Lab Session 11

String Handling Instructions

Primitive String Instructions

- The x86 instruction set has five groups of instructions for processing arrays of bytes, words, and double words.
- Each instruction implicitly uses ESI, EDI, or both registers to address memory.
- References to the accumulator imply the use of AL, AX, or EAX, depending on the instruction data size. String primitives execute efficiently because they automatically repeat and increment array indexes.

String Primitive Instructions.

Instruction	Description
MOVSB, MOVSW, MOVSD	**Move string data:** Copy data from memory addressed by ESI to memory addressed by EDI.
CMPSB, CMPSW, CMPSD	**Compare strings:** Compare the contents of two memory locations addressed by ESI and EDI.
SCASB, SCASW, SCASD	**Scan string:** Compare the accumulator (AL, AX, or EAX) to the contents of memory addressed by EDI.
STOSB, STOSW, STOSD	**Store string data:** Store the accumulator contents into memory addressed by EDI.
LODSB, LODSW, LODSD	**Load accumulator from string:** Load memory addressed by ESI into the accumulator.

1. MOVSB, MOVSW, and MOVSD

The MOVSB, MOVSW, and MOVSD instructions copy data from the memory location pointed to by ESI to the memory location pointed to by EDI. The two registers are either incremented or decremented automatically (based on the value of the Direction flag):

MOVSB	Move (copy) bytes
MOVSW	Move (copy) words
MOVSD	Move (copy) doublewords

Using a Repeat Prefix

By itself, a string primitive instruction processes only a single memory value or pair of values. If you add a repeat prefix, the instruction repeats, using ECX as a counter. The repeat prefix permits you to process an entire array using a single instruction. The following repeat prefixes are used:

REP	Repeat while ECX > 0
REPZ, REPE	Repeat while the Zero flag is set and ECX > 0
REPNZ, REPNE	Repeat while the Zero flag is clear and ECX > 0

Example #1: Copy a String

In the following example, MOVSB moves 10 bytes from string1 to string2. The repeat prefix first tests ECX > 0 before executing the MOVSB instruction. If ECX = 0, the instruction is ignored and control passes to the next line in the program. If ECX > 0, ECX is decremented and the instruction repeats:

```
INCLUDE Irvine32.inc
.data

string1 BYTE 'this is first string',0
string2 BYTE 'this is second string',0

.code
main PROC
cld        ; clear direction flag
mov esi,OFFSET string1          ; ESI points to source
mov edi,OFFSET string2          ; EDI points to target
mov ecx,sizeof string1          ; set counter to 10
rep movsb                       ; move bytes
mov edx,offset string2          ; changed String
call writestring
main ENDP
END main
```

ESI and EDI are automatically incremented when MOVSB repeats. This behavior is controlled by the CPU's Direction flag.

Direction Flag

String primitive instructions increment or decrement ESI and EDI based on the state of the Direction flag. The Direction flag can be explicitly modified using the CLD and STD instructions:

```
CLD                             ; clear Direction flag (forward direction)
STD                             ; set Direction flag (reverse direction)
```

Direction Flag Usage in String Primitive Instructions.

Value of the Direction Flag	Effect on ESI and EDI	Address Sequence
Clear	Incremented	Low-high
Set	Decremented	High-low

2. CMPSB, CMPSW, and CMPSD

The CMPSB, CMPSW, and CMPSD instructions each compare a memory operand pointed to by ESI to a memory operand pointed to by EDI: You can use a repeat prefix with CMPSB, CMPSW, and CMPSD. The Direction flag determines the incrementing or decrementing of ESI and EDI.

Example # 2: Comparing Doublewords

Suppose you want to compare a pair of double words using CMPSD. In the following example, source has a smaller value than target, so the JA instruction will not jump to label L1.

```
INCLUDE Irvine32.inc
.data

greater BYTE 'source > target',0
lessOrEqual BYTE 'source <target',0
source BYTE 'abcd',0
target BYTE 'abc',0

.code
main PROC
mov esi,OFFSET source
mov edi,OFFSET target
cmpsd                          ; compare doublewords
ja L1                          ; jump if source > target
mov edx,offset lessOrEqual     ;else print source <= target
call writestring
jmp endd
L1:
mov edx,offset greater
call writestring

endd:
exit
main ENDP
END main
```

3. SCASB, SCASW, and SCASD

The SCASB, SCASW, and SCASD instructions compare a value in AL/AX/EAX to a byte, word, or double word, respectively, addressed by EDI. The instructions are useful when looking for a single value in a string or array. Combined with the REPE (or REPZ) prefix, the string or array is scanned while ECX > 0 and the value in AL/ AX/ EAX match each subsequent value in memory. The REPNE prefix scans until either AL/AX/EAX matches a value in memory or ECX = 0.

Example #3: Scan for a Matching Character

```
INCLUDE Irvine32.inc
.data

alpha BYTE "ABCDEFGH",0

.code
main PROC
mov edi,OFFSET alpha          ; EDI points to the string
mov al,'F'                    ; search for the letter F
mov ecx,LENGTHOF alpha        ; set the search count
cld                           ; direction = forward
repne scasb                   ; repeat while not equal
jnz quit                      ; quit if letter not found
dec edi                       ; found: back up EDI

quit:
exit
main ENDP
END main
```

JNZ was added after the loop to test for the possibility that the loop stopped because ECX = 0 and the character in AL was not found.

4. STOSB, STOSW, and STOSD

The STOSB, STOSW, and STOSD instructions store the contents of AL/AX/EAX, respectively, in memory at the offset pointed to by EDI. EDI is incremented or decremented based on the state of the Direction flag. When used with the REP prefix, these instructions are useful for filling all elements of a string or array with a single value. For example, the following code initializes each byte in string1 to 0FFh:

```
.data
Count = 100
string1 BYTE Count DUP(?)
.code
mov al,0FFh                   ; value to be stored
mov edi,OFFSET string1        ; EDI points to target
mov ecx,Count                 ; character count
Cld                           ; direction = forward
rep stosb                     ; fill with contents of AL
```

5. LODSB, LODSW, and LODSD

The LODSB, LODSW, and LODSD instructions load a byte or word from memory at ESI into AL/AX/EAX, respectively. ESI is incremented or decremented based on the state of the Direction flag. The REP prefix is rarely used with LODS because each new value loaded into the accumulator overwrites its previous contents. Instead, LODS is used to load a single value. In the next example, LODSB substitutes for the following two instructions (assuming the Direction flag is clear):

```
mov al,[esi]        ; move byte into
inc esi             ; point to next byte
```

Example#4: Array Multiplication:

The following program multiplies each element of a doubleword array by a constant value. LODSD and STOSD work together:

```
TITLE Multiply an Array (Mult.asm)
;       This program multiplies each element of an array
;       of 32-bit integers by a constant value.
INCLUDE Irvine32.inc
.data
array DWORD 1,2,3,4,5,6,7,8,9,10        ; test data
multiplier DWORD 10                     ; test data
.code
main PROC
Cld                                     ; direction = forward
mov esi,OFFSET array                    ; source index
mov edi,esi                             ; destination index
mov ecx,LENGTHOF array                  ; loop counter
L1:
Lodsd                                   ; load [ESI] into EAX
mul multiplier                          ; multiply by a value
Stosd                                   ; store EAX into [EDI]
loop L1
mov esi , OFFSET array
mov ecx, LENGTHOF array
mov ebx, TYPE array
call dumpmem                            ; updated array Display
Exit
main ENDP
END main
```

String Procedures

1. STR_CPY

The Str_copy procedure copies a null-terminated string from a source location to a target location.

Syntax: INVOKE Str_copy, ADDR source, ADDR target

2. STR_LENGTH

The Str_length procedure returns the length of a string in the EAX register. When you call it, pass the string's offset.

Syntax: INVOKE Str_length, ADDR myString

3. STR_COMPARE

The Str_compare procedure compares two strings. It affects the CF and ZF as shown in the following table.

Syntax: INVOKE Str_compare, ADDR string1, ADDR string2

4. Str_trim Procedure

The Str_trim procedure removes all occurrences of a selected trailing character from a null terminated string.

Syntax: INVOKE Str_trim, ADDR string, char_to_trim

5. Str_ucase Procedure

The Str_ucase procedure converts a string to all uppercase characters. It returns no value. When you call it, pass the offset of a string:

Syntax: INVOKE Str_ucase, ADDR myString

String Library Demo Program

```
INCLUDE Irvine32.inc
.data
string_1 BYTE "abcde////",0
string_2 BYTE "ABCDE",0
msg0 BYTE "string_1 in upper case: ",0
msg1 BYTE "string_1 and string_2 are equal",0
msg2 BYTE "string_1 is less than string_2",0
msg3 BYTE "string_2 is less than string_1",0
msg4 BYTE "Length of string_2 is ",0
msg5 BYTE "string_1 after trimming: ",0
.code
main PROC
call trim_string
```

```
call upper_case
call compare_strings
call print_length
exit
main ENDP

trim_string PROC
                        ; Remove trailing characters from string_1.
INVOKE Str_trim, ADDR string_1, '/'
mov edx,OFFSET msg5
call WriteString
mov edx,OFFSET string_1
call WriteString
call Crlf
ret
trim_string ENDP

upper_case PROC
                        ; Convert string_1 to upper case.
mov edx,OFFSET msg0
call WriteString
INVOKE Str_ucase, ADDR string_1
mov edx,OFFSET string_1
call WriteString
call Crlf
ret
upper_case ENDP


compare_strings PROC
                        ; Compare string_1 to string_2.
INVOKE Str_compare, ADDR string_1, ADDR string_2
.IF ZERO?
mov edx,OFFSET msg1
.ELSEIF CARRY?
mov edx,OFFSET msg2         ; string 1 is less than...
.ELSE
mov edx,OFFSET msg3         ; string 2 is less than...
.ENDIF
call WriteString
call Crlf
ret
compare_strings ENDP

print_length PROC
                                ; Display the length of string_2.
mov edx,OFFSET msg4
```

```
call WriteString
INVOKE Str_length, ADDR string_2
call WriteDec
call Crlf
ret
print_length ENDP
END main
```

Exercise

1. Write a program to find the index(location) of the first occurrence of the character '#' in the given string.

```
Str1 BYTE '127&j~3#^&*#*#45^',0
```

2. Repeat the task 1 by creating a procedure named scan_char. Call the procedure to find the index(location) of the first occurrence of the character '#' in the given string.

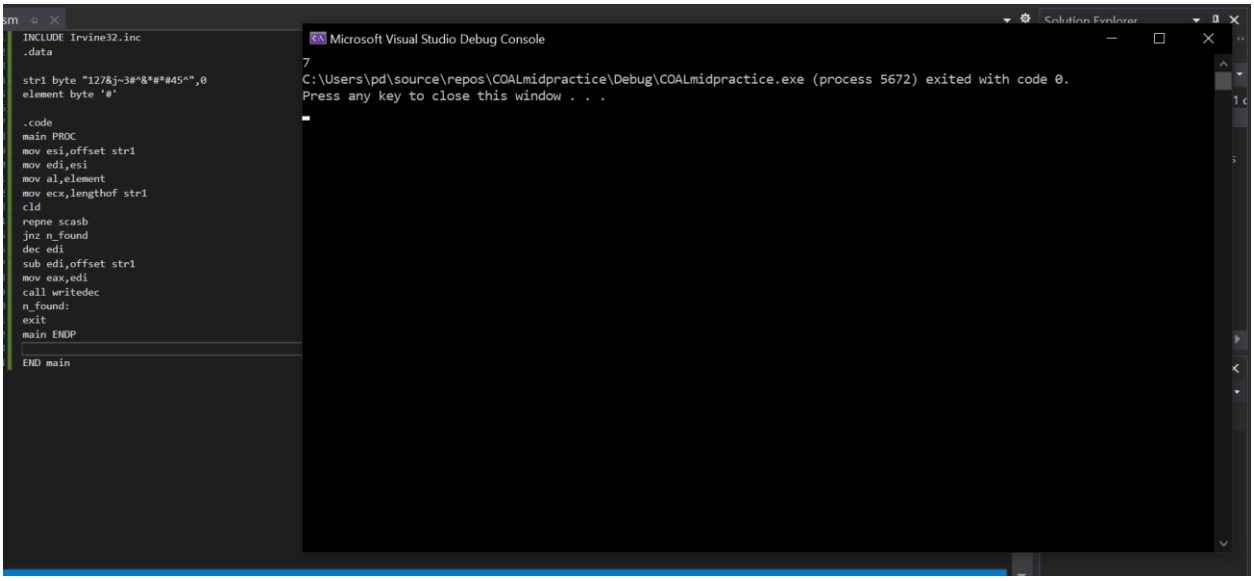
3. Create IsCompare procedure to compare two strings.

4. Create *Move* procedure to perform move operation on two strings.

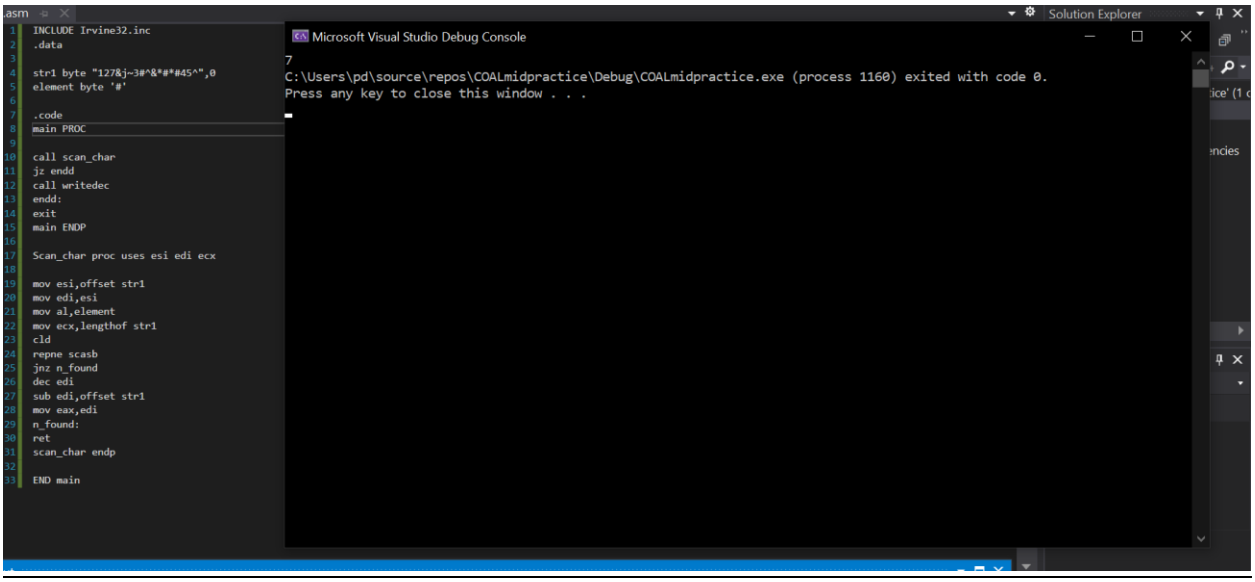
5. Create a Str_Reverse procedure to reverse strings.

6. Create a procedure that Loads an array of integer by multiplying it with 3. Display updated Array.

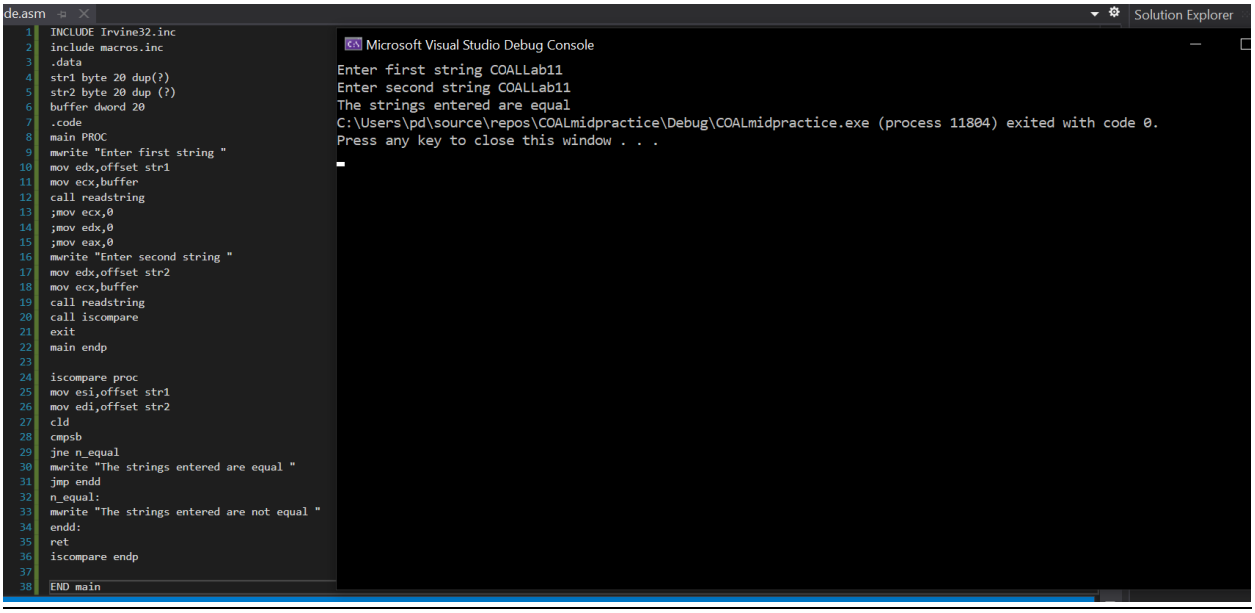
TASK 1:


INCLUDE Irvine32.inc
.data
str1 byte "127&j~3#^&*#*#45^",0
element byte '#'
.code
main PROC
mov esi,offset str1
mov edi,esi
mov al,element
mov ecx,lengthof str1
cld
repne scasb
jnz n_found
dec edi
sub edi,offset str1
mov eax,edi
call writedec
n_found:
exit
main ENDP
END main
Microsoft Visual Studio Debug Console
7
C:\Users\pd\source\repos\COALmidpractice\Debug\COALmidpractice.exe (process 5672) exited with code 0.
Press any key to close this window . . .

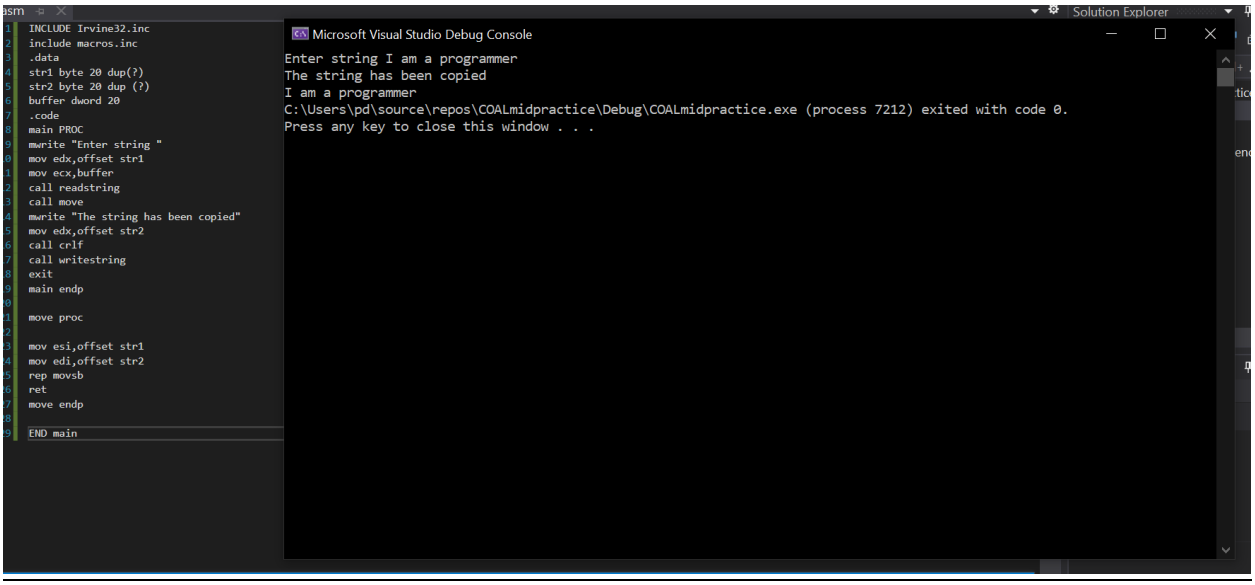
TASK 2:


INCLUDE Irvine32.inc
.data
str1 byte "127&j~3#^&*#*#45^",0
element byte '#'
.code
main PROC
call scan_char
jz endd
call writedec
endd:
exit
main ENDP
Scan_char proc uses esi edi ecx
mov esi,offset str1
mov edi,esi
mov al,element
mov ecx,lengthof str1
cld
repne scasb
jnz n_found
dec edi
sub edi,offset str1
mov eax,edi
n_found:
ret
scan_char endp
END main
Solution Explorer
Microsoft Visual Studio Debug Console
7
C:\Users\pd\source\repos\COALmidpractice\Debug\COALmidpractice.exe (process 1160) exited with code 0.
Press any key to close this window . . .

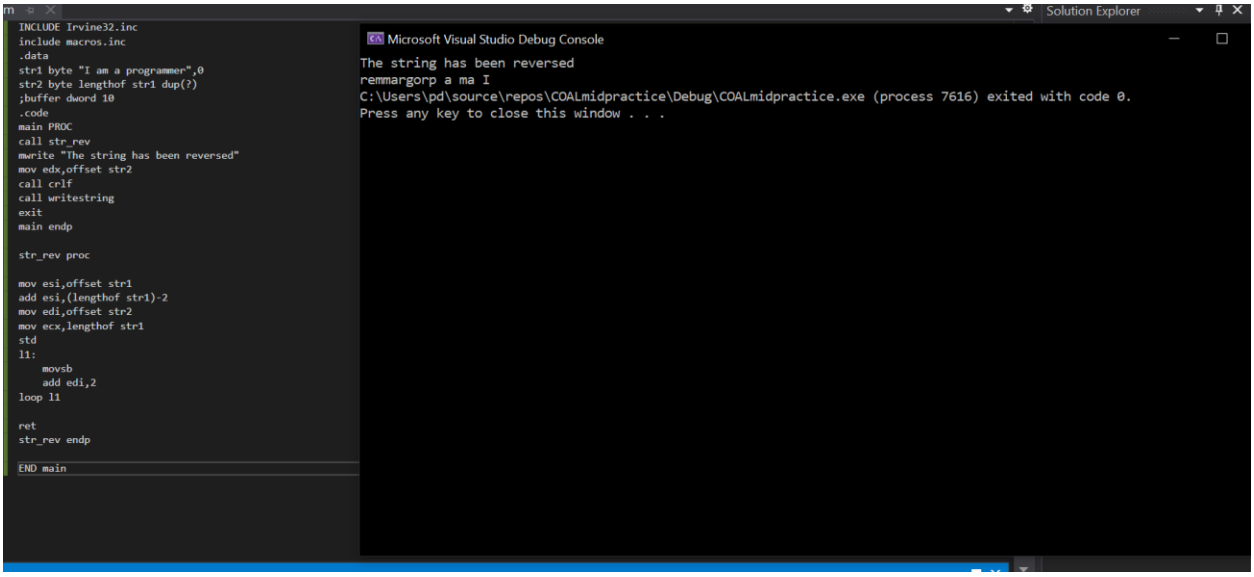
TASK 3:


de.asm
Solution Explorer
INCLUDE Irvine32.inc
include macros.inc
.data
str1 byte 20 dup(?)
str2 byte 20 dup (?)
buffer dword 20
.code
main PROC
mwrite "Enter first string "
mov edx,offset str1
mov ecx,buffer
call readstring
;mov ecx,0
;mov edx,0
;mov eax,0
mwrite "Enter second string "
mov edx,offset str2
mov ecx,buffer
call readstring
call iscompare
exit
main endp
iscompare proc
mov esi,offset str1
mov edi,offset str2
cld
cmpsb
jne n_equal
mwrite "The strings entered are equal "
jmp endd
n_equal:
mwrite "The strings entered are not equal "
endd:
ret
iscompare endp
END main
Microsoft Visual Studio Debug Console
Enter first string COALLab11
Enter second string COALLab11
The strings entered are equal
C:\Users\pd\source\repos\COALmidpractice\Debug\COALmidpractice.exe (process 11804) exited with code 0.
Press any key to close this window . . .

TASK 4:


asm
Solution Explorer
INCLUDE Irvine32.inc
include macros.inc
.data
str1 byte 20 dup(?)
str2 byte 20 dup (?)
buffer dword 20
.code
main PROC
mwrite "Enter string "
mov edx,offset str1
mov ecx,buffer
call readstring
call move
mwrite "The string has been copied"
mov edx,offset str2
call crlf
call writestring
exit
main endp
move proc
mov esi,offset str1
mov edi,offset str2
rep movsb
ret
move endp
END main
Microsoft Visual Studio Debug Console
Enter string I am a programmer
The string has been copied
I am a programmer
C:\Users\pd\source\repos\COALmidpractice\Debug\COALmidpractice.exe (process 7212) exited with code 0.
Press any key to close this window . . .

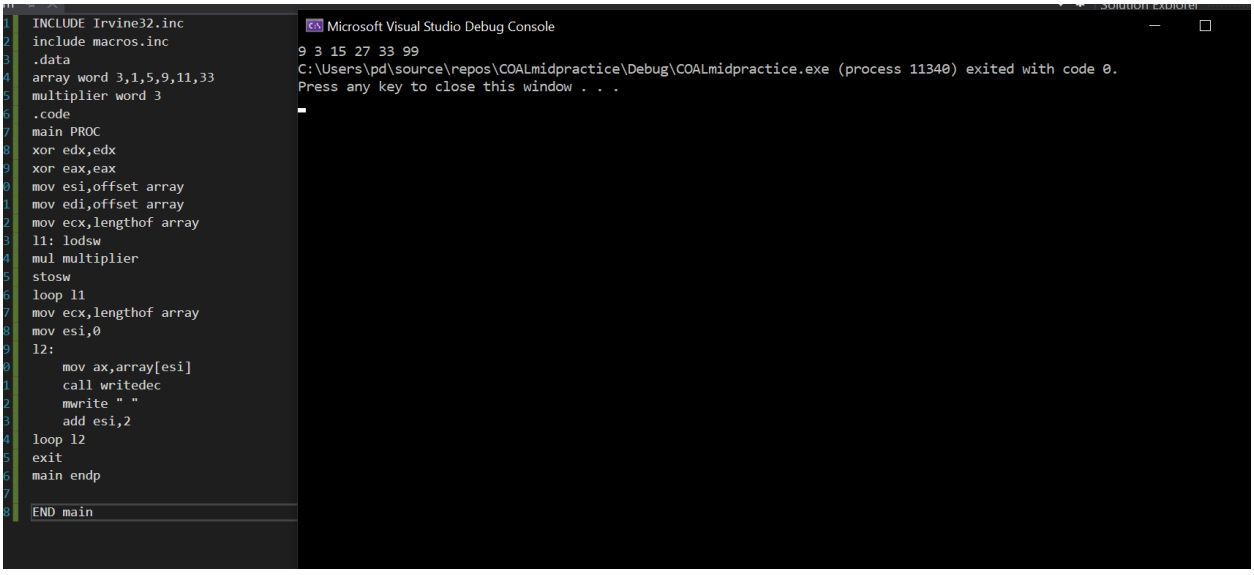
TASK 5:



```
INCLUDE Irvine32.inc
include macros.inc
.data
str1 byte "I am a programmer",0
str2 byte lengthof str1 dup(?)
;buffer dword 10
.code
main PROC
call str_rev
mwrite "The string has been reversed"
mov edx,offset str2
call crlf
call writestring
exit
main endp

str_rev proc

mov esi,offset str1
add esi,(lengthof str1)-2
mov edi,offset str2
mov ecx,lengthof str1
std
l1:
    movsb
    add edi,2
loop l1

ret
str_rev endp

END main
```

```
Microsoft Visual Studio Debug Console
The string has been reversed
remmargorp a ma I
C:\Users\pd\source\repos\COALmidpractice\Debug\COALmidpractice.exe (process 7616) exited with code 0.
Press any key to close this window . . .
```

TASK 6:



```
INCLUDE Irvine32.inc
include macros.inc
.data
array word 3,1,5,9,11,33
multiplier word 3
.code
main PROC
xor edx,edx
xor eax,eax
mov esi,offset array
mov edi,offset array
mov ecx,lengthof array
l1: lodsw
mul multiplier
stosw
loop l1
mov ecx,lengthof array
mov esi,0
l2:
    mov ax,array[esi]
    call writedec
    mwrite " "
    add esi,2
loop l2
exit
main endp

END main
```

```
Microsoft Visual Studio Debug Console
9 3 15 27 33 99
C:\Users\pd\source\repos\COALmidpractice\Debug\COALmidpractice.exe (process 11340) exited with code 0.
Press any key to close this window . . .
```