

A Simple Machine Language

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The Machine's Architecture



- ◆ 16 general-purpose registers
 - ◆ numbered 0 through F (in hexadecimal)
- ◆ Each register is
 - ◆ **one byte (8 bits)** long
 - ◆ assigned **an unique four-bit pattern** to represent its register number
 - ◆ E.g.
 - 0000 (0x0) -> register 0
 - 0100 (0x4) -> register 4

The Machine's Architecture (Cont.)



- ◆ Main memory
 - ◆ 256 memory cells
 - ◆ Each cell is located by an integer (8 bits)
 - ◆ 0 (0x00) ~ 255 (0xFF)
- ◆ Floating-point values are stored in the eight-bit format discussed in Section 1.7 and summarized in Figure 1.26

The Machine's Language



- ◆ Machine language
 - ◆ two bytes (16 bits) long
 - ◆ op-code field -> leftmost 4 bits
 - ◆ operand field -> the remaining 12 bits

Example

◆ From Questions & Exercises

- ◆ Suppose the memory cells at addresses B0 to B8 in the machine described in Appendix C contain the (hexadecimal) bit patterns given in the following table:

Address	Contents
B0	13
B1	B8
B2	A3
B3	02
B4	33
B5	B8
B6	C0
B7	00
B8	0F



Example (Cont.)

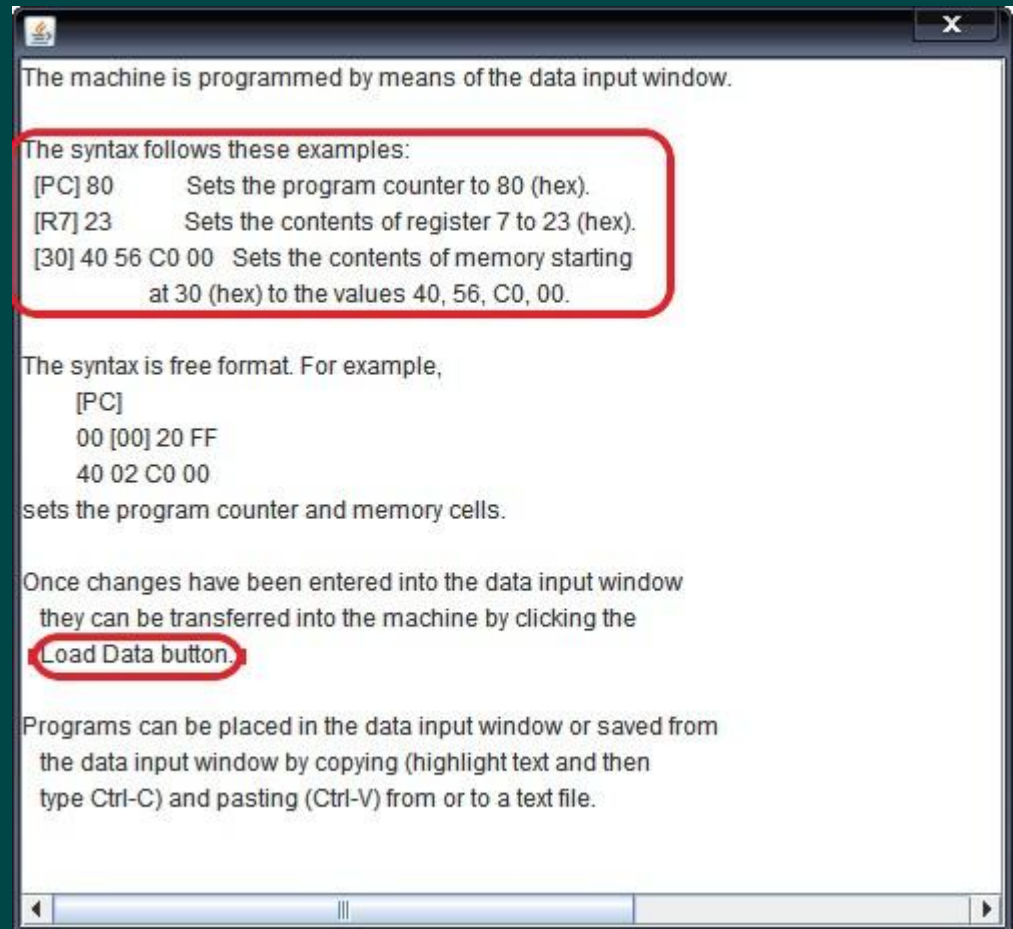
- a. If the program counter starts at B0, what bit pattern is in register number 3 after the first instruction has been executed?

Syntax

[PC] B0

[B0] 13 B8 A3 02

33 B8 C0 00 0F



Load Data

The screenshot shows a 'Simple Computer' emulator window with a 'Data Input Window' at the top. The input window contains the text: [PC] B0 and [B0] 13 B8 A3 02 33 B8 C0 00 0F. Below this is a table representing the CPU and Main Memory. The CPU section lists registers R0 through RF, with R7 labeled 'PC' and R8 labeled 'IR'. The Main Memory section is a grid with columns 0-9 and A-F, and rows 0-F. A red box highlights the input data, and a red arrow points from it to the 'Load Data' button at the bottom of the interface.

CPU			Main Memory															
			0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
R0	00		0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R1	00		1	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R2	00		2	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R3	00		3	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R4	00		4	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R5	00		5	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R6	00		6	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R7	00	PC	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R8	00	IR	0000	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R9	00		8	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RA	00		9	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RB	00		A	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RC	00		B	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RD	00		C	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RE	00		D	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RF	00		E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
			F	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

Buttons at the bottom: Clear Memory, Load Data, Run, Single Step, Halt, Help.

Load Data (Cont.)

Simple Computer

Data Input Window

[PC] B0
[B0] 13 B8 A3 02 33 B8 C0 00 0F

CPU

R0	00
R1	00
R2	00
R3	00
R4	00
R5	00
R6	00
R7	00
R8	00
R9	00
RA	00
RB	00
RC	00
RD	00
RE	00
RF	00

IR 0000

Main Memory

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
1	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
3	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
4	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
5	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
6	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
7	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
8	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
9	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
A	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
B	13	B8	A3	02	33	B8	C0	00	0F	00	00	00	00	00	00	00
C	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
D	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

Clear Memory Load Data Run Single Step Halt Help

The Result of Sub-problem a

The screenshot shows a 'Simple Computer' emulator window titled 'Data Input Window'. The window contains the following text:

```
[PC] B0  
[B0] 13 B8 A3 02 33 B8 C0 00 0F
```

Below the text is a table showing the state of the CPU registers and Main Memory. The CPU registers are listed on the left, and the Main Memory is a grid of 16 columns (0-F) and 16 rows (0-F). The PC register is B2, and the IR register is 13B8. The R3 register is 0F. The Main Memory at address B0 contains the value 13B8A30233B8C0000F.

CPU	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
R0 00	0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R1 00	1	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R2 00	2	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R3 0F	3	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R4 00	4	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R5 00	5	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R6 00	6	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R7 00	7	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R8 00	8	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R9 00	9	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RA 00	A	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RB 00	B	13	B8	A3	02	33	B8	C0	00	0F	00	00	00	00	00	00
RC 00	C	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RD 00	D	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RE 00	E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RF 00	F	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

At the bottom of the window are several buttons: Clear Memory, Load Data, Run, Single Step, Halt, and Help. The 'Single Step' button is highlighted with a red circle. Red arrows point from the 'Single Step' button to the R3 0F register, the PC B2 register, and the IR 13B8 register.

Example (Cont.)

- b. What bit pattern is in memory cell B8 when the halt instruction is executed?



The Result of Sub-problem b

Simple Computer

Data Input Window

[PC] B0
[B0] 13 B8 A3 02 33 B8 C0 00 0F

HALT execution Changed from 0x0F to 0xC3

CPU				Main Memory															
				0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
R0	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R1	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R2	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R3	C3			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R4	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R5	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R6	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R7	00	PC	B8	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R8	00	IR	C000	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
R9	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RA	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RB	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RC	00			13	B8	A3	02	33	B8	C0	00	C3	00	00	00	00	00	00	00
RD	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RE	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
RF	00			00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

Clear Memory Load Data Run Single Step Halt Help