

Solution 2

Question 1

Exercise 4.26

1.

EX to 1st only : 2 nops

MEM to 1st only : 2 nops

EX to 2nd only : 1 nop

MEM to 2nd only : 1nop

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

2. 1

3.

EX to 1st only : 2 nops

MEM to 1st only : 2 nops

EX to 2nd only : 1 nop

MEM to 2nd only : 1nop

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

CPI = 1.85, 46% are stall cycles

4.

EX to 1st only : 0 nop

MEM to 1st only : 1 nop

EX to 2nd only : 0 nop

MEM to 2nd only : 0 nop

EX to 1st and EX to 2nd : 0 nop

CPI = 1.2, 17% are stall cycles

5.

EX to 1st only : 0 nop

MEM to 1st only : 2 nops

EX to 2nd only : 1 nop

MEM to 2nd only : 1 nop

EX to 1st and EX to 2nd : 1 nop

EX/MEM only : CPI = 1.65

EX to 1st only : 1 nop

MEM to 1st only : 1 nop

EX to 2nd only : 0 nop

MEM to 2nd only : 0 nop

EX to 1st and EX to 2nd : 1 nop

MEM/WB only : CPI = 1.35

6.

EX/MEM only : speedup = 1.12

MEM/WB only : speedup = 1.37

full-forwarding : speedup = 1.42

Question 2

Exercise 4.27

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 code executes correctly. We need hazard detection only to insert a stall when the instruction following a load uses the result of the load. That does not happen in this case.

3. 9

Question 3

Exercise 4.28

1. $CPI = 1 + 25\% * 55\% * 3 = 1.14125$

2. $CPI = 1 + 25\% * 45\% * 3 = 1.3375$

3. $CPI = 1 + 25\% * 15\% * 3 = 1.1125$

4. $speedup = Ins * 1.1125 / [Ins * (1 + 12.5\% * 15\% * 3)] = 1.0532$

5. $\text{speedup} = \text{Ins} * 1.1125 / [\text{Ins} * 1.1 + \text{Ins} * (12.5\% * 15\% * 3)] = 0.962$

6. 0.25