CSE 331 - Homework 1

1-

	diameter	Cost per wafer	Dies per wafer	Defects/cm^2
Wafer_X	16cm	15	64	0,02
Wafer_Y	20cm	24	100	0,03

A) Wafer Area $= \pi \times (\text{diameter}/2)^2$

↳ For Wafer_X $= \pi \times (16/2)^2 = \pi \times 64 = 201{,}06\ cm^2$

↳ For Wafer_Y $= \pi \times (20/2)^2 = \pi \times 100 = 314{,}15\ cm^2$

Die Area = Wafer area / dies per wafer

↳ For Wafer_X $= 201{,}06 / 64 = 3{,}14\ cm^2$

↳ For Wafer_Y $= 314.15 / 100 = 3{,}14\ cm^2$

B) $$\text{Yield} = \frac{1}{(1+(\text{Defects per area} \times \text{Die area}/2))^2}$$

↳ For Wafer_X $= \dfrac{1}{(1+(0{,}02 \times (3{,}14/2)))^2} = 0{,}940$

↳ For Wafer_Y $= \dfrac{1}{(1+(0{,}03 \times (3{,}14/2)))^2} = 0.912$

$$\text{Cost per die} = \frac{\text{Cost per wafer}}{\text{Dies per wafer} \times \text{yield}}$$

↳ For Wafer_X $= \dfrac{15}{64 \times 0{,}940} = 0{,}24$

↳ For Wafer_Y $= \dfrac{24}{100 \times 0{,}912} = 0{,}26$

c) Wafer cost decreases by 20%

Dies per wafer increased by 10%

Defects per area unit increased by 15%

↳ For Wafer_X;

$$\text{Cost per wafer} = 15 - \frac{15.20}{100} = 12$$

$$\text{Dies per wafer} = 64 + \frac{64.10}{100} = 70{,}4$$

$$\text{Defects per area} = 0{,}02 + \frac{0{,}02 \times 15}{100} = 0{,}023$$

$$\text{Wafer area} = \pi \times (16/2)^2 = \pi \times 64 = 201{,}06\ cm^2$$

$$\text{Die area} = 201{,}06 / 70.4 = 2{,}85\ cm^2$$

$$\text{Yield} = \frac{1}{(1+(0{,}023 \times (2{,}85/2)))^2} = 0.937$$

$$\text{Cost per die} = \frac{12}{70.4 \times 0.937} = 0.18$$

→ So, the wafer_x cost per die is decreases by 25% according to the before year.

↳ For Wafer_Y;

$$\text{Cost per wafer} = 24 - \frac{24.20}{100} = 19.2$$

$$\text{Dies per wafer} = 100 + \frac{100.10}{100} = 110$$

$$\text{Defects per area} = 0.03 + \frac{0.03 \times 15}{100} = 0.034$$

$$\text{Wafer area} = \pi \times (20/2)^2 = \pi \times 100 = 314.15\ cm^2$$

$$\text{Die area} = 314.15 / 110 = 2{,}85\ cm^2$$

$$\text{Yield} = \frac{1}{(1+(0{,}034 \times (2{,}85/2)))^2} = 0.909$$

$$\text{Cost per die} = \frac{19.2}{110 \times 0.909} = 0.19$$

→ So, the wafer_Y cost per die is decreases by 26.9% according to the before year.

2- The clock rate of P1 is 3 GHz and P2 is 1.5 GHz.
Given a program that has one billion instructions divided into classes as follows: 30% R-type, 50% I-type, 20% J-type.

Required Cycles	R type	I type	J type
P1	2	4	3
P2	3	3	3

↳

A) Clock cycles

↳ For P1 $= 2 \times \frac{30}{100} \times 10^9 + 4 \times \frac{50}{100} \times 10^9 + 3 \times \frac{20}{100} \times 10^9$

$= 6 \times 10^8 + 20 \times 10^8 + 6 \times 10^8 = 32 \times 10^8$

↳ For P2 $= 3 \times \frac{30}{100} \times 10^9 + 3 \times \frac{50}{100} \times 10^9 + 3 \times \frac{20}{100} \times 10^9$

$= 9 \times 10^8 + 15 \times 10^8 + 6 \times 10^8 = 30 \times 10^8$

B) Average clock cycles per instruction (CPI)

$$CPI = \frac{\text{CPU clock cycles}}{\text{Instruction count}}$$

↳ For $P_1 = \frac{32 \times 10^8}{10^9} = 3.2$

↳ For $P_2 = \frac{30 \times 10^8}{10^9} = 3$

c) Execution time $= \frac{\text{Instruction count} \times CPI}{\text{Clock rate}}$, $3 GHz = 3 \times 10^9 Hz$
$1{,}5 GHz = 1{,}5 \times 10^9 Hz$

↳ For P1 $= \frac{10^9 \times 3.2}{3 \times 10^9} = 1.06$

↳ For $P_2 = \frac{10^9 \times 3}{1{,}5 \times 10^9} = 2$

D) $\frac{2}{1.06} = 1.88$

→ P_1 is faster than P_2 by 1.88 times.