EEL 5764 Problem Set #2

1) 3.1)

fld	f2, 0(Rx)	1 + 3 = 4
fmul.d	f2, f0, f2	1 + 4 = 5
fdiv.d	f8, f2, f0	1 + 10 = 11
fld	f4, 0(Ry)	1 + 3 = 4
fadd.d	f4, f0, f4	1 + 2 = 3
fadd.d	f10, f8, f2	1 + 2 = 3
fsd	f4, 0(Ry)	1 + 1 = 2
addi	Rx, Rx, 8	1 + 0 = 1
addi	Ry, Ry, 8	1 + 0 = 1
sub	x20, x4, Rx	1 + 0 = 1
bnz	x20, loop	1 + 1 = 2

⇒ 37 cycles per loop iteration

3.3)

	pipeline 0	pipeline 1
1	fld f2, 0(Rx)	nop
3	stall x3	nop x3
1	fmul.d f2, f0, f2	nop
4	stall x4	nop x4
1	fdiv.d f8, f0, f0	fld f4, 0(Ry)
3	stall x3	nop x3
1	stall	fadd.d f4, f0, f4
2	stall x2	stall x2
4	stall x4	nop x4
1	fadd.d f10, f8, f2	fsd f4, 0(Ry)
1	stall	stall
1	stall	addi Rx, Rx, 8
1	addi Ry, Ry, 8	sub x20, x4, Rx
1	bnz x20, loop	nop
1	stall	
1	done	

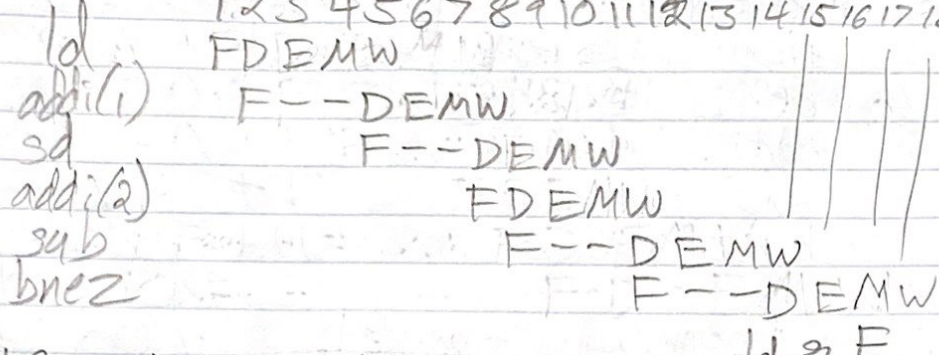
26 cycles per loop iteration

Problem Set #2 (cont.)

2 (c.) a)

dependancy	source	dest
x1	ld	addi (1)
x1	addi(1)	sd
x2	addi(2)	sub
x4	sub	bnez

b)

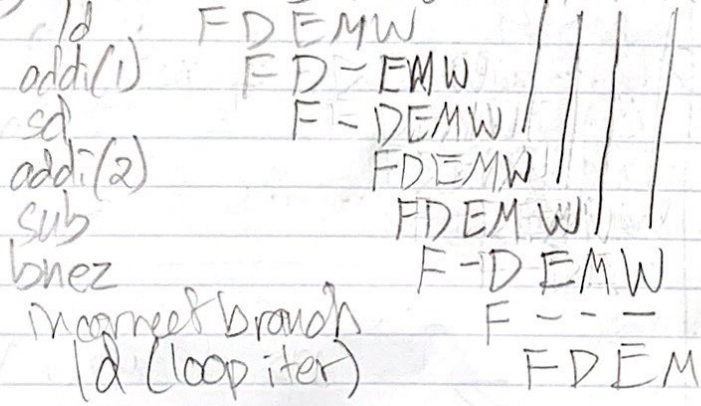


16 cycles per loop + 2 for the last iteration.

w/ x2 + 396, being x3's initial value.
Should have 99 loop iterations total

$(99 \cdot 16) + 2 =$ **1586 cycles** ← w/o forwarding

c)



w/ forwarding ↓

9 cycles per loop + 2 for last one. $\Rightarrow (99 \cdot 9) + 5 =$ **894 cycles**

Problem Set #2 (cont'd)

2 (c.1) d) With static "taken" prediction, the loop cycles now 8 cycles.

$\Rightarrow (8 \cdot 99) + 4 =$ **796 cycles** w/ forwarding and static "taken" prediction

e)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ld	F1	F2	D1	D2	X1	X2	M1	M2	W1	W2										
addi(1)		F1	F2	D1	D2	–	–	–	X1	X2	M1	M2	W1	W2						
eq			F1	F2	D1	–	–	–	D2	X1	X2	M1	M2	W1	W2					
addi(2)				F1	F2	–	–	–	D1	D2	X1	X2	M1	M2	W1	W2				
sub					F1	–	–	–	F2	D1	D2	–	X1	X2	M1	M2	W1	W2		
bnez									F1	F2	D1	–	D2	X1	X2	M1	M2	W1	W2	
ld sec. loop.									F1	F2	–	D1	D2	X1	X2	M1	M2	W1	W2	

10 cycles per loop + 9 on last loop. still 99 iterations

$(99 \cdot 10) + 9 =$ **999 cycles**

f) 0.9 ns for the 5-stage pipeline
then $0.8/2 + 0.1 \Rightarrow 0.5$ ns for the 10-stage pipeline

g) 5-stage CPI $\Rightarrow \frac{796 \text{ cycles}}{(99 \cdot 6)} = 1.34$ cycles/inst

10-stage CPI $\Rightarrow \frac{999 \text{ cycles}}{99 \cdot 6} = 1.68$ cycles/inst

$1.34 \text{ CPI} \cdot 0.9 \text{ s/cycle} = 1.206 \text{ s/inst}$

$1.68 \text{ CPI} \cdot 0.5 \text{ s/cycle} = 0.84 \text{ s/inst.}$

Problem Set #2 (cont.)

2(c.3) a) 2ns ← longest stage + 0.1ns reg delay
⇒ **2.1ns**

b) Ideal CPI = 1 $\frac{5 \text{ cycles}}{4 \text{ inst}}$ = **1.25 CPI**

c) n is # of inst here

$\text{speedup} = \frac{n \cdot 1 \cdot 1.7e\text{-}9}{n \cdot 1.25 \cdot 2.1e\text{-}9}$ $\quad \text{speedup} = \frac{n \cdot CPI_{2.1ns} \cdot \text{cycle time}}{n \cdot CPI_{new} \cdot \text{cycle time}}$

⇒ **speedup = 2.67**

d) Would ignore stalls and longest stage doesn't matter, only reg delay

⇒ $\frac{n \cdot 1 \cdot 1.7}{n \cdot 1 \cdot 0.1}$ = **70 = speedup**

c.7) a) $\frac{n \cdot 9 \cdot 5.1}{n \cdot 11 \cdot 8 \cdot 0.6}$ = **1.45 = speedup**

b) 5-stage CPI = $9/5 + (0.2 \cdot 0.05 \cdot 2) = 1.22$
12-stage CPI = $11/8 + (0.2 \cdot 0.05 \cdot 5) = 1.425$

Speedup $= \frac{n \cdot 1.22 \cdot 1}{n \cdot 1.425 \cdot 0.6} = 1.17$