



Information Technology University
Department of Computer Science
CS505: Advanced Computer Architecture
Midterm Exam (Fall 2023)

Name

Time allowed: 90 Minutes

Instructions:

Roll#

Maximum Marks: 40

1. This is a close book and close notes exam.
2. Write your registration number on all pages.
3. You are advised to concentrate on your own exam, looking around will not help you anyway!
4. Mobile phones not allowed.
5. Exchange of calculators not allowed.
6. University has a zero-tolerance policy towards cheating/plagiarism. If any student found violating the above instruction may require to leave the room and may be deemed to have failed examination

Student Signature Solution Date

Question # 1: (2+3+5=10 Marks)

- a. Consider the following performance measurements for a program:

Measurement	Computer A	Computer B
Instruction count	08 billion	10 billion
Clock rate	5 GHz	4 GHz
CPI	1.1	1.0

Which computer is faster? (Answer with proper calculation) (2 Marks)

$$\begin{aligned} A: 5 \times 10^9 / 1.1 \times 10^6 &= 4.54 \times 10^3 \Rightarrow A \text{ Faster} \\ B: 4 \times 10^9 / 1 \times 10^6 &= 4 \times 10^3 \end{aligned}$$

- b. A given application written in Java runs 12 seconds on a desktop processor. A new Java compiler is released that requires only 65% as many instructions as the old compiler. Unfortunately, it increases the CPI by 1.1. How fast can we expect the application to run using this new compiler? (3 Marks)

$$\begin{aligned} & \frac{12 \times 0.65}{1.1} \\ & 7.09 \text{ sec} \end{aligned}$$

- c. If a company has 10,000 computers, each with a MTTF of 35 days, and it experiences catastrophic failure only if 1/3 of the computers fail, what is the MTTF for the system? (5 Marks)

$$\begin{aligned} \frac{1}{3} \times 10,000 &= 3333 \\ \text{MTTF} &= \left(\frac{35}{10,000} \right) \times 3333 \\ &= 11.67 \text{ day} \end{aligned}$$

Question 2: (2+2+3+3=10 Marks)

- a. Consider the following instructions: identify and circle all data hazard(s) if there are any? (02 Marks)

LD S1,100(S2)
 ADD S2,S1,S3
 LD S2,50(S4)
 SUB S3,S2,S1
 ADD S2,S3,S1
 SD S2,100(S1)

- b. Now apply hardware forwarding and again identify and circle all data hazard(s) if there are any? (03 Marks)

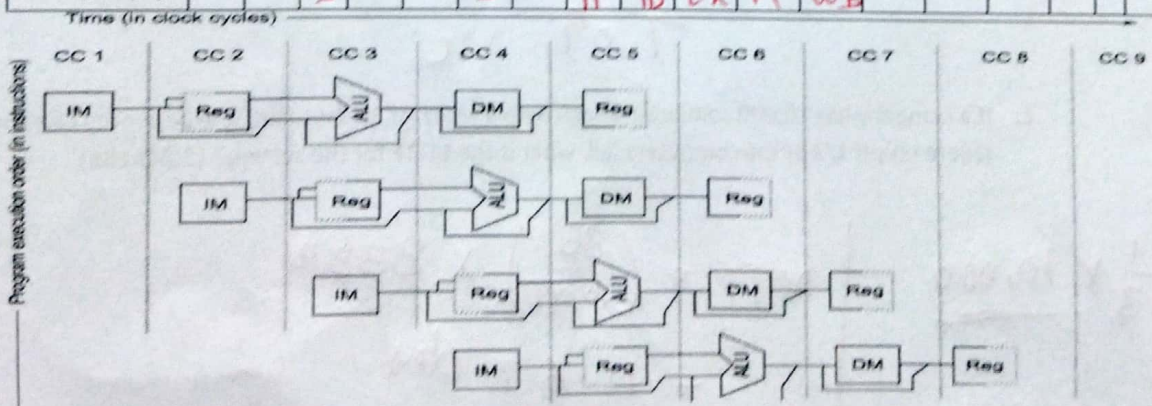
LD S1,100(S2)
 ADD S2,S1,S3
 LD S2,50(S4)
 SUB S3,S2,S1
 ADD S2,S3,S1
 SD S2,100(S1)

- c. Fill in the following with an addition of possible stall(s) if there are any? [Use the instructions from part a e.g., without forwarding]. (03 Marks)

Instructions	CC 1	CC 2	CC 3	CC 4	CC 5	CC 6	CC 7	CC 8	CC 9	CC 10	CC 11	CC 12	CC 13	CC 14	CC 15	CC 16	CC 17	CC 18	...
LD S1,100(S2)	IF	ID	EX	M	WB														
ADD S2,S1,S3		IF	S	S	ID	EX	M	WB											
LD S2,50(S4)			S	S	IF	ID	EX	M	WB										
SUB S3,S2,S1			S	S		IF	S	S	ID	EX	M	WB							
ADD S2,S3,S1			S	S		S	S	IF	S	S	ID	EX	M	WB					
SD S2,100(S1)			S	S		S	S	S	S	IF	S	S	ID	EX	M	WB			

- d. Now apply hardware forwarding, Fill the following with addition of possible stall(s) if there are any? [Use the instructions from part b e.g., with forwarding]. (03 Marks)

Instructions	CC 1	CC 2	CC 3	CC 4	CC 5	CC 6	CC 7	CC 8	CC 9	CC 10	CC 11	CC 12	CC 13	CC 14	CC 15	CC 16	CC 17	CC 18	...
LD S1,100(S2)	IF	ID	EX	M	WB														
ADD S2,S1,S3		IF	S	ID	EX	M	WB												
LD S2,50(S4)			S	IF	ID	EX	M	WB											
SUB S3,S2,S1			S		IF	S	ID	EX	M	WB									
ADD S2,S3,S1			S		S	IF	ID	EX	M	WB									
SD S2,100(S1)			S		S		IF	ID	EX	M	WB								



Question 3: (3+7=10 Marks)

a. Write down instructions for following machine code? (3 Marks)

Op	Rs	Rt	Rd	Shamt	funct	Instruction
00000000	00010001	00001111	00001011	00000000	00100010	addt
00001000	00001101	00001101		00001001		addi r25, r25, 9
00100011	00001100	00010010		00110000		lw r24, r25, 96

The table for general instructions format and registers is following
 t0 – t7 are reg's 8 – 15 AND s0 – s7 are reg's 16 – 23

Instruction	Format	op	rs	rt	rd	shamt	funct	address
add	R	0	reg	reg	reg	0	32 _{ten}	n.a.
sub (subtract)	R	0	reg	reg	reg	0	34 _{ten}	n.a.
add immediate	I	8 _{ten}	reg	reg	n.a.	n.a.	n.a.	constant
lw (load word)	I	35 _{ten}	reg	reg	n.a.	n.a.	n.a.	address
sw (store word)	I	43 _{ten}	reg	reg	n.a.	n.a.	n.a.	address

b. Consider the following loop with MIPS code and unroll 3 copies of loop. (7 Marks)

For (i=999; i>=4; i=i-1)

x[i-2]=x[i]+s;

Loop:

L.D F0, 0(R1); F0=array element

ADD.D F4, F0, F2; add scalar in F2

S.D F4, -16(R1); store result

DADDUI R1, R1, #-8; decrement by 1 index;

BNE R1, R2, Loop; branch check R1!=R2

LD F0, 0(R1)
LD F6, -8(R1)
LD F8, -16(R1)
ADD.D F4, F0, F2
ADD.D F7, F6, F2
ADD.D F9, F8, F2
SD F4, 0(R1)
S.D F7, -8(R1)
DADDUI R1, R1, #-24
S.D F9, -16(R1)
BNE R1, R2, Loop



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Question 4: (10 Marks)

Run the Tomasulo algorithm for 8th to 17th cycles and fill/mark changes on given diagram. The state of 7th cycle is given.

Instruction status					
Instruction	j	k	Issue	Execution complete	Write Result
LD F6 34+	R2		1	3	4
LD F2 45+	R3		2	5	6
MULT F0 F2	F4		3	16	17
SUBD F8 F6	F2		4	8	9
DIVD F10 F0	F6		5		
ADDD F6 F8	F2		6	12	13

	Busy	Address
Load1	No	
Load2	No	
Load3	No	

Reservation Stations		S1	S2	RS for j	RS for k
Time	Name	Busy	Op	Vj	Vk
1	Add1	Yes	SUBD	M(34+R2)	M(45+R3)
0	Add2	Yes	ADDD		M(45+R3)
	Add3	No			Add1
9	Mult1	Yes	MULTD	M(45+R3)	R(F4)
0	Mult2	Yes	DIVD		M(34+R2)

Register result status

Clock	F0	F2	F4	F6	F8	F10	F12	...	F30
7	FU	Mult1	M(45+R3)		Add2	Add1	Mult2		

Run Sheet

Reservation Stations		S1	S2	RS for j	RS for k	Busy	Address
Time	Name	Busy	Op	Vj	Vk		
0	Add1					Load1	No
0	Add2					Load2	No
	Add3					Load3	No
0	Mult1						
0	Mult2	Yes	Div	M*F4	M(34+R2)		

Register result status

Clock	F0	F2	F4	F6	F8	F10	F12	...	F30
8	FU								

Reservation Stations		S1	S2	RS for j	RS for k	Busy	Address
Time	Name	Busy	Op	Vj	Vk		
0	Add1					Load1	No
0	Add2					Load2	No
	Add3					Load3	No
0	Mult1						
0	Mult2						

Register result status

Clock	F0	F2	F4	F6	F8	F10	F12	...	F30
	FU								