T4.16 (1) 流：350ps

非流：250+350+150+300+200 = 1250ps；

(2) 流：5×350 = 1750ps

非流：1250 ps

(3) ID；300

(4) Loads+Stores；为15%+20% = 35%

(5) ALU/Logic + Loads；为45%+25% = 65%

T4.19

$s0	$s1	$s2	$s3	$s4
27	22	33	26	54

→ (不会产生数据冒险)

∴ $2, $3的值错误，所以会产生数据冒险

T4.22 (1)

sd, x29, 12(x16)	IF	ID	EX	MEM	WB								
ld x29, 8(x16)		IF	ID	EX	MEM	WB							
sub x17, x15, x14			IF	ID	EX	MEM	WB						
bez x17, x15. x14				X	X	IF	ID	EX	MEM	WB			
addbez x15, x11, x14							IF	ID	EX	MEM	WB		
sub x15, x30, x14								IF	ID	EX	MEM	WB	

(2) 不能；重排只会改变有冲突的指令对；

(3) 不能；nop也要从指令存储器中获取

(4) 35%。

T4.26

1) (EX to 1st only)

```
add x11, x12, x13
add x14, x11, x15
add x5, x6, x7
```

(MEM to 1st only:)

```
ld x11, 0(x12)
add x15, x11, x13
add x5, x6, x7
```

(EX to 2nd only)

```
add x11, x12, x13
add x5, x6, x7
add x14, x11, x12
```

(MEM to 2nd only)

```
ld x11, 0(x12)
add x5, x6, x7
add x14, x11, x13
```

(EX to 1st and EX to 2nd:)

```
add x11, x12, x13
add x5, x11, x15
add x16, x11, x12
```

2) (EX to 1 only: 2nops)

```
add x11, x12, x13
nop
nop
add x14, x11, x15
add x5, x6, x7
```

(MEM to 1 only: 2stalls)

```
ld x11, 0(x12)
nop
nop
add x15, x11, x13
add x5, x6, x7
```

(EX to 2 only: 1nop)

```
add x11, x12, x13
add x5, x6, x7
nop
add x14, x11, x12
```

(MEM to 2nd only: 1nop)

```
ld x11, 0(x12)
add x5, x6, x7
nop
add x14, x11, x13
```

(EX to 1st and EX to 2nd: 2nops)

```
add x11, x12, x13
nop
nop
add x5, x11, x15
add x16, x11, x12
```

(3) 例:
```
lw   $s0, 0($s1)
add  $s1, $t0, $t1
add  $s2, $s1, $s0
add  $s3, $s4, $s5
```
从整体看,需2个nop,插入在②~③之间

(4) $2\times0.05+1\times0.05+2\times0.2+2\times0.1+1\times0.1$
$=0.85$

$\therefore CPI=1+0.85=1.85$

$\frac{0.85}{1.85}=46\%$ 无冒险

(5) 高路MEM不能解决;

$\because 20\%\times1=0.2$

CPI: $1+0.2=1.2$

$\frac{0.2}{1.2}=16.7\%$

(阻塞时钟周期占比)

(6)

EX/MEM	EX to 1	0
	MEM to 1	2
	MEM to 2	1
	EX to 2	1
	EX to 1/2	1
MEM/WB	EX to 1	1
	EX to 2	0
	MEM to 1	1
	MEM to 2	0
	EX to 1/2	1

$\Rightarrow 0\times0.05+2\times0.2+1\times0.05+1\times0.1+1\times0.1$
$=0.65$ stalls

CPI: $1+0.65=1.65$

$\Rightarrow 1\times0.05+1\times0.2+1\times0.1=0.35$ stalls

CPI: $1+0.35=1.35$

(7) EX/MEX: $\frac{1.85}{1.65}=1.12$

/MEM/WB: $\frac{1.85}{1.35}=1.37$

全旁路: $\frac{1.85}{1.2}=1.54$

(9) ∵ EX to1 与 EX to2 产生阻塞数不同,
但MEM to 1/2 会造成相同阻塞

(8) 全旁路: CPI=1.2
时钟: 130 ⇒新时钟 230.

加速比 $=\frac{1.2\times130}{1\times230}=0.68$ (CPI=1 无数据冲突)

T4.27 (1) 1~2: 2 nops (add与lw)
3~4: 1 nop (lw与or)
4~5: 2 nops (or与sw)

(2) 怎样重排都不会减少;

(3) 正常执行;

(4)

周期	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9
add	IF	ID	EX	MEM	WB				
lw		IF	ID	EX	MEM	WB			
lw			IF	ID	EX	MEM	WB		
or				IF	ID	EX	MEM	WB	
sw					IF	ID	EX	MEM	WB
旁路单元	X	X	0	2	1	0	0		
冒险单元	X	X	0	0	1	2	2		

(5) 需要MEM/WB register的 rd 输入信号:

① 检测 data hazard, (add与lw间)

② 检测 lw与or指令间的 data hazard.