Review Questions

2.1 List and briefly discuss the obstacles that arise when clock speed and logic density increase.

2.2 What are the advantages of using a cache?

2.3 Briefly describe some of the methods used to increase processor speed.

2.4 Briefly characterize Amdahl's law.

2.5 Define clock rate. Is it similar to clock speed?

2.6 Define MIPS and FLOPS.

2.7 When is the Harmonic mean an appropriate measure of the value of a system?

2.8 Explain each variable that is related to Little's Law.

2.9 What are the SPEC benchmarks?

2.10 While evaluating a system's performance using SPEC benchmarks, why is each program compiled and run three times?

Problems

2.1 A benchmark program is run first on a 200 MHz, and then on a 400 MHz processor. The executed program consists of 200,000 instruction executions, with the following instruction mix and clock cycle count:

Instruction Type	Instruction Count	Cycles per Instruction
Integer arithmetic	1,00,000	1
Data transfer	60,000	2
Floating point	30,000	2
Control transfer	10,000	2

Determine the effective *CPI* and MIPS rate for both the cases.

2.2 Consider two different machines, with two different instruction sets, both of which have a clock rate of 200 MHz. The following measurements are recorded on the two machines running a given set of benchmark programs:

Instruction Type	Instruction Count (millions)	Cycles per Instruction
Machine A		
Arithmetic and logic	8	1
Load and store	4	3
Branch	2	4
Others	4	3
Machine A		
Arithmetic and logic	10	1
Load and store	8	2
Branch	2	4
Others	4	3

a. Determine the effective *CPI*, MIPS rate, and execution time for each machine.

b. Comment on the results.

√2.3 Early examples of CISC and RISC design are the VAX 11/780 and the IBM RS/6000, respectively. Using a typical benchmark program, the following machine characteristics result:

Processor	Clock Frequency (MHz)	Performance (MIPS)	CPU Time (secs)
VAX 11/780	5	1	12 x
IBM RS/6000	25	18	x

The final column shows that the VAX required 12 times longer than the IBM measured in CPU time.

a. What is the relative size of the instruction count of the machine code for this benchmark program running on the two machines?

b. What are the *CPI* values for the two machines?

2.4 Four benchmark programs are executed on three computers with the following results:

	Computer A	Computer B	Computer C
Program 1	1	10	20
Program 2	1000	100	20
Program 3	500	1000	50
Program 4	100	800	100

The table shows the execution time in seconds, with 100,000,000 instructions executed in each of the four programs. Calculate the MIPS values for each computer for each program. Then calculate the arithmetic and harmonic means assuming equal weights for the four programs, and rank the computers based on arithmetic mean and harmonic mean.

2.5 The following table, based on data reported in the literature [HEAT84], shows the execution times, in seconds, for five different benchmark programs on three machines.

Benchmark	Processor		
	R	M	Z
E	417	244	134
F	83	70	70
H	66	153	135
I	39,449	35,527	66,000
K	772	368	369

a. Compute the speed metric for each processor for each benchmark, normalized to machine R. That is, the ratio values for R are all 1.0. Other ratios are calculated using Equation (2.5) with R treated as the reference system. Then compute the arithmetic mean value for each system using Equation (2.3). This is the approach taken in [HEAT84].

b. Repeat part (a) using M as the reference machine. This calculation was not tried in [HEAT84].

c. Which machine i...