| | Delay | E.g | Pipeline |
|---|---|---|---|
| **1. Read After Write** | | | |
| **1. RAW one lower** | | | |
| *add/sub/sll/slt/and/or/xor/nor* | | | |
| + without forwarding (sw also cause RAW) | +2 | sll $t3, x, x<br>sw $t3, 0(x) | F D E M W<br>F / / D E M W |
| + with forwarding | +0 | sll $t3, x, x<br>slt x, $t3, x | F D E M W<br>F D E M W |
| *lw* | | | |
| + without forwarding | +2 | lw $t3, x(x)<br>srl x, $t3, x | F D E M W<br>F / / D E M W<br>F D E M W |
| + with forwarding | +1 | lw $t3, x(x)<br>srl x, $t3, x<br>sw x, x($t3) | F D E M W<br>F D / E M W<br>F / D E M W |
| **2. RAW two lower** | | | |
| *add/sub/sll/slt/and/or/xor/nor* | | | |
| + without forwarding (sw also cause RAW) | +1 | sll $t3, x, x<br>xxx x, x, x<br>slt x, $t3, x | F D E M W<br>F D E M W<br>F / D E M W |
| + with forwarding | +0 | sll $t3, x, x<br>xxx x, x, x<br>slt x, $t3, x | F D E M W<br>F D E M W<br>F D E M W |
| *lw* | | | |
| + without forwarding | +1 | lw $t3, x(x)<br>xxx x, x, x<br>srl x, $t3, x | F D E M W<br>F D E M W<br>F / D E M W |
| + load Word with forwarding<br>(3rd instruction RAW on the 1st) | +0 | lw $t3, x(x)<br>xxx x, x, x<br>sw x, x($t3) | F D E M W<br>F D E M W<br>F D E M W |
| **3. Branch**** | | | |
| i) at MEM/Decode, ii) no forwarding<br>iii) *imm* after write (non-lw/lw)* | +2 | sll/lw $t3, x<br>beq $t3, x, L | F D E M W<br>/ / F D E M W |
| i) at MEM, ii) forwarding<br>iii) *imm* after write (non-lw)* | +0 | sll $t3, x, x<br>beq $t3, x, L | F D E M W<br>F D E M W |
| i) at MEM, ii) forwarding,<br>iii) *imm* after write (lw)* | +1 | lw $t3, x (x)<br>beq $t3, x, L | F D E M W<br>F / D E M W |
| i) at Decode, ii) forwarding<br>iii) *imm* after write (non-lw)* | +1 | sll $t3, x, x<br>beq $t3, x, L | F D E M W<br>F / D E M W |
| i) at Decode, ii) forwarding<br>iii) *imm* after write (lw)* | +2 | lw $t3, x (x)<br>beq $t3, x, L | F D E M W<br>F / / D E M W |
| **4. After-branch** | | | |
| No prediction / wrong prediction (at MEM)<br>No prediction / wrong prediction (at Decode) | +3<br>+1 | | F D E M W<br>/ / / F D E M W |
| Correct prediction | +0 | | F D E M W<br>F D E M W |
| Delayed branching | Fail: +1/0<br>Success: +0 | | |
| | | | |

**be careful, doesn't consider being 2-after write, but rule of thumb is just -1 the "imm after write" case