ECEN 651 HW4

C.1

(a)

```
LD     R1 , 0(R2)      ①
DADDI  R1 , R1 , 1     ②
SD     R1 , 0 , (R2)   ③
DADDI  R2 , R2 , 4     ④
DSUB   R4 , R3 , R2    ⑤
BNEZ   R4 , Loop       ⑥
```

(b)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
①	F	D	X	M	W													
②		F	s	s	D	X	M	W										
③					F	s	s	D	X	M	W							
④								F	D	X	M	W						
⑤									F	s	s	D	X	M	W			
⑥												F	s	s	D	X	M	W

R3 = R2 + 296 ∴ 99 loops in total

in each iteration (first 98)

16 cycles are required, in the last iteration 18 cycles are required

∴ 16 × 98 + 18 = 1584

(c)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
①	F	D	X	M	W									
②		F	D	s	X	M	W							
③			F	~~F~~ s	D	X	M	W						
④					F	D	X	M	W					
⑤						F	D	X	M	W				
⑥							F	s	D	X	M	W		
xx								~~F~~	~~F~~	s	s	s	s	
①									~~F~~	~~D~~	~~X~~	~~M~~	~~W~~	
										F	D	X	M	W

2 RAW stalls and a flush at the end of each iteration can be overlapped with the beginning of the next iteration

$\therefore 98 \times (12-3) + 12 = 894$ cycles

(d)

	1	2	3	4	5	6	7	8	9	10	11	12	13
①	F	D	X	M	W								
②		F	D	s	X	M	W						
③			F	s	D	X	M	W					
④					F	D	X	M	W				
⑤						F	D	X	M	W			
⑥							F	s	D	X	M	W	
⋮										F	D	X	M	W
①														

$8 \times 98 + 12 = 796$ cycles

C.2

a. jump and calls freq 1%

taken branches freq 15% × 60% = 9%

not taken branches freq 15% × 40% = 6%

(1) for jump and call inst

F D ~~X~~ X M W

F F D X M W

F D ..

F ..

1 stall in this case

(2) for taken conditional branch,

F D X M W

F stall F D X M W

F ...

2 stalls in this case

(3) for not taken conditional branch

F D X M W

F S D X M W

F D ..

1 stall

∴ average stall number = 1 × 1% + 2 × 9% + 1 × 6%

= 0.25

$$\text{speedup} = \frac{1}{1+0.25} \times 4 = \frac{1}{\frac{5}{4}} \times 4 = \frac{16}{5} = 3.2$$

$$\text{Ideal speedup} = \frac{1}{1+0} \times 4 = 4$$

$$\text{actual speedup} = \frac{4}{3.2} = 1.25$$

∴ 25% speed up

b. ideal speedup : $\frac{1}{1+0} \times 15 = 15$

(1) for jump and call:

∵ ~~hazard~~ branch is resolved in 5th cycle ∴ 4 stalls are required (wasted IF)

(2) for not-taken branch

∵ branch is resolved in 10th cycle

8 stalls ~~is~~ are required

(3) for taken branches

8 stalls and 1 wasted IF

9 stalls

∴ average stall number = $4 \times 1\% + 8 \times 6\% + 9 \times 9\%$

$= 1.33$

actual speedup : $\frac{1}{\frac{1+5}{1+1.33}} \times 15 = 6.438$

overall speedup without hazard

$= \frac{15}{6.438} = 2.33$

133% improved