1.

> Check yourself problem on pg 40: “A given application written in Java runs 15 seconds on a desktop processor. A new Java compiler is released that requires only 0.6 [times?] as many instructions as the old compiler. Unfortunately, it increases the CPI by 1.1. How fast can we expect the application to run using this new compiler? Pick the right answer from the three choices below.

Compiler	Time	CPI	Instructions
Old	15s		I
New		1.1CPI	0.6I

b - $15 \times 0.6 \times 1.1 = 9.9s$

2.

1.4

> (assuming p.55): Assume a color display using 8 bits for each of the primary colors (red, green, blue) per pixel and a frame size of 1280 x 1024.

a. What is the minimum size in bytes of the frame buffer to store a frame?

$$\text{Pixel count} = 1280 \cdot 1024 = 1,310,720$$

$$24 \text{ bits per pixel}$$

$$24 \cdot 1,310,720 = 31,457,280$$

$$31,457,280 \text{ bits} = 3,932,160 \text{ bytes}$$

3,932,160 bytes to store a frame

b. How long would it take, at a minimum, for the frame to be sent over a 100 Mbit/s network?

a 1 Mbit/s connections transfers 1,000,000 bits per second. $100 \cdot 1,000,000 = 100,000,000$. we have 31,457,280 bits to transfer, so $\frac{31,457,280}{100,000,000} = .32$.

.32 seconds

3.

1.7

> Compilers can have a profound impact on the performance of an application. Assume that for a program, compiler A results in a dynamic instruction count of 1.0E9 and has an execution time of 1.1 s, while compiler B results in a dynamic instruction count of 1.2E9 and an execution time of 1.5 s.

	Compiler A	Compiler B
Instruction Count	$1.0 \cdot 10^9$	$1.2 \cdot 10^9$
Execution Time	1.1s	1.5s

a. Find the average CPI for each program given that the processor has a clock cycle time of 1ns.

average cpi = cycles\instruction

cpi for a = $\frac{1.1 \cdot 10^9}{10^9} = 1.1$

cpi for b = $\frac{1.5 \cdot 10^9}{1.2 \cdot 10^9} = 1.25$

b. Assume the compiled programs run on two different processors. If the execution times on the two processors are the same, how much faster is the clock of the processor running compiler A's code versus the clock of the processor running compiler B's code?

.9 seconds

c. A new compiler is developed that uses only 6.0E8 instructions and has an average CPI of 1.1. What is the speedup of using this new compiler versus using compiler A or B on the original processor?

instruction count = $6 \cdot 10^8$
cpi = 1.1

speedup = $(6 \cdot 10^8) \cdot 1.1$

> on the two processors are the same, how much faster is the clock of the processor running compiler A’s code versus the clock of the processor running compiler B’s code? What is the speedup of using this new compiler versus using compiler A or B on the original processor?

4.

1.9

> Assume for arithmetic, load/store, and branch instructions, a processor has CPIs of 1, 12, and 5, respectively. Also assume that on a single processor a program requires the execution of 2.56E9 arithmetic instructions, 1.28E9 load/store instructions, and 256 million branch instructions. Assume that each processor has a 2GHz clock frequency.
>
> Assume that, as the program is parallelized to run over multiple cores, the number of arithmetic and load/store instructions per processor is divided by 0.7 x p (where p is the number of processors) but the number of branch instructions per processor remains the same.

Single Processor	**Arithmetic**	**Load/store**	**Branch**
Instructions	2.56×10^9	1.28×10^9	256 million
CPI	1	12	5
Clock Frequency	$2GHz$	$2GHz$	$2GHz$
Parallelized	$\frac{IPC}{0.7 \times p}$	$\frac{IPC}{0.7 \times p}$	

1.9.1.

> Find the total execution time for this program on 1, 2, 4, and 8 processors, and show the relative speedup of the 2, 4, and 8 processor result relative to the single processor result. the execution time of the program on 1, 2, 4, or 8 processors? processor to match the performance of four processors using the original CPI values

Processors	Calculation	Time	Speedup
1	$\frac{(2.56 \times 10^9) + (1.28 \times 10^9 \times 12) + (2.56 \times 10^8 \times 5)}{2 \times 10^9}$	**9.6s**	
2	$\frac{\left(\frac{2.56 \times 10^9}{.7 \times 2}\right) + \left(\frac{1.28 \times 10^9 \times 12}{.7 \times 2}\right) + \left(\frac{2.56 \times 10^8 \times 5}{.7 \times 2}\right)}{2 \times 10^9}$	**8.7s**	**0.9s**
4	$\frac{\left(\frac{2.56 \times 10^9}{.7 \times 4}\right) + \left(\frac{1.28 \times 10^9 \times 12}{.7 \times 4}\right) + \left(\frac{2.56 \times 10^8 \times 5}{.7 \times 4}\right)}{2 \times 10^9}$	**4.3s**	**5.3s**
8	$\frac{\left(\frac{2.56 \times 10^9}{.7 \times 8}\right) + \left(\frac{1.28 \times 10^9 \times 12}{.7 \times 8}\right) + \left(\frac{2.56 \times 10^8 \times 5}{.7 \times 8}\right)}{2 \times 10^9}$	**2.17s**	**7.43**

1.9.2

> If the CPI of the arithmetic instructions was doubled, what would the impact be on

Processors	Calculation	Time	Speedup
1	$\frac{(2.56 \times 10^9 \times 2) + (1.28 \times 10^9 \times 12) + (2.56 \times 10^8 \times 5)}{2 \times 10^9}$	**16s**	
2	$\frac{\left(\frac{2.56 \times 10^9}{.7 \times 2} \times 2\right) + \left(\frac{1.28 \times 10^9 \times 12}{.7 \times 2}\right) + \left(\frac{2.56 \times 10^8 \times 5}{.7 \times 2}\right)}{2 \times 10^9}$	**11.4s**	**4.6s**
4	$\frac{\left(\frac{2.56 \times 10^9}{.7 \times 4} \times 2\right) + \left(\frac{1.28 \times 10^9 \times 12}{.7 \times 4}\right) + \left(\frac{2.56 \times 10^8 \times 5}{.7 \times 4}\right)}{2 \times 10^9}$	**5.7s**	**10.3s**
8	$\frac{\left(\frac{2.56 \times 10^9}{.7 \times 8} \times 2\right) + \left(\frac{1.28 \times 10^9 \times 12}{.7 \times 8}\right) + \left(\frac{2.56 \times 10^8 \times 5}{.7 \times 8}\right)}{2 \times 10^9}$	**2.86s**	**13.14**

1.9.3.

> To what should the CPI of load/store instruction be reduced in order for a single processor to match the performance of four processors using the origin CPI values?

$$\frac{(2.56 \times 10^9) + (1.28 \times 10^9 \times 12) + (2.56 \times 10^8 \times x)}{2 \times 10^9} = 4.3$$

-36.40625

5.

1.10

> Assume a 15 cm diameter wafer has a cost of 12, contains 84 dies, and has 0.020 defects/cm2. Assume a 20 cm diameter wafer has a cost of 15, contains 100 dies, and has 0.031 defects/cm2.

Wafer	diameter	Cost	Dies	Defects
First	15cm	12	84	$\frac{0.020 \text{ defects}}{cm^2}$
Second	20cm	15	100	$\frac{0.031 \text{ defects}}{cm^2}$

1.10.1.

> Find the yield for both wafers.

wafer	Equation	Yield
First	$\frac{1}{\left[1+\left(0.02 \times \frac{0.21}{2}\right)\right]^2}$	≈ 0.5
Second	$\frac{1}{\left[1+\left(0.031 \times \frac{3.14}{2}\right)\right]^2}$	≈ 0.91

1.10.2

> Find the cost per die for both wafers.

Wafer	Equation	Cost per die
Fist	$\frac{12}{84 \times 0.5}$	$\approx .2857$
Second	$\frac{15}{100 \times 0.91}$	$\approx .165$

1.10.3

> If the number of dies per wafer is increased by 10% and the defects per area unit increases by 15%, find the die area and yield

Wafer	Equation	Die Area
First	$\frac{\frac{1}{4}\pi 15^2}{84 \times 0.1}$	≈ 21.04
Second	$\frac{\frac{1}{4}\pi 20^2}{100 \times 0.1}$	≈ 31.42

Wafer	Equation	Yield
First	$\frac{1}{\left[1 + \left((0.02 \times 0.1) \times \frac{21.04}{2}\right)\right]^2}$	$\approx .96$
Second	$\frac{1}{\left[1 + \left((0.031 \times 0.1) \times \frac{31.42}{2}\right)\right]^2}$	$\approx .91$

1.10.4

> Assume a fabrication process improves the yield from 0.92 to 0.95. Find the defects per area unit for each version of the technology given a die area of 200 mm2.

Equation	Defects Per Area
$\frac{1}{\left[1 + \left(x \times \frac{200}{2}\right)\right]^2} = .95$	≈ 0.0203

6.

1.12

> Section 1.10 cites as a pitfall the utilization of a subset of the performance equation as a performance metric. To illustrate this, consider the following two processors. P1 has a clock rate of 4 GHz, average CPI of 0.9, and requires the execution of 5.0E9 instructions. P2 has a clock rate of 3 GHz, an average CPI of 0.75, and requires the execution of 1.0E9 instructions

Processor	Clock Rate	CPI	Instructions
P1	4GHz	0.9	5.0×10^9
P2	3GHz	0.75	1.0×10^9

1.12.1.

> One usual fallacy is to consider the computer with the larges clock rate as having the larges performance. Check if this is true for P1 and P2.

Processor	Equation	Time	Performance
P1	$\frac{5.0\times10^9\times0.9}{4\times10^9}$	**1.125**	.88
P2	$\frac{1.0\times10^9\times0.75}{3\times10^9}$	**.25**	4

1.12.2.

> Another fallacy is to consider that the processor executing the largest number of instructions will need a large CPU time. Considering that processor P1 is executing a sequence of 1.0E9 instructions and that the CPI of processors P1 and P2 do not change, determine the number of instructions that P2 can execute in the same time that P1 needs to execute 1.0E9.

Processor	Equation	Time	Instructions
P1	$\frac{1.0\times10^9\times0.9}{4\times10^9}$	**0.225**	
P2	$\frac{x\times0.75}{3\times10^9} = 0.225$		9×10^8

1.12.3.

> A common fallacy is to use MIPS (millions of instructions per second) to compare the performance of two different processors, and consider that the processor with the largest MIPS has the largest performance. Check if this is true for P1 and P2.

Processor	Equation	MIPS
P1	$\frac{4\times10^9}{0.9\times10^6}$	4444.44
P2	$\frac{3\times10^9}{0.75\times10^6}$	4000

1.12.4.

> Another common performance figure is MFLOPS (millions of floating-point operations per second, defined as

> $$\text{MFLOPS} = \frac{\text{No. FP operations}}{\text{execution time} \times 10^6}$$
>
> But this figure has the same problem as MIPS. Assume that 40% of the instructions executed on both P1 and P2 are floating point instructions. Find the MFLOPS figures for the program.

Processor	Equation	MFLOPS
P1	$\frac{.4(5\times10^9)}{1.125\times10^6}$	**1777**
P2	$\frac{.4(1\times10^9)}{.25\times10^6}$	**1600**

7.

> Computer A has an overall CPI of 1.3 and can be run at a clock rate of 600MHz. Computer B has a CPI of 2.5 and can be run at a clock rate of 750 Mhz. We have a particular program we wish to run. When compiled for computer A, this program has exactly 100,000 instructions. How many instructions would the program need to have when compiled for Computer B, in order for the two computers to have exactly the same execution time for this program?

Computer	CPI	Clock Rate
A	1.3	600MHz
B	2.5	750MHz

Computer	Equation	Time	Instructions
A	$\frac{10^5\times1.3}{600\times10^6}$	0.000216	100,000
B	$\frac{x\times2.5}{750\times10^6} = 0.000216$	0.000216	6500