



**PONTIFÍCIA UNIVERSIDADE CATÓLICA DE MINAS  
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Instituto de Ciências Exatas e de Informática

# **Exercício Prático — Arquitetura de Computadores II**

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## **Parte 1 - Exercícios**

### **O que é um arquivo fonte?**

Um arquivo de texto que contém instruções de linguagem de programação.

### **O que é registrador?**

É uma parte do processador que possui um padrão de bits.

### **Qual o caractere que, na linguagem assembly do SPIM, inicia um comentário?**

O caractere que inicia um comentário em assembly é o caractere "#".

### **Quantos bits há em cada instrução de máquina MIPS?**

Em cada instrução de máquina MIPS há um total de 32 bits.

### **O que é o contador de programa?**

O contador de programa (program counter) é parte do processador que contém o endereço da próxima instrução de máquina para ser obtida.

### **Ao executarmos uma instrução, quanto será adicionado ao contador de programa?**

Ao executarmos uma instrução, será adicionado 4 para o contador de programa.

### **O que é uma diretiva, tal como a diretiva .text?**

Diretiva é uma declaração que diz o montador algo sobre o que o programador quer, mas não corresponde diretamente a uma instrução de máquina.

### **O que é um endereço simbólico?**

O endereço simbólico é um nome usado no código-fonte em linguagem assembly para um local na memória.

### **Em qual endereço o simulador SPIM coloca a primeira instrução de máquina quando ele está sendo executado?**

Ao executar, a primeira instrução se localiza no endereço 0x00400000.

### **Algumas instruções de máquina possuem uma constante como um dos operandos. Como é chamado tal operando?**

Tal operando é nomeado como operando imediato.

**Como é chamada uma operação lógica executada entre bits de cada coluna dos operandos para produzir um bit de resultado para cada coluna?**

A operação utilizada nesse contexto é a operação bitwise.

**Quando uma operação é de fato executada, como estão os operandos na ALU?**

Ambos operandos devem vir de registros.

**Dezesseis bits de dados de uma instrução de ori são usados como um operando imediato. Durante execução, o que deve ser feito primeiro?**

Os dados são estendidos em zero à esquerda por 16 bits.

**Qual das instruções seguintes armazenam no registrador \$5 um padrão de bits que representa positivo 48?**

ori \$5,\$0, 48

**A instrução de ori pode armazenar o complemento de dois de um número em um registrador**

A resposta é não, pois se trata de operações lógicas e não aritméticas.

**Qual das instruções seguintes limpa todos os bits no registrador \$8 com exceção do byte de baixa ordem que fica inalterado?**

A instrução que realiza tal operação é andi \$8,\$8,0xFF, pois ao realizar o and entre os dados, ele mantém apenas o que for 1 entre os operandos.

**Qual é o resultado de um ou exclusivo de padrão sobre ele mesmo?**

O resultado é o contrário do original.

**Todas as instruções de máquina têm os mesmos campos?**

Não. Diferentes de instruções de máquina possuem campos diferentes.

## Parte 2 - Exercícios

### Programas

#### Programa - 01

```
programa_1.asm*
12 # ori: Registrador Destino, Registrador A, Imediato -> Dest = A | I
13 # and: Registrador Destino, Registrador A, Registrador B -> Dest = A & B
14 # xor: Registrador Destino, Registrador A, Registrador B -> Dest = A XOR B
15 # nor: Registrador Destino, Registrador A, Registrador B -> Dest = A NOR B
16
17 .text
18 .globl main
19
20
21 main:
22
23     # Atribuição de valores
24     ori $t0, $zero, 2 # a
25     ori $t1, $zero, 3 # b
26     ori $t2, $zero, 4 # c
27     ori $t3, $zero, 5 # d
28
29     # Somando valores
30     add $t0, $t0, $t1 # Atribuição -> t0: s0 + s1 (a + b)
31     add $t1, $t2, $t3 # Atribuição -> t1: s2 + s3 (c + d)
32     sub $t4, $t0, $t1 # Atribuição -> (x)s4: t0 - t1
33
34     sub $t3, $t0, $t1 # Atribuição -> t3: s0 - s1 (a - b)
35     add $t5, $t3, $t5 # Atribuição -> (y)s5: t3 - s4 (t3 + x)
36     sub $t1, $t4, $t5 # Atribuição -> s1 = x - y
37
38
```

Figura 1: Imagem do programa 1

#### Programa - 02

```
2
3
4 # Aritméticas
5 # add: Registrador Destino, Registrador A, Registrador B -> Dest = A + B
6 # addi: Registrador Destino, Registrador A, Imediato -> Dest = A + Imediato
7 # sub: Registrador Destino, Registrador A, Registrador B -> Dest = A - B
8
9
10 # Lógicas
11 # andi: Registrador Destino, Registrador A, Imediato -> Dest = A & I
12 # orisi: Registrador Destino, Registrador A, Imediato -> Dest = A | I
13 # andi: Registrador Destino, Registrador A, Registrador B -> Dest = A & B
14 # nori: Registrador Destino, Registrador A, Registrador B -> Dest = A XOR B
15 # nori: Registrador Destino, Registrador A, Registrador B -> Dest = A NOR B
16
17 .text
18 .globl main
19
20 main:
21
22     ori $t0, $zero, 1 # Atribuição -> x = 1
23     add $t0, $t0, $t0 # Atribuição -> t0 = 2x
24     add $t0, $t0, $t0 # Atribuição -> t0 = 4x
25     add $t0, $t0, $t0 # Atribuição -> t0 = 8x
26     addi $t1, $t0, 15 # Atribuição -> y = 5x + 15
27
28
```

Figura 2: Imagem do programa 2

#### Programa - 03

```
21 main:
22
23     ori $t0, $zero, 3 # Atribuição s0 = 15
24     ori $t1, $zero, 4 # Atribuição s1 = 4
25
26     add $t0, $t0, $t0 # Atribuição t0 = 2x
27     add $t0, $t0, $t0 # Atribuição t0 = 4x
28     add $t0, $t0, $t0 # Atribuição t0 = 8x
29     add $t0, $t0, $t0 # Atribuição t0 = 16x
30     sub $t0, $t0, $t0 # Atribuição t0 = 15x
31
32     add $t1, $t1, $t1 # Atribuição t1 = 2y
33     add $t1, $t1, $t1 # Atribuição t1 = 4y
34     add $t1, $t1, $t1 # Atribuição t1 = 8y
35     add $t1, $t1, $t1 # Atribuição t1 = 16y
36     add $t1, $t1, $t1 # Atribuição t1 = 32y
37     add $t1, $t1, $t1 # Atribuição t1 = 64y
38     add $t1, $t1, $t1 # Atribuição t1 = 128y
39     add $t1, $t1, $t1 # Atribuição t1 = 256y
40     add $t1, $t1, $t1 # Atribuição t1 = 512y
41
42     add $t2, $t0, $t1 # Atribuição t2 = t0 + t1
43     add $t2, $t2, $t2 # Atribuição t2 = 2 * t2
44     add $t2, $t2, $t2 # Atribuição t2 = 4 * t2
45
46     add $t3, $zero, $t2 # Atribuição z = (15x + 67y) * 4
47
```

Figura 3: Imagem do programa 3

## Programa - 04

```
programa_3.asm programma_4.asm
5
6
7 .text
8 .globl main
9
10 main:
11     ori $s0, $zero, 3 # -> s0 = 15
12     ori $s1, $zero, 4 # -> s1 = 4
13
14     sll $t0, $s0, 4 # -> t0 = 16x
15     sub $t0, $t0, $s0 # -> t0 = 15x
16
17     sll $t1, $s1, 6 # -> t1 = 64x
18     add $t1, $t1, $s1 # -> t1 = 65x
19     add $t1, $t1, $s1 # -> t1 = 66x
20     add $t1, $t1, $s1 # -> t1 = 67x
21
22     add $t2, $t1, $s0 # -> t2 = (15x + 67y)
23     sll $t2, $t2, 2 # -> t2 = (15x + 67y) * 4
24     add $t2, $t2, $zero, $t2 # -> z = t2
25
26
27
28
29
30
31
```

Figura 4: Imagem do programa 4

## Programa - 05

```
programa_5.asm* programma_6.asm*
1
2 .text
3 .globl main
4
5 main:
6
7     ori $s0, $zero, 0x1B6A # s0 = 6250
8     sll $s0, $s0, 4 # s0 = 6250 * 16
9
10
11    ori $s1, $zero, 0x30D4 # s1 = 12500
12    sll $s1, $s1, 4 # s1 = 12500 * 16
13
14    add $s2, $s0, $s1
15
16
17
18
19
20
21
22
```

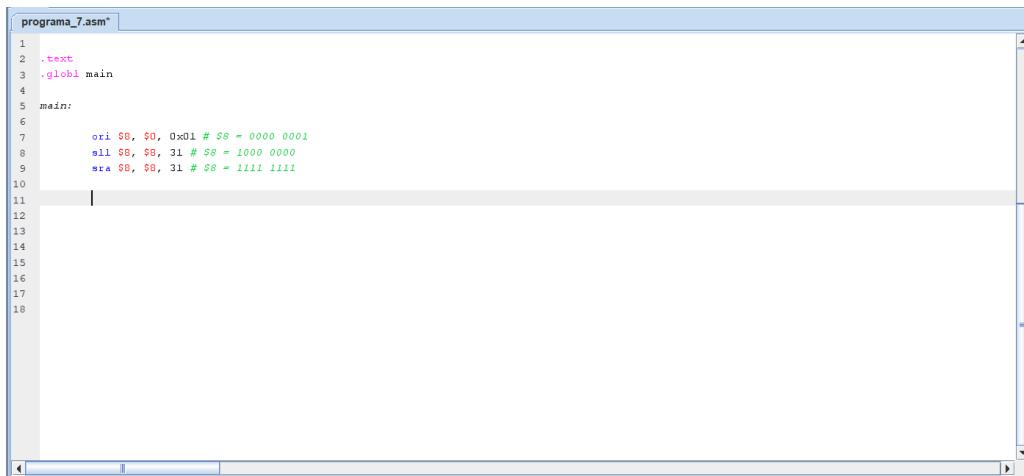
Figura 5: Imagem do programa 5

## Programa - 06

```
programa_5.asm programma_6.asm*
1
2 .text
3 .globl main
4
5 main:
6
7     ori $s0, $zero, 0xFFFF # s0 = FFFF
8     sll $s0, $s0, 16 # s0 = FFFF 0000
9     ori $t0, $zero, 0XFFFF # t0 = 0000 FFFF
10    or $s0, $t0, $s0 # s0 = FFFF FFFF
11
12    ori $s1, $zero, 0x493E # s1 = 0x493E
13    sll $s1, $s1, 4 # s1 = 0x493E0
14
15    sll $t1, $s1, 2
16
17    sub $s2, $s0, $t1 # s2 = Maior possivel - 4y
18
19
20
21
22
23
24
25
```

Figura 6: Imagem do programa 6

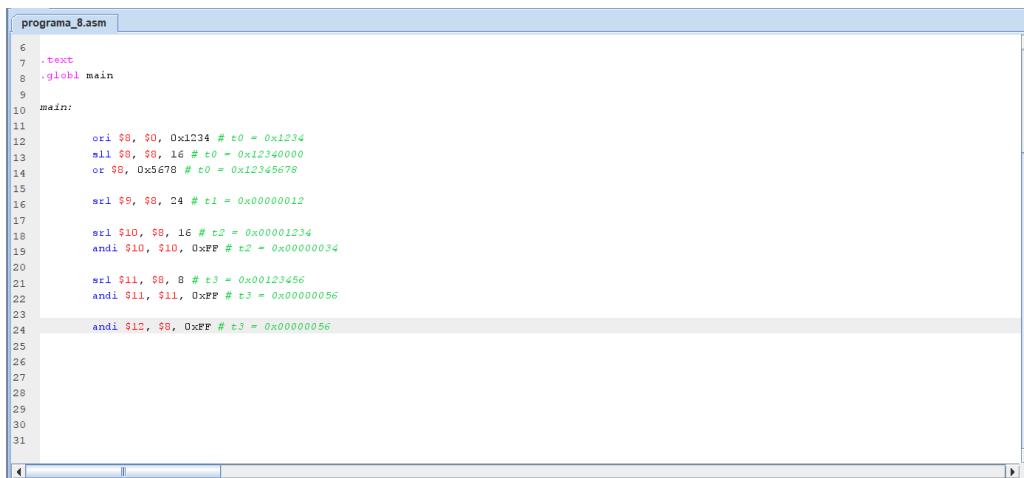
## Programa - 07



```
programa_7.asm*
1
2 .text
3 .globl main
4
5 main:
6
7     ori $8, $0, 0xd1 # $8 = 0000 0001
8     sll $8, $8, 31 # $8 = 1000 0000
9     sra $8, $8, 31 # $8 = 1111 1111
10
11
12
13
14
15
16
17
18
```

Figura 7: Imagem do programa 7

## Programa - 08



```
programa_8.asm
6
7 .text
8 .globl main
9
10 main:
11
12     ori $8, $0, 0x1234 # t0 = 0x1234
13     sll $8, $8, 16 # t0 = 0x12340000
14     or $8, 0x5678 # t0 = 0x12345678
15
16     srl $9, $8, 24 # t1 = 0x00000012
17
18     srl $10, $8, 16 # t2 = 0x00001234
19     andi $10, $10, 0xFF # t2 = 0x00000034
20
21     srl $11, $8, 8 # t3 = 0x00123456
22     andi $11, $11, 0xFF # t3 = 0x00000056
23
24     andi $12, $8, 0xFF # t3 = 0x00000056
25
26
27
28
29
30
31
```

Figura 8: Imagem do programa 8

## Programa - 09

A screenshot of a text editor window titled "programa\_9.asm". The code is written in assembly language. It starts with a .text section containing a main routine. Inside the routine, it performs several memory operations: loading values from memory into registers \$t0, \$t1, \$t2, and \$t3, and then adding them together to calculate a sum. The result is then stored back into memory. Following the routine, there is a .data section defining four variables (x1, x2, x3, x4) and one variable (soma). The assembly code uses labels like .text, .globl, .main, and .data, and instructions like lw, add, and sw.

```
programa_9.asm
10 .text
11 .globl main
12
13 main:
14     lw $t0, x1 # $t0 = 15
15     lw $t1, x2 # $t1 = 25
16     lw $t2, x3 # $t2 = 13
17     lw $t3, x4 # $t3 = 17
18
19     add $t4, $t0, $t1 # t4 = (t0 + t1)
20     add $t4, $t4, $t2 # t4 = (t0 + t1) + t2
21     add $t4, $t4, $t3 # t4 = ((t0 + t1) + t2) + t3
22
23     sw $t4, soma
24
25
26
27
28 .data
29 x1: .word 15
30 x2: .word 25
31 x3: .word 13
32 x4: .word 17
33 soma: .word -1
34
35
36
```

Line: 36 Column: 1  Show Line Numbers

Figura 9: Imagem do programa 9

## Programa - 10

A screenshot of a text editor window titled "programa\_10.asm". The code is written in assembly language. It starts with a .text section containing a main routine. Inside the routine, it performs several arithmetic operations: loading values from memory into registers \$t0, \$t1, \$t2, and \$t3, performing shifts (sll), subtractions (sub), additions (add), and then storing the result back into memory. Following the routine, there is a .data section defining three variables (x, z, y) and their corresponding word values. The assembly code uses labels like .text, .globl, .main, and .data, and instructions like lw, sll, sub, add, and sw.

```
programa_10.asm
9
10 .text
11 .globl main
12
13 main:
14
15     lw $t0, x # t0 = x
16     lw $t1, z # t1 = y
17
18     sll $t2, $t0, 7 # t2 = 128x
19     sub $t2, $t2, $t0 # t2 = 127x
20
21     sll $t3, $t1, 6 # t3 = 64z
22     add $t3, $t3, $t1 # t3 = 65z
23
24     sub $t4, $t2, $t3 # t4 = 127x - 65z
25     addi $t4, $t4, 1   # t4 = 127x - 65z + 1
26
27     sw $t4, y
28
29
30
31
32 .data
33 x: .word 5
34 z: .word 7
35 y: .word
```

Line: 1 Column: 1  Show Line Numbers

Figura 10: Imagem do programa 10

## Programa - 11

A screenshot of a text editor window titled "programa\_11.asm". The code is written in assembly language. It includes sections for .text and .data, defines symbols x, z, and y, and contains instructions for loading values into registers t0, t1, and t2, performing arithmetic operations (subtraction and multiplication), and storing the result in register t3. A note in the comments states that the value of y will be overwritten after execution.

```
programa_11.asm
8
9
10 .text
11 .globl main
12
13 main:
14     lw $t0, x # t0 = x
15     lw $t1, z # t1 = z
16
17     sub $t2, $t0, $t1 # t2 = x - z
18
19     ori $t3, $zero, 0x493E # t3 = 0x493E
20     sll $t3, $t3, 4 # t3 = 0x493E0
21
22     add $t3, $t2, $t3 # t3 = (x - z) + 300000
23     sw $t3, y
24
25
26
27
28
29 .data
30 x: .word 100000
31 z: .word 200000
32 y: .word 0    # esse valor deverá ser sobreescrito após a execução do programa.
33
34
```

Figura 11: Imagem do programa 11

## Programa - 12

A screenshot of a text editor window titled "programa\_12.asm". The code is written in assembly language. It includes sections for .text and .data, defines symbols x, ptr1, ptr2, and ptr3, and contains instructions for loading values into registers t0, t1, and t2, and performing a multiplication operation (sll). The .data section defines the values for x, ptr1, ptr2, and ptr3.

```
programa_12.asm
# Descrição das instruções

# Memória
# lw Registrador, deslocamento(Endereço ou Label)
# sw Registrador, deslocamento(Endereço ou Label)

.text
.globl main

main:
    lw $t0, ptr3
    lw $t1, ($t0)
    lw $t2, ($t1)
    lw $s0, ($t2)

    sll $s0, $s0, 1

    sw $s0, x

.data
x: .word 5
ptr1: .word x
ptr2: .word ptr1
ptr3: .word ptr2
```

Figura 12: Imagem do programa 12

## Programa - 13

```
programa_13.asm
.text
.globl main

main:
    lw $t0, A # t0 = A
    sra $t1, $t0, 31
    beq $t1, $zero, positivo
    sub $t0, $zero, $t0
    sw $t0, A

positivo:
    # FIM

.data
A: .word -7
```

Figura 13: Imagem do programa 13

## Programa - 14

```
programa_14.asm
9
10 .text
11 .globl main
12
13 main:
14     lw $t0, A # t0 = A
15     andi $t1, $t0, 1 # t1 = t0 & 1
16     beq $t1, $zero, par # par
17     bne $t1, $zero, impar # impar
18
20 par:
21     la $t2, B
22     sw $zero, ($t2)
23
24 impar:
25     la $t2, B
26     addi $t3, $zero, 1
27     sw $t3, ($t2)
28
29 .data
30 A: .word 5
31 B: .word
32
33
34
35 |
```

Line: 35 Column: 1  Show Line Numbers

Figura 14: Imagem do programa 14

## Programa - 15

```
programa_15

.text
.globl main

main:

    lw $t0, a
    lw $t1, i
    addi $s0, $t0, 0
    addi $t2, $t0, 400

    loop:
        beq $t0, $t2, fim
        sll $t3, $t1, 1
        addi $t3, $t3, 1
        sw $t3, ($t0)
        add $s0, $s0, $t3
        addi $t1, $t1, 1
        addi $t0, $t0, 4
    loop

fim:
    sw $s0, ($t2)

.data
a: .word 0x10010008
i: .word 0
```

Figura 15: Imagem do programa 15

## Programa - 16

```
programa_16.asm

.text
.globl main
main:
    lw $t0, x
    lw $t1, y
    lw $t2, z
    mult $t0, $t1
    mflo $t4
    div $t4, $t2
    mflo $t5
    sw $t5, resultado

.data
x: .word 0x186A00
y: .word 0x13800
z: .word 0x1A80
resultado: .word 0
```

Figura 16: Imagem do programa 16

## Programa - 17

```
programa_12.asm* programa_17.asm

.text
.globl main

main:
    lw $t0, x
    lw $t1, y

    add $t0, $t0, $zero
    beq $t1, $zero, fim
    addi $t1, $zero, 1

loop:
    beq $t1, $t1, fim

    add $t0, $t0, $t0
    addi $t1, $t1, 1

    j loop

fim:
    sw $t0, k

.data
x: .word 0
y: .word 6
k: .word 0
```

Figura 17: Imagem do programa 17

## Programa - 18

```
programa_18.asm*
1
2 .globl main
3 main:
4     lw $t0, x # t0 = x
5     lw $t1, y # t1 = y
6     add $t2, $zero, $zero # k = 0
7     add $t3, $zero, $zero # i = 0
8     add $t4, $zero, $zero # j = 0
9     add $t5, $zero, $zero # soma parcial
10    add $t6, $zero, $zero # soma acumulada
11    beq $t1, $zero, store
12    addi $t2, $zero, 1
13 pot:
14    addi $t3, $t3, 1
15    add $t2, $t2, $t3
16    add $t3, $zero, $zero
17    bne $t1, $zero, multi
18    j multi
19    tim
20 mult:
21    add $t3, $t3, $t4
22    addi $t2, $t2, 1
23    bne $t2, $zero, multi
24    add $t4, $zero, $t3
25    j pot
26
27 fim:
28    add $t2, $zero, $t4
29 store:
30    sw $t2, k
31
32 .data
33 x: .word 2
34 y: .word 3
35 k: .word 0
```

Figura 18: Imagem do programa 18

## Programa - 19

```
programa_19.asm"
11 .text
12 .globl main      # O valor presente em A é 2 em B é 4 para a execução deste programa -> Não foi possível exibir no print devido ao tamanho.
13 main:
14     lw $t0, A
15     lw $t1, B
16     add $t0, $zero, $zero
17     add $t1, $zero, $zero
18     count0:
19         count0:
20             beq $t2, $zero, done0
21             srl $t2, $t2, 1
22             addi $t0, $t0, 1
23             j count0
24     done0:
25         add $t1, $zero, $zero
26         add $t0, $t1, $zero
27     count1:
28         beq $t2, $zero, done1
29         srl $t2, $t2, 1
30         addi $t1, $t1, 1
31         j count1
32     done1:
33         sub $t4, $t0, $t2
34         beq $t4, $zero, mul64
35         bne $t4, $zero, check1
36     check1:
37         sub $t4, $t1, $t2
38         beq $t4, $zero, mul64
39         bne $t4, $zero, mul32
40     mul32:
41         mul $t0, $t0, $t1
42     mul64:
43         mult $t0, $t1
44         mtlo $t2
45         mthi $t3
```

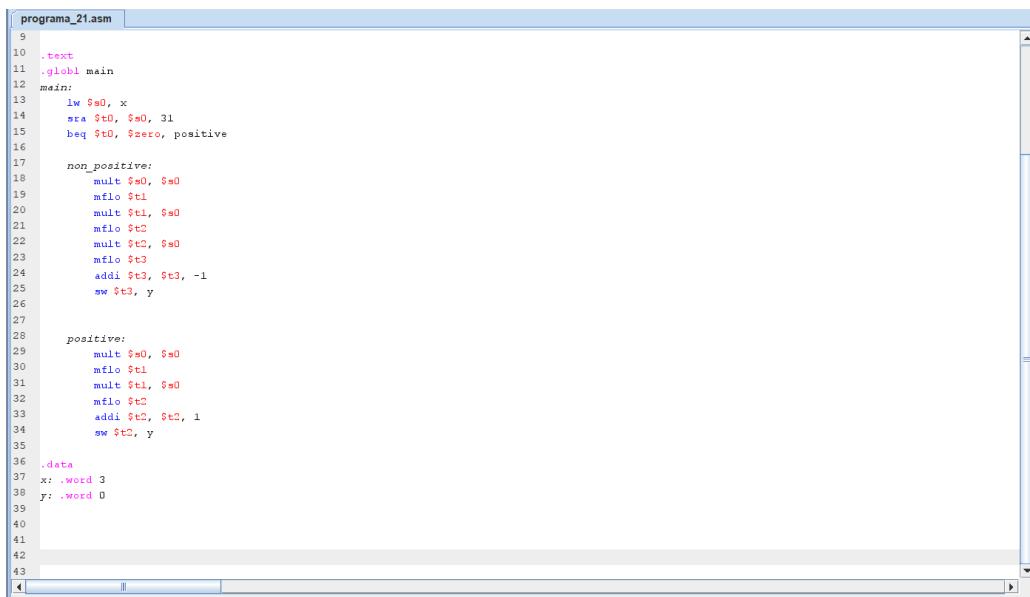
Figura 19: Imagem do programa 19

## Programa - 20

```
programa_20.asm"
6
7 .text
8 .globl main
9 main:
10    lw $t0, x
11    andi $t0, $s0, 1
12    beq $t0, $zero, even
13
14    odd:
15        mul $t1, $s0, $s0
16        mul $t2, $t1, $s0
17        mul $t3, $t2, $t1
18        sub $t3, $t3, $t2
19        addi $t3, $t3, 1
20        sw $t3, y
21
22    even:
23        mul $t1, $s0, $s0
24        mul $t2, $t1, $s0
25        mul $t3, $t2, $s0
26        add $t4, $t3, $t2
27        sll $t1, $t1, 1
28        sub $t4, $t4, $t1
29        sw $t4, y
30
31 .data
32 x: .word 4
33 y: .word 0
34
35
36
37
38
39
```

Figura 20: Imagem do programa 20

## Programa - 21



The screenshot shows a text editor window titled "programa\_21.asm". The code is written in assembly language for the MIPS architecture. It defines a global variable "main" at address 31, which contains a loop. The loop checks if the value in register \$t0 is zero. If it is, it branches to the "positive" label. Otherwise, it enters a "non\_positive" block where it multiplies \$s0 by \$s0, moves the result to \$t1, and then multiplies \$t1 by \$s0 again, moving the result to \$t2. It then adds 1 to \$t2 and stores the result back to \$t2. Finally, it branches back to the start of the loop. The ".data" section defines two variables: "x" at address 3 and "y" at address 0.

```
programa_21.asm
9
10 .text
11 .globl main
12 main:
13     lw $s0, x
14     sra $t0, $s0, 31
15     beq $t0, $zero, positive
16
17     non_positive:
18         mult $s0, $s0
19         mflo $t1
20         mult $t1, $s0
21         mflo $t2
22         mult $t2, $s0
23         mflo $t3
24         addi $t3, $t3, -1
25         sw $t3, y
26
27
28     positive:
29         mult $s0, $s0
30         mflo $t1
31         mult $t1, $s0
32         mflo $t2
33         addi $t2, $t2, 1
34         sw $t2, y
35
36 .data
37 x: .word 3
38 y: .word 0
39
40
41
42
43
```

Figura 21: Imagem do programa 21

# Execuções

## Execução - 01

Name	Number	Value
Szero	0	0x00000000
Sat	1	0x00000000
Sr0	2	0x00000000
Sr1	3	0x00000000
Sr0	4	0x00000000
Sr1	5	0x00000000
Sr2	6	0x00000000
Sr3	7	0x00000000
Sr0	8	0x00000005
Sr1	9	0x00000009
Sr2	10	0x00000000
Sr3	11	0xffffffff
Sr4	12	0x00000000
Sr5	13	0x00000000
Sr6	14	0x00000000
Sr7	15	0x00000000
Sr0	16	0x00000002
Sr1	17	0x00000001
Sr2	18	0x00000004
Sr3	19	0x00000000
Sr4	20	0xffffffff
Sr5	21	0xffffffffb
Sr6	22	0x00000000
Sr7	23	0x00000000
Sr8	24	0x00000000
Sr9	25	0x00000000
Sr0	26	0x00000000
Sr1	27	0x00000000
Sr2	28	0x00000000
Sr3	29	0x7fffffc
Sr4	30	0x00000000
Sra	31	0x000400025
pc		0x00000000
hi		0x00000000
lo		0x00000000

Figura 22: Imagem da execução programa 1

## Execução - 02

Name	Number	Value
Szero	0	0x00000000
Sat	1	0x00000000
Sr0	2	0x00000000
Sr1	3	0x00000000
Sr0	4	0x00000000
Sr1	5	0x00000000
Sr2	6	0x00000000
Sr3	7	0x00000005
Sr0	8	0x00000000
Sr1	9	0x00000000
Sr2	10	0x00000000
Sr3	11	0x00000000
Sr4	12	0x00000000
Sr5	13	0x00000000
Sr6	14	0x00000000
Sr7	15	0x00000000
Sr0	16	0x00000000
Sr1	17	0x00000014
Sr2	18	0x00000000
Sr3	19	0x00000000
Sr4	20	0x00000000
Sr5	21	0x00000000
Sr6	22	0x00000000
Sr7	23	0x00000000
Sr8	24	0x00000000
Sr9	25	0x00000000
Sr0	26	0x00000000
Sr1	27	0x00000000
Sr2	28	0x00000000
Sr3	29	0xffffffff
Sr4	30	0x00000000
Sra	31	0x00000000
pc		0x000400014
hi		0x00000000
lo		0x00000000

Figura 23: Imagem do execução programa 2

## Execução - 03

The screenshot shows the Mars Simulation Environment during the execution of program 3. The assembly code in the Text Segment window is as follows:

```

Text Segment
Blgt Address Code Basic Source
0x00000000 0x34100003 ori $t0, $zero, 3 # s0 = 15
0x00000004 0x34110004 ori $t1, $zero, 4 # s1 = 4
0x00000008 0x02104020 add $t0,$t0,$t0 t0 = 2x
0x0000000c 0x02104020 add $t1,$t1,$t1 t1 = 2y
0x00000010 0x02104020 add $t0,$t0,$t0 t0 = 3x
0x00000014 0x10104020 add $t0,$t0,$t0 t0 = 16x
0x00000018 0x10104022 sub $t0,$t0,$t0 t0 = 15x
0x0000001c 0x02114020 add $t0,$t0,$t0 t0 = 2y
0x00000020 0x02114020 add $t1,$t1,$t1 t1 = 16y
0x00000024 0x10104020 add $t0,$t0,$t0 t0 = 8y
0x00000028 0x10104020 add $t0,$t0,$t0 t0 = 16y
0x0000002c 0x10104020 add $t0,$t0,$t0 t0 = 32y

```

The Data Segment window shows memory starting at address 0x10010000. The Registers window lists the following values:

Name	Number	Value
\$s0	0	0x00000000
\$at	1	0x00000000
\$v0	2	0x00000000
\$v1	3	0x00000000
\$a0	4	0x00000000
\$a1	5	0x00000000
\$a2	6	0x00000000
\$a3	7	0x00000000
\$t0	8	0x0000002d
\$t1	9	0x0000010c
\$t2	10	0x00000044
\$t3	11	0x00000000
\$t4	12	0x00000000
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$s0	16	0x00000003
\$a1	17	0x00000004
\$t2	18	0x00000044
\$t3	19	0x00000000
\$t4	20	0x00000000
\$t5	21	0x00000000
\$t6	22	0x00000000
\$t7	23	0x00000000
\$t8	24	0x00000000
\$t9	25	0x00000000
\$t0	26	0x00000000
\$t1	27	0x00000000
\$sp	28	0x10000000
\$fp	29	0x7fffffc
\$ra	30	0x00000000
pc	31	0x00000035
hi		0x00000000
lo		0x00000000

The Mars Messages window shows two entries indicating the program has finished running.

Figura 24: Imagem do execução programa 3

## Execução - 04

The screenshot shows the Mars Simulation Environment during the execution of program 4. The assembly code in the Text Segment window is as follows:

```

Text Segment
Blgt Address Code Basic Source
0x00000000 0x34100003 ori $t0, $zero, 3 # s0 = 15
0x00000004 0x34110004 ori $t1, $zero, 4 # s1 = 4
0x00000008 0x02104020 add $t0,$t0,$t0 t0 = 2x
0x0000000c 0x02104020 add $t1,$t1,$t1 t1 = 2y
0x00000010 0x02104020 add $t0,$t0,$t0 t0 = 3x
0x00000014 0x10104020 add $t0,$t0,$t0 t0 = 16x
0x00000018 0x10104022 sub $t0,$t0,$t0 t0 = 15x
0x0000001c 0x02114020 add $t0,$t0,$t0 t0 = 2y
0x00000020 0x02114020 add $t1,$t1,$t1 t1 = 16y
0x00000024 0x10104020 add $t0,$t0,$t0 t0 = 8y
0x00000028 0x10104020 add $t0,$t0,$t0 t0 = 16y
0x0000002c 0x10104020 add $t0,$t0,$t0 t0 = 32y

```

The Data Segment window shows memory starting at address 0x10010000. The Registers window lists the following values:

Name	Number	Value
\$s0	0	0x00000000
\$at	1	0x00000000
\$v0	2	0x00000000
\$v1	3	0x00000000
\$a0	4	0x00000000
\$a1	5	0x00000000
\$a2	6	0x00000000
\$a3	7	0x00000000
\$t0	8	0x0000002d
\$t1	9	0x0000010c
\$t2	10	0x00000044
\$t3	11	0x00000000
\$t4	12	0x00000000
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$s0	16	0x00000003
\$a1	17	0x00000004
\$t2	18	0x00000044
\$t3	19	0x00000000
\$t4	20	0x00000000
\$t5	21	0x00000000
\$t6	22	0x00000000
\$t7	23	0x00000000
\$t8	24	0x00000000
\$t9	25	0x00000000
\$t0	26	0x00000000
\$t1	27	0x00000000
\$sp	28	0x10000000
\$fp	29	0x7fffffc
\$ra	30	0x00000000
pc	31	0x00000035
hi		0x00000000
lo		0x00000000

The Mars Messages window shows two entries indicating the program has finished running.

Figura 25: Imagem do execução programa 4

## Execução - 05

Name	Number	Value
Szero	0	0x00000000
Sat	1	0x00000000
Sv0	2	0x00000000
Sv1	3	0x00000000
Sa0	4	0x00000000
Sa1	5	0x00000000
Sa2	6	0x00000000
Sa3	7	0x00000000
Sa0	8	0x00000000
Sa1	9	0x00000000
Sa2	10	0x00000000
Sa3	11	0x00000000
Sa4	12	0x00000000
Sa5	13	0x00000000
Sa6	14	0x00000000
Sa7	15	0x00000000
Sa0	16	0x000186a0
Sa1	17	0x00030d40
Sa2	18	0x0004593e
Sa3	19	0x00000000
Sa4	20	0x00000000
Sa5	21	0x00000000
Sa6	22	0x00000000
Sa7	23	0x00000000
Sa8	24	0x00000000
Sa9	25	0x00000000
Sa0	26	0x00000000
Sa1	27	0x00000000
Sgp	28	0x10000000
Sfp	29	0x7fffffc
Sra	30	0x00000000
pc	31	0x00400014
hi		0x00000000
lo		0x00000000

Figura 26: Imagem do execução programa 5

## Execução - 06

Name	Number	Value
Szero	0	0x00000000
Sat	1	0x00000000
Sv0	2	0x00000000
Sv1	3	0x00000000
Sa0	4	0x00000000
Sa1	5	0x00000000
Sa2	6	0x00000000
Sa3	7	0x00000000
Sa0	8	0x0000ffff
Sa1	9	0x00124fe0
Sa2	10	0x00000000
Sa3	11	0x00000000
Sa4	12	0x00000000
Sa5	13	0x00000000
Sa6	14	0x00000000
Sa7	15	0x00000000
Sa0	16	0xffffffff
Sa1	17	0xffffd7e0
Sa2	18	0xffffed80
Sa3	19	0x00000000
Sa4	20	0x00000000
Sa5	21	0x00000000
Sa6	22	0x00000000
Sa7	23	0x00000000
Sa8	24	0x00000000
Sa9	25	0x00000000
Sa0	26	0x00000000
Sa1	27	0x00000000
Sgp	28	0x00000000
Sfp	29	0x7fffffc
Sra	30	0x00000000
pc	31	0x00400020
hi		0x00000000
lo		0x00000000

Figura 27: Imagem do execução programa 6

## Execução - 07

The screenshot shows the Mars Simulation Environment during the execution of program 7. The registers pane displays the state of various寄存器 (Registers) from \$zero to \$lo. The data segment pane shows memory starting at address 0x10010000, with values ranging from 0x00000000 to 0xffffffff. The text segment pane shows assembly code with comments explaining operations like ori, sll, sra, and andi. The Mars Messages window indicates the program has finished running.

Name	Number	Value
\$zero	0	0x00000000
\$at	1	0x00000000
\$v0	2	0x00000000
\$v1	3	0x00000000
\$a0	4	0x00000000
\$a1	5	0x00000000
\$a2	6	0x00000000
\$s0	7	0x00000000
\$s1	8	0xffffffff
\$t1	9	0x00000000
\$t2	10	0x00000000
\$t3	11	0x00000000
\$t4	12	0x00000000
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$a0	16	0x00000000
\$a1	17	0x00000000
\$s2	18	0x00000000
\$s3	19	0x00000000
\$s4	20	0x00000000
\$s5	21	0x00000000
\$s6	22	0x00000000
\$t7	23	0x00000000
\$t8	24	0x00000000
\$t9	25	0x00000000
\$k0	26	0x00000000
\$k1	27	0x00000000
\$gp	28	0x10000000
\$sp	29	0x7ffffeffc
\$fp	30	0x00000000
\$ra	31	0x00000000
\$pc		0x00400000
\$hi		0x00000000
\$lo		0x00000000

Figura 28: Imagem do execução programa 7

## Execução - 08

The screenshot shows the Mars Simulation Environment during the execution of program 8. The registers pane displays the state of various寄存器 (Registers) from \$zero to \$lo. The data segment pane shows memory starting at address 0x10010000, with values ranging from 0x00000000 to 0xffffffff. The text segment pane shows assembly code with comments explaining operations like ori, sll, sra, and andi. The Mars Messages window indicates the program has finished running.

Name	Number	Value
\$zero	0	0x00000000
\$at	1	0x00000000
\$v0	2	0x00000000
\$v1	3	0x00000000
\$a0	4	0x00000000
\$a1	5	0x00000000
\$a2	6	0x00000000
\$s0	7	0x00000000
\$t0	8	0x12345678
\$t1	9	0x00000000
\$t2	10	0x00000000
\$t3	11	0x00000000
\$t4	12	0x00000000
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$a0	16	0x00000000
\$a1	17	0x00000000
\$s2	18	0x00000000
\$s3	19	0x00000000
\$s4	20	0x00000000
\$s5	21	0x00000000
\$s6	22	0x00000000
\$t7	23	0x00000000
\$t8	24	0x00000000
\$t9	25	0x00000000
\$k0	26	0x00000000
\$k1	27	0x00000000
\$gp	28	0x10000000
\$sp	29	0x7ffffeffc
\$fp	30	0x00000000
\$ra	31	0x00000000
\$pc		0x00400000
\$hi		0x00000000
\$lo		0x00000000

Figura 29: Imagem do execução programa 8

## Execução - 09

The screenshot shows the Mars Simulation Environment during the execution of program 9. The registers pane displays the state of various寄存器 (Registers) from \$zero to \$lo. The data segment pane shows memory starting at address 0x10010000, with values ranging from 0x00000000 to 0xffffffff. The text segment pane shows assembly code with comments explaining operations like lw, add, and sw. The Mars Messages window indicates the program has finished running.

Name	Number	Value
\$zero	0	0x00000000
\$at	1	0x10010000
\$v0	2	0x00000000
\$v1	3	0x00000000
\$a0	4	0x00000000
\$a1	5	0x00000000
\$a2	6	0x00000000
\$s0	7	0x00000000
\$t0	8	0x00000000
\$t1	9	0x00000019
\$t2	10	0x00000000
\$t3	11	0x00000011
\$t4	12	0x00000044
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$a0	16	0x00000000
\$a1	17	0x00000000
\$s2	18	0x00000000
\$s3	19	0x00000000
\$s4	20	0x00000000
\$s5	21	0x00000000
\$s6	22	0x00000000
\$t7	23	0x00000000
\$t8	24	0x00000000
\$t9	25	0x00000000
\$k0	26	0x00000000
\$k1	27	0x00000000
\$gp	28	0x10000000
\$sp	29	0x7ffffeffc
\$fp	30	0x00000000
\$ra	31	0x00400034
\$pc		0x00400000
\$hi		0x00000000
\$lo		0x00000000

Figura 30: Imagem do execução programa 9

## Execução - 10

The screenshot shows the Mars Simulation Environment during the execution of program 10. The registers pane displays the state of various寄存器 (Registers) from \$zero to \$t0, \$t1, ..., \$t31. The data segment pane shows memory starting at address 0x10010000 with values ranging from 0x00000000 to 0xffffffff. The text segment pane shows assembly code with comments and addresses from 0x00000000 to 0x0000000f. The Mars Messages window indicates the program has finished running.

Figura 31: Imagem do execução programa 10

## Execução - 11

The screenshot shows the Mars Simulation Environment during the execution of program 11. The registers pane displays the state of various寄存器 (Registers) from \$zero to \$t0, \$t1, ..., \$t31. The data segment pane shows memory starting at address 0x10010000 with values ranging from 0x00000000 to 0xffffffff. The text segment pane shows assembly code with comments and addresses from 0x00000000 to 0x0000000f. The Mars Messages window indicates the program has finished running.

Figura 32: Imagem do execução programa 11

## Execução - 12

The screenshot shows the Mars Simulation Environment during the execution of program 12. The registers pane displays the state of various寄存器 (Registers) from \$zero to \$t0, \$t1, ..., \$t31. The data segment pane shows memory starting at address 0x10010000 with values ranging from 0x00000000 to 0xffffffff. The text segment pane shows assembly code with comments and addresses from 0x00000000 to 0x0000000f. The Mars Messages window indicates the program has finished running.

Figura 33: Imagem do execução programa 12

## Execução - 13

**Text Segment**

Blkt	Address	Code	Basic	Source
	0x00000000	0xb3011001lui \$1,0x000001001	15: lw \$t0, A # t0 = A	
	0x00000004	0xb2c30000lw \$8,0x00000000(\$1)		
	0x00000008	0x00004fc3lra \$9,\$8,0x00000001f	27: sra \$t1, \$t0, 31	
	0x0000000c	0x11200003beq \$9,\$0,0x000000003	28: beq \$t1, zero, positivo	
	0x00000010	0x11200003beq \$9,\$0,0x000000003	29: beq \$t1, zero, negativo	
	0x00000014	0xb3011001lui \$1,0x000001001	30: lw \$t0, A	
	0x00000018	0xacd80000sw \$8,0x00000000(\$1)		

**Data Segment**

Address	Value (+0)	Value (+4)	Value (+8)	Value (+C)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x10010000	0x00000007	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010020	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010040	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010060	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010080	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100e0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010100	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010120	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000

**Registers**

Name	Number	Value
\$zero	0	0x00000000
\$at	1	0x10010000
\$v0	2	0x00000000
\$v1	3	0x00000000
\$t0	4	0x00000000
\$t1	5	0x00000000
\$t2	6	0x00000000
\$t3	7	0x00000000
\$t4	8	0x00000000
\$t5	9	0x00000001
\$t6	10	0x10010004
\$t7	11	0x00000000
\$t8	12	0x00000000
\$t9	13	0x00000000
\$t10	14	0x00000000
\$t11	15	0x00000000
\$t12	16	0x00000000
\$t13	17	0x00000000
\$t14	18	0x00000000
\$t15	19	0x00000000
\$t16	20	0x00000000
\$t17	21	0x00000000
\$t18	22	0x00000000
\$t19	23	0x00000000
\$t20	24	0x00000000
\$t21	25	0x00000000
\$t22	26	0x00000000
\$t23	27	0x00000000
\$t24	28	0x00000000
\$t25	29	0x7fffffc
\$t26	30	0x00000000
\$t27	31	0x00000000
pc		0x00400014
hi		0x00000000
lo		0x00000000

**Mars Messages**

Reset: reset completed.

Clear -- program is finished running (dropped off bottom) --

Figura 34: Imagem do execução programa 13

## Execução - 14

**Text Segment**

Blkt	Address	Code	Basic	Source
	0x00000000	0xb3011001lui \$1,0x000001001	15: lw \$t0, a	
	0x00000004	0xb2c30000lw \$8,0x00000000(\$1)		
	0x00000008	0x00004fc3lra \$9,\$8,0x00000001f	17: andi \$t1, \$t0, 1 # t1 = 0 & 1	
	0x00000010	0x11200003beq \$9,\$0,0x000000003	18: beq \$t1, zero, par # par	
	0x00000014	0xb3011001lui \$1,0x000001001	22: la \$t2, R	
	0x00000018	0x34200004ori \$10,\$1,0x000000004		
	0x00000020	0x34d40000sw \$10,\$1,0x000000004	23: sw \$tzero, (\$t2)	
	0x00000024	0x34200004ori \$10,\$1,0x000000004	26: la \$t2, R	
	0x00000028	0x20000001add \$11,\$9,0x000000...-27:	addi \$t3, \$tzero, 1	
	0x0000002c	0x34db0000sw \$11,0x00000000(\$1...-28:	sw \$t3, (\$t2)	

**Data Segment**

Address	Value (+0)	Value (+4)	Value (+8)	Value (+C)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x10010000	0x00000005	0x00000001	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010020	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010040	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010060	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010080	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100e0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010100	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010120	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000

**Registers**

Name	Number	Value
\$zero	0	0x00000000
\$at	1	0x10010000
\$v0	2	0x00000000
\$v1	3	0x00000000
\$t0	4	0x00000000
\$t1	5	0x00000000
\$t2	6	0x00000000
\$t3	7	0x00000000
\$t4	8	0x00000005
\$t5	9	0x00000001
\$t6	10	0x10010004
\$t7	11	0x00000000
\$t8	12	0x00000000
\$t9	13	0x00000000
\$t10	14	0x00000000
\$t11	15	0x00000000
\$t12	16	0x00000000
\$t13	17	0x00000000
\$t14	18	0x00000000
\$t15	19	0x00000000
\$t16	20	0x00000000
\$t17	21	0x00000000
\$t18	22	0x00000000
\$t19	23	0x00000000
\$t20	24	0x00000000
\$t21	25	0x00000000
\$t22	26	0x00000000
\$t23	27	0x00000000
\$t24	28	0x7fffffc
\$t25	29	0x00000000
\$t26	30	0x00000000
\$t27	31	0x00000000
pc		0x00400014
hi		0x00000000
lo		0x00000000

**Mars Messages**

Reset: reset completed.

Clear -- program is finished running (dropped off bottom) --

Figura 35: Imagem do execução programa 14

## Execução - 15

**Text Segment**

Blkt	Address	Code	Basic	Source
	0x00000000	0xb3011001lui \$1,0x000001001	15: lw \$t0, a	
	0x00000004	0xb2c30000lw \$8,0x00000000(\$1)		
	0x00000008	0x00004fc3lra \$9,\$8,0x00000001f	16: lw \$t1, i	
	0x00000010	0xb3011001lui \$1,0x000001001	20: addi \$t2, \$t0, 400	
	0x00000014	0xb2c30000lw \$8,0x00000000(\$1)	21: beq \$t0, \$t0, fim	
	0x00000018	0x110a0007beq \$8,\$10,0x000000001	22: addi \$t2, \$t1, 1	
	0x00000020	0x34200004ori \$11,\$1,0x000000004	24: addi \$t3, \$t1, 1	
	0x00000024	0xb2c30000lw \$8,0x00000000(\$1)	27: sw \$t3, (\$t2)	
	0x00000028	0x20000002add \$16,\$16,11	29: add \$t0, \$t0, 11	
	0x00000032	0xb3011001lui \$1,0x000001001	31: addi \$t1, \$t1, 1	
	0x00000036	0xb2c30000lw \$8,0x00000000(\$1)	32: add \$t0, \$t0, 4	
	0x00000040	0x34200004ori \$10,\$1,0x000000004	34: j loop	
	0x00000044	0xb3011001lui \$1,0x000001001	38: sw \$t0, (\$t2)	

**Data Segment**

Address	Value (+0)	Value (+4)	Value (+8)	Value (+C)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x10010000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010020	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010040	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010060	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010080	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100e0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010100	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010120	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010140	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010160	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010180	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100101a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100101c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100101e0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000

**Registers**

Name	Number	Value
\$zero	0	0x00000000
\$at	1	0x10010000
\$v0	2	0x00000000
\$v1	3	0x00000000
\$t0	4	0x00000000
\$t1	5	0x00000000
\$t2	6	0x00000000
\$t3	7	0x00000000
\$t4	8	0x00000000
\$t5	9	0x00000000
\$t6	10	0x10010004
\$t7	11	0x00000000
\$t8	12	

## Execução - 16

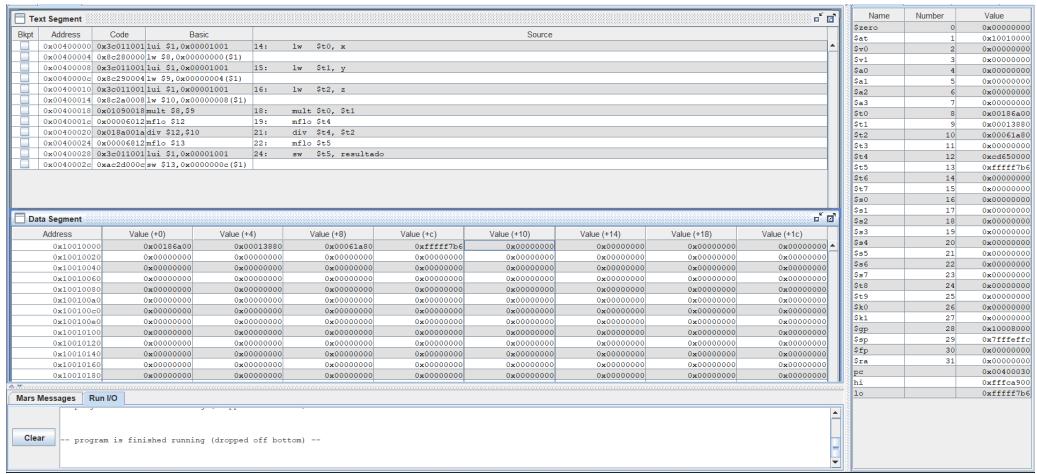


Figura 37: Imagem do execução programa 16

## Execução - 17

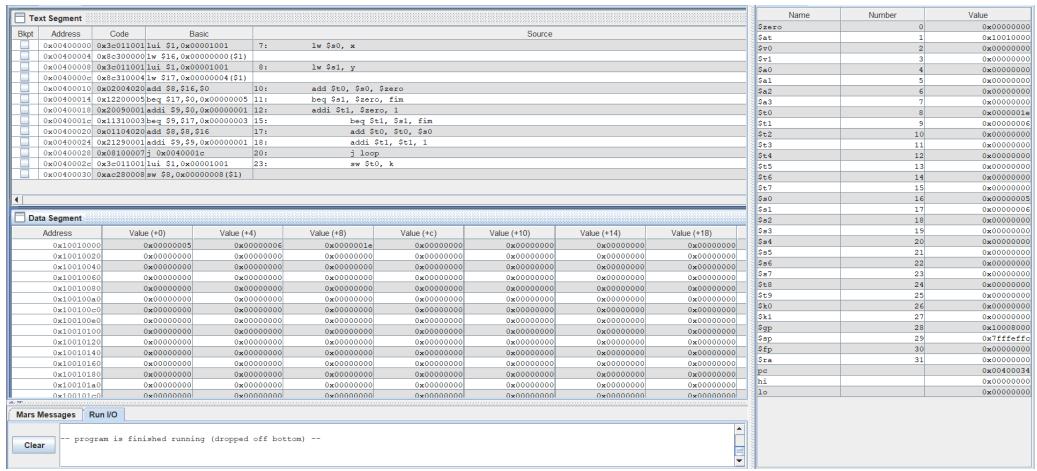


Figura 38: Imagem do execução programa 17

## Execução - 18

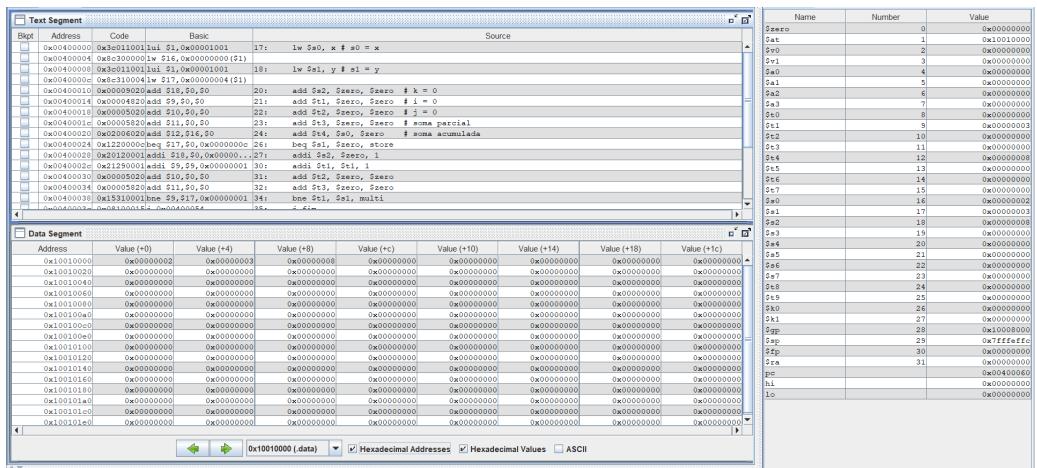


Figura 39: Imagem da execução programa 18

## Execução - 19

The screenshot shows the Mars Simulation Environment during the execution of program 19. The Text Segment window displays assembly code with columns for Blkt, Address, Code, Basic, and Source. The Data Segment window shows memory dump details. The Registers window lists various寄存器 (Registers) with their names, numbers, and values. The Run I/O window contains messages indicating the program has finished running.

Name	Number	Value
szero	0	0x00000000
sat	1	0x00000020
sv1	2	0x00000000
sv1	3	0x00000000
sw0	4	0x00000000
sa1	5	0x00000000
sa2	6	0x00000000
sa3	7	0x00000000
st0	8	0x00000002
st1	9	0x00000003
st2	10	0x00000000
st3	11	0x00000000
st4	12	0xfffffe3
st5	13	0x00000000
st6	14	0x00000000
st7	15	0x00000000
sw0	16	0x00000002
sa1	17	0x00000004
st2	18	0x00000008
st3	19	0x00000000
st4	20	0x00000000
st5	21	0x00000000
st6	22	0x00000000
st7	23	0x00000000
st8	24	0x00000000
st9	25	0x00000000
sk0	26	0x00000000
sk1	27	0x00000000
st9	28	0x00000000
sp	29	0xfffffeff
fp	30	0x00000000
ra	31	0x00000000
hi		0x00000000
lo		0x00000000

Figura 40: Imagem do execução programa 19

## Execução - 20

The screenshot shows the Mars Simulation Environment during the execution of program 20. The Text Segment window displays assembly code with columns for Blkt, Address, Code, Basic, and Source. The Data Segment window shows memory dump details. The Registers window lists various寄存器 (Registers) with their names, numbers, and values. The Run I/O window contains messages indicating the program has finished running.

Name	Number	Value
szero	0	0x00000000
sat	1	0x10000000
sv0	2	0x00000000
sv1	3	0x00000000
sv0	4	0x00000000
sa0	5	0x00000000
sa1	6	0x00000000
sa2	7	0x00000000
st0	8	0x00000000
st1	9	0x00000000
st2	10	0x00000000
st3	11	0x00000000
st4	12	0x00000000
st5	13	0x00000000
st6	14	0x00000000
st7	15	0x00000000
st8	16	0x00000000
st9	17	0x00000000
st0	18	0x00000000
st1	19	0x00000000
st2	20	0x00000000
st3	21	0x00000000
st4	22	0x00000000
st5	23	0x00000000
st6	24	0x00000000
st7	25	0x00000000
st8	26	0x00000000
st9	27	0x00000000
sk0	28	0x00000000
sk1	29	0x00000000
st9	30	0x00000000
sp	31	0x00000000
ra		0x00000000
pc		0x00000000
hi		0x00000000
lo		0x00000000

Figura 41: Imagem do execução programa 20

## Execução - 21

The screenshot shows the Mars Simulation Environment during the execution of program 21. The Text Segment window displays assembly code with columns for Blkt, Address, Code, Basic, and Source. The Data Segment window shows memory dump details. The Registers window lists various寄存器 (Registers) with their names, numbers, and values. The Run I/O window contains messages indicating the program has finished running.

Name	Number	Value
szero	0	0x00000000
sat	1	0x10000000
sv0	2	0x00000000
sv1	3	0x00000000
sv0	4	0x00000000
sa0	5	0x00000000
sa1	6	0x00000000
sa2	7	0x00000000
st0	8	0x00000000
st1	9	0x00000000
st2	10	0x0000001c
st3	11	0x00000000
st4	12	0x00000000
st5	13	0x00000000
st6	14	0x00000000
st7	15	0x00000000
st8	16	0x00000000
st9	17	0x00000000
st0	18	0x00000000
st1	19	0x00000000
st2	20	0x00000000
st3	21	0x00000000
st4	22	0x00000000
st5	23	0x00000000
st6	24	0x00000000
st7	25	0x00000000
st8	26	0x00000000
st9	27	0x00000000
sk0	28	0x00000000
sk1	29	0x00000000
st9	30	0x00000000
sp	31	0x00000000
ra		0x00000000
pc		0x00000000
hi		0x00000000
lo		0x0000001b

Figura 42: Imagem do execução programa 21

## **Perguntas a serem respondidas**

**Se tivermos 2 inteiros, cada um com 32 bits, quantos bits podemos esperar para o produto?**

A resposta correta é 64 bits

**Quais os registradores que armazenam os resultados na multiplicação?**

Os registradores que armazenam os resultados de uma multiplicação são o hi e o lo, que guardam os bits mais significativos e menos significativos, respectivamente.

**Qual a operação usada para multiplicar inteiros em comp. de dois?**

Em MIPS, a operação realizada para multiplicar inteiros em complemento de dois é a operação mult.

**Qual instrução move os bits menos significativos da multiplicação para o reg. 8?**

Para mover o bit menos significativo para o registrador 8, é necessário utilizar mflo.

**Se tivermos dois inteiros, cada um com 32 bits, quantos bits deveremos estar preparados para receber no quociente?**

Para uma divisão inteira de 32 bits, o quociente pode armazenar até os 32 bits.

**Após a instrução div, qual registrador possui o quociente?**

O registrador que armazenará o quociente é o registrador lo.

**Qual a inst. Usada para dividir dois inteiros em comp. de dois?**

Tal instrução diz a respeito sobre a instrução div.

**Faça um arithmetic shift right de dois no seguinte padrão de bits: 1001 1011**

O resultado de uma instrução será aplicada ao número 1001 1011, deslocando-se 2 bits, resulta em: 1110 0110

**Qual o efeito de um arithmetic shift right de uma posição?**

Se o inteiro for unsigned, o shift pode ocasionar um valor errado. Se o inteiro for signed, o shift o divide por 2.