HW3 Q2.1

Cycle 0

LOOP: subi r1, r1, 1 Fetch muld f0, f1, f1 addd f0, f2, f2

bne r1, r0, LOOP

addd f1, f2, f3

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | | 1 | 1 |
| f2 | | 2 | 1 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | | 2 | 1 |

| | Inst | Reg | Value | Valid |
|---|------|-----|-------|-------|
| Α | ı | ı | ı | 0 |
| В | ı | ı | ı | 0 |
| С | ı | ı | ı | 0 |
| D | - | - | - | 0 |
| Ε | - | - | - | 0 |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|--------------------|-------|-------|-----|-------|-------|-----|--|
| - | - | 0 | - | 1 | 0 | 1 | |
| - | - | 0 | - | 1 | 0 | - | |
| 1 1 | | | | | | | |
| FP MULT (4 cycles) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|------------------|-------|-------|-----|-------|-------|-----|--|
| - | ı | 0 | ı | ı | 0 | I | |
| - | I | 0 | ı | I | 0 | Í | |
| . | | | | | | | |
| FP ADD (1 cycle) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|-------------------|-------|-------|-----|-------|-------|-----|--|
| - | - | 0 | - | - | 0 | | |
| - | - | 0 | - | - | 0 | 1 | |
| : | | | | | | | |
| INT ALU (1 cycle) | | | | | | | |

addd f1, f2, f3

LOOP: subi r1, r1, 1 Dispatch muld f0, f1, f1 Fetch addd f0, f2, f2 bne r1, r0, LOOP

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | | 1 | 1 |
| f2 | | 2 | 1 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | Α | 2 | 0 |

| | Inst | Reg | Value | Valid |
|---|------|-----|-------|-------|
| Α | subi | r1 | 1 | 0 |
| В | - | - | - | 0 |
| С | - | - | - | 0 |
| D | - | - | - | 0 |
| Ε | - | - | - | 0 |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|--------------------|-------|-------|-----|-------|-------|-----|--|
| - | - | 0 | - | - | 0 | 1 | |
| - | - | 0 | - | - | 0 | - | |
| : | | | | | | | |
| FP MULT (4 cycles) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|------------------|-------|-------|-----|-------|-------|-----|--|
| - | ı | 0 | ı | I | 0 | Í | |
| - | ı | 0 | 1 | ı | 0 | Í | |
| . | | | | | | | |
| FP ADD (1 cycle) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|-------------------|-------|-------|-----|-------|-------|-----|--|
| - | 2 | 1 | ı | ı | 0 | Α | |
| - | ı | 0 | - | I | 0 | ı | |
| :] | | | | | | | |
| INT ALU (1 cycle) | | | | | | | |

LOOP: subi r1, r1, 1 Issue (E1) muld f0, f1, f1 Dispatch addd f0, f2, f2 Fetch bne r1, r0, LOOP

addd f1, f2, f3

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | В | 1 | 0 |
| f2 | | 2 | 1 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | Α | 2 | 0 |

| | Inst | Reg | Value | Valid |
|---|------|-----|-------|-------|
| Α | subi | r1 | ı | 0 |
| В | muld | f1 | ı | 0 |
| С | - | - | - | 0 |
| D | ı | ı | 1 | 0 |
| Ε | - | - | = | 0 |

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|--------------------|-------|-------|-----|-------|-------|-----|
| Tag | value | vallu | Tag | value | vallu | NOB |
| - | 0 | 1 | ı | 1 | 1 | В |
| - | - | 0 | - | 1 | 0 | - |
| • | | | | | | |
| | | | | | | 7 |
| FP MULT (4 cycles) | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|------------------|-------|-------|-----|-------|-------|-----|
| - | I | 0 | ı | I | 0 | Í |
| - | 1 | 0 | - | 1 | 0 | ı |
| • I | | | | | | |
| FP ADD (1 cycle) | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-------------------|-------|-------|-----|-------|-------|-----|
| - | 2 | 1 | ı | ı | 0 | Α |
| - | - | 0 | - | - | 0 | - |
| : | | | | | | |
| INT ALU (1 cycle) | | | | | | |

LOOP: subi r1, r1, 1 WB

muld f0, f1, f1 Issue (E1) addd f0, f2, f2 Dispatch

bne r1, r0, LOOP Fetch (and predict as Taken)

addd f1, f2, f3

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | В | 1 | 0 |
| f2 | С | 2 | 0 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | Α | 2 | 0 |

| Inst | Reg | Value | Valid |
|------|--------------|--------------------|---------------------|
| subi | r1 | 1 | 1 |
| muld | f1 | - | 0 |
| addd | f2 | - | 0 |
| - | - | - | 0 |
| ı | - | ı | 0 |
| | subi muld | subi r1 muld f1 | subi r1 1 muld f1 - |

ROB

 Tag
 Value
 Valid
 Tag
 Value
 Valid
 ROB

 0
 1
 1
 1
 B

 0
 0

 FP MULT (4 cycles)

| 0 | 1 | - | J | 4 | | |
|------------------|---|------|-----------|------------------|------------------|--|
| | | | 2 | 1 | С | |
| - | 0 | 1 | 1 | 0 | 1 | |
| • | | | | | | |
| FP ADD (1 cycle) | | | | | | |
| | • | FP A | FP ADD (1 | FP ADD (1 cycle) | FP ADD (1 cycle) | |

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-------------------|-------|-------|-----|-------|-------|-----|
| - | - | 0 | - | - | 0 | 1 |
| - | - | 0 | - | - | 0 | - |
| • | | | | | | |
| INT ALU (1 cycle) | | | | | | |

LOOP: subi r1, r1, 1 Commit
muld f0, f1, f1 Issue (E2)
addd f0, f2, f2 Issue (E1)
bne r1, r0, LOOP Dispatch
LOOP: subi r1, r1, 1 Fetch

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | В | 1 | 0 |
| f2 | С | 2 | 0 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | - | 1 | 1 |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | ı | ı | 1 | 0 | 0 |
| В | muld | f1 | = | 0 | 0 |
| С | addd | f2 | - | 0 | 0 |
| D | bne | - | - | 0 | Т |
| Ε | - | - | - | 0 | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|-------|-------|-------|---------|---------|-------|-----|--|
| = | 0 | 1 | ı | 1 | 1 | В | |
| - | - | 0 | - | 1 | 0 | - | |
| 1 : 1 | | | | | | | |
| | | FP N | 1ULT (4 | cycles) | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|------------------|-------|-------|-----|-------|-------|-----|--|
| - | 0 | 1 | - | 2 | 1 | C | |
| - | ı | 0 | ı | 1 | 0 | ı | |
| : | | | | | | | |
| FP ADD (1 cycle) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | | |
|-----|-------------------|-------|-----|-------|-------|-----|--|--|
| ı | 1 | 1 | ı | 0 | 1 | D | | |
| ı | ı | 0 | ı | ı | 0 | Í | | |
| | <u> </u> | | | | | | | |
| | INT ALU (1 cycle) | | | | | | | |

LOOP: subi r1, r1, 1

muld f0, f1, f1 Issue (E3)

addd f0, f2, f2 WB

bne r1, r0, LOOP Issue (E1)
LOOP: subi r1, r1, 1 Dispatch
muld f0, f1, f1 Fetch

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | В | 1 | 0 |
| f2 | С | 2 | 0 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid | |
|----|-----|-------|-------|--|
| r0 | | 0 | 1 | |
| r1 | Е | 1 | 0 | |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | ı | ı | ľ | 0 | 0 |
| В | muld | f1 | ľ | 0 | 0 |
| С | addd | f2 | 2 | 1 | 0 |
| D | bne | - | - | 0 | Т |
| Ε | subi | r1 | - | 0 | 0 |

... ROB

| | | 1 | | | | 1 | |
|-----|-------|-------|---------|---------|-------|-----|--|
| Tag | Value | Valid | Tag | Value | Valid | ROB | |
| - | 0 | 1 | - | 1 | 1 | В | |
| - | ı | 0 | ı | ı | 0 | ı | |
| 1 1 | | | | | | | |
| | | FP N | 1ULT (4 | cycles) | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | | |
|-----|-------|-------|-------|--------|-------|-----|--|--|
| - | ı | 0 | ı | ı | 0 | ı | | |
| - | - | 0 | - | - | 0 | 1 | | |
| | • | | | | | | | |
| | | FP A | DD (1 | cycle) | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|-------------------|-------|-------|-----|-------|-------|-----|--|
| - | 1 | 1 | ı | 0 | 1 | D | |
| - | 1 | 1 | ı | ı | 0 | Е | |
| : | | | | | | | |
| INT ALU (1 cycle) | | | | | | | |

LOOP: subi r1, r1, 1

muld f0, f1, f1 Issue (E4)
addd f0, f2, f2 Waiting
bne r1, r0, LOOP WB(Taken)
LOOP: subi r1, r1, 1 Issue (E1)
muld f0, f1, f1 Dispatch
addd f0, f2, f2 Fetch

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | F | 1 | 0 |
| f2 | С | 2 | 0 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | E | 1 | 0 |

| Inst | Reg | Value | Valid | T/NT |
|------|-----------------------------|-------------------------------|-------------------------|---|
| 1 | - | - | 0 | 0 |
| muld | f1 | 1 | 0 | 0 |
| addd | f2 | 2 | 1 | 0 |
| bne | ı | 1 | 1 | Т |
| subi | r1 | = | 0 | 0 |
| muld | f1 | - | 0 | 0 |
| | muld addd bne subi | muld f1 addd f2 bne - subi r1 | addd f2 2 bne subi r1 - | 0 0 muld f1 - 0 addd f2 2 1 bne - 1 subi r1 - 0 |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|--------------------|-------|-------|-----|-------|-------|-----|--|
| - | 0 | 1 | - | 1 | 1 | В | |
| - | 0 | 1 | В | - | 0 | F | |
| : | | | | | | | |
| FP MULT (4 cycles) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|------------------|-------|-------|-----|-------|-------|-----|--|
| - | - | 0 | - | - | 0 | - | |
| - | ı | 0 | ı | ı | 0 | ı | |
| :] | | | | | | | |
| FP ADD (1 cycle) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|-------------------|-------|-------|-----|-------|-------|-----|--|
| 1 | - | 0 | - | - | 0 | - | |
| 1 | 1 | 1 | - | - | 0 | Е | |
| | | | | | | | |
| INT ALU (1 cycle) | | | | | | | |

LOOP: subi r1, r1, 1

muld f0, f1, f1 WB
addd f0, f2, f2 Waiting
bne r1, r0, LOOP Waiting
LOOP: subi r1, r1, 1 WB
muld f0, f1, f1 Waiting
addd f0, f2, f2 Dispatch

bne r1, r0, LOOP Fetch (and predict as taken)

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | F | 1 | 0 |
| f2 | G | 2 | 0 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | Е | 1 | 0 |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | = | - | ı | 0 | 0 |
| В | muld | f1 | 0 | 1 | 0 |
| С | addd | f2 | 2 | 1 | 0 |
| D | bne | 1 | - | 1 | Т |
| Ε | subi | r1 | 0 | 1 | 0 |
| F | muld | f1 | - | 0 | 0 |
| G | addd | f2 | - | 0 | 0 |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|--------------------|-------|-------|-----|-------|-------|-----|--|
| - | - | 0 | - | ı | 0 | ı | |
| - | 0 | 1 | ı | 0 | 1 | F | |
| : | | | | | | | |
| FP MULT (4 cycles) | | | | | | | |

| L | Tag | Value | Valid | Tag | Value | Valid | ROB | |
|---|------------------|-------|-------|-----|-------|-------|-----|--|
| | - | 0 | 1 | - | 2 | 1 | G | |
| Ī | - | - | 0 | - | - | 0 | 1 | |
| : | | | | | | | | |
| | FP ADD (1 cycle) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | | |
|-------------------|-------|-------|-----|-------|-------|-----|--|--|
| - | - | 0 | - | - | 0 | - | | |
| - | - | 0 | - | - | 0 | - | | |
| : | | | | | | | | |
| INT ALU (1 cycle) | | | | | | | | |

LOOP: subi r1, r1, 1

muld f0, f1, f1 Commit
addd f0, f2, f2 Waiting
bne r1, r0, LOOP Waiting
LOOP: subi r1, r1, 1 Waiting
muld f0, f1, f1 Issue(E1)
addd f0, f2, f2 Issue(E1)
bne r1, r0, LOOP Dispatch
LOOP: subi r1, r1, 1 Fetch

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | F | 0 | 0 |
| f2 | G | 2 | 0 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | Ε | 1 | 0 |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | - | - | - | 0 | 0 |
| В | - | - | - | 0 | 0 |
| С | addd | f2 | 2 | 1 | 0 |
| D | bne | ı | ľ | 1 | T |
| Ε | subi | r1 | 0 | 1 | 0 |
| F | muld | f1 | ı | 0 | 0 |
| G | addd | f2 | - | 0 | 0 |
| Н | bne | - | - | 0 | Т |

ROB

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-----|-------|-------|-----|-------|-------|-----|
| - | - | 0 | - | - | 0 | - |
| - | 0 | 1 | - | 0 | 1 | F |
| | ļ | | • | ļ | | _ |

FP MULT (4 cycles)

 Tag
 Value
 Valid
 Tag
 Value
 Valid
 ROB

 0
 1
 2
 1
 G

 0
 0

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-------------------|-------|-------|-----|-------|-------|-----|
| 1 | 0 | 1 | ı | 0 | 1 | Н |
| - | - | 0 | - | - | 0 | 1 |
| | | | | | | |
| INT ALU (1 cycle) | | | | | | |

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2 Commit
bne r1, r0, LOOP Waiting
LOOP: subi r1, r1, 1 Waiting
muld f0, f1, f1 Issue(E2)
addd f0, f2, f2 WB
bne r1, r0, LOOP Issue(E1)
LOOP: subi r1, r1, 1 Dispatch
muld f0, f1, f1 Fetch

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | F | 0 | 0 |
| f2 | G | 2 | 0 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid | |
|----|-----|-------|-------|--|
| r0 | | 0 | 1 | |
| r1 | 1 | 1 | 0 | |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | 1 | ı | ı | 0 | 0 |
| В | | 1 | - | 0 | 0 |
| С | 1 | ı | 1 | 0 | 0 |
| D | bne | - | ı | 1 | Т |
| Ε | subi | r1 | 0 | 1 | 0 |
| F | muld | f1 | ı | 0 | 0 |
| G | addd | f2 | 2 | 1 | 0 |
| Н | bne | ı | ı | 0 | T |
| 1 | subi | r1 | - | 0 | 0 |

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|--------------------|-------|-------|-----|-------|-------|-----|
| - | I | 0 | ľ | ı | 0 | ı |
| - | 0 | 1 | ľ | 0 | 1 | F |
| 1 : 1 | | | | | | |
| FP MULT (4 cycles) | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|------------------|-------|-------|-----|-------|-------|-----|--|
| - | - | 0 | - | - | 0 | - | |
| - | - | 0 | - | - | 0 | - | |
| | | | | | | | |
| FP ADD (1 cycle) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-------------------|-------|-------|-----|-------|-------|-----|
| ı | 0 | 1 | ľ | 0 | 1 | Н |
| 1 | 0 | 1 | - | - | 0 | - 1 |
| :] | | | | | | |
| INT ALU (1 cycle) | | | | | | |

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP Commit
LOOP: subi r1, r1, 1 Waiting
muld f0, f1, f1 Issue(E3)
addd f0, f2, f2 Waiting

bne r1, r0, LOOP WB (not taken!)

LOOP: subi r1, r1, 1 Issue(E1) muld f0, f1, f1 Dispatch addd f0, f2, f2 Fetch

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | J | 0 | 0 |
| f2 | G | 2 | 0 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | I | 1 | 0 |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | ľ | ı | ľ | 0 | 0 |
| В | ľ | ı | ľ | 0 | 0 |
| С | ľ | ı | ľ | 0 | 0 |
| D | 1 | ı | 1 | 0 | 0 |
| Ε | subi | r1 | 0 | 1 | 0 |
| F | muld | f1 | ľ | 0 | 0 |
| G | addd | f2 | 2 | 1 | 0 |
| Н | bne | ı | 1 | 1 | NT |
| 1 | subi | r1 | ľ | 0 | 0 |
| J | muld | f1 | - | 0 | 0 |

ROB

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|--------------------|-------|-------|-----|-------|-------|-----|--|
| - | 0 | 1 | F | ı | 0 | J | |
| - | 0 | 1 | II. | 0 | 1 | F | |
| | | | | | | | |
| FP MULT (4 cycles) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-----|-------|-------|-----|-------|-------|-----|
| - | - | 0 | - | - | 0 | 1 |
| - | - | 0 | - | - | 0 | - |
| | | | • | T | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | | |
|-------------------|-------|-------|-----|-------|-------|-----|--|--|
| - | - | 0 | - | - | 0 | - | | |
| - | 0 | 1 | - | 1 | 0 | 1 | | |
| : 1 | | | | | | | | |
| INT ALU (1 cycle) | | | | | | | | |

Cycle 11 (Frozen for recovery)

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1 Waiting muld f0, f1, f1 Issue(E3) addd f0, f2, f2 Waiting

bne r1, r0, LOOP WB (not taken!)

LOOP: subi r1, r1, 1 muld f0, f1, f1 addd f0, f2, f2

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | F | 0 | 0 |
| f2 | G | 2 | 0 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | Е | 1 | 0 |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | ľ | ı | ľ | 0 | 0 |
| В | ľ | ı | ľ | 0 | 0 |
| С | ľ | ı | ľ | 0 | 0 |
| D | ľ | ı | ľ | 0 | 0 |
| Ε | subi | r1 | 0 | 1 | 0 |
| F | muld | f1 | ľ | 0 | 0 |
| G | addd | f2 | 2 | 1 | 0 |
| Н | bne | ı | ľ | 1 | NT |
| 1 | - | - | - | 0 | 0 |
| J | - | - | - | 0 | 0 |

ROB

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|--------------------|-------|-------|-----|-------|-------|-----|--|
| - | ı | 0 | ı | ı | 0 | 1 | |
| - | 0 | 1 | ľ | 0 | 1 | F | |
| 1 | | | | | | | |
| FP MULT (4 cycles) | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-----|-------|-------|-----|-------|-------|-----|
| 1 | - | 0 | - | 1 | 0 | - |
| = | - | 0 | - | - | 0 | - |

| Tag | Value | Valid | Tag | Value | Valid | ROB | | |
|-----|-------------------|-------|-----|-------|-------|-----|--|--|
| - | - | 0 | - | - | 0 | - | | |
| - | - | 0 | - | - | 0 | - | | |
| 1 1 | | | | | | | | |
| | INT ALU (1 cycle) | | | | | | | |

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1 Commit
muld f0, f1, f1 Issue(E4)
addd f0, f2, f2 Waiting
bne r1, r0, LOOP Waiting
addd f1, f2, f3 Fetch

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | F | 0 | 0 |
| f2 | G | 2 | 0 |
| f3 | | 3 | 1 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | | 0 | 1 |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | ı | 1 | ı | 0 | 0 |
| В | ı | 1 | ı | 0 | 0 |
| С | - | - | - | 0 | 0 |
| D | 1 | ı | 1 | 0 | 0 |
| Ε | 1 | ı | 1 | 0 | 0 |
| F | muld | f1 | ı | 0 | 0 |
| G | addd | f2 | 2 | 1 | 0 |
| Н | bne | ı | 1 | 1 | NT |
| 1 | 1 | ı | 1 | 0 | 0 |
| J | - | - | - | 0 | 0 |
| | - | | | | |

ROB

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|-----|-------|-------|-----|-------|-------|-----|--|
| - | ı | 0 | - | ı | 0 | ı | |
| - | 0 | 1 | - | 0 | 1 | F | |
| 1 1 | | | | | | | |

FP MULT (4 cycles)

| Tag | Value | Valid | Tag | Value | Valid | ROB | | | |
|-----|-------|-------|-----|-------|-------|-----|--|--|--|
| - | - | 0 | - | - | 0 | - | | | |
| - | - | 0 | - | - | 0 | - | | | |
| | • | | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|-------------------|-------|-------|-----|-------|-------|-----|--|
| 1 | - | 0 | - | - | 0 | 1 | |
| - | - | 0 | - | - | 0 | 1 | |
| :] | | | | | | | |
| INT ALL (1 cycle) | | | | | | | |

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1

muld f0, f1, f1 WB

addd f0, f2, f2 Waiting

bne r1, r0, LOOP Waiting

addd f1, f2, f3 Dispatch

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | F | 0 | 0 |
| f2 | G | 2 | 0 |
| f3 | 1 | 3 | 0 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | | 0 | 1 |

| | Inst | Reg | Value | Valid | T/NT |
|---|-------|------|-------|-------|-------|
| | 11130 | iteg | value | valiu | 1/111 |
| Α | - | - | - | 0 | 0 |
| В | ľ | ı | ľ | 0 | 0 |
| С | ľ | ı | ľ | 0 | 0 |
| D | ľ | ı | ľ | 0 | 0 |
| Ε | - | - | ı | 0 | 0 |
| F | muld | f1 | 0 | 1 | 0 |
| G | addd | f2 | 2 | 1 | 0 |
| Н | bne | ı | 1 | 1 | NT |
| I | addd | f3 | - | 0 | 0 |
| J | - | - | - | 0 | 0 |

ROB

| Tag | Value | Valid | Tag | Value | Valid | ROB | | |
|--------------------|-------|-------|-----|-------|-------|-----|--|--|
| - | ı | 0 | ľ | ı | 0 | Í | | |
| - | ı | 0 | ı | ı | 0 | ı | | |
| : | | | | | | | | |
| FP MULT (4 cycles) | | | | | | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB | | |
|-----|-------|-------|-----|-------|-------|-----|--|--|
| - | 0 | 1 | - | 2 | 1 | | | |
| - | - | 0 | - | - | 0 | - | | |
| • | | | | | | | | |

FP ADD (1 cycle)

Tag Value Valid Tag Value Valid ROB
- - 0 - 0 -

- 0 - - 0

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1

muld f0, f1, f1 Commit
addd f0, f2, f2 Waiting
bne r1, r0, LOOP Waiting
addd f1, f2, f3 Issue(E1)

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | | 0 | 1 |
| f2 | G | 2 | 0 |
| f3 | 1 | 3 | 0 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | | 0 | 1 |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | = | 1 | - | 0 | 0 |
| В | ľ | 1 | ı | 0 | 0 |
| С | ľ | 1 | ı | 0 | 0 |
| D | - | ı | 1 | 0 | 0 |
| Ε | 1 | ı | 1 | 0 | 0 |
| F | 1 | 1 | 1 | 0 | 0 |
| G | addd | f2 | 2 | 1 | 0 |
| Н | bne | ı | 1 | 1 | NT |
| 1 | addd | f3 | 1 | 0 | 0 |
| J | = | - | - | 0 | 0 |

ROB

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-----|-------|-------|-----|-------|-------|-----|
| - | - | 0 | - | - | 0 | - |
| - | - | 0 | - | - | 0 | - |
| | | | | | | |

FP MULT (4 cycles)

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-----|-------|-------|-----|-------|-------|-----|
| - | 0 | 1 | - | 2 | 1 | |
| - | - | 0 | - | - | 0 | - |
| | 1 | | _ | | | |

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-------------------|-------|-------|-----|-------|-------|-----|
| ı | ı | 0 | ı | ı | 0 | 1 |
| - | - | 0 | - | - | 0 | 1 |
| : | | | | | | |
| INT ALU (1 cycle) | | | | | | |

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2 Commit

bne r1, r0, LOOP Waiting

addd f1, f2, f3 WB

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | | 0 | 1 |
| f2 | | 2 | 1 |
| f3 | 1 | 3 | 0 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | | 0 | 1 |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | - | - | - | 0 | 0 |
| В | ľ | ı | ľ | 0 | 0 |
| С | ľ | ı | ľ | 0 | 0 |
| D | ľ | ı | ľ | 0 | 0 |
| Ε | ı | - | ı | 0 | 0 |
| F | ı | - | ı | 0 | 0 |
| G | 1 | 1 | 1 | 0 | 0 |
| Н | bne | ı | 1 | 1 | NT |
| 1 | addd | f3 | 2 | 1 | 0 |
| J | - | - | - | 0 | 0 |

ROB

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|--------------------|-------|-------|-----|-------|-------|-----|--|
| ı | ı | 0 | ı | ı | 0 | ı | |
| ı | ı | 0 | ı | ı | 0 | ı | |
| : | | | | | | | |
| FP MULT (4 cycles) | | | | | | | |

 Tag
 Value
 Valid
 Tag
 Value
 Valid
 ROB

 0
 0

 0
 0

| Value | Valid | Tag | Value | Valid | ROB | | |
|-------------------|-----------------|------------|----------------|------------|----------------|--|--|
| 1 | 0 | 1 | 1 | 0 | - | | |
| - | 0 | - | - | 0 | - | | |
| | | | | | | | |
| INT ALU (1 cycle) | | | | | | | |
| | Value - - | - 0 - 0 | - 0 - - 0 - | - 0 - 0 | - 0 0 - 0 0 | | |

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP Commit

addd f1, f2, f3 Waiting

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | | 0 | 1 |
| f2 | | 2 | 1 |
| f3 | 1 | 3 | 0 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | | 0 | 1 |

| | Inst | Reg | Value | Valid | T/NT |
|---|-------|-----|-------|-------|------|
| Α | - | - | - | 0 | 0 |
| В | ı | - | - | 0 | 0 |
| С | Ti Ti | ı | ı | 0 | 0 |
| D | ï | ı | • | 0 | 0 |
| Ε | ï | - | - | 0 | 0 |
| F | 1 | - | 1 | 0 | 0 |
| G | ï | - | - | 0 | 0 |
| Н | - | - | - | 0 | 0 |
| 1 | addd | f3 | 2 | 1 | 0 |
| J | - | - | - | 0 | 0 |

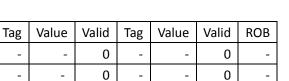
ROB

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-----|-------|-------|-----|-------|-------|-----|
| - | - | 0 | - | - | 0 | - |
| - | - | 0 | - | - | 0 | - |
| | | | | | | |

FP MULT (4 cycles)

| Tag | Value | Valid | Tag | Value | Valid | ROB |
|-----|-------|-------|-----|-------|-------|-----|
| - | - | 0 | - | - | 0 | - |
| - | - | 0 | - | - | 0 | - |
| | | | : | | | |

FP ADD (1 cycle)



INT ALU (1 cycle)

LOOP: subi r1, r1, 1 muld f0, f1, f1 addd f0, f2, f2 bne r1, r0, LOOP LOOP: subi r1, r1, 1 muld f0, f1, f1 addd f0, f2, f2

bne r1, r0, LOOP

addd f1, f2, f3 Commit

| | Tag | Value | Valid |
|----|-----|-------|-------|
| f0 | | 0 | 1 |
| f1 | | 0 | 1 |
| f2 | | 2 | 1 |
| f3 | | 2 | 0 |

| | Tag | Value | Valid |
|----|-----|-------|-------|
| r0 | | 0 | 1 |
| r1 | | 0 | 1 |

| | Inst | Reg | Value | Valid | T/NT |
|---|------|-----|-------|-------|------|
| Α | ı | ı | ı | 0 | 0 |
| В | ı | ı | ı | 0 | 0 |
| С | ı | ı | ı | 0 | 0 |
| D | ı | ı | - | 0 | 0 |
| Ε | ı | ı | 1 | 0 | 0 |
| F | ı | ı | ı | 0 | 0 |
| G | ı | ı | 1 | 0 | 0 |
| Н | ı | ı | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 | 0 | 0 |
| J | - | ı | = | 0 | 0 |

ROB

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|--------------------|-------|-------|-----|-------|-------|-----|--|
| - | - | 0 | - | _ | 0 | - | |
| - | - | 0 | - | = | 0 | - | |
| : | | | | | | | |
| FP MULT (4 cycles) | | | | | | | |

 Tag
 Value
 Valid
 Tag
 Value
 Valid
 ROB

 0
 0

 0
 0

| Tag | Value | Valid | Tag | Value | Valid | ROB | |
|-----|-------------------|-------|-----|-------|-------|-----|--|
| - | - | 0 | - | - | 0 | - | |
| - | - | 0 | - | - | 0 | - | |
| | | | : | | | | |
| | INT ALU (1 cycle) | | | | | | |

HW3 Q2.2

As we see in Q2.1, there are at most 6 instructions in ROB when executing this code, but when there are 6 instructions in Cycle 9, the C item in ROB is in the process of committing. If ROB size is 6, the new dispatch can't take place in the C item in ROB (which is in committing) at the same clock cycle, so the minimum ROB size is 7.