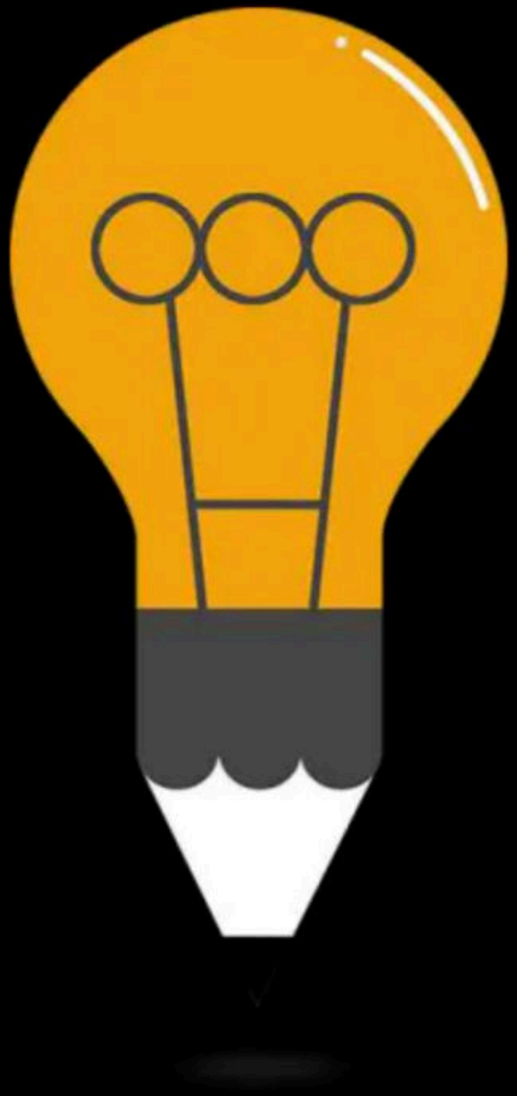
Micro-Operations: Part I

Complete Course on Computer Organization & Architecture for GATE 2024 & 2025

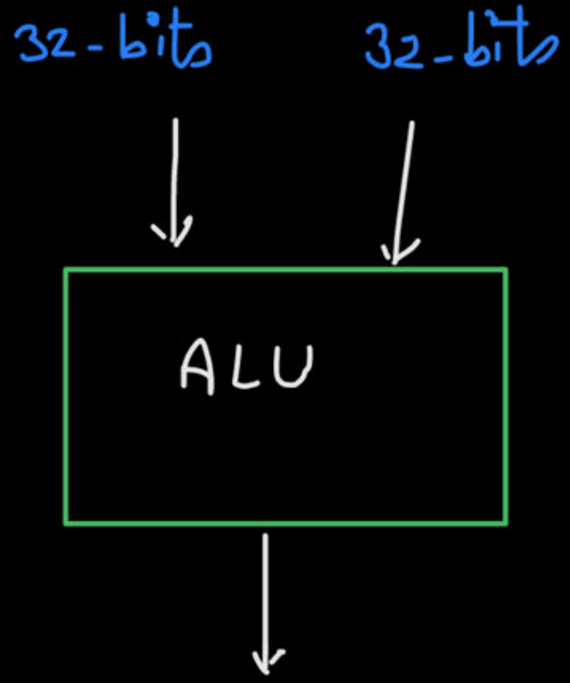
Vishvadeep Gothi • Lesson 3 • Feb 15, 2023



Micro-Operations

By: Vishvadeep Gothi

Architecture Type (Based on Size of Input)



32-bit architecture

⇓

CPU word size = 32-bits = 4bytes

CPU executes instⁿs one by one, to execute program

To execute one instⁿ, CPU performs so many small small operations

Micro Operation

↳ smallest operation, which CPU can perform at a time.

The operations executed on values stored in registers

Symbolic Notation to describe the micro-ops: Register Transfer Language (RTL)

smallest

⇒ one CPU cycle time ⇒ one ^ micro-operation performed.

⟶ some micro-operations may take more than one CPU cycle time.

Micro Operation

1. Register Transfer: R2 ← R1 or R1 → R2

2. Comma:

3. Memory Transfer:

Read ⇒ CPU ← From memory

Register ← M[address]

DR ← M[5000]

DR ← M[AR]

write :-

memory ← CPU

M[Address] ← DR

R1 ← M[700]

R1 = 50

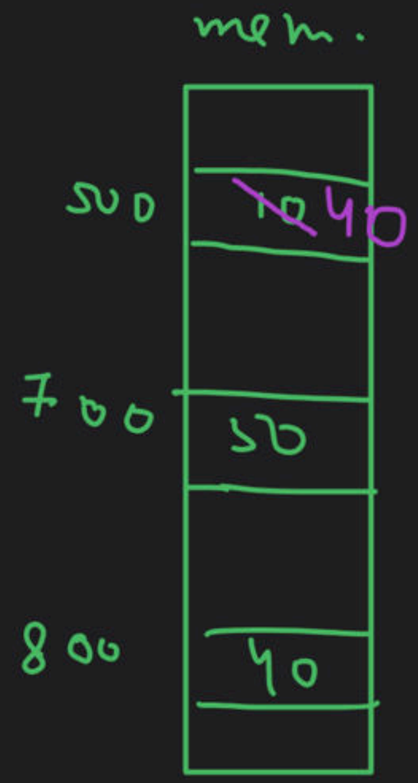
R2 = 800

R3 ← M[R2]

R3 = 40

R4 = 5200

M[R4] ← R3

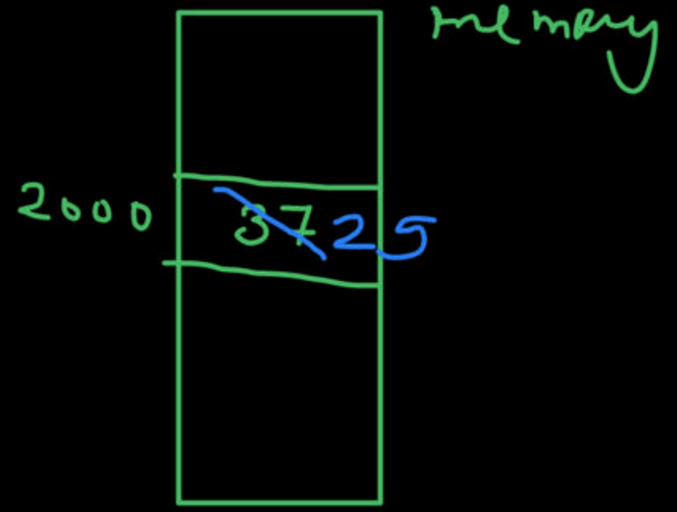


Ans = 25

Question

Consider the following program segment. Here R1 and R2 are the general purpose register. Assume that the content of memory location 2000 is 37. All numbers are in decimal. After the execution of this program the value of memory location 2000 is?

Instructions	Operations
MOV R1, #12	R1 ← #12
MOV R2, (2000)	R2 ← M[2000]
SUB R2, R1	R2 ← R2 – R1
MOV (2000), ~~R3~~ R2	M[2000] ← ~~R3~~ R2
HALT	Stop



R1 = 12

R2 = ~~37~~ 25

Ans = 27

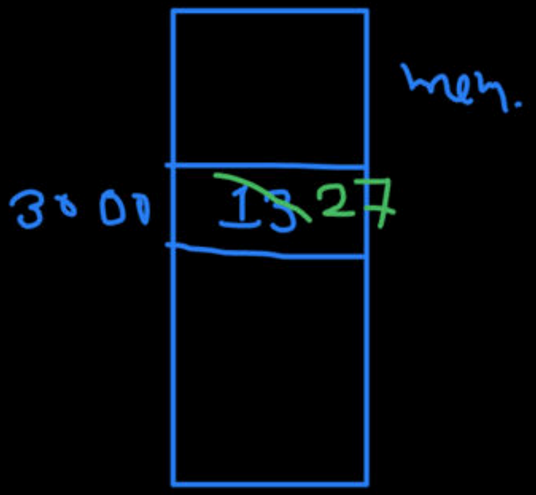
Question

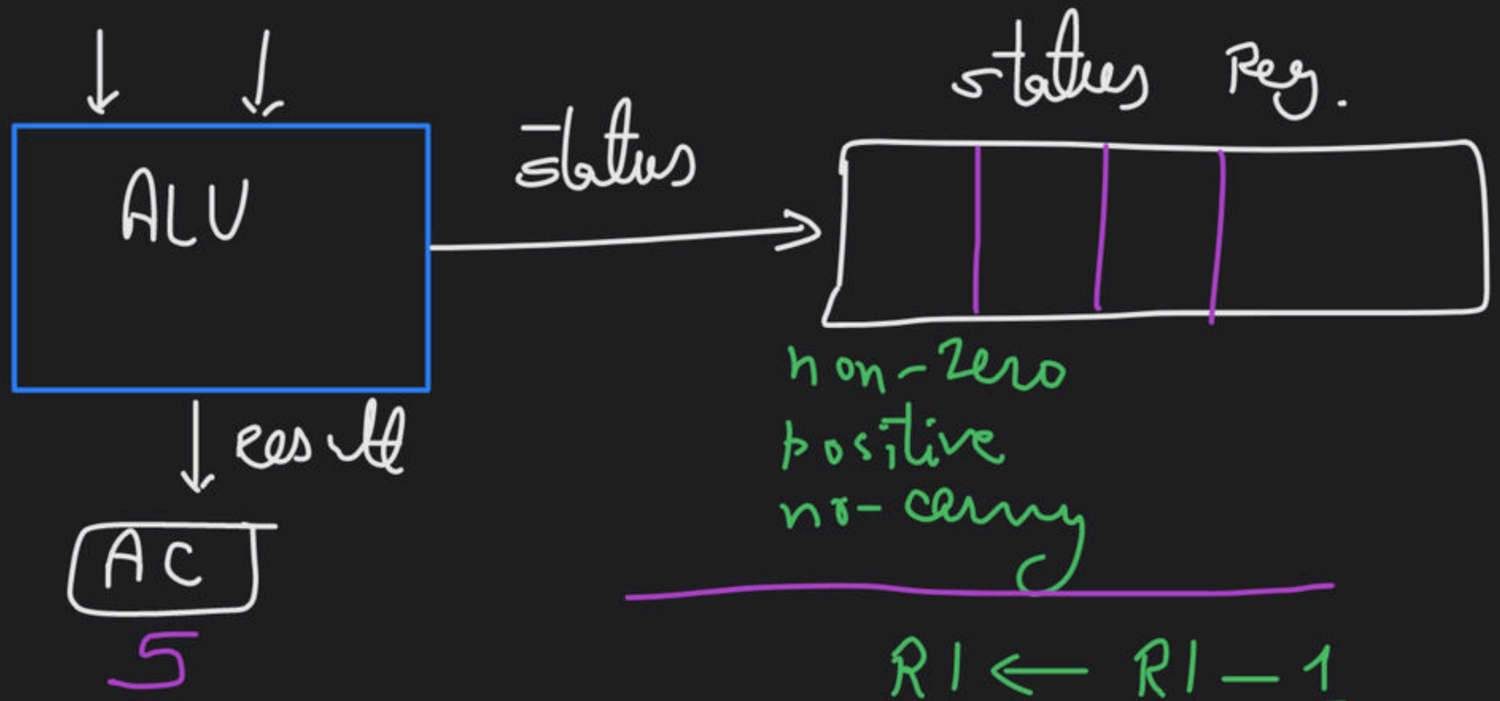
Consider the following program segment. Here R1 and R2 are the general purpose register. Assume that the content of memory location 3000 is 13. All numbers are in decimal. After the execution of this program the value of memory location 3000 is?

Instructions	Operations
MOV R1, #7	R1 ← #7
MOV R2, (3000)	R2 ← M[3000]
ADD R2, R1	R2 ← R2 + R1
ADD R1, R2	R1 ← R1 + R2
MOV (3000), R1	M[3000] ← R1
HALT	Stop

R1 = ~~7~~ 27

R2 = ~~13~~ 20





R1 = 6

R1 ← R1 − 1

Do something if result is zero or non-zero

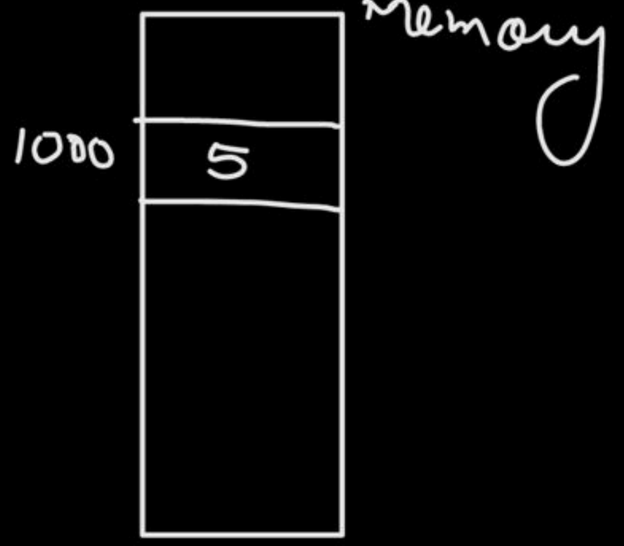
Ans= 23

Question

Consider the following program segment. Here R1 and R2 are the general-purpose register. Assume that the content of memory location 1000 is 5. All the numbers are in decimal.

	Instructions	Operations
	MOV R1, (1000)	R1 ← M[1000]
	MOV R2, #8	R2 ← #8
LOOP:	ADD R2, R1	R2 ← R2 + R1
	DEC R1	R1 ← R1 – 1
	BNZ LOOP	Branch on not zero to loop
	HALT	Stop

The value of R2 at the end of program execution is?



R1 = 5 4 3 2 1 0

R2 = 8 13 17 20 22

23

1

Question GATE-2007

Consider the following program segment. Here R1, R2 and R3 are the general purpose registers.

	Instruction	Operation	Instruction Size (no. of words)
	MOV R1,(3000)	R1← M[3000]	2
LOOP:	MOV R2,(R3)	R2← M[R3]	1
	ADD R2,R1	R2← R1 + R2	1
	MOV (R3),R2	M[R3]← R2	1
	INC R3	R3← R3 + 1	1
	DEC R1	R1← R1 − 1	1
	BNZ LOOP	Branch on not zero	2
	HALT	Stop	1

Assume that the content of memory location 3000 is 10 and the content of the register R3 is 2000. The content of each of the memory locations from 2000 to 2010 is 100. The program is loaded from the memory location 1000. All the numbers are in decimal.

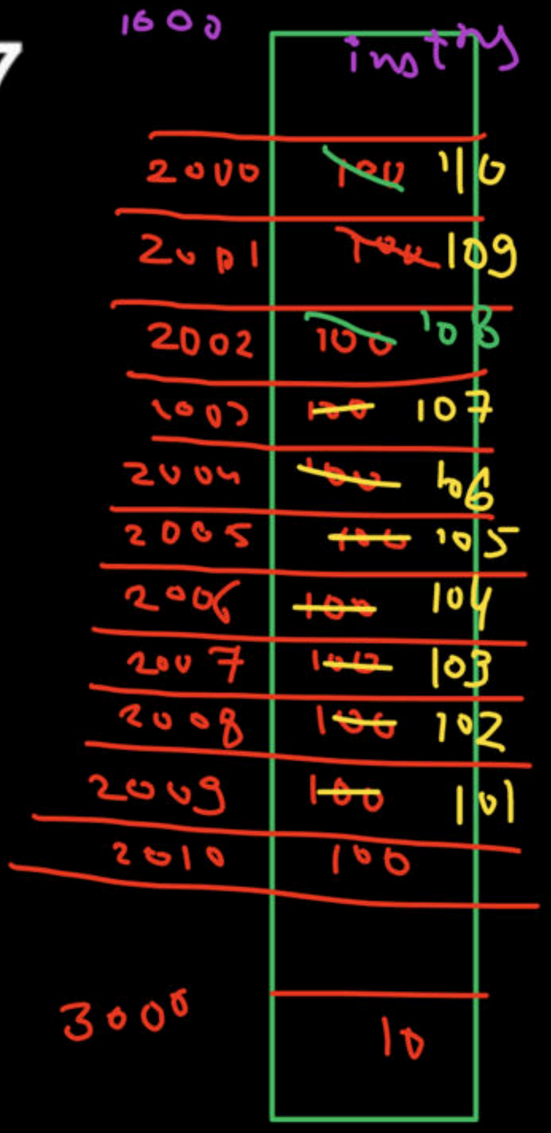
Assume that the memory is word addressable. The number of memory references for accessing the data in executing the program completely is

A. 10 B. 11 C. 20 D. 21

R3 = ~~2000~~ ~~2001~~ ~~2002~~ 2010

R1 = ~~10~~ ~~9~~ ~~8~~ . . . 0

R2 = ~~100~~ ~~110~~ ~~106~~ ~~109~~ ~~100~~ 106



if loop runs x times

then total memory references for data $= (2 * x) + 1$

---

loop runs 10 times

$x = 10$

$= (2 * 10) + 1$

$= 21$

Question GATE-2007

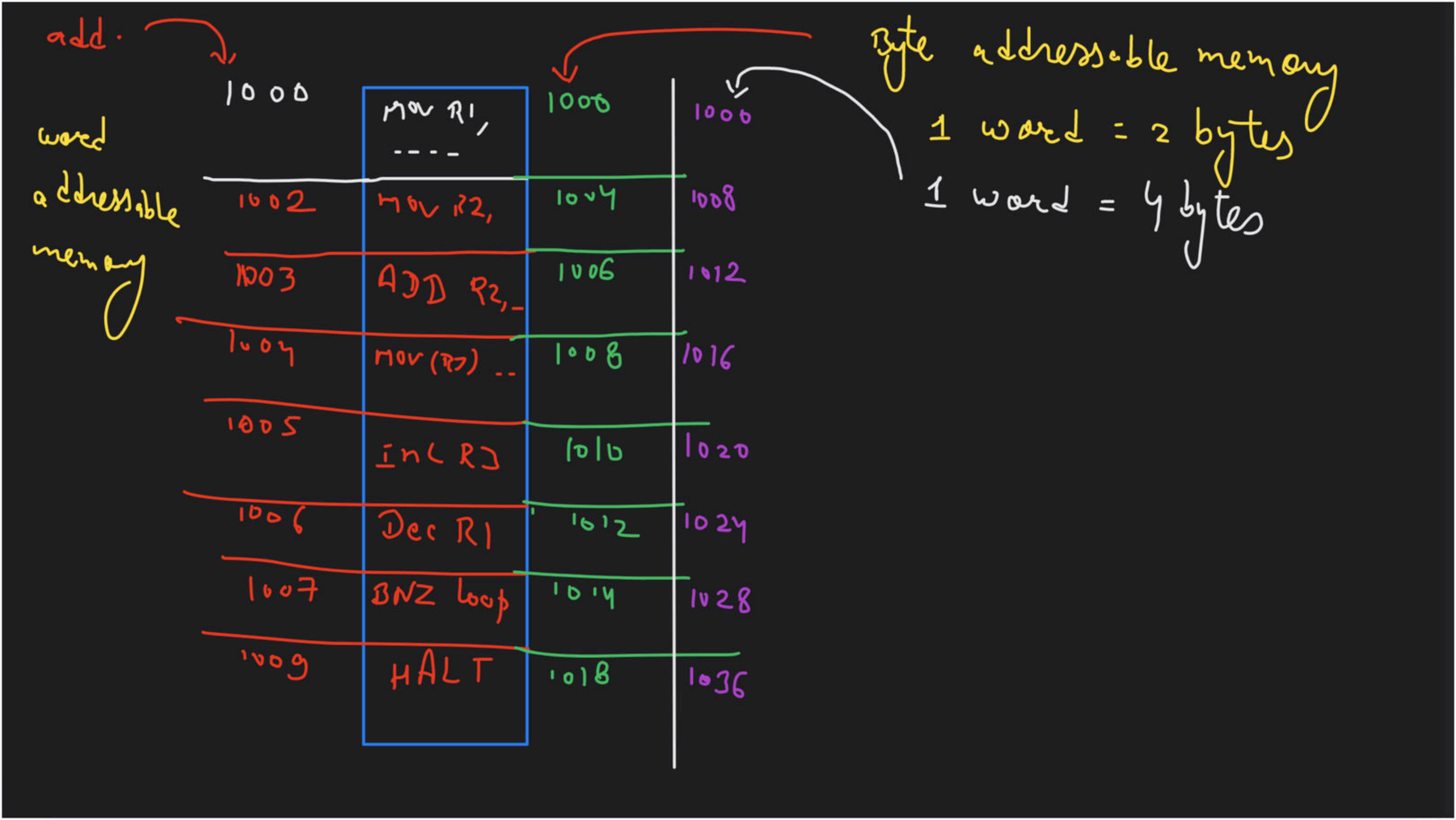
Consider the following program segment. Here R1, R2 and R3 are the general purpose registers.

	Instruction	Operation	Instruction Size (no. of words)
	MOV R1,(3000)	R1← M[3000]	2
LOOP:	MOV R2,(R3)	R2← M[R3]	1
	ADD R2,R1	R2← R1 + R2	1
	MOV (R3),R2	M[R3]← R2	1
	INC R3	R3← R3 + 1	1
	DEC R1	R1← R1 – 1	1
	BNZ LOOP	Branch on not zero	2
	HALT	Stop	1

Assume that the content of memory location 3000 is 10 and the content of the register R3 is 2000. The content of each of the memory locations from 2000 to 2010 is 100. The program is loaded from the memory location 1000. All the numbers are in decimal.

Assume that the memory is word addressable. After the execution of this program, the content of memory location 2010 is:

A. 100 B. 101 C. 102 D. 110


add.
1000
word addressable memory
MOV R1, ----
1002
MOV R2, ----
1003
ADD R2, ----
1004
MOV (R7) ...
1005
INC R3
1006
DEC R1
1007
BNZ loop
1009
HALT
1000
1004
1006
1008
1012
1016
1020
1024
1028
1036
Byte addressable memory
1 word = 2 bytes
1 word = 4 bytes

Question GATE-2007

Consider the following program segment. Here R1, R2 and R3 are the general purpose registers.

	Instruction	Operation	Instruction Size (no. of words)
	MOV R1,(3000)	R1← M[3000]	2
LOOP:	MOV R2,(R3)	R2← M[R3]	1
	ADD R2,R1	R2← R1 + R2	1
	MOV (R3),R2	M[R3]← R2	1
	INC R3	R3← R3 + 1	1
	DEC R1	R1← R1 – 1	1
	BNZ LOOP	Branch on not zero	2
	HALT	Stop	1

Assume that the content of memory location 3000 is 10 and the content of the register R3 is 2000. The content of each of the memory locations from 2000 to 2010 is 100. The program is loaded from the memory location 1000. All the numbers are in decimal.

Assume that the memory is byte addressable and the word size is 32 bits. If an interrupt occurs during the execution of the instruction "INC R3", what return address will be pushed on to the stack?

4 bytes

A. 1005 B. 1020 C. 1024 D. 1040

when interrupt occurs during any inst^n execution, then current inst^n is executed completly, then next inst^n's address is stored on stack as return address.

Question GATE-2021

Consider the following instruction sequence where registers R1, R2 and R3 are general purpose and MEMORY[X] denotes the content at the memory location X.

Instruction	**Semantics**	**Instruction Size** (bytes)
MOV R1, (5000)	R1 ← MEMORY[5000]	4
MOV R2, (R3)	R2 ← MEMORY[R3]	4
ADD R2, R1	R2 ← R1+R2	2
MOV (R3), R2	MEMORY[R3] ← R2	4
INC R3	R3 ← R3+1	2
DEC R1	R1 ← R1-1	2
BNZ 1004	Branch if not zero to the given absolute address	2
HALT	Stop	1

Assume that the content of the memory location 5000 is 10, and the content of the register R3 is 3000. The content of each of the memory locations from 3000 to 3010 is 50. The instruction sequence starts from the memory location 1000. All the numbers are in decimal format. Assume that the memory is byte addressable.

After the execution of the program, the content of memory location 3010 is _____.

Happy Learning.!