

### 1.1

Consider three different processors P1, P2 and P3 executing the same instruction set with the clock rates and CPIs given in the following table

	Processor	Clock Rate	CPI
<b>a.</b>	P1	3 GHz	1.5
	P2	2.5 GHz	1.0
	P3	4 GHz	2.2
<b>b.</b>	P1	2 GHz	1.2
	P2	3 GHz	0.8
	P3	4 GHz	2.0

- (1) Which processor has the highest performance expressed in instructions per second?
- (2) If the processor each execute a program in 10 seconds, find the number of cycles and the number of instructions.

### 1.2

The table below shows the instruction type breakdown of a given application execute on 1, 2, 4 or 8 processors. Using this data, you will be exploring the speed-up of applications on parallel processors.

	Processors	No. Instructions per Processor			CPI		
		Arithmetic	Load/Store	Branch	Arithmetic	Load/Store	Branch
<b>a.</b>	1	2560	1280	256	1	4	2
	2	1280	640	128	1	5	2
	4	640	320	64	1	7	2
	8	320	160	32	1	12	2
	Processors	No. Instructions per Processor			CPI		
		Arithmetic	Load/Store	Branch	Arithmetic	Load/Store	Branch
<b>b.</b>	1	2560	1280	256	1	4	2
	2	1280	640	128	1	6	2
	4	640	320	64	1	8	2
	8	320	160	32	1	10	2

- (1) The table above shows the number of instructions required per processor to complete a program on a multiprocessor with 1, 2, 4 or 8 processors. What is the total number of instructions executed per processor? What is the aggregate number of instructions executed across all processors?
- (2) Given the CPI values on the right of the table above, find the total execution time for this program on 1, 2, 4 and 8 processors. Assume that each processor has a 2 GHz clock frequency.
- (3) If the CPI of the arithmetic instructions was doubled, what would the impact be on the execution time of the program on 1, 2, 4 or 8 processors?

The table below shows the number of instructions per processor core on a multicore processor as well as the average CPI for executing the program on 1, 2, 4 or 8 cores. Using this data, you will be exploring the speedup of applications on multicore processors.

	Cores per Processor	Instructions per Core	Average CPI
<b>a.</b>	1	1.00E+10	1.2
	2	5.00E+09	1.4
	4	2.50E+09	1.8
	8	1.25E+09	2.6
	Cores per Processor	Instructions per Core	Average CPI
<b>b.</b>	1	1.00E+10	1.0
	2	5.00E+09	1.2
	4	2.50E+09	1.4
	8	1.25E+09	1.7

- (4) Assuming a 3GHz clock frequency, what is the execution time of a program using 1, 2, 4, or 8 cores?
- (5) Assume that the power consumption of a processor core can be described by the following equation:

$$Power = \frac{5.0mA}{MHz} Voltage^2$$

where the operation voltage of the processor is described by the following equation:

$$Voltage = \frac{1}{5} Frequency + 0.4$$

with the frequency measured in GHz. So, at 5GHz, the voltage would be 1.4V. Find the power consumption of the program executing on 1, 2, 4 and 8 cores assuming that each core is operating at a 3 GHz clock frequency. Likewise, find the power consumption of the program executing on 1, 2, 4 or 8 cores assuming that each core is operating at 500 MHz