

Homework 1

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CISC 340 Computer Architecture

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1

MIPS instructions that compute $a = b - (c - d)$

```
1 .data
2     a: .word 1
3     b: .word 2
4     c: .word 3
5     d: .word 4
6 .text
7     lw $t0, a($zero)
8     lw $t1, b($zero)
9     lw $t2, c($zero)
10    lw $t3, d($zero)
11    # Problem 1 specific:
12    sub $v0, $t2, $t3
13    sub $t0, $t1, $v0
```

Successful execution in MARS:

Text Segment				
Bkpt	Address	Code	Basic	Source
<input type="checkbox"/>	0x00400000	0x3c011001	lui \$1,4097	10: lw \$t0, a(\$zero) # \$t0 = 1
<input type="checkbox"/>	0x00400004	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400008	0x8c280000	lw \$8,0(\$1)	
<input type="checkbox"/>	0x0040000c	0x3c011001	lui \$1,4097	11: lw \$t1, b(\$zero) # \$t1 = 2
<input type="checkbox"/>	0x00400010	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400014	0x8c290004	lw \$9,4(\$1)	
<input type="checkbox"/>	0x00400018	0x3c011001	lui \$1,4097	12: lw \$t2, c(\$zero) # \$t2 = 3
<input type="checkbox"/>	0x0040001c	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400020	0x8c2a0008	lw \$10,8(\$1)	
<input type="checkbox"/>	0x00400024	0x3c011001	lui \$1,4097	13: lw \$t3, d(\$zero) # \$t3 = 4
<input type="checkbox"/>	0x00400028	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x0040002c	0x8c2b000c	lw \$11,12(\$1)	
<input type="checkbox"/>	0x00400030	0x014b1022	sub \$2,\$10,\$11	20: sub \$v0, \$t2, \$t3 # \$v0 = c - d = -1
<input type="checkbox"/>	0x00400034	0x01224022	sub \$8,\$9,\$2	22: sub \$t0, \$t1, \$v0 # a = b - (c - d) = 3
<input type="checkbox"/>	0x00400038	0x2402000a	addiu \$2,\$0,10	25: li \$v0, 10
<input type="checkbox"/>	0x0040003c	0x0000000c	syscall	26: syscall

Mars Messages

Run I/O

-- program is finished running --

2

MIPS instructions that compute $a = 15 * (b + c)$

```

1 .data
2     a: .word 1
3     b: .word 2
4     c: .word 3
5     d: .word 4
6 .text
7     lw $t0, a($zero)
8     lw $t1, b($zero)
9     lw $t2, c($zero)
10    lw $t3, d($zero)
11    # Problem 2 specific:
12    add $v0, $t1, $t2
13    addi $t4, $zero, 15
14    mul $t0, $t4, $v0

```

I couldn't find a way to multiply the expression without using the mul instruction. So I used the mul instruction to do the multiplication with three total instructions. Successful execution in MARS:

Text Segment				
Bkpt	Address	Code	Basic	Source
<input type="checkbox"/>	0x00400000	0x3c011001	lui \$1,4097	10: lw \$t0, a(\$zero) # \$t0 = 1
<input type="checkbox"/>	0x00400004	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400008	0x8c280000	lw \$8,0(\$1)	
<input type="checkbox"/>	0x0040000c	0x3c011001	lui \$1,4097	11: lw \$t1, b(\$zero) # \$t1 = 2
<input type="checkbox"/>	0x00400010	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400014	0x8c290004	lw \$9,4(\$1)	
<input type="checkbox"/>	0x00400018	0x3c011001	lui \$1,4097	12: lw \$t2, c(\$zero) # \$t2 = 3
<input type="checkbox"/>	0x0040001c	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400020	0x8c2a0008	lw \$10,8(\$1)	
<input type="checkbox"/>	0x00400024	0x3c011001	lui \$1,4097	13: lw \$t3, d(\$zero) # \$t3 = 4
<input type="checkbox"/>	0x00400028	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x0040002c	0x8c2b000c	lw \$11,12(\$1)	
<input type="checkbox"/>	0x00400030	0x012a1020	add \$2,\$9,\$10	21: add \$v0, \$t1, \$t2 # \$v0 = b + c = 5
<input type="checkbox"/>	0x00400034	0x200c000f	addi \$12,\$0,15	23: addi \$t4, \$zero, 15 # \$t4 = 15
<input type="checkbox"/>	0x00400038	0x71824002	mul \$8,\$12,\$2	25: mul \$t0, \$t4, \$v0 # a = 15 * (b + c) = 75
<input type="checkbox"/>	0x0040003c	0x2402000a	addiu \$2,\$0,10	28: li \$v0, 10
<input type="checkbox"/>	0x00400040	0x0000000c	syscall	29: syscall

Mars Messages	Run I/O
-- program is finished running --	

3

MIPS instructions for provided code

```

1 .data
2     a: .word 1

```

```

3      b: .word 2
4      c: .word 3
5      d: .word 4
6      array: .space 40 # Problem 3 specific
7 .text
8      lw $t0, a($zero)
9      lw $t1, b($zero)
10     lw $t2, c($zero)
11     lw $t3, d($zero)
12     # Problem 3 specific:
13     addi $t4, $zero, 10
14     addi $t5, $zero, 4
15     addi $t6, $zero, 1
16     while:
17         ble $t4, 0, exit
18         subi $t8, $t4, 1
19         mul $t7, $t5, $t8
20         add $v0, $t4, $t1
21         sllv $v1, $t6, $v0
22         sw $v1, array($t7)
23         subi $t4, $t4, 1
24         j while
25     exit:
26         li $v0, 10
27         syscall

```

Successful execution in MARS:

Text Segment				
Bkpt	Address	Code	Basic	Source
<input type="checkbox"/>	0x00400000	0x3c011001	lui \$1,4097	11: lw \$t0, a(\$zero) # \$t0 = 1
<input type="checkbox"/>	0x00400004	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400008	0x8c280000	lw \$8,0(\$1)	
<input type="checkbox"/>	0x0040000c	0x3c011001	lui \$1,4097	12: lw \$t1, b(\$zero) # \$t1 = 2
<input type="checkbox"/>	0x00400010	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400014	0x8c290004	lw \$9,4(\$1)	
<input type="checkbox"/>	0x00400018	0x3c011001	lui \$1,4097	13: lw \$t2, c(\$zero) # \$t2 = 3
<input type="checkbox"/>	0x0040001c	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400020	0x8c2a0008	lw \$10,8(\$1)	
<input type="checkbox"/>	0x00400024	0x3c011001	lui \$1,4097	14: lw \$t3, d(\$zero) # \$t3 = 4
<input type="checkbox"/>	0x00400028	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x0040002c	0x8c2b000c	lw \$11,12(\$1)	
<input type="checkbox"/>	0x00400030	0x200c000a	addi \$12,\$0,10	26: addi \$t4, \$zero, 10 # \$t4 = 10
<input type="checkbox"/>	0x00400034	0x200d0004	addi \$13,\$0,4	27: addi \$t5, \$zero, 4 # \$t5 = 4, use this to multiply by n to index ...
<input type="checkbox"/>	0x00400038	0x200e0001	addi \$14,\$0,1	28: addi \$t6, \$zero, 1 # \$t6 = 1, use this for the bit shifting left
<input type="checkbox"/>	0x0040003c	0x2181ffff	addi \$1,\$12,-1	32: ble \$t4, 0, exit # if n becomes less than or equal to 0 then ...
<input type="checkbox"/>	0x00400040	0x28210000	slti \$1,\$1,0	
<input type="checkbox"/>	0x00400044	0x1420000b	bne \$1,\$0,11	
<input type="checkbox"/>	0x00400048	0x20010001	addi \$1,\$0,1	35: subi \$t8, \$t4, 1 # \$t8 = n - 1
<input type="checkbox"/>	0x0040004c	0x0181c022	sub \$24,\$12,\$1	
<input type="checkbox"/>	0x00400050	0x71b87802	mul \$15,\$13,\$24	38: mul \$t7, \$t5, \$t8 # \$t7 = n * 4
<input type="checkbox"/>	0x00400054	0x01891020	add \$2,\$12,\$9	41: add \$v0, \$t4, \$t1 # \$v0 = n + b
<input type="checkbox"/>	0x00400058	0x004e1804	sllv \$3,\$14,\$2	44: sllv \$v1, \$t6, \$v0 # \$v1 = 1 << n + b
<input type="checkbox"/>	0x0040005c	0x3c011001	lui \$1,4097	47: sw \$v1, array(\$t7) # A[n-1] = 1 << n + b
<input type="checkbox"/>	0x00400060	0x002f0821	addu \$1,\$1,\$15	
<input type="checkbox"/>	0x00400064	0xac230010	sw \$3,16(\$1)	
<input type="checkbox"/>	0x00400068	0x20010001	addi \$1,\$0,1	50: subi \$t4, \$t4, 1 # --n
<input type="checkbox"/>	0x0040006c	0x01816022	sub \$12,\$12,\$1	
<input type="checkbox"/>	0x00400070	0x0810000f	j 0x0040003c	52: j while # jump back to top of loop
<input type="checkbox"/>	0x00400074	0x2402000a	addiu \$2,\$0,10	55: li \$v0, 10 # \$v0 = 10 is terminate execution, syscall looks i...
<input type="checkbox"/>	0x00400078	0x0000000c	syscall	56: syscall

Mars Messages
Run I/O

```
-- program is finished running --
```

4

MIPS instructions for C code from problem 2.27 in textbook

```

1 .data
2     a: .word 3
3     b: .word 4
4     D: .space 80
5 .text
6     lw $s0, a($zero)
7     lw $s1, b($zero)
8     la $s2, D
9
10    addi $t0, $zero, 0
11    outerloop:
12        bge $t0, $s0, exitouter
13
14        addi $t1, $zero, 0
15    innerloop:
16        bge $t1, $s1, exitinner

```

```

17
18         add $v0, $t0, $t1
19         mul $v1, $t1, 4
20         mul $v1, $v1, 4
21         sw $v0, D($v1)
22
23         addi $t1, $t1, 1
24         j innerloop
25
26     exitinner:
27         addi $t0, $t0, 1
28         j outerloop
29
30     exitouter:
31         li $v0, 10
32         syscall

```

Successful execution in MARS:

Text Segment				
Bkpt	Address	Code	Basic	Source
<input type="checkbox"/>	0x00400000	0x3c011001	lui \$1,4097	25: lw \$s0, a(\$zero) # a = 3
<input type="checkbox"/>	0x00400004	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400008	0x8c300000	lw \$16,0(\$1)	
<input type="checkbox"/>	0x0040000c	0x3c011001	lui \$1,4097	26: lw \$s1, b(\$zero) # b = 4
<input type="checkbox"/>	0x00400010	0x00200821	addu \$1,\$1,\$0	
<input type="checkbox"/>	0x00400014	0x8c310004	lw \$17,4(\$1)	
<input type="checkbox"/>	0x00400018	0x3c011001	lui \$1,4097	27: la \$s2, D # put address of D into \$s2
<input type="checkbox"/>	0x0040001c	0x34320008	ori \$18,\$1,8	
<input type="checkbox"/>	0x00400020	0x20080000	addi \$8,\$0,0	30: addi \$t0, \$zero, 0 # i = 0
<input type="checkbox"/>	0x00400024	0x0110082a	slt \$1,\$8,\$16	32: bge \$t0, \$s0, exitouter # while i < a
<input type="checkbox"/>	0x00400028	0x1020000f	beq \$1,\$0,15	
<input type="checkbox"/>	0x0040002c	0x20090000	addi \$9,\$0,0	35: addi \$t1, \$zero, 0 # j = 0
<input type="checkbox"/>	0x00400030	0x0131082a	slt \$1,\$9,\$17	37: bge \$t1, \$s1, exitinner # while j < b
<input type="checkbox"/>	0x00400034	0x1020000a	beq \$1,\$0,10	
<input type="checkbox"/>	0x00400038	0x01091020	add \$2,\$8,\$9	41: add \$v0, \$t0, \$t1 # \$v0 = i + j
<input type="checkbox"/>	0x0040003c	0x20010004	addi \$1,\$0,4	43: mul \$v1, \$t1, 4 # \$v1 = 4*j to used in D[4*j]
<input type="checkbox"/>	0x00400040	0x71211802	mul \$3,\$9,\$1	
<input type="checkbox"/>	0x00400044	0x20010004	addi \$1,\$0,4	44: mul \$v1, \$v1, 4 # get byte address of index, (4*j) * 4
<input type="checkbox"/>	0x00400048	0x70611802	mul \$3,\$3,\$1	
<input type="checkbox"/>	0x0040004c	0x3c011001	lui \$1,4097	46: sw \$v0, D(\$v1) # D[4*j] = i + j
<input type="checkbox"/>	0x00400050	0x00230821	addu \$1,\$1,\$3	
<input type="checkbox"/>	0x00400054	0xac220008	sw \$2,8(\$1)	
<input type="checkbox"/>	0x00400058	0x21290001	addi \$9,\$9,1	48: addi \$t1, \$t1, 1 # j++
<input type="checkbox"/>	0x0040005c	0x0810000c	j 0x00400030	49: j innerloop # jump to top of inner loop
<input type="checkbox"/>	0x00400060	0x21080001	addi \$8,\$8,1	52: addi \$t0, \$t0, 1 # i++
<input type="checkbox"/>	0x00400064	0x08100009	j 0x00400024	53: j outerloop # jump to top of outer loop
<input type="checkbox"/>	0x00400068	0x2402000a	addiu \$2,\$0,10	58: li \$v0, 10
<input type="checkbox"/>	0x0040006c	0x0000000c	syscall	59: syscall

Mars Messages	Run I/O
<pre>-- program is finished running --</pre>	