CPSC 240: Computer Organization and Assembly Language
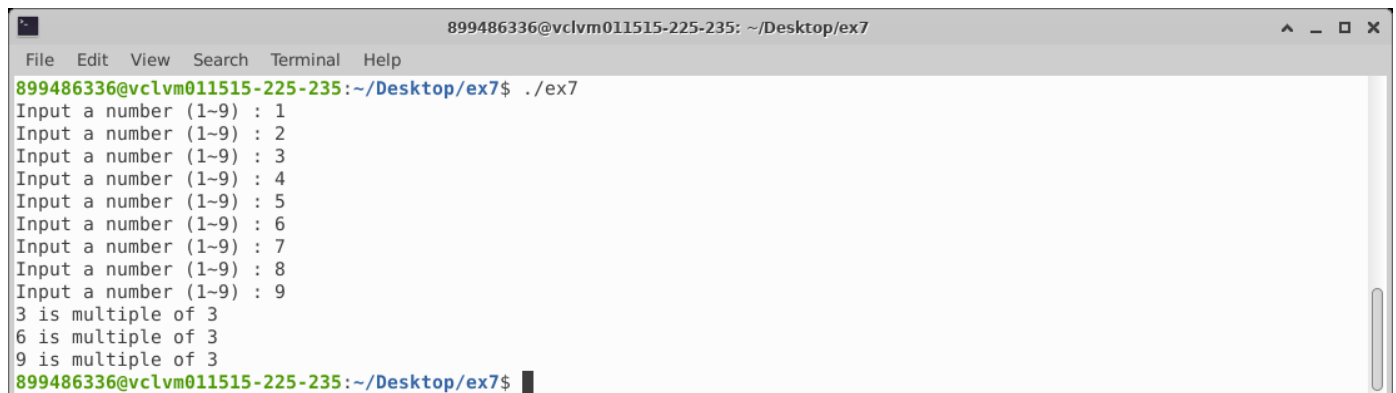## Assignment 07, Fall Semester 2023

CWID:_____ Name:_____

1. Download the "CPSC-240 Assignment07.docx" document.
2. Design the "input.asm" program, input 9 values from 1 to 9 from the keyboard, find out the multiples of 3 from the input values, and display the multiples of 3 in the terminal emulator window. The corresponding C/C++ code is as follows:

```
char msg1[] = "Input a number (1~9): ";
char msg2[] = " is Multiple of 3.";
char buffer;
char num;
char ascii[10];

register int r10 = 0;
do {
    cout << msg1;
    cin >> buffer;
    ascii[r10] = buffer;
    r10++;
} while(r10 < 9);
r10 = 0;
do {
    num = atoi(ascii[r10]);
    if(num%3 == 0) {
        cout << ascii[r10] << msg2;
    }
    r10++;
} while(r10 < 9);
```

3. Assemble the "input.asm" file and link the "input.o" file to get the "input" executable file.
4. Run the "input" file to display the input value and multiple of 3 in Terminal Emulator window.
5. Insert source code (input.asm) and simulation results (Terminal Emulator window) at the bottom of the document. Write an analysis to verify the simulation results.
6. Save the file in pdf format and submit the pdf file to Canvas before 23:59 pm on 11/02/2023.

Sample output:

Alternatively, the corresponding C/C++ code can be replaced as follows:

```cpp
char num;
char buffer;
char msg1[] = "Input a number (1~9): ";
char msg2[] = " is multiple of 3.";

register int r10 = 0;
do {
    cout << msg1;
    cin >> buffer;
    num = atoi(buffer);
    if(num%3 == 0) {
        cout << buffer << msg2;
    }
    r10++;
} while(r10 < 9);
```
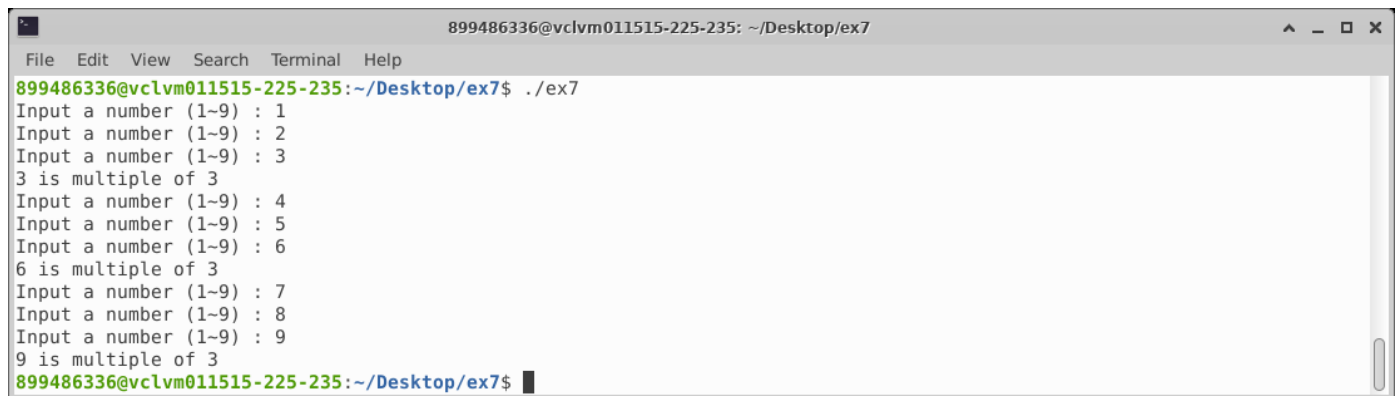
Sample output:


```
899486336@vclvm011515-225-235: ~/Desktop/ex7
File   Edit   View   Search   Terminal   Help
899486336@vclvm011515-225-235:~/Desktop/ex7$ ./ex7
Input a number (1~9) : 1
Input a number (1~9) : 2
Input a number (1~9) : 3
3 is multiple of 3
Input a number (1~9) : 4
Input a number (1~9) : 5
Input a number (1~9) : 6
6 is multiple of 3
Input a number (1~9) : 7
Input a number (1~9) : 8
Input a number (1~9) : 9
9 is multiple of 3
899486336@vclvm011515-225-235:~/Desktop/ex7$
```

[Insert input.asm here]

```asm
; input.asm
; char msg1[] = "Input a number (1~9) : ";
; char msg2[] = "Multiple of 3 include: ";
; char buffer;
; char num;
; char ascii[10];
;
; register int r10 = 0;
; do {
;     cout << msg1;
;     cin >> buffer;
;     ascii[r10] = buffer;
;     r10++;
; } while(r10 < 9);
; r10 = 0;
; do {
;     num = atoi(ascii[r10]);
;     if(num%3 == 0) {
;         cout << ascii[r10] << msg2;
;     }
;     r10++;
; } while(r10 < 9);
```

```nasm
section .data
    msg1 db    "Input a number (1~9) : " ;input message
    msg2 db    " is multiple of 3",10 ;output message

section .bss
    buffer  resb                        1   ;1-byte for buffer
    num   resb 1                        ;1-byte for num
    ascii       resb                    10 ;10-byte for ascii

section .text
    global _start
_start:
    mov  r10, 0
inLoop:
    ; cout << mesg
    mov  rax, 1                         ;SYS_write
    mov  rdi, 1                         ;write to STD_OUT
    mov  rsi, msg1                      ;address of mesg
    mov  rdx, 23                        ;23 character to write
    syscall                             ;calling system services

    ; cin >> buffer
    mov  rax, 0                         ;SYS_read
    mov  rdi, 1                         ;read from STD_IN
    mov  rsi, buffer                    ;address of the buffer
    mov  rdx, 2                         ;input length = 2
    syscall                             ;calling system services
    mov  al, byte[buffer]              ;al=[buffer] (ex: '5'=35h)
    mov  byte[ascii+r10], al           ;[num+r10] = al
    add  r10, 1                         ;r10 = r10 + 1
    cmp  r10, 9                         ;compare r10 with 9
    jne  inLoop                         ;if(r10!=10) goto inLoop

    mov  r10, 0
outLoop:
    ; if(num%3 != 0)
    mov  al, byte[ascii+r10]           ;al = [num+r10]
    and  al, 0fh                        ;convert ascii to number
    mov  ah, 0                             ;ah = 0
    mov  bl, 3                             ;bl = 3
    div  bl                             ;ah = ax%bl, al = ax/bl
    cmp  ah, 0                             ;compare ah wieh 0
    jne  not_mul3                       ;if(rem!=0) goto not_mul3

    ; else
    ; cout << ascii
    Mov  rax, 1                         ;SYS_write
    Mov  rdi, 1                         ;where to write
    Lea  rsi, [ascii+r10]              ;address of ascii+r10
    Mov  rdx, 1                         ;1 character to write
    syscall                             ;calling system services
```

```asm
        ; cout << msg2
        Mov   rax, 1                      ;SYS_write
        Mov   rdi, 1                      ;where to write
        Mov   rsi, msg2                   ;address of buffer
        Mov   rdx, 18                     ;18 character to write
        syscall                           ;calling system services

not_mul3:
        add   r10, 1                      ;r10 = r10 + 1
        cmp   r10, 9                      ;compare r10 with 10
        jne   outLoop                     ;if(r10!=10) goto outloop

done:
        mov   rax, 60                     ;terminate excuting process
        mov   rdi, 0                      ;exit status
        syscall                           ;calling system services
```

[Insert input simulation result here]


```
899486336@vclvm011515-225-235: ~/Desktop/ex7

File  Edit  View  Search  Terminal  Help
899486336@vclvm011515-225-235:~/Desktop/ex7$ ./ex7
Input a number (1~9) : 1
Input a number (1~9) : 2
Input a number (1~9) : 3
Input a number (1~9) : 4
Input a number (1~9) : 5
Input a number (1~9) : 6
Input a number (1~9) : 7
Input a number (1~9) : 8
Input a number (1~9) : 9
3 is multiple of 3
6 is multiple of 3
9 is multiple of 3
899486336@vclvm011515-225-235:~/Desktop/ex7$
```

[Insert input simulation result verification here]

$3 \% 3 = 0$

$6 \% 3 = 0$

$9 \% 3 = 0$

[Insert input.asm here]

```asm
; input.asm
;char num;
;char buffer;
;char msg1[] = "Input a number (1~9) : ";
;char msg2[] = "Multiple of 3 include: ";
;
;register int r10 = 0;
;do {
;     cout << msg1;
;     cin >> buffer;
;     if(buffer%3 != 0) {
;     } else {
```

```
;            ascii[r10] = buffer;
;        }
;        cout << msg2 << ascii;
;        r10++;
;} while(r10 < 9);


section .data
    msg1    db      "Input a number (0~9) : "   ;input message
    msg2    db      " is multiple of 3",10   ;output message
    buffer  db      "00"                    ;buffer = input char & LF
    num     db      0                       ;num = input number
    ascii   db      "0"                     ;ascii = output string

section .text
    global _start
_start:
    mov     r10, 0
doloop:
    ; cout << mesg
    Mov     rax, 1                  ;SYS_write
    mov     rdi, 1                  ;write to STD_OUT
    mov     rsi, msg1               ;address of mesg
    mov     rdx, 23                 ;23 character to write
    syscall                         ;calling system services

    ; cin >> buffer
    mov     rax, 0                  ;SYS_read
    mov     rdi, 1                  ;read from STD_IN
    mov     rsi, buffer             ;address of the buffer
    mov     rdx, 2                  ;input length = 1
    syscall                         ;calling system services
    mov     al, byte[buffer]        ;al = buffer (ex: '5'=35h)
    and     al, 0fh                 ;al = block bit7~4 (ex: 05h)
    ;mov    byte[num], al           ;num = al (ex: num=05h)

    ; if(num%3 != 0)
    ;mov    al, byte[num]           ;al=num
    Mov     ah, 0                   ;ah=0
    mov     bl, 3                   ;bl=3
    div     bl                      ;ah=ax%bl, al=ax/bl
    cmp     ah, 0                   ;compare ah with 0
    jne     not_mul3                    ;if(rem!=0) goto not_mul3

    ; else
    Add     byte[ascii], al         ;ascii[r10] = al

    ; cout << ascii
    Mov     rax, 1                  ;SYS_write
    Mov     rdi, 1                  ;where to write
    Mov     rsi, buffer             ;address of buffer
    Mov     rdx, 1                  ;11 character to write
```

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```asm
        syscall                             ;calling system services

        ; cout << msg2
        Mov     rax, 1                      ;SYS_write
        Mov     rdi, 1                      ;where to write
        Mov     rsi, msg2                   ;address of buffer
        Mov     rdx, 18                     ;18 character to write
        syscall                             ;calling system services

        mov     byte[ascii], '0'            ;reset ascii

not_mul3:
        add     r10, 1                      ;r10 = r10 + 1
        cmp     r10, 9                      ;compare r10 with 9
        jne     doloop                      ;if(r10!=10) goto doloop

done:
        mov     rax, 60                      ;terminate excuting process
        mov     rdi, 0                      ;exit status
        syscall                              ;calling system services
```
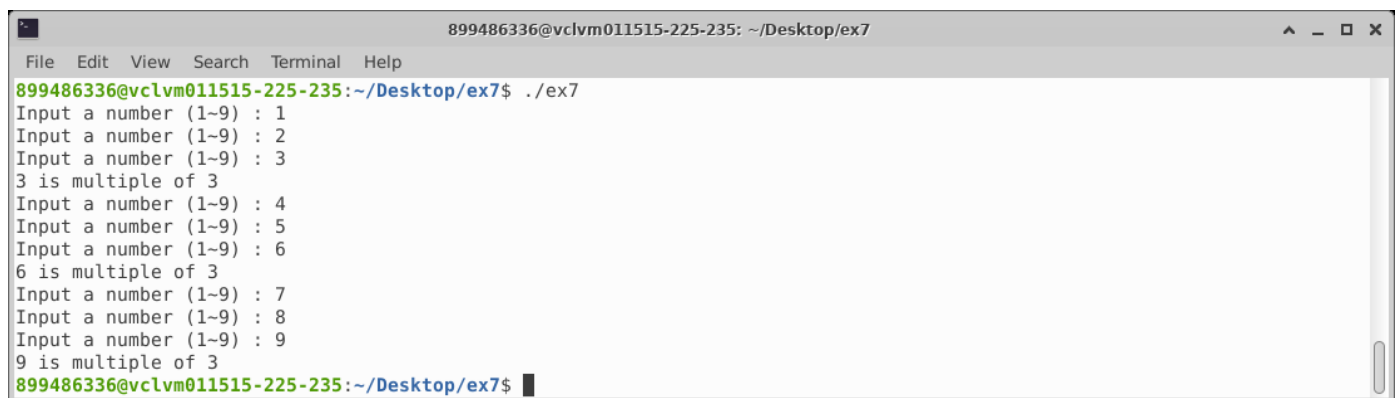
[Insert input simulation result here]

```
899486336@vclvm011515-225-235: ~/Desktop/ex7                          ^ _ □ X

 File   Edit   View   Search   Terminal   Help
899486336@vclvm011515-225-235:~/Desktop/ex7$ ./ex7
Input a number (1~9) : 1
Input a number (1~9) : 2
Input a number (1~9) : 3
3 is multiple of 3
Input a number (1~9) : 4
Input a number (1~9) : 5
Input a number (1~9) : 6
6 is multiple of 3
Input a number (1~9) : 7
Input a number (1~9) : 8
Input a number (1~9) : 9
9 is multiple of 3
899486336@vclvm011515-225-235:~/Desktop/ex7$ ▮
```

[Insert input simulation result verification here]

$3 \% 3 = 0$

$6 \% 3 = 0$

$9 \% 3 = 0$