (½ = 0.5).

1. Give the CPU execution time equation and define the terms you use. (6 pts.)

CPU Execution Time = CPU Clock Cycles for a program \* Clock cycle time

or

CPU Execution Time = CPU Clock cycles for a program / Clock Rate

CPU Clock Cycle: The time for one clock period, usually of the processor clock, which runs at a constant rate. In the above

Clock Cycle Time: The length of time of each clock cycle

Clock Rate: Inverse of clock cycle time, i.e how many clock cycles in a set unit of time

2. What is the relationship between execution time and throughput? (3 pts.)

Execution time is the amount of time it takes to complete a task, whilst throughput is the number of tasks completed per unit of time

3. What is the relationship between clock cycle time and clock rate? (3 pts.)

Clock Cycle time and Clock rate are inverses

Clock Cycle Time: The length of time of each clock cycle

Clock Rate: Inverse of clock cycle time, i.e how many clock cycles in a set unit of time

4. Consider a processor with a clock rate of 250 MHz. What is the clock cycle time? (6 pts.)

Clock cycle time = 1/clock rate = 1/(250\*10^6 Hz) = 1/[(1/4)\*10^9 Hz] = 4 nanoseconds

5. Consider a processor with a clock rate of 2 GHz. What is the clock cycle time? (6 pts.)

Clock cycle time = 1/clock rate = 1/(2\*10^9 Hz) = 0.5 nanoseconds or 500 picoseconds

6. Find the execution time for a program that executes 10 billion instructions on a processor with an average CPI of 1.5 and a clock frequency of 3 GHz. (10 pts.)

Execution Time = (Instruction Count \* CPI)/(Clock frequency)

= (10\*10^9 instructions \* 1.5 cycles/instruction)/(3\*10^9 Hz)=5 seconds

7. For the following instruction set workload and cycle values, find the average CPI. (10 pts.)

|  |  |  |
| --- | --- | --- |
| Instruction type | Instruction frequency | Cycles per instruction |
| ALU | 0.5 | 2 |
| Branch | 0.3 | 8 |
| Load/Store | 0.2 | 3 |

=(.5\*2)+(.3\*8)+(.2\*3)= 4.0 Cycles/Instruction

8. A processor has a 500 MHz clock frequency and an average CPI of 2 on a given program. If the processor executes that program in 10 seconds, find: (7.5 pts. each)

(a) the number of instructions, and

2.5 Billion instructions

(b) the number of cycles.

5 Billion

(IC \* 2CPI)/500MHz = 10 sec

IC = (10sec\*500\*10^6 Hz)/(2 cycles/instruction)

= 2.5\*10^9 instructions = 2.5 Billion instructions

CPI = Cycles/instruction 🡪 2=Cycles/2.5 Billion instructions 🡪 Cycles = 5 Billion

9. If a processor redesign could reduce the average CPI of a workload from 2 to 1 and also reduce the clock cycle time from 5 nsec to 2.5 nsec, what is the total speedup? (10 pts.)

Speedup = exec time old / exec time new = (IC old \* CPI old \* CCT old) / (IC new \* CPI new \* CCT new)

= (CPI old \* CCT old) / (CPI new \* CCT new) = (2 \* 5\*10^-9) / (1 \* 2.5\*10^-9) = 4

10. If a computer is redesigned to reduce the clock cycle time from 6 nsec to 4 nsec and a new compiler is implemented to reduce the number of instructions to 2/3 of the original total and alter the instruction frequencies in the following manner, what would be the total speedup? (15 pts.)

|  |  |  |  |
| --- | --- | --- | --- |
| Instruction type | Old instruction frequency | New instruction frequency | Cycles per instruction (same for old and new) |
| ALU | 0.2 | 0.6 | 1 |
| Branch | 0.4 | 0.2 | 5 |
| Load/Store | 0.4 | 0.2 | 2 |

Old

|  |  |
| --- | --- |
| Freq | CPI |
| .2 | 1 |
| .4 | 5 |
| .4 | 2 |
| Avg CPI = | (.2\*1)+(.4\*5)+(.4\*2)=3.0 |

New

|  |  |
| --- | --- |
| Freq | CPI |
| .6 | 1 |
| .2 | 5 |
| .2 | 2 |
| Avg CPI= | (.6\*1)+(.2\*5)+(.2\*2)=2.0 |

Speedup=(IC\_old\*CPI\_old\*CCT\_old)/(IC\_new\*CPI\_new\*CCT\_new)

=CPI\_old/CPI\_new

=3.0/2.0

=1.5

11. Give the equation for Amdahl’s Law and define the terms you use. (6 pts.)

T 1

overall\_speedup = ----------------- = ---------------

T\*[ (1-f) + f/s ] [ (1-f) + f/s ]

s: speedup of a fraction of program execution time

f: fraction of a program execution time

12. Use Amdahl’s Law to determine the overall speedup if an enhancement with speedup of 10 can be used 2/3rds of the time. (10 pts.)

f=2/3, s=10

Overall Speedup = 1/{[1-(2/3)]+ [(2/3)/10]} = 2.5