

1. (a) · R-type / I-type : $30 + 250 + 150 + 25 + 200 + 25 + 20 = 700 \text{ (ps)}$

- lw : $30 + 250 + 150 + 25 + 200 + 250 + 25 + 20 = 950 \text{ (ps)} \vee$
- sw : $30 + 250 + 150 + 200 + 25 + 250 = 905 \text{ (ps)}$
- bzg : $30 + 250 + 150 + 25 + 200 + 5 + 25 + 20 = 705 \text{ (ps)}$

↳ · R/I-type : 710ps
· lw : 960ps \vee $\left. \begin{array}{l} \cdot sw : 915ps \\ \cdot bzg : 715ps \end{array} \right\} \because \text{latency of the register file } 150 \rightarrow 160$

$$12\% \times (25\% + 11\%) = 4.32\%$$

$$960 \times (100 - 4.32) = 918.528$$

$\therefore 950 \text{ ps} \rightarrow 918.528 \text{ ps} : 1.034 \text{ 배 빨라짐.}$

1. (b) $1000 + 200 + 4 \times 10 + 100 + 2 \times 30 + 2000 + 5 + 100 + 2 \times 1 + 2 \times 500$
 $= 4507$

↳ 4707 ($\because \text{cost of the register file } 200 \rightarrow 400$)
 $\therefore 4507 \rightarrow 4707 : 1.044 \text{ 배 더워짐.}$

1. (c) 비용과 속도가 동시에 증가하기 때문에 비용이나 속도 중 상황에 알게 증가하는 결과를 얻을 수 있다.

2. (a)

		1	2	3	4	5	6	7	8	9	10	11	12
sd	\$s5, 12(\$s3)	IF	ID	EX	MEM	WB							
ld	\$s5, 8(\$s3)	IF	ID	EX	MEM	WB							
sub	\$s4, \$s2, \$s1	IF	ID	EX	MEM	WB							
beqz	\$s4, label		st	st	IF	ID	EX	MEM	WB				
add	\$s2, \$s0, \$s1		st	st	IF	ID	EX	MEM	WB				
sub	\$s2, \$s6, \$s1			st	st	IF	ID	EX	MEM	WB			

2. (b)

No. Every instruction must be fetched.

⇒ Every data access causes a stall.

2. (c)

No. NOPs must be fetched from instruction memory.

2(d)

$$25\% + 11\% = 36\%$$

3.(a) (b)

ld	\$s0, 0(\$s3)	IF ID EX MEM WB				
ld	\$s1, 8(\$s3)	IF ID EX MEM WB				
add	\$s2, \$s0, \$s1	IF ID St EX MEM WB				
addi	\$s3, \$s3, -16	IF St ID EX MEM WB				
bnez	\$s2, LOOP	St IF ID EX MEM WB				
ld	\$s0, 0(\$s3)	IF ID EX MEM WB				
ld	\$s1, 8(\$s3)	IF ID EX MEM WB				
add	\$s2, \$s0, \$s1	IF ID St EX MEM WB				
addi	\$s3, \$s3, -16	IF St ID EX MEM WB				
bnez	\$s2, LOOP	IF ID EX MEM WB				

There are no cycles that all stages are useful.

4.(a)

```

add $s3, $s1, $s0
nop
nop
lw $s2, 4($s3)
lw $s1, 0($s4)
nop
or $s2, $s3, $s2
nop
nop
sw $s2, 0($s3)

```

4.(b)

It's impossible to reduce NOPs.

4.(c)

The code executes correctly.

4.(d)

IF	ID	EX	MEM	WB	PCWrite=1	ALUin1=X	ALUin2=X
1	2	3	4	5			
IF	ID	EX	MEM	WB	PCWrite=1	ALUin1=X	ALUin2=X
IF	ID	EX	MEM	WB	PCWrite=1	ALUin1=0	ALUin2=0
IF	ID	EX	MEM		PCWrite=1	ALUin1=r	ALUin2=0
IF	ID	EX			PCWrite=1	ALUin1=0	ALUin2=0

4.(e)

4.(f)