

Homework 2

Question 1

1. 3 nop instructions are necessary.

```
ld x11, 0(x5)
add x12, x6, x7
nop
nop
add x13, x11, x12
add x28, x29, x30
```

2.	Dependency type	the number of over-count nop
	EX to 1st only	2
	MEM to 1st only	1
	EX to 2nd only	2
	MEM to 2nd only	1
	EX to 1st and EX to 2nd	2

So 1 nop instruction are over-counted by analyzing dependency type independently.

3. Assuming no other hazards, the CPI for the program is 1.55

$$5\% * 3 + 20\% * 2 + 5\% * 2 + 10\% * 1 + 10\% * 3 + 50\% * 1 = 1.55$$

$$\text{percent: } (1.55-1)/1.55 = 35\%$$

4. The CPI of full forwarding pipeline is 1, and 0% of cycles are stalls.

5. Calculate the two cases separately.

1. only from EX/MEM: The CPI is

$$(55\% * 1 + 20\% * 2 + 5\% * 2 + 10\% * 1 + 10\% * 2) = 1.35$$

2. only from MEM/WB: The CPI is

$$(75\% * 1 + 5\% * 3 + 10\% * 2 + 10\% * 3) = 1.4$$

So it's better to forward only from EX/MEM pipeline register, and the CPI is 1.35.

6. Because the clock cycle must be the maximum of all the stages. The speedup of forwarding is

$$1. \text{ EX/MEM: } 120 * 5 / 120 * 1.35 = 3.70$$

$$2. \text{ MEM/WB: } 120 * 5 / 120 * 1.4 = 3.57$$

$$3. \text{ Full: } 120 * 5 / 130 * 1 = 4.62$$

Question 2

```
1.  add x15, x12, x11
    nop
    nop
    ld  x13, 4(x15)
    ld  x12, 0(x2)
    nop
    or  x13, x15, x13
    nop
    nop
    sd  x13, 0(x15)
```

2. The load/store can't run correctly if a ld and its next instruction happen data hazard. But in this program there isn't hazard, so it will run correctly.
3. The code cost 9 cycles.

Question 3

1. Always-Taken CPI:

$$25\% * 2 * 55\% + 1 = 1.275$$

2. Always-Not-Taken:

$$25\% * 2 * 45\% + 1 = 1.225$$

3. 2-Bit CPI:

$$25\% * 15\% * 2 + 1 = 1.075$$

4. speedup:

$$(3 * 12.5\% + 1 * 87.5\%) / (12.5\% * 15\% * 2 + 1) = 1.205$$

5. speedup:

$$(3 * 12.5\% + 2 * 12.5\% + 1 * 75\%) / (12.5\% * 15\% * 2 + 1 * 12.5\% + 1) = 1.375 / 1.1625 = 1.18$$

6. Accuracy: $(85\% - 80\%) / 20\% = 25\%$