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CPE301 – SPRING 2016

Design Assignment 1

DO NOT REMOVE THIS PAGE DURING SUBMISSION:

The student understands that all required components should be submitted in complete for grading of this assignment.

NO	SUBMISSION ITEM	COMPLETED (Y/N)	MARKS (/MAX)
0.	COMPONENTS LIST AND CONNECTION BLOCK DIAGRAM w/ PINS		
1.	INITIAL CODE OF TASK 1/A		
2.	INCREMENTAL / DIFFERENTIAL CODE OF TASK 2/B		
3.	INCREMENTAL / DIFFERENTIAL CODE OF TASK 3/C		
4.	INCREMENTAL / DIFFERENTIAL CODE OF TASK 4/D		
5.	INCREMENTAL / DIFFERENTIAL CODE OF TASK 5/E		
6.	SCHEMATICS		
7.	SCREENSHOTS OF EACH TASK OUTPUT		
8.	SCREENSHOT OF EACH DEMO		
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0.	COMPONENTS LIST AND CONNECTION BLOCK DIAGRAM w/ PINS		

The only component used in this assignment is AVR Studio 7 simulator. Instead of showing block diagrams, here is the complete code used. In later sections, only part of the following will be shown to point out how a particular task was accomplished.

```
.def   count  =      r22
.def   temp   =      r25
.def   zero   =      r0

.cseg
;******************** Task a *******************;
       sub           zero,  zero   ;; make zero register.
       ;; Initialize X and Y pointers to point to ramend / 2
       ldi           xl,    low(ramend / 2)
       ldi           xh,    high(ramend / 2)
       movw          yl,    xl     ;; Y = X
       mov           r16,   xl     ;; r16 = low(x)
       ldi           count, 25     ;; count = 25
loop25:       ;; Store 25 integers into ramend/2 and up.
       st            y+,    r16    ;; *y = r16; y++
       inc           r16           ;; r16++
       dec           count         ;; count--
       brne          loop25        ;; goto to loop25 if count == 0
;******************** Task b *******************;
       ;; reset y register to x
       movw          yl,    xl     ;; y = x
       ldi           count, 25     ;; counter = 25
       ldi           r17,   7      ;; r17 = 7 // divisor
       call          Add25         ;; call Add25 routine
       mov           r20,   r10    ;; get return values.
       mov           r21,   r11    ;;     r21:r20 <- r11:r10
;******************** Task d *******************;
       ;; if r21:r20 is larger than 8 bits, set bit 3 in r7
       cp            r21,   zero   ;; check if high byte is 0
       breq          lessthan8bits7
       mov           temp,  zero
       sbr           temp,  4
       mov           r7,           temp   ;; set bit 3 in r7 is true
lessthan8bits7:
;******************** Task c *******************;
       ;; reset y register to x
       movw          yl,    xl     ;; y <- x
       ldi           count, 25     ;; counter = 25
       ldi           r17,   3      ;; r17 = 3 // divisor
       call          Add25
       mov           r23,   r10
       mov           r24,   r11    ;; r24:r23 <- r11:r10
;******************** Task d *******************;
       ;; if r24:r23 is larger than 8 bits, set bit 3 in r7
       cp            r24,   zero   ;; check if high byte is 0
       breq          lessthan8bits3
       mov           temp,  zero
       sbr           temp,  4
       mov           r7,    temp   ;; set bit 3 in r7 is true
lessthan8bits3:
end:
       rjmp end

;; Routine to add 25 integers previously stored divisible by 3.
;; Registers used:
;;            r1, r16, r15, r17, r18, r20,
Add25:
       clr           r10           ;; Clear registers r11:r10
       clr           r11
add25Loop:
       ld            r1,    y+     ;; get next value
       mov           r16,   r1     ;; store it in r16
       call   div8u                ;; call divide routine
       cp            r15,   zero   ;; Check if remainder is 0
       brne   notDivByR            ;;
       add           r10,   r1            ;; Add if remainder is 0
       adc           r11,   zero   ;; add values
notDivByR:
       dec           count         ;; loop counter
       brne   add25Loop
       ret                         ;; return to calling routine

;**** A P P L I C A T I O N   N O T E   A V R 2 0 0 ************************
;*
;* Title:            Multiply and Divide Routines
;* Version:          1.1
;* Last updated:     97.07.04
;* Target:           AT90Sxxxx (All AVR Devices)
;*
;* Support E-mail:   avr@atmel.com
;*
;***************************************************************************
;*
;* "div8u" - 8/8 Bit Unsigned Division
;*
;* This subroutine divides the two register variables "dd8u" (dividend) and
;* "dv8u" (divisor). The result is placed in "dres8u" and the remainder in
;* "drem8u".
;*
;* Number of words   :14
;* Number of cycles  :97
;* Low registers used:1 (drem8u)
;* High registers used  :3 (dres8u/dd8u,dv8u,dcnt8u)
;*
;***************************************************************************
;***** Subroutine Register Variables

.def   drem8u =r15          ;remainder
.def   dres8u =r16          ;result
.def   dd8u   =r16          ;dividend
.def   dv8u   =r17          ;divisor
.def   dcnt8u =r18          ;loop counter
;***** Code
div8u: sub    drem8u,drem8u ;clear remainder and carry
       ldi    dcnt8u,9      ;init loop counter
d8u_1: rol    dd8u          ;shift left dividend
       dec    dcnt8u        ;decrement counter
       brne   d8u_2         ;if done
       ret                  ;    return
d8u_2: rol    drem8u        ;shift dividend into remainder
       sub    drem8u,dv8u   ;remainder = remainder - divisor
       brcc   d8u_3         ;if result negative
       add    drem8u,dv8u   ;    restore remainder
       clc                  ;    clear carry to be shifted into result
       rjmp   d8u_1         ;else
d8u_3: sec                  ;    set carry to be shifted into result
       rjmp   d8u_1
```

Application note from AVR was used to perform unsigned 8-bit division to obtain the remainder of an operation.

1.	INITIAL CODE OF TASK A		

Store 25 numbers starting from the RAMEND/2 location. Capture the lower 8bits of the variable/memory location RAM_MIDDLE = RAMEND/2 address and use them as your values. You can increment or decrement from RAM_MIDDLE location to get the subsequent 24 numbers. Use the X/Y/Z registers as pointers to fill up 25 numbers starting from location=RAM_MIDDLE.

```
;******************** Task a ********************;
      sub         zero, zero  ;; make zero register.
      ;; Initialize X and Y pointers to point to ramend / 2
      ldi         xl,   low(ramend / 2)
      ldi         xh,   high(ramend / 2)
      movw        yl,   xl    ;; Y = X
      mov         r16,  xl    ;; r16 = low(x)
      ldi         count,      25    ;; count = 25
loop25:           ;; Store 25 integers into ramend/2 and up.
      st          y+,   r16   ;; *y = r16; y++
      inc         r16         ;; r16++
      dec         count       ;; count--
      brne        loop25            ;; goto to loop25 if count == 0
```

2.	INITIAL CODE OF TASK B		

Use X/Y/Z register to parse through the 25 numbers and add all numbers divisible by 7 and place the result in R20:21.

```
;******************** Task b ********************;
      ;; reset y register to x
      movw        yl,   xl    ;; y = x
      ldi         count,      25    ;; counter = 25
      ldi         r17,  7     ;; r17 = 7 // divisor
      call        Add25       ;; call Add25 routine
      mov         r20,  r10   ;; get return values.
      mov         r21,  r11   ;;    r21:r20 <- r11:r10
```

The line

```
      call        Add25       ;; call Add25 routine
```

calls the subroutine Add25, which takes as parameters `count`, and `r17` to add 25 unsigned integers from the location at Y and up. Add25 is implemented as follows.

```
Add25:
      clr         r10         ;; Clear registers r11:r10
      clr         r11
add25Loop:
      ld          r1,   y+    ;; get next value
      mov         r16,  r1    ;; store it in r16
      call  div8u             ;; call divide routine
      cp          r15,  zero  ;; Check if remainder is 0
      brne  notDivByR         ;;
      add         r10,  r1          ;; Add if remainder is 0
      adc         r11,  zero  ;; add values
notDivByR:
      dec         count       ;; loop counter
      brne        add25Loop
      ret                     ;; return to calling routine
```

3.	INITIAL CODE OF TASK C		

Use X/Y/Z register to parse through the 25 numbers and add all numbers divisible by 3 and place the result in R23:24. Parsing of the numbers for task b and c has to be done simultaneously.

```
;******************** Task c ********************;
      ;; reset y register to x
      movw        yl,   xl    ;; y <- x
      ldi         count,      25    ;; counter = 25
      ldi         r17,  3     ;; r17 = 3 // divisor
      call        Add25
      mov         r23,  r10
      mov         r24,  r11   ;; r24:r23 <- r11:r10
```

Notice that task C also calls the `Add25` subroutine.

4.	INITIAL CODE OF TASK D		

Check and set register R07.3 if the sum is greater than 8-bits.

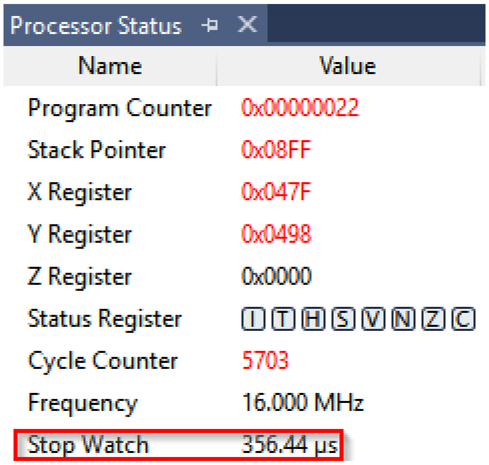
```
;******************** Task d ********************;
      ;; if r24:r23 is larger than 8 bits, set bit 3 in r7
      cp          r24,  zero  ;; check if high byte is 0
      breq        lessthan8bits3
      mov         temp, zero
      sbr         temp, 4
      mov         r7,   temp  ;; set bit 3 in r7 is true
```

Task D is implemented twice. Once after Task B, and again after Task C to check the result of the operations for both tasks. For both tasks, the sum was greater than 8 bits.

For Task B,	For Task C,
0x85 +0x8c + 0x93 = **0x01A4**	0x81 + 0x84 + 0x87 + 0x8a + 0x8d + 0x90 + 0x93 + 0x96 = **0x045C**

4. INITIAL CODE OF TASK D

Determine the execution time @ 16MHz/#cycles of your algorithm using the simulation.



Processor Status

Name	Value
Program Counter	0x00000022
Stack Pointer	0x08FF
X Register	0x047F
Y Register	0x0498
Z Register	0x0000
Status Register	I T H S V N Z C
Cycle Counter	5703
Frequency	16.000 MHz
Stop Watch	356.44 µs

6. SCHEMATICS

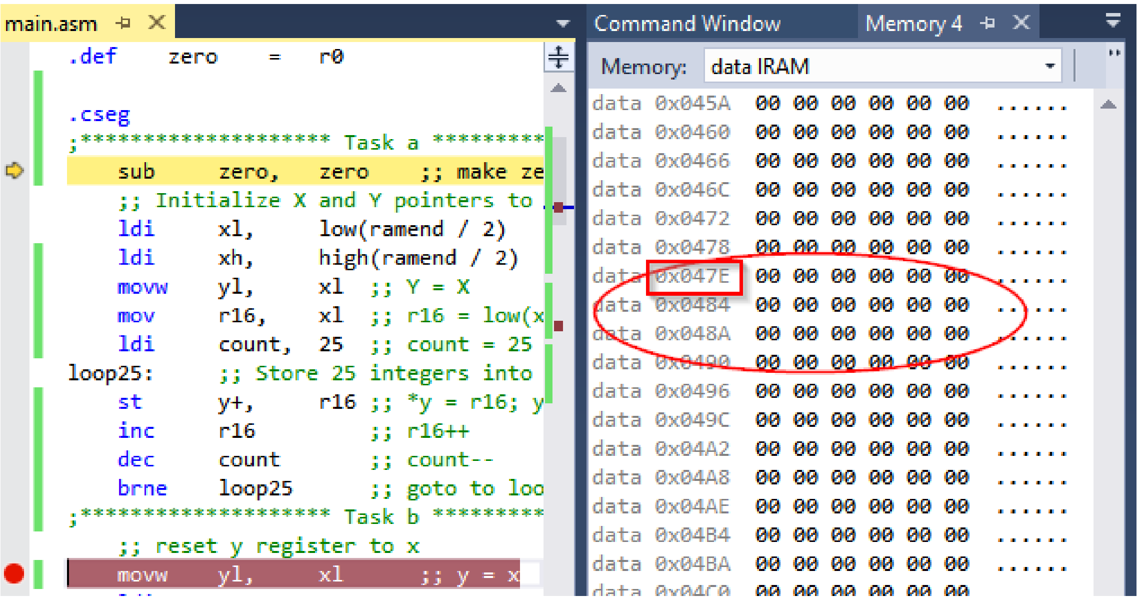
There were no schematics in this assignment.

7. SCREENSHOTS OF EACH TASK OUTPUT

TASK A:

Starting at RAMEND/2, memory should hold values corresponding to the lower byte of their memory location. If RAMEND = 0x08FF, RAMEND/2 = 0x047F.

Before Task A:

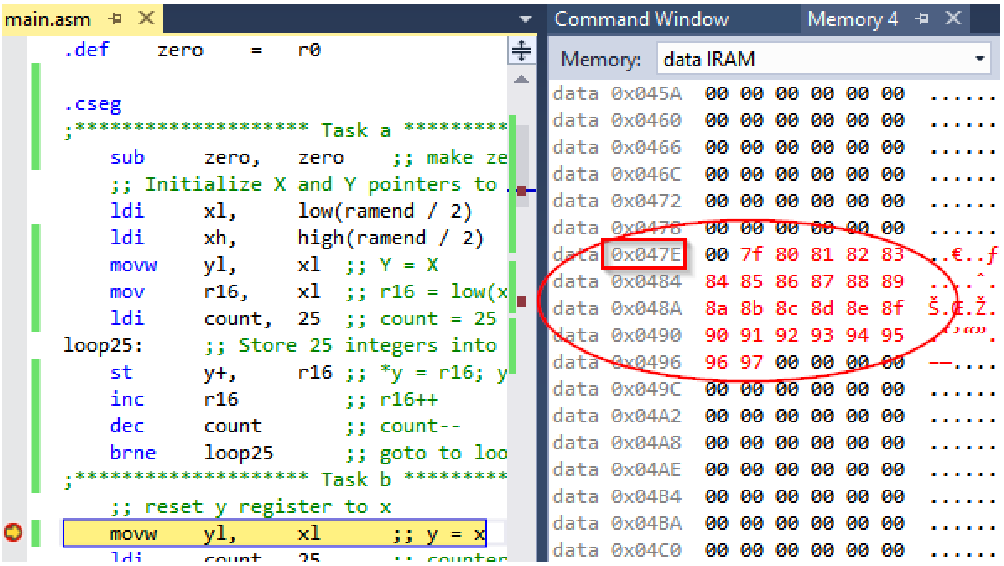


```
.def     zero     =    r0

.cseg
;******************** Task a *********
    sub      zero,    zero     ;; make ze
    ;; Initialize X and Y pointers to .
    ldi      xl,      low(ramend / 2)
    ldi      xh,      high(ramend / 2)
    movw     yl,      xl   ;; Y = X
    mov      r16,     xl   ;; r16 = low(x
    ldi      count,   25   ;; count = 25
loop25:      ;; Store 25 integers into
    st       y+,      r16 ;; *y = r16; y
    inc      r16           ;; r16++
    dec      count         ;; count--
    brne     loop25        ;; goto to loo
;******************** Task b *********
    ;; reset y register to x
    movw     yl,      xl       ;; y = x
```

Memory: data IRAM

```
data 0x045A  00 00 00 00 00 00  ......
data 0x0460  00 00 00 00 00 00  ......
data 0x0466  00 00 00 00 00 00  ......
data 0x046C  00 00 00 00 00 00  ......
data 0x0472  00 00 00 00 00 00  ......
data 0x0478  00 00 00 00 00 00  ......
data 0x047E  00 00 00 00 00 00  ......
data 0x0484  00 00 00 00 00 00  ......
data 0x048A  00 00 00 00 00 00  ......
data 0x0490  00 00 00 00 00 00  ......
data 0x0496  00 00 00 00 00 00  ......
data 0x049C  00 00 00 00 00 00  ......
data 0x04A2  00 00 00 00 00 00  ......
data 0x04A8  00 00 00 00 00 00  ......
data 0x04AE  00 00 00 00 00 00  ......
data 0x04B4  00 00 00 00 00 00  ......
data 0x04BA  00 00 00 00 00 00  ......
data 0x04C0  00 00 00 00 00 00
```

After Task A:



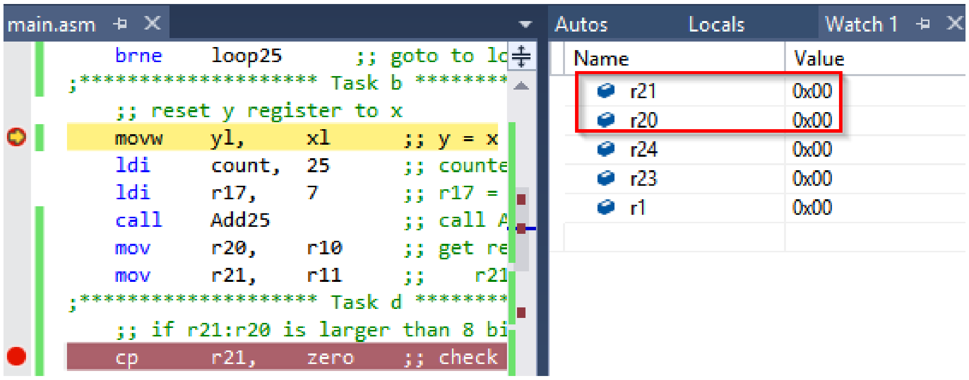
```
.def    zero    =   r0

.cseg
;******************** Task a *********
    sub     zero,   zero    ;; make ze
    ;; Initialize X and Y pointers to .
    ldi     xl,     low(ramend / 2)
    ldi     xh,     high(ramend / 2)
    movw    yl,     xl  ;; Y = X
    mov     r16,    xl  ;; r16 = low(x
    ldi     count,  25  ;; count = 25
loop25:     ;; Store 25 integers into
    st      y+,     r16 ;; *y = r16; y
    inc     r16         ;; r16++
    dec     count       ;; count--
    brne    loop25      ;; goto to loo
;******************** Task b *********
    ;; reset y register to x
    movw    yl,     xl      ;; y = x
    ldi     count,  25      ;; counter
```

```
data 0x045A  00 00 00 00 00 00  ......
data 0x0460  00 00 00 00 00 00  ......
data 0x0466  00 00 00 00 00 00  ......
data 0x046C  00 00 00 00 00 00  ......
data 0x0472  00 00 00 00 00 00  ......
data 0x0478  00 00 00 00 00 00  ......
data 0x047E  00 7f 80 81 82 83  ..€..ƒ
data 0x0484  84 85 86 87 88 89  ....ˆ.
data 0x048A  8a 8b 8c 8d 8e 8f  Š.Œ.Ž.
data 0x0490  90 91 92 93 94 95  .‘’“”•
data 0x0496  96 97 00 00 00 00  –—....
data 0x049C  00 00 00 00 00 00  ......
data 0x04A2  00 00 00 00 00 00  ......
data 0x04A8  00 00 00 00 00 00  ......
data 0x04AE  00 00 00 00 00 00  ......
data 0x04B4  00 00 00 00 00 00  ......
data 0x04BA  00 00 00 00 00 00  ......
data 0x04C0  00 00 00 00 00 00  ......
```

Task B:

Add all numbers previously stored that are divisible by 7 and place them in r21:r20.

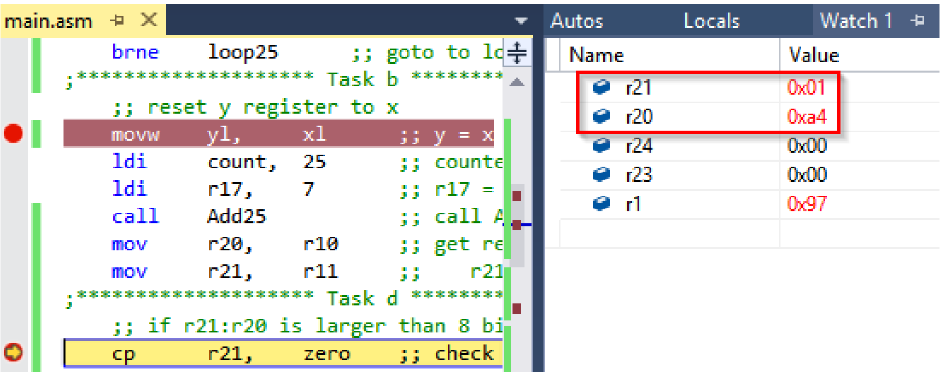
Before Task B:



```
    brne    loop25      ;; goto to lo
;******************** Task b ********
    ;; reset y register to x
    movw    yl,     xl      ;; y = x
    ldi     count,  25      ;; counte
    ldi     r17,    7       ;; r17 =
    call    Add25           ;; call A
    mov     r20,    r10     ;; get re
    mov     r21,    r11     ;;    r21
;******************** Task d ********
    ;; if r21:r20 is larger than 8 bi
    cp      r21,    zero    ;; check
```

Name	Value
r21	0x00
r20	0x00
r24	0x00
r23	0x00
r1	0x00

After Task B:



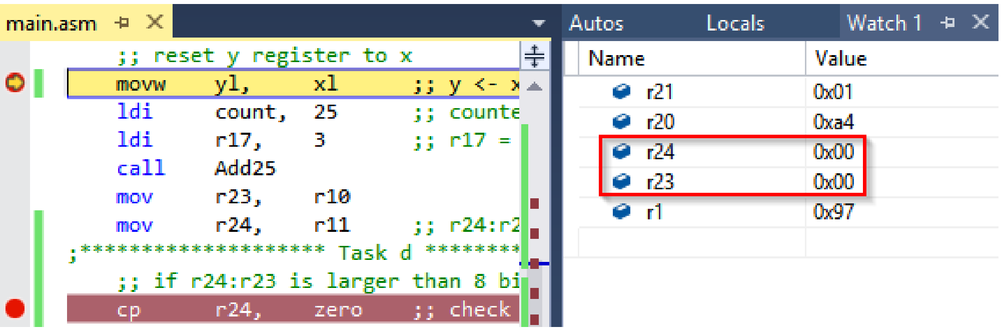
```
    brne    loop25      ;; goto to lo
;******************** Task b ********
    ;; reset y register to x
    movw    yl,     xl      ;; y = x
    ldi     count,  25      ;; counte
    ldi     r17,    7       ;; r17 =
    call    Add25           ;; call A
    mov     r20,    r10     ;; get re
    mov     r21,    r11     ;;    r21
;******************** Task d ********
    ;; if r21:r20 is larger than 8 bi
    cp      r21,    zero    ;; check
```

Name	Value
r21	0x01
r20	0xa4
r24	0x00
r23	0x00
r1	0x97

Task C:

Add all numbers previously stored that are divisible by 3 and place them in r24:r23.

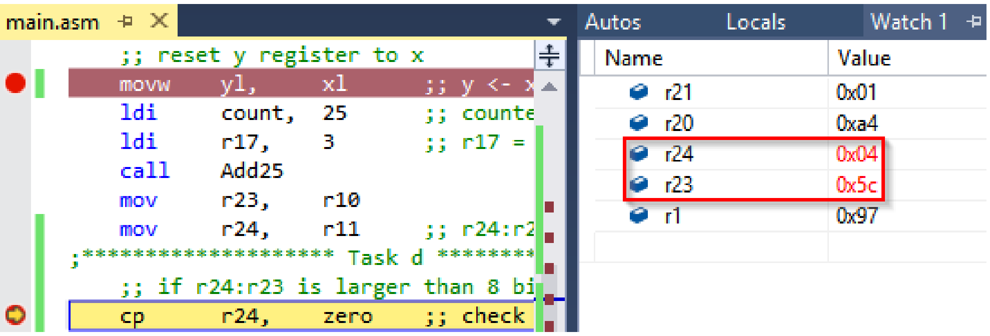
Before Task C:



```
    ;; reset y register to x
    movw    yl,     xl      ;; y <- x
    ldi     count,  25      ;; counte
    ldi     r17,    3       ;; r17 =
    call    Add25
    mov     r23,    r10
    mov     r24,    r11     ;; r24:r2
;******************** Task d ********
    ;; if r24:r23 is larger than 8 bi
    cp      r24,    zero    ;; check
```

Name	Value
r21	0x01
r20	0xa4
r24	0x00
r23	0x00
r1	0x97

After Task C:



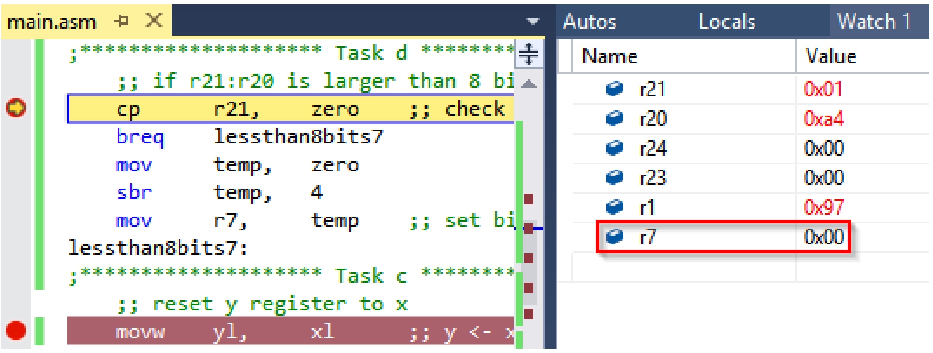
```
    ;; reset y register to x
    movw    yl,     xl      ;; y <- x
    ldi     count,  25      ;; counte
    ldi     r17,    3       ;; r17 =
    call    Add25
    mov     r23,    r10
    mov     r24,    r11     ;; r24:r2
;******************** Task d ********
    ;; if r24:r23 is larger than 8 bi
    cp      r24,    zero    ;; check
```

Name	Value
r21	0x01
r20	0xa4
r24	0x04
r23	0x5c
r1	0x97

Task D:

Set bit 3 in register r7 if the result is greater than 8-bits. The following illustrates this task after task b is computed.

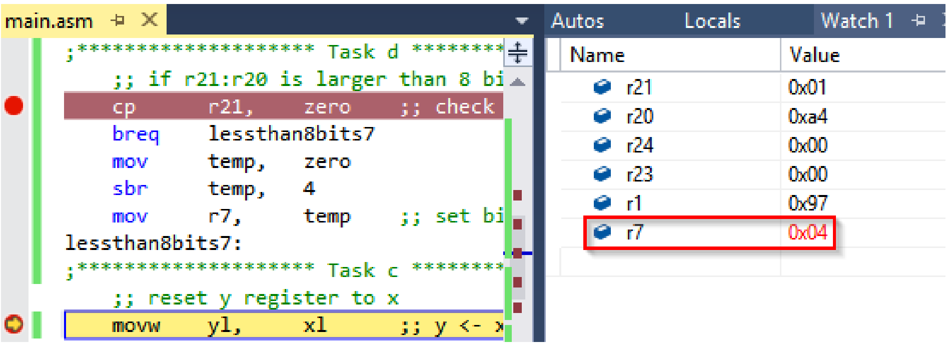
Before Task D:



```
;******************** Task d ********
    ;; if r21:r20 is larger than 8 bi
    cp      r21,     zero     ;; check
    breq    lessthan8bits7
    mov     temp,    zero
    sbr     temp,    4
    mov     r7,      temp     ;; set bi
lessthan8bits7:
;******************** Task c ********
    ;; reset y register to x
    movw    yl,      xl       ;; y <- x
```

Name	Value
r21	0x01
r20	0xa4
r24	0x00
r23	0x00
r1	0x97
r7	0x00

After Task D:



```
;******************** Task d *******
    ;; if r21:r20 is larger than 8 bi
    cp      r21,     zero     ;; check
    breq    lessthan8bits7
    mov     temp,    zero
    sbr     temp,    4
    mov     r7,      temp     ;; set bi
lessthan8bits7:
;******************** Task c *******
    ;; reset y register to x
    movw    yl,      xl       ;; y <- x
```

Name	Value
r21	0x01
r20	0xa4
r24	0x00
r23	0x00
r1	0x97
r7	0x04

8.	SCREENSHOT OF EACH DEMO		

See simulation output on previous section.

9.	VIDEO LINKS OF EACH DEMO		
Videos were not requested.			
10.	Github Repository		
https://github.com/martinjaime/CpE301_Assignments2016S.git			

Student Academic Misconduct Policy
http://studentconduct.unlv.edu/misconduct/policy.html

"This assignment submission is my own, original work".
Martin Jaime