Q1)

$$\frac{\text{cycles}}{\text{ins}} = \frac{\text{cycles}}{s} \times \frac{s}{\text{ins}} \Rightarrow \frac{\text{ins}}{s} = \frac{\text{cycles}}{s} \times \frac{\text{ins}}{\text{cycles}}$$

$$\frac{\text{ins}}{s} = \frac{\text{clock rate}}{\text{CPI}}$$

P1:

$$\frac{\text{ins}}{s} = \frac{3G}{1.5} = 2G$$

P2:

$$\frac{\text{ins}}{s} = \frac{2.5G}{1} = 2.5G$$

P3:

$$\frac{\text{ins}}{s} = \frac{4G}{2.2} = 1.82G$$

a) $P2 > P1 > P3 \Rightarrow$ P2 has the highest instructions per cycle

b) $t = 10s$

P_1: $\frac{\text{ins}}{s} = 2G \Rightarrow \text{ins} = 2G \cdot 10$

$\text{ins} = 20G$

$\text{cycles} = \text{clock} \times t$

$\text{cycles} = 3G \times 10$

$= 30G$

P_2:

$\text{ins} = 2.5G \cdot 10$

$\text{ins} = 25G$

$\text{cycles} = 2.5G \times 10 = 25G$

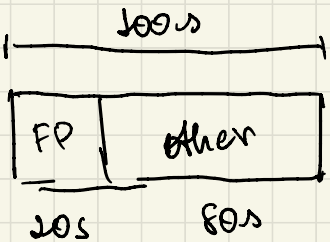
P_3: $\text{ins} = 1.82G \cdot 10$

$\text{ins} = 18.2G$

$\text{cycles} = 4G \times 10 = 40G$

Q2)

a)



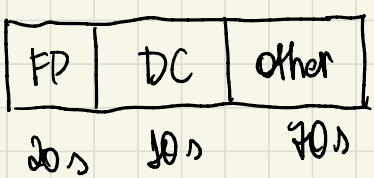
Consider the original time as 100s (without speeding up) $\Rightarrow t_0 = 100s$

After speeding up, FP consumes 10s. Thus, our total execution time will be

$t_s = (10 + 80)s = 90s$

$$S = \frac{t_0}{t_s} = \frac{100}{90} = 1.11$$

b)

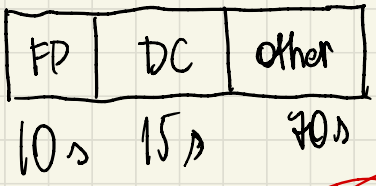


After speeding up, we have

$t_s = \underbrace{10s}_{FP} + \underbrace{15s}_{DC} + \underbrace{70s}_{other} = 95s$

$$S = \frac{100}{95} = 1.05$$

c)



$$\%_{FP} = \frac{10}{95} = 10.5\%$$

$$\%_{DC} = \frac{15}{95} = 15.8\%$$

Q3)

a)

RAW

Ins 3 - 1 (R_1)
" 3 - 2 (R_2)
" 4 - 3 (R_3)
" 6 - 5 (R_0)
" 7 - 6 (R_4)

WAR

Ins 5 - 1 (R_0)
" 5 - 2 (R_0)
" 5 - 4 (R_0)

~~WAW~~

b)

Instructions		c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	c12	c13	c14	c15	c16	c17	c18	c19	c20	c21
LD	R1, A(R0)	IF	ID	EXE	MEM	WB														IF	ID	EXE
LD	R2, B(R0)		IF	ID	EXE	MEM	WB														…	
DADDI	R3, R1, R2			IF	-	-	ID	EXE	MEM	WB												
SD	C(R0), R3						IF	-	-	ID	EXE	MEM	WB									
DADDI	R0, R0, 4									IF	ID	EXE	MEM	WB								
DSUB	R4, R5, R0										IF	-	-	ID	EXE	MEM	WB					
BNEQZ	R4, LOOP													IF	-	-	ID	EXE	MEM	WB		

No forwarding. 18 cycles for reach to the next IF, and each 18 cycles decrease R5 by 4. Assume R0 is 0 in the beginning. We need 100x18 cycles = 1800 cycles

c)

Instructions		c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	c12	c13	c14	c15
LD	R1, A(R0)	IF	ID	EXE	MEM	WB						IF	ID	EXE	MEM	WB
LD	R2, B(R0)		IF	ID	EXE	MEM	WB									…
DADDI	R3, R1, R2			IF	ID	-	EXE	MEM	WB							
SD	C(R0), R3				IF	-	ID	EXE	MEM	WB						
DADDI	R0, R0, 4						IF	ID	EXE	MEM	WB					
DSUB	R4, R5, R0							IF	ID	EXE	MEM	WB				
BNEQZ	R4, LOOP								IF	ID	EXE	MEM	WB			

Forwarding. 10 cycles for reach to the next IF, and each 10 cycles decrease R5 by 4. Assume R0 is 0 in the beginning. We need 100x10 cycles = 1000 cycles