Question 1

Instruction	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
LD R2, [R1+16]	IF	ID	EX	MEM	WB							
ADD R4, R4, 16		IF	ID	EX	MEM	WB						
CMP R2, R4			IF	ID	EX	MEM	WB					
BEQ FOO				IF	ID	ID	EX	MEM	WB			
SUB R4,R2,8					IF	IF						
FOO:ADD R4,R2,R4							IF	ID	EX	MEM	WB	

Instruction	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
LD R2, [R1+16]	IF	ID	EX	MEM	WB							
ADD R4, R4, 16		IF	ID	EX	MEM	WB						
CMP R2, R4			IF	ID	EX	MEM	WB					
BEQ FOO				IF	ID	ID	EX	MEM	WB			
SUB R4,R2,8					IF	IF	ID	EX	MEM	WB		
FOO:ADD R4,R2,R4							IF	ID	EX	MEM	WB	

Instruction	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
LD R2, [R1+16]	F0	F1	ID	EX	WB							
ADD R4, R4, 16		F0	F1	ID	EX1	EX2	WB					
CMP R2, R4			F0	F1	ID	ID	EX	WB				
BEQ FOO				F0	F1	F1	ID	ID	EX	WB		
SUB R4,R2,8					F0	F0	F1	F1	ID	EX1	EX2	WB
FOO:ADD R4,R2,R4					F0	F0						

Instruction	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	
FOO:ADD R4,R2,R4								F0	F1	ID	EX1	EX2	WB

Question 2

Instruction	1	2	3	4	5	6	7	8	9	10	11	12
add r2, r2, r3	IF0	IF1	ID	X0	WB							
foo: addi r3, r3, #1		IF0	IF1	ID	X0	WB						
add r10, r3, r5			IF0	IF1	ID	X0	WB					
ld r4, (r10)				IF0	IF1	ID	X0	X1	X2	X3	WB	
add r7, r7, r4					IF0	IF1	ID	ID	X0		WB	
bne r3, r7, foo						IF0	IF1	IF1	IF1	IF1	ID	ID
ldr r3, L9							IF0	IF0	IF0	IF0	IF1	IF1
mov r0, #0											IF0	IF0

flush flush

Instruction	...	IF0	IF1	ID	X0	WB	
foo: addi r3, r3, #1		IF0	IF1	ID	X0	WB	
add r10, r3, r5			IF0	IF1	ID	X0	WB
ld r4, (r10)				IF0	IF1	ID	X0 X1 X2 X3 WB
add r7, r7, r4					IF0	IF1	ID ID X0 WB
bne r3, r7, foo						IF0	IF1 IF1 IF1 IF1 ID
ldr r3, L9							IF0 IF0 IF0 IF0 IF1 IF1
mov r0, #0							IF0 IF0
foo: addi r3, r3, #1							IF0 IF1 ID X0 WB

flush flush

Question 3

A):
1. Predict "not taken"

   CPI = 1+0.1*(0.7*4+0.3*0)+0.1*1*2=1+0.28+0.2=1.48

2. Predict "taken"
   CPI = 1+0.1*(0.7*0+0.3*4)+0.1*0=1.12

B): 1. predict "not taken"
CPI = 1+0.1*[0.5*(0.7*3+0.3*0)+0.5*(0.7*4+0.3*1)]+0.1*[0.5*1*1+0.5*1*3]=1+0.26+0.2=1.46

B): 2. predict "taken"
CPI = 1+0.1*[0.5*(0.7*0+0.3*3)+0.5*(0.7*1+0.3*4)]+0.1*[0.5*1*1+0.5*1*3]=1+0.14+0.2=1.34

C): CPI =1+0+0.2=1.2

D):
Stall1= 0.5*(2+0.5*(2+0.5...
=0.5*(0.5*2)*2=1
CPI_hzd1= 0.5 * 1=0.5
Stall1= 0.25*(1+0.25*(1+0.25...
=0.25*(0.25*2)*4/3=0.083

CPI_hzd2= 0.25*0.083=0.021
CPI = 1.48+0.5+0.021=2.001
IPC = 1/CPI = 0.500

Question 4:

A): False.
B): True

C): False
D): Not known
E): False
F): Not known

Question 5:

A):

1 bit PHT	Cycle 0	Cycle 7	Cycle 13	Cycle 19
bne	0	1	1	0

2 bit PHT	Cycle 0	Cycle 7	Cycle 13	Cycle 19
bne	00	01	10	01

BTB	Cycle 0	Cycle 7	Cycle 13	Cycle 19
bne	00	foo	foo	foo->next

B):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
add r2, r2, r3	IF	ID	X0	WB																						
foo: add r3, r3, #1		IF	ID	X0	WB																					
cmp r3, r7			IF	ID	X0	X1	WB																			
bne r3, r7, foo				IF	ID	ID	X0	WB																		
ldr r3, .L9					IF	IF	FLUSH																			
foo: add r3, r3, #1								IF	ID	X0	WB															
cmp r3, r7									IF	ID	X0	X1	WB													
bne r3, r7, foo										IF	ID	ID	X0	WB												
ldr r3, .L9											IF	IF	FLUSH													
foo: add r3, r3, #1														IF	ID	X0	WB									
cmp r3, r7															IF	ID	X0	X1	WB							
bne r3, r7, foo																IF	ID	ID	X0	WB						
ldr r3, .L9																	IF	IF	ID	X0	X1	WB				
mov r0, #0																		IF	IF	ID	ID	X0	WB			
str r2, [r3,#0]																			IF	IF	IF	ID	X0	X1	WB	
ret																				IF	IF	IF	ID	ID	X0	WB