BÁO CÁO THỰC HÀNH KIẾN TRÚC MÁY TÍNH TUẦN 7

Assignment 1

- Code

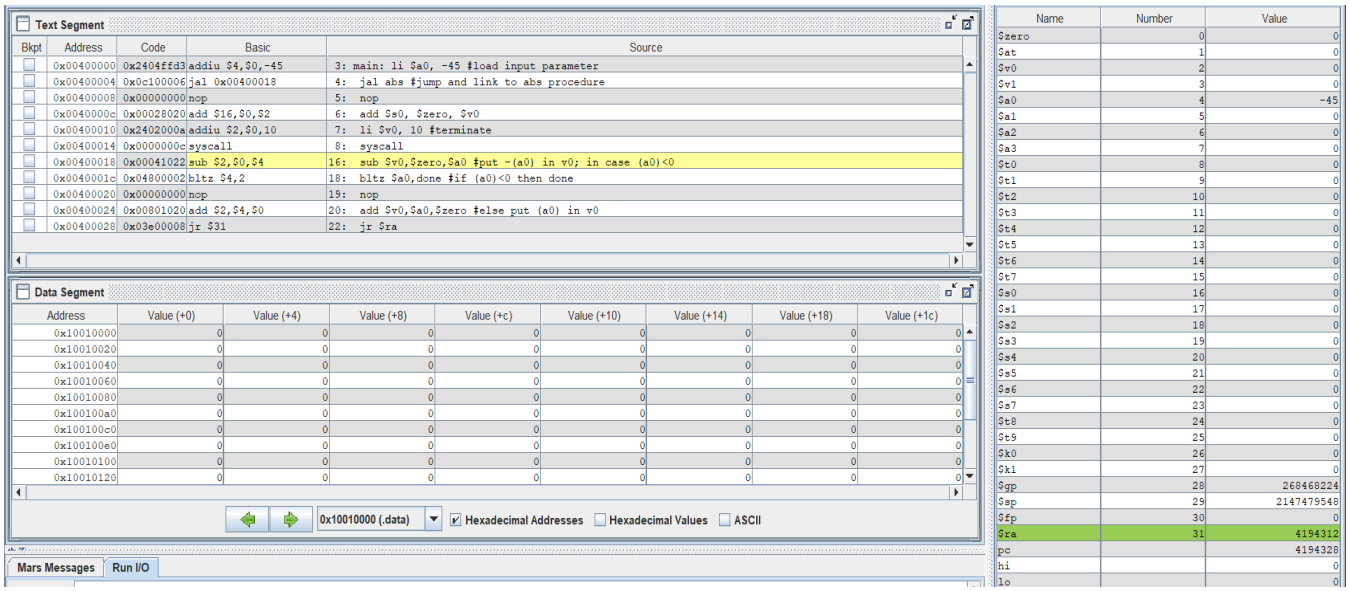
```
#Laboratory Exercise 7 Home Assignment 1
.text
main: li $a0, 45 #load input parameter
 jal abs #jump and link to abs procedure
 nop
 add $s0, $zero, $v0
 li $v0, 10 #terminate
 syscall
endmain:
#---------------------------------------------------------------
# function abs
# param[in] $a0 the interger need to be gained the absolute value
# return $v0 absolute value
#---------------------------------------------------------------
abs:
 sub $v0,$zero,$a0 #put -(a0) in v0; in case (a0)<0

 bltz $a0,done #if (a0)<0 then done
 nop
 add $v0,$a0,$zero #else put (a0) in v0
done:
 jr $ra
```

- **TH: $a0 = -45 <0**
- Lệnh: jal abs

⇨ $pc = 4194328, $$ra = 4194312

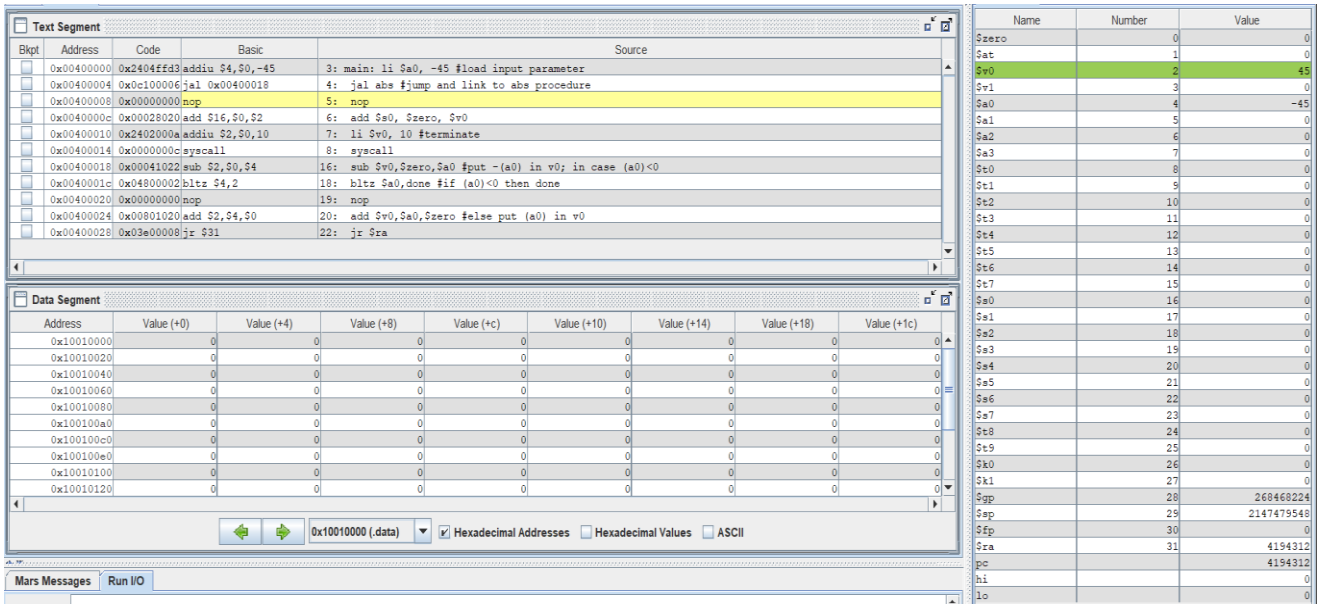
⇨ Gọi ra thủ tục abs



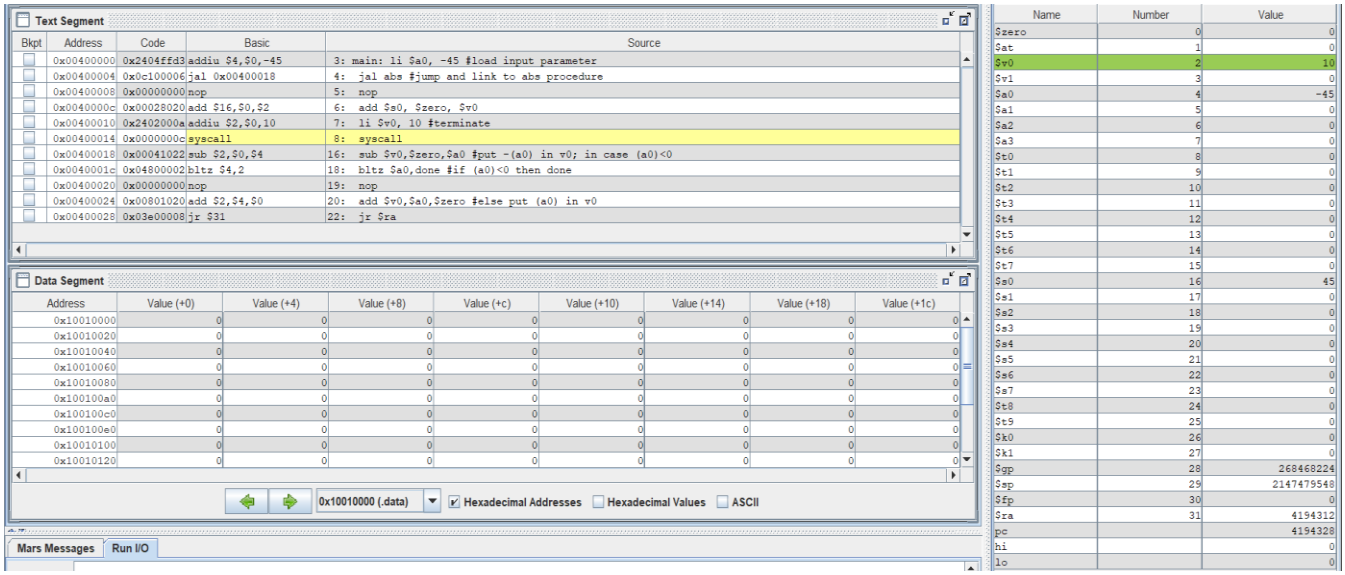
- Lệnh: jr $ra

⇨ $pc = 4194312, $ra = 4194312

⇨ Trả về hàm main từ thủ tục abs



- **Kết quả chạy chương trình: $a0 = 45**



Text Segment

Bkpt	Address	Code	Basic	Source
	0x00400000	0x2404ffd3	addiu $4,$0,-45	3: main: li $a0, -45 #load input parameter
	0x00400004	0x0c100006	jal 0x00400018	4: jal abs #jump and link to abs procedure
	0x00400008	0x00000000	nop	5: nop
	0x0040000c	0x00028020	add $16,$0,$2	6: add $s0, $zero, $v0
	0x00400010	0x2402000a	addiu $2,$0,10	7: li $v0, 10 #terminate
	0x00400014	0x0000000c	syscall	8: syscall
	0x00400018	0x00041022	sub $2,$0,$4	16: sub $v0,$zero,$a0 #put -(a0) in v0; in case (a0)<0
	0x0040001c	0x04800002	bltz $4,2	18: bltz $a0,done #if (a0)<0 then done
	0x00400020	0x00000000	nop	19: nop
	0x00400024	0x00801020	add $2,$4,$0	20: add $v0,$a0,$zero #else put (a0) in v0
	0x00400028	0x03e00008	jr $31	22: jr $ra

Data Segment

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

0x10010000 (.data) Hexadecimal Addresses Hexadecimal Values ASCII

Mars Messages Run I/O

Name	Number	Value
$zero	0	0
$at	1	0
$v0	2	10
$v1	3	0
$a0	4	-45
$a1	5	0
$a2	6	0
$a3	7	0
$t0	8	0
$t1	9	0
$t2	10	0
$t3	11	0
$t4	12	0
$t5	13	0
$t6	14	0
$t7	15	0
$s0	16	45
$s1	17	0
$s2	18	0
$s3	19	0
$s4	20	0
$s5	21	0
$s6	22	0
$s7	23	0
$t8	24	0
$t9	25	0
$k0	26	0
$k1	27	0
$gp	28	268468224
$sp	29	2147479548
$fp	30	0
$ra	31	4194312
pc		4194328
hi		0
lo		0

- **Nhận xét:** Chương trình nhảy tới thủ tục abs từ lệnh jal abs. Trong thủ tục abs, chương trình so sánh $a0 với $zero, nếu $a0 >0 thì sẽ chạy lệnh add $v0,$a0,$zero , nếu $a0 < 0 thì sẽ chạy lệnh sub $v0,$zero,$a0 (#put -(a0) in v0; in case (a0)<0)

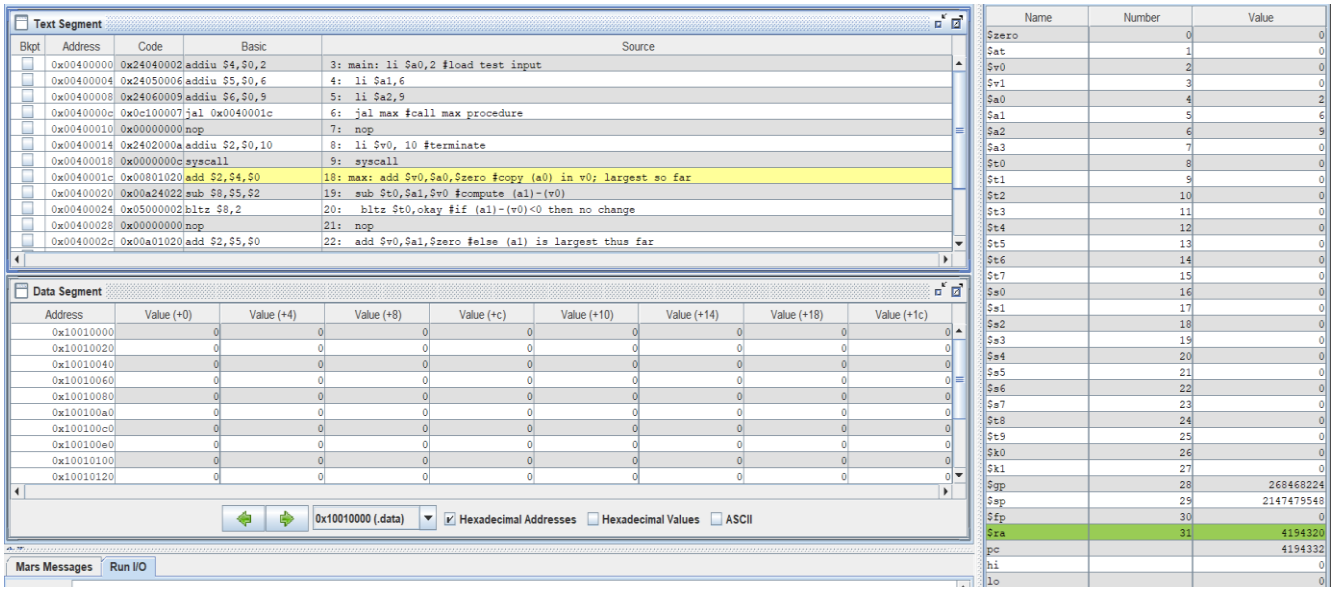
Assignment 2

- Code :

```
.text
main: li $a0,2 #load test input
 li $a1,6
 li $a2,9
 jal max #call max procedure
 nop
 li $v0, 10 #terminate
 syscall
```

```
endmain:
#-----------------------------------------------------------------
#Procedure max: find the largest of three integers
#param[in] $a0 integers
#param[in] $a1 integers
#param[in] $a2 integers
#return $v0 the largest value
#-----------------------------------------------------------------
max: add $v0,$a0,$zero #copy (a0) in v0; largest so far
 sub $t0,$a1,$v0 #compute (a1)-(v0)
  bltz $t0,okay #if (a1)-(v0)<0 then no change
 nop
 add $v0,$a1,$zero #else (a1) is largest thus far
okay: sub $t0,$a2,$v0 #compute (a2)-(v0)
 bltz $t0,done #if (a2)-(v0)<0 then no change
 nop
 add $v0,$a2,$zero #else (a2) is largest overall
done: jr $ra #return to calling program
```

- Lệnh : jal max #call max procedure

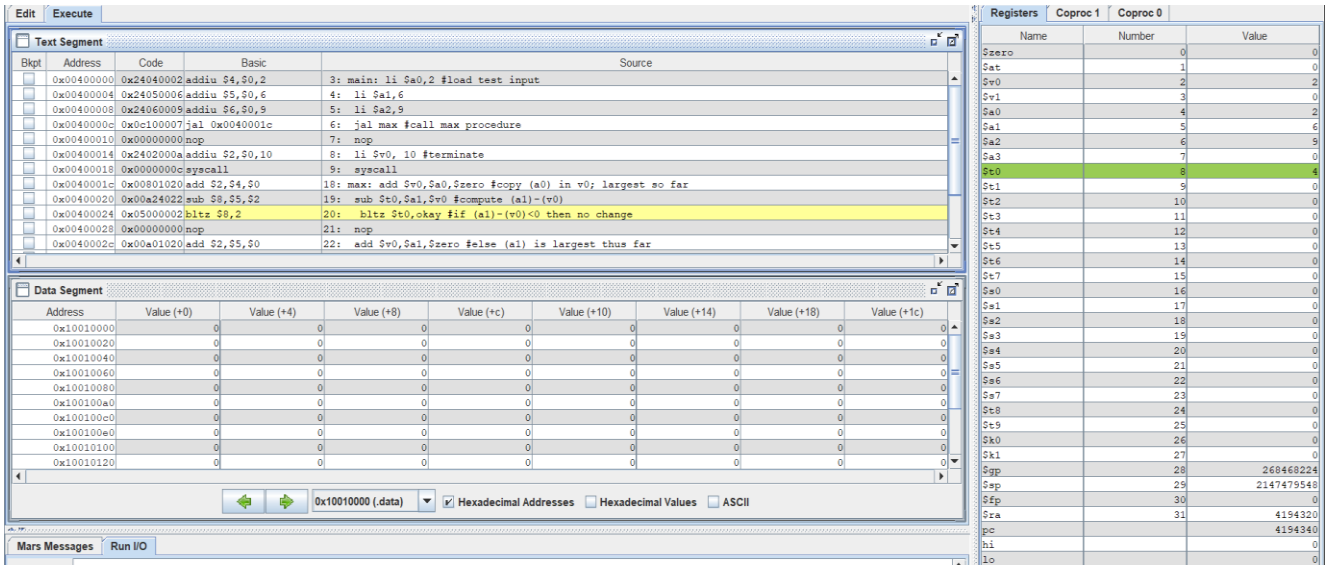


⇨ Nhảy đến địa chỉ thủ tục **max** và địa chỉ trả về lưu tại $ra = 3194320

- **Trong thủ tục max**
  - Lệnh add $v0,$a0,$zero :

    ⇨ $v0 = $a0 = 2 (giá trị lớn nhất tạm thời là $a0 được gán cho $v0)

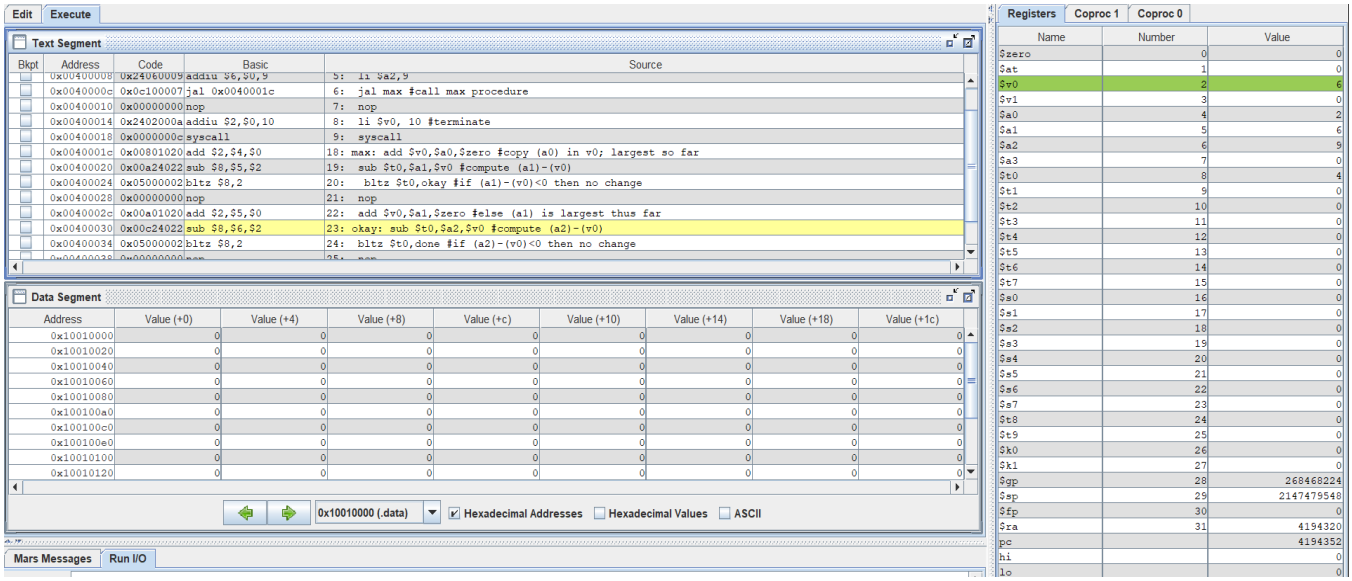
  - Lệnh sub $t0,$a1,$v0 #compute (a1)-(v0)



⇨ $t0 = $a1 - $v0 = 4

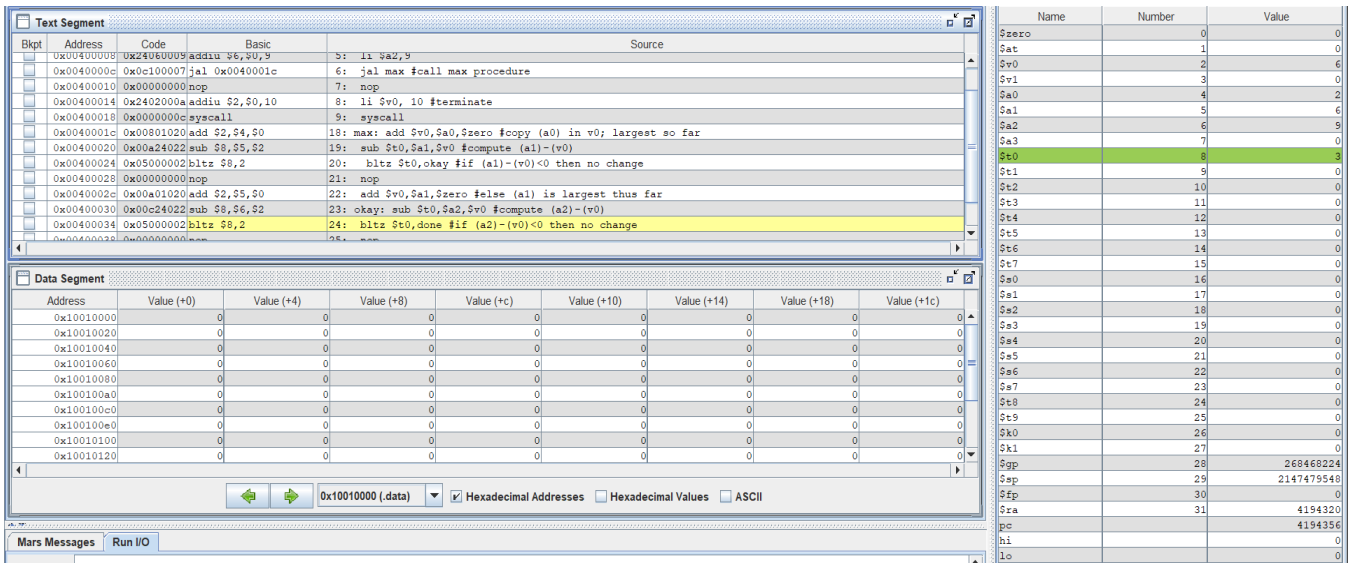
- Lệnh bltz $t0,okay #if (a1)-(v0)<0 then no change
  ⇨ Nếu $t0 < 0(a1<v0) => Nhảy tới okay
  ⇨ Vì trong th này $t0 = 4=> chương trình không nhảy tới **okay** mà tiếp tục chạy

- Lệnh add $v0,$a1,$zero



⇨ Gán lại giá trị lớn nhất $v0 là $a1

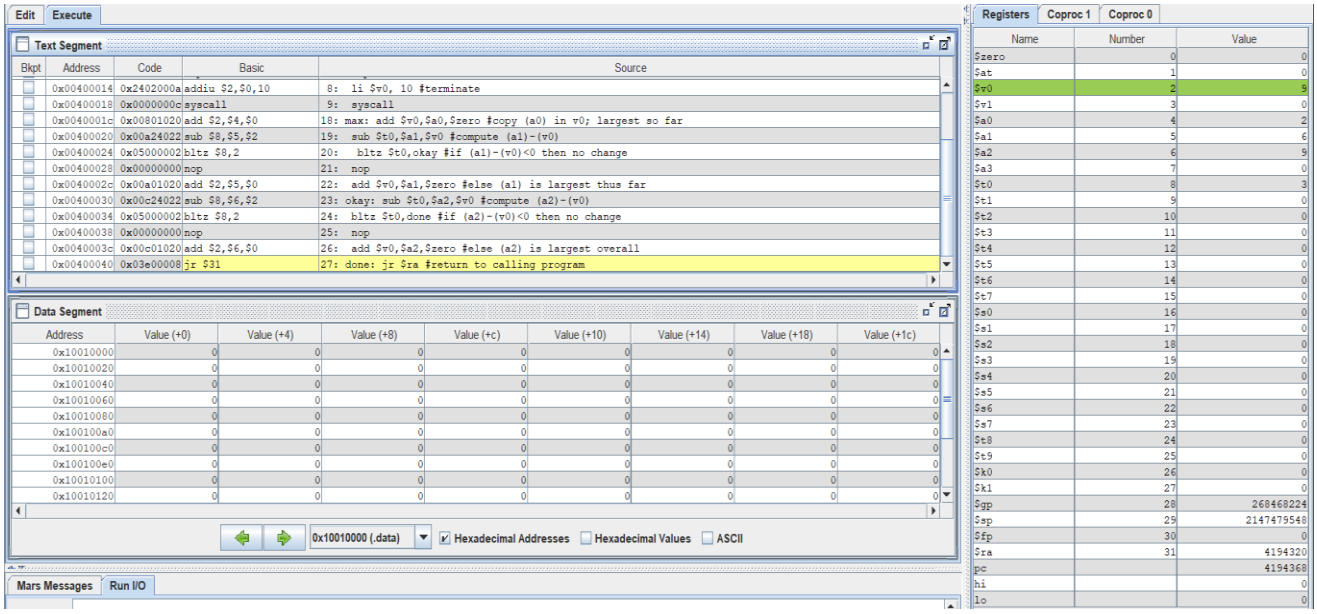
- Lệnh okay: sub $t0,$a2,$v0 #compute (a2)-(v0)



⇨ $t0 = $a2 - $v0 = 9-6 = 3

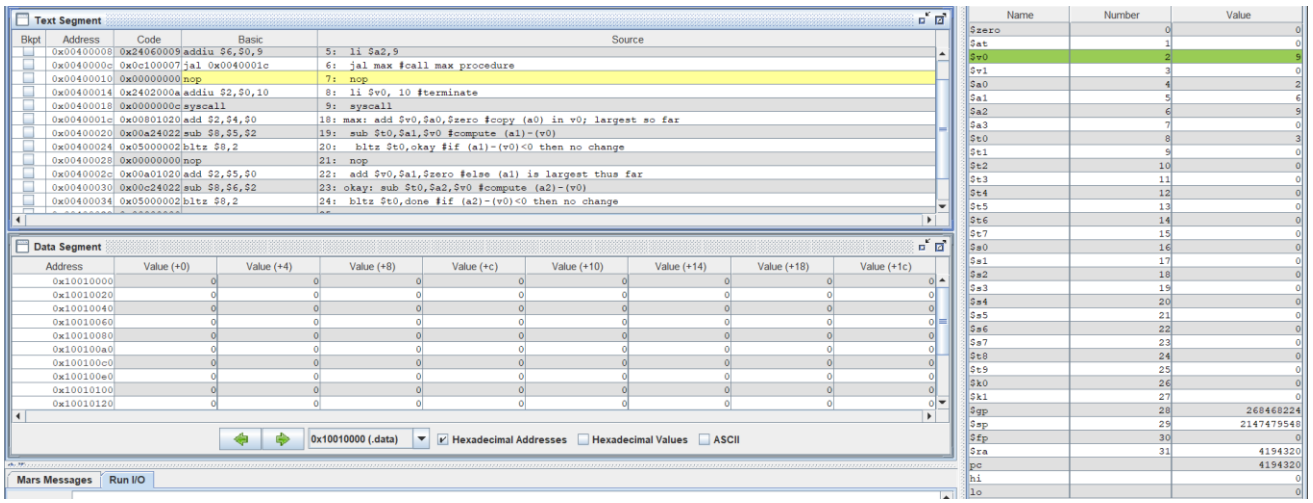
- Lệnh bltz $t0,done #if (a2)-(v0)<0 then no change
  ⇨ Vì $t0 = 3 > 0 ($a2 > $v0) => chương trình chạy tiếp mà không nhảy vào **done**

- Lệnh add $v0,$a2,$zero #else (a2) is largest overall



⇨ Gán lại giá trị lớn nhất $v0 = $a2

- Lệnh done: jr $ra



⇨ Nhảy về **main** qua địa chỉ trả về $ra = 4194320

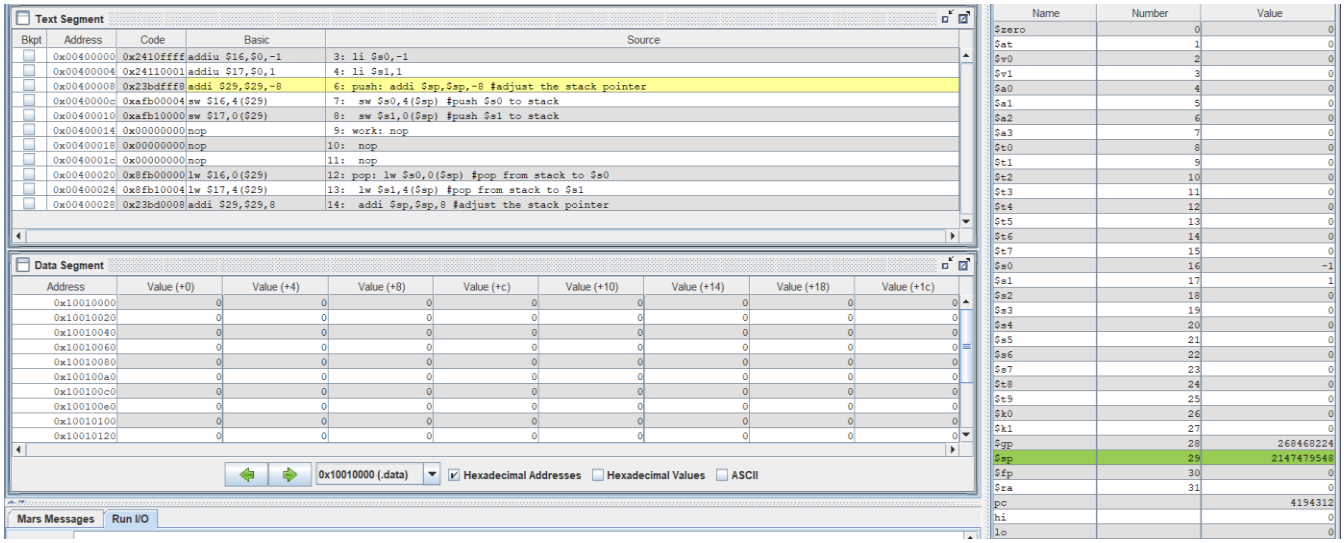
Assignment 3

- **Code:**

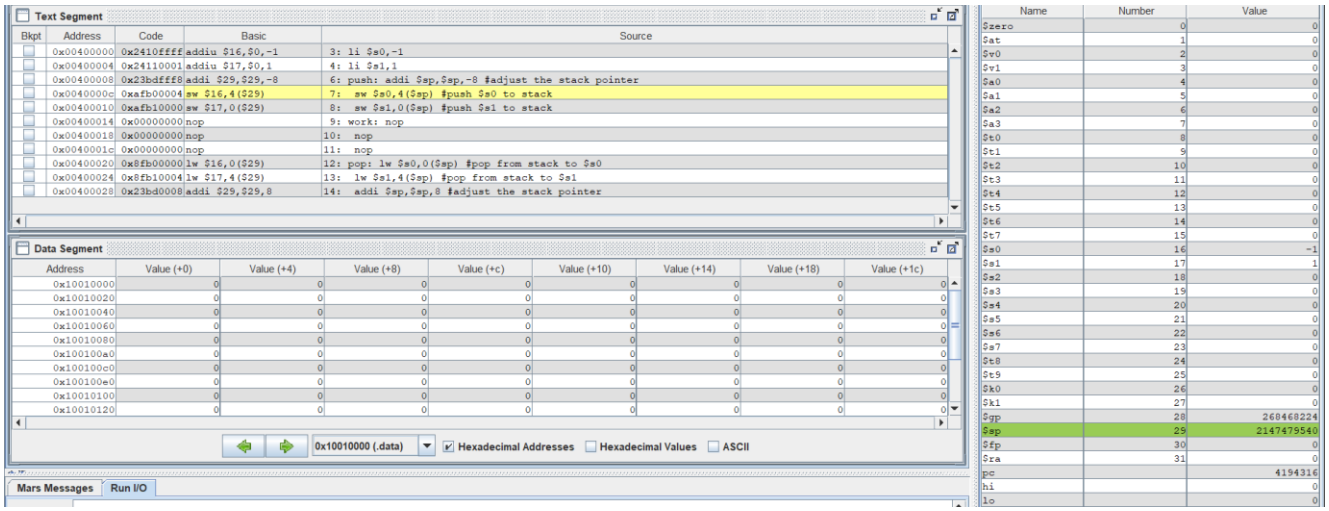
```
#Laboratory Exercise 7, Home Assignment 3
.text
li $s0,-1
li $s1,1

push: addi $sp,$sp,-8 #adjust the stack pointer
 sw $s0,4($sp) #push $s0 to stack
 sw $s1,0($sp) #push $s1 to stack
work: nop
 nop
 nop
pop: lw $s0,0($sp) #pop from stack to $s0
 lw $s1,4($sp) #pop from stack to $s1
 addi $sp,$sp,8 #adjust the stack pointer
```

- Lúc đầu $sp = 2147479548

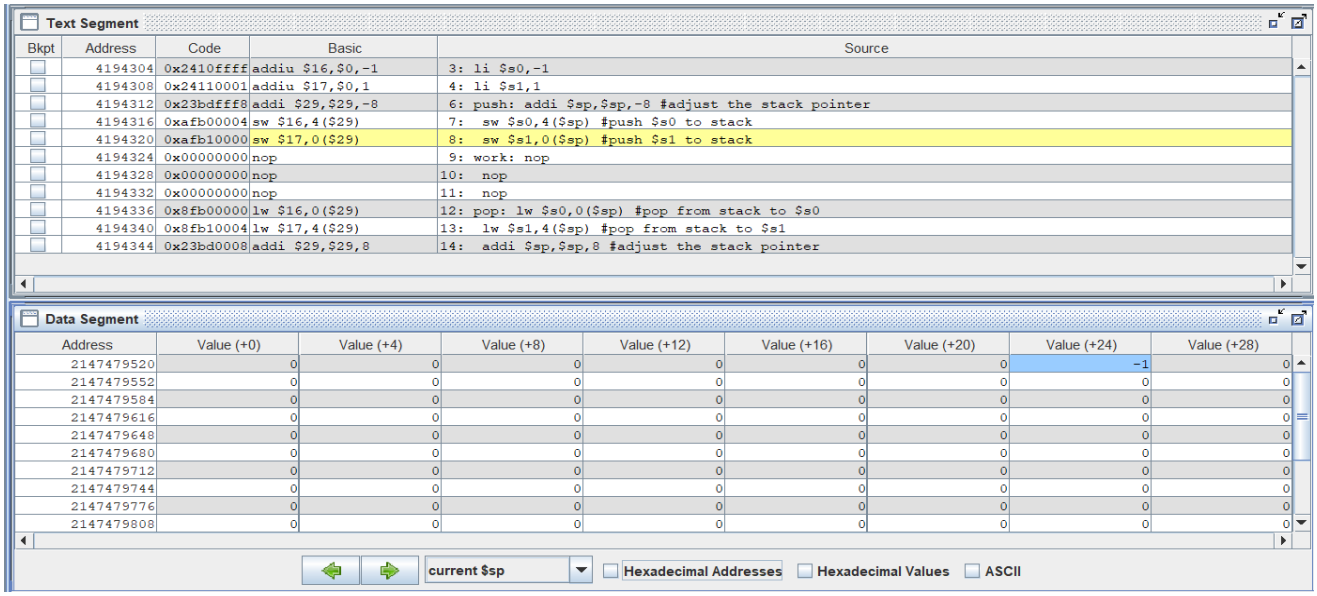


- Lệnh push: addi $sp,$sp,-8



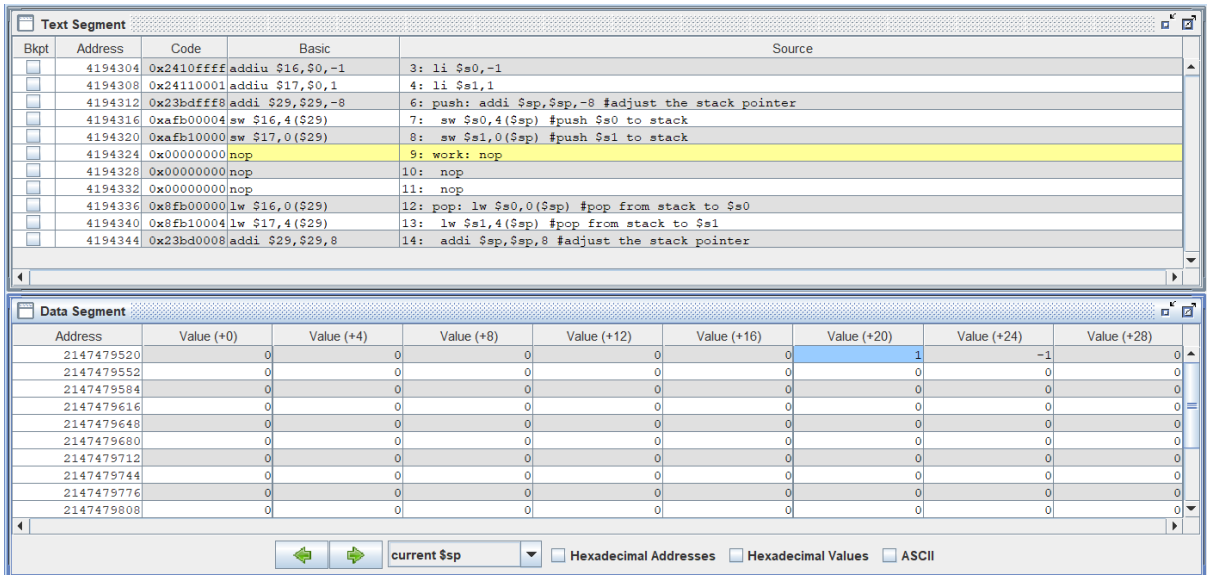
⇨ $sp = 2147479548 – 8 = 2147479540

- Lệnh sw $s0,4($sp)



⇨ Ở biến nhớ địa chỉ 2147479544 lưu giá trị -1

- Lệnh sw $s1,0($sp)



Text Segment

Bkpt	Address	Code	Basic	Source
	4194304	0x2410ffff	addiu $16,$0,-1	3: li $s0,-1
	4194308	0x24110001	addiu $17,$0,1	4: li $s1,1
	4194312	0x23bdfff8	addi $29,$29,-8	6: push: addi $sp,$sp,-8 #adjust the stack pointer
	4194316	0xafb00004	sw $16,4($29)	7: sw $s0,4($sp) #push $s0 to stack
	4194320	0xafb10000	sw $17,0($29)	8: sw $s1,0($sp) #push $s1 to stack
	4194324	0x00000000	nop	9: work: nop
	4194328	0x00000000	nop	10: nop
	4194332	0x00000000	nop	11: nop
	4194336	0x8fb00000	lw $16,0($29)	12: pop: lw $s0,0($sp) #pop from stack to $s0
	4194340	0x8fb10004	lw $17,4($29)	13: lw $s1,4($sp) #pop from stack to $s1
	4194344	0x23bd0008	addi $29,$29,8	14: addi $sp,$sp,8 #adjust the stack pointer

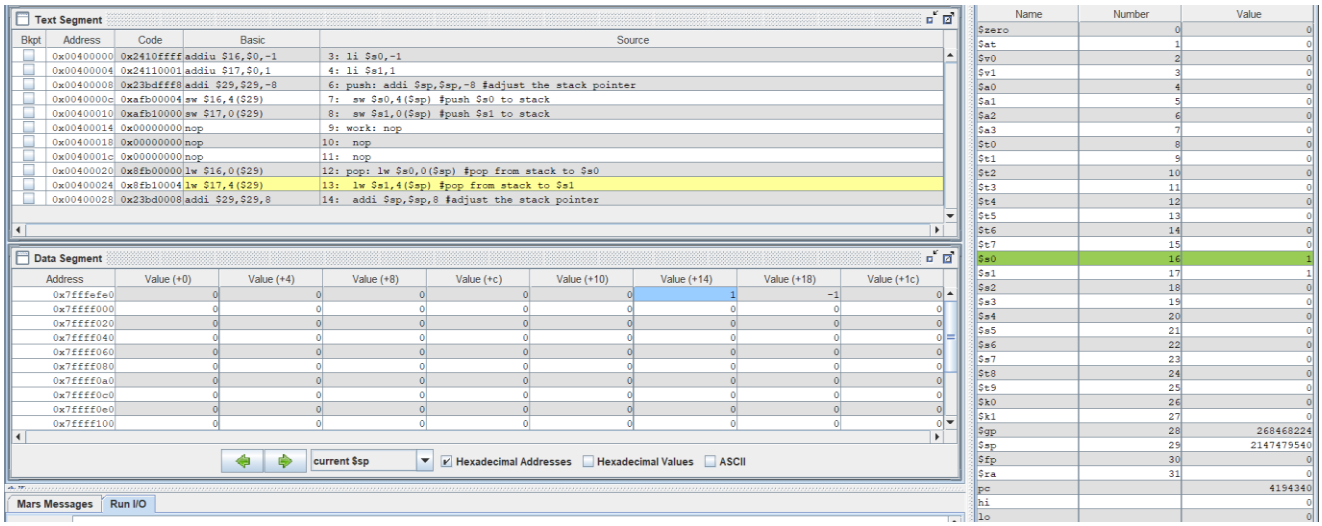
Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+12)	Value (+16)	Value (+20)	Value (+24)	Value (+28)
2147479520	0	0	0	0	0	1	-1	0
2147479552	0	0	0	0	0	0	0	0
2147479584	0	0	0	0	0	0	0	0
2147479616	0	0	0	0	0	0	0	0
2147479648	0	0	0	0	0	0	0	0
2147479680	0	0	0	0	0	0	0	0
2147479712	0	0	0	0	0	0	0	0
2147479744	0	0	0	0	0	0	0	0
2147479776	0	0	0	0	0	0	0	0
2147479808	0	0	0	0	0	0	0	0

current $sp Hexadecimal Addresses Hexadecimal Values ASCII

⇨ Ở biến nhớ địa chỉ 2147479540 lưu giá trị 1($s1 được bỏ vào ngăn xếp sau $s0)

- Lệnh pop: lw $s0,0($sp)



Text Segment

Bkpt	Address	Code	Basic	Source
	0x00400000	0x2410ffff	addiu $16,$0,-1	3: li $s0,-1
	0x00400004	0x24110001	addiu $17,$0,1	4: li $s1,1
	0x00400008	0x23bdfff8	addi $29,$29,-8	6: push: addi $sp,$sp,-8 #adjust the stack pointer
	0x0040000c	0xafb00004	sw $16,4($29)	7: sw $s0,4($sp) #push $s0 to stack
	0x00400010	0xafb10000	sw $17,0($29)	8: sw $s1,0($sp) #push $s1 to stack
	0x00400014	0x00000000	nop	9: work: nop
	0x00400018	0x00000000	nop	10: nop
	0x0040001c	0x00000000	nop	11: nop
	0x00400020	0x8fb00000	lw $16,0($29)	12: pop: lw $s0,0($sp) #pop from stack to $s0
	0x00400024	0x8fb10004	lw $17,4($29)	13: lw $s1,4($sp) #pop from stack to $s1
	0x00400028	0x23bd0008	addi $29,$29,8	14: addi $sp,$sp,8 #adjust the stack pointer

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x7fffefe0	0	0	0	0	0	1	-1	0
0x7ffff000	0	0	0	0	0	0	0	0
0x7ffff020	0	0	0	0	0	0	0	0
0x7ffff040	0	0	0	0	0	0	0	0
0x7ffff060	0	0	0	0	0	0	0	0
0x7ffff080	0	0	0	0	0	0	0	0
0x7ffff0a0	0	0	0	0	0	0	0	0
0x7ffff0c0	0	0	0	0	0	0	0	0
0x7ffff0e0	0	0	0	0	0	0	0	0
0x7ffff100	0	0	0	0	0	0	0	0

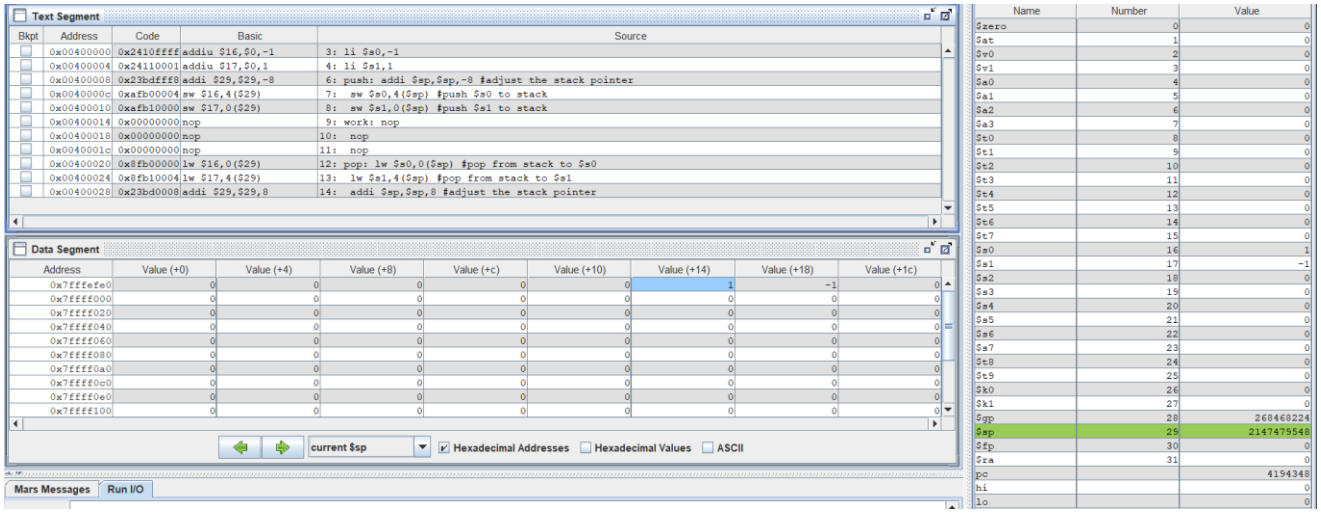
current $sp Hexadecimal Addresses Hexadecimal Values ASCII

Mars Messages Run I/O

Name	Number	Value
$zero	0	0
$at	1	0
$v0	2	0
$v1	3	0
$a0	4	0
$a1	5	0
$a2	6	0
$a3	7	0
$t0	8	0
$t1	9	0
$t2	10	0
$t3	11	0
$t4	12	0
$t5	13	0
$t6	14	0
$t7	15	0
$s0	16	1
$s1	17	1
$s2	18	0
$s3	19	0
$s4	20	0
$s5	21	0
$s6	22	0
$s7	23	0
$t8	24	0
$t9	25	0
$k0	26	0
$k1	27	0
$gp	28	268468224
$sp	29	2147479540
$fp	30	0
$ra	31	0
pc		4194340
hi		0
lo		0

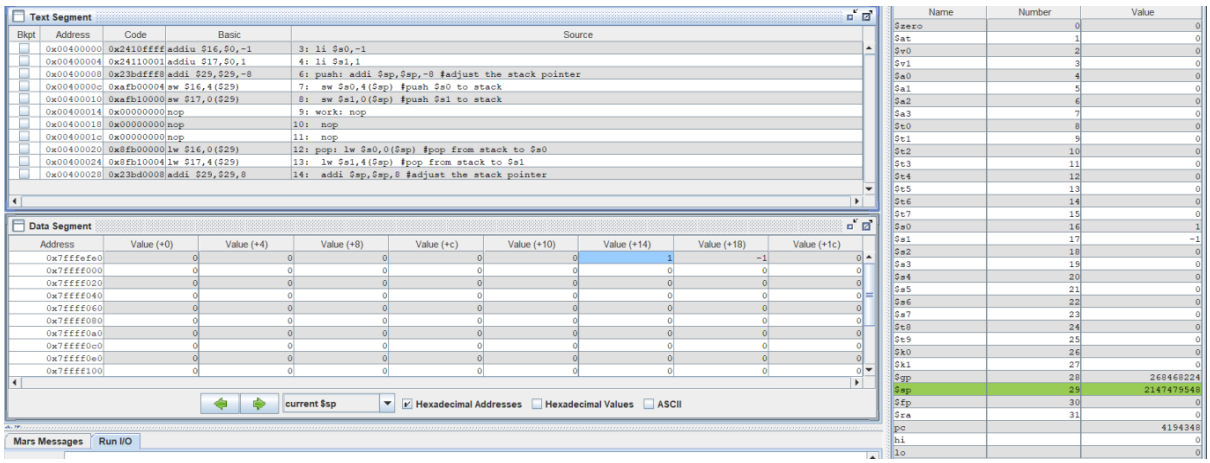
⇨ $s0 =1 => lấy từ đầu ngăn xếp ra biến $s0

- Lệnh lw $s1,4($sp)



⇨ $s1 = -1 => lấy ở cuối ngăn xếp ra biến $s1

- Lệnh addi $sp,$sp,8



⇨ $sp = 214749548 => Xóa 2 mục trong stack

Assignment 4

- Code:

```
#Laboratory Exercise 7, Home Assignment 4
.data
Message: .asciiz "Ket qua tinh giai thua la: "
.text
main: jal WARP

print: add $a1, $v0, $zero # $a0 = result from N!
 li $v0, 56
 la $a0, Message
 syscall
quit: li $v0, 10 #terminate
 syscall
endmain:
#---------------------------------------------------------------
#Procedure WARP: assign value and call FACT
#---------------------------------------------------------------

WARP: sw $fp,-4($sp) #save frame pointer (1)
 addi $fp,$sp,0 #new frame pointer point to the top (2)
 addi $sp,$sp,-8 #adjust stack pointer (3)
 sw $ra,0($sp) #save return address (4)

 li $a0,3 #load test input N
 jal FACT #call fact procedure
 nop

 lw $ra,0($sp) #restore return address (5)
 addi $sp,$fp,0 #return stack pointer (6)
```

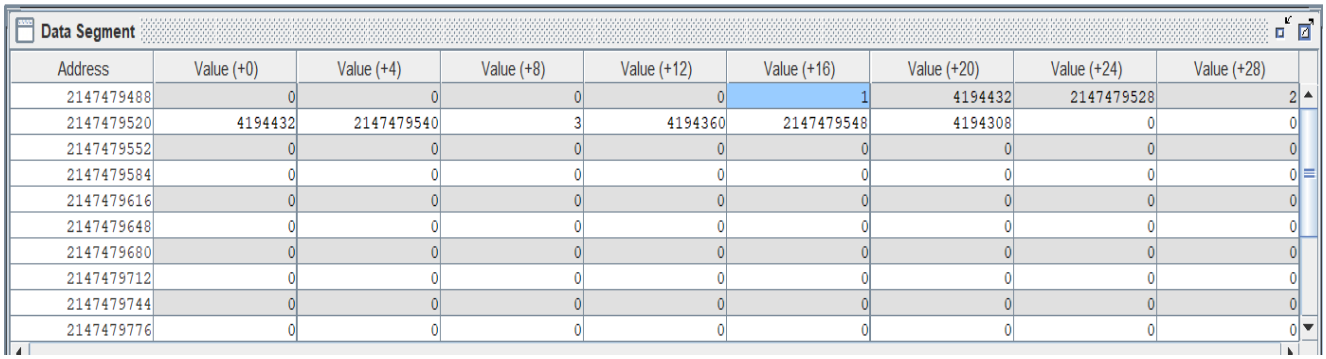
```
 lw $fp,-4($sp) #return frame pointer (7)
 jr $ra
wrap_end:
#-----------------------------------------------------------------
#Procedure FACT: compute N!
#param[in] $a0 integer N
#return $v0 the largest value
#-----------------------------------------------------------------

FACT: sw $fp,-4($sp) #save frame pointer
 addi $fp,$sp,0 #new frame pointer point to stack's top
 addi $sp,$sp,-12 #allocate space for $fp,$ra,$a0 in stack
 sw $ra,4($sp) #save return address
 sw $a0,0($sp) #save $a0 register

 slti $t0,$a0,2 #if input argument N < 2
 beq $t0,$zero,recursive#if it is false ((a0 = N) >=2)
 nop
 li $v0,1 #return the result N!=1
 j done
 nop
recursive:
 addi $a0,$a0,-1 #adjust input argument
 jal FACT #recursive call
 nop
 lw $v1,0($sp) #load a0
 mult $v1,$v0 #compute the result
 mflo $v0
done: lw $ra,4($sp) #restore return address
 lw $a0,0($sp) #restore a0
```

```
 addi $sp,$fp,0 #restore stack pointer
 lw $fp,-4($sp) #restore frame pointer
 jr $ra #jump to calling
fact_end:
```

Bộ nhớ ngăn xếp trong trường hợp n = 3 (3!)



Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+12)	Value (+16)	Value (+20)	Value (+24)	Value (+28)
2147479488	0	0	0	0	1	4194432	2147479528	2
2147479520	4194432	2147479540	3	4194360	2147479548	4194308	0	0
2147479552	0	0	0	0	0	0	0	0
2147479584	0	0	0	0	0	0	0	0
2147479616	0	0	0	0	0	0	0	0
2147479648	0	0	0	0	0	0	0	0
2147479680	0	0	0	0	0	0	0	0
2147479712	0	0	0	0	0	0	0	0
2147479744	0	0	0	0	0	0	0	0
2147479776	0	0	0	0	0	0	0	0

Nhận xét:

- Frame pointer được lưu mỗi khi gọi thủ tục FACT ở ô nhớ -4($sp)
- Sau đó ta cấp bộ nhớ cho các phần tử fp,$ra,$a0 trong stack bằng lệnh addi $sp,$sp,-12
- Chương trình sẽ lưu lần lượt địa chỉ trả $ra về và giá trị hiện tại của thanh ghi $a0 lần lượt vào 2 vị trí đã được cấp phát còn lại ($a0 ở 0($sp) và $ra ở 4($sp)) trong ngăn xếp