#### **CSC205**

# Project 1: Assembly Language Programming in MARIE Topic: Parity

**Total possible points: 20 (+5 bonuses)** 

### A. Introduction

The objective in this project is to implement a parity checker in MARIE.

Parity checking is very useful in applications of network communication and data storage. RAM memory typically incorporates a parity checker on board. RAID uses parity as one method of safeguarding data integrity.

Let X be an input string. An even parity checker outputs the value 1 if X contains an odd number of 1's in the input X. The checker outputs the value 0 otherwise.

Before the invention of Unicode, ASCII was the standard representation of characters. In the ASCII system, there are in total 128 characters (including digits, letters in uppercase and lowercase, punctuations and selected special characters). Table 1 shows the printable ASCII characters (excluding whitespace) that are recognized by MARIE. Each character has 7 bits. When the characters are stored on a disk or transmitted across a network, a parity bit may be added to the end of each code to make up for 8 bits.

Glyph	Dec	Binary	Glyph	Dec	Binary	Glyph	Dec	Binary
- JF			<u>@</u>	64	100 0000	- JF	96	110 0000
!	33	010 0001	A	65	100 0001	а	97	110 0001
"	34	010 0010	В	66	100 0010	b	98	110 0010
#	35	010 0011	С	67	100 0011	С	99	110 0011
\$	36	010 0100	D	68	100 0100	d	100	110 0100
%	37	010 0101	E	69	100 0101	е	101	110 0101
&	38	010 0110	F	70	100 0110	f	102	110 0110
1	39	010 0111	G	71	100 0111	g	103	110 0111
(	40	010 1000	H	72	100 1000	h	104	110 1000
)	41	010 1001	I	73	100 1001	i	105	110 1001
*	42	010 1010	J	74	100 1010	j	106	110 1010
+	43	010 1011	K	75	100 1011	k	107	110 1011
,	44	010 1100	L	76	100 1100	1	108	110 1100
-	45	010 1101	M	77	100 1101	m	109	110 1101
•	46	010 1110	N	78	100 1110	n	110	110 1110
/	47	010 1111	0	79	100 1111	0	111	110 1111
0	48	011 0000	P	80	101 0000	р	112	111 0000
1	49	011 0001	Q	81	101 0001	q	113	111 0001
2	50	011 0010	R	82	101 0010	r	114	111 0010
3	51	011 0011	S	83	101 0011	s	115	111 0011
4	52	011 0100	T	84	101 0100	t	116	111 0100
5	53	011 0101	U	85	101 0101	u	117	111 0101
6	54	011 0110	v	86	101 0110	v	118	111 0110
7	55	011 0111	W	87	101 0111	W	119	111 0111
8	56	011 1000	X	88	101 1000	x	120	111 1000

9	57	011 1001	Y	89	101 1001	У	121	111 1001
:	58	011 1010	Z	90	101 1010	z	122	111 1010
;	59	011 1011	[	91	101 1011	{	123	111 1011
<	60	011 1100	\	92	101 1100		124	111 1100
=	61	011 1101	]	93	101 1101	}	125	111 1101
>	62	011 1110	^	94	101 1110	~	126	111 1110
?	63	011 1111		95	101 1111			

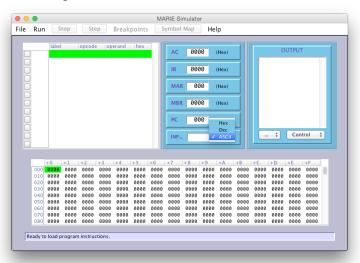
Table 1: Printable ASCII characters

# **B.** Problem description

Write a parity checker for the ASCII system. The parity checker should repeatedly execute a loop that performs the following tasks:

- 1. Ask the user for an input X, which can be any printable ASCII character from Table 1;
- 2. Output the decimal code of X;
- 3. Output the total number of 1's that appears in the binary code of X;
- 4. Output the parity bit which, when added to the binary code of X, will make the number of 1's even.

The user may enter input directly as ASCII characters by setting the input mode on the simulator, as shown in the picture below.

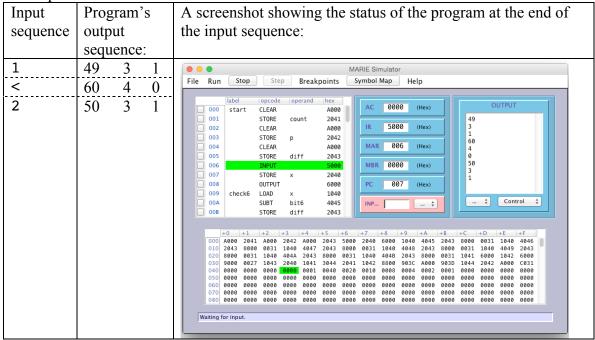


# C. Examples

Example 1:

Input	Prog	ram	ı's	A screenshot showing the status of the program at the end of the			
sequence	outpi	ut		input sequence:			
	seque	enc	e:				
I	73	3	1	● ● MARIE Simulator			
n	110	5	1	File Run Stop Step Breakpoints Symbol Map Help			
t	116	4	0	label opcode operand hex   AC 0000 (Hex)   OUTPUT			
r	114	4	0	001 STORE count 2041 116 116 4			
O	111	6	0	STORE   P   2042   MAR   006   Hex			

Example 2:



# **D.** Automated IO testing

Automated IO testing enables your program to be tested with a vast number of inputs, thus ensuring your program behavior meets the designated requirements such as correctness of response and efficiency.

You may test your program using an IO test package for MARIE at https://github.com/huiannie/MarieTest

#### E. Deliverables

Please test all the algorithms you write to make sure that they work as desired. Then submit the following items through Blackboard:

- 1. An electronic copy of your program source code, with proper documentations.
- 2. A screenshot of your program's execution result for the following input sequence:
- 3. Results of automated IO testing.

## F. Grading

- 1. [3 pts] Correctness of your count of 1's for each input.
- 2. [3 pts] Correctness of your parity bit for each input.
- 3. [3 pts] Correctness of your Input of X and the display of X in decimal.
- 4. [2 pts] Consistence of your program's execution results shown in screenshot.
- 5. [2 pts] Evidence of conducting automated IO test.
- 6. [2 pts] Efficiency (your program must produce results within the time limit set by the automated IO test driver).
- 7. [5 pts] Documentation of your source code.
- 8. [5 bonus pts] The reverse engineered source code of the sample program found in Appendix A.

# Appendix A (Source: parity-nested.mas)

Convert machine code to assembly code. Where an assembly code requires an argument, record the address of the argument in the symbol table.

	_	2		
Pass (1)			Symbol	Page 1
			table	

Address         Label code (best guess)         Hash (best guess)         Address to (best guess)						table			
001         104A         LOAD 04A         S2           002         404F         SUBT 04F         S3           003         204D         STORE 04D         S4           004         8000         SKIPCOND 000         S5           005         0029         S6         O0D           006         104A         S7           007         4050         S8           008         204D         S9           009         8000         S10           00A         0029         S10           00A         0029         S11           00B         104A         S12           00C         4051         S13           00D         204D         S13           00E         8000         S15           00F         0029         S16           010         104A         S17           011         4052         S18           012         204D         S19           013         8000         S19           014         0029         S19           015         104A         S19           018         8000         S10	Address	Label		-		Address	Symbol		
002         404F         SUBT 04F         S3           003         204D         STORE 04D         S4           004         8000         SKIPCOND 000         S5           005         0029         S6           006         104A         S7           007         4050         S8           008         204D         S9           009         8000         S10           00A         0029         S11           00B         104A         S12           00C         4051         S13           00D         204D         S15           00F         0029         S16           010         104A         S17           011         4052         S18           012         204D         S15           013         8000         S15           014         0029         S16           015         104A         S19           015         104A         S19           016         4053         S19           017         204D         S10           018         8000         S10           019         0029	000		003F	JNS 03F	S1	03F	S1		
003         204D         STORE 04D         S4           004         8000         SKIPCOND 000         S5           005         0029         S6         S6           006         104A         S7         S8           007         4050         S8         S8           008         204D         S9         S9           009         8000         S10         S12           00A         0029         S11         S12           00C         4051         S13         S12           00C         4051         S13         S13           00F         0029         S16         S15           00F         0029         S16         S17           010         104A         S15         S16           011         4052         S18         S17           012         204D         S18         S19           013         8000         S16         S18           017         204D         S19         S18           017         204D         S10         S19           018         8000         S0         S0           019         0029         S	001		104A	LOAD 04A	S2	04A	S2		
004         8000         SKIPCOND 000         S5           005         0029         S6           006         104A         S7           007         4050         S8           008         204D         S9           009         8000         S10           00A         0029         S11           00B         104A         S12           00C         4051         S13           00D         204D         S15           00E         8000         S15           00F         0029         S16           010         104A         S17           011         4052         S18           012         204D         S17           013         8000         S19           014         0029         S19           015         104A         S19           016         4053         S19           017         204D         S19           018         8000         S10           019         0029         S10           010         8000         S10           011         8000         S10           012 <td>002</td> <td></td> <td>404F</td> <td>SUBT 04F</td> <td>S3</td> <td>04F</td> <td>S3</td>	002		404F	SUBT 04F	S3	04F	S3		
005	003		204D	STORE 04D	S4	04D	S4		
005			8000	SKIPCOND 000					
006									
007			104A						
008         204D           009         8000           00A         0029           00B         104A           00C         4051           00D         204D           00E         8000           00F         0029           010         104A           011         4052           012         204D           013         8000           014         0029           015         104A           016         4053           017         204D           018         8000           019         0029           01A         104A           01B         4054           01C         204D           01B         4054           01C         204D           01E         0029           01F         104A           020         4055           021         204D           022         8000           023         0029           024         104B           025         6000           026         104C           027         6000 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>S8</td>							S8		
S10   S10   S11   S11   S12   S13   S13   S13   S14   S15   S16   S16   S17   S16   S17   S16   S17   S17   S18   S17   S18   S17   S19   S16   S19   S19									
00A         0029         S11           00B         104A         S12           00C         4051         S13           00D         204D         S14           00E         8000         S15           00F         0029         S16           010         104A         S17           011         4052         S18           012         204D         S19           013         8000         S19           014         0029         S16           015         104A         S19           016         4053         S19           017         204D         S19           018         8000         S19           019         0029         S16           010         018         8000           011         014A         S17           018         8000         S19           019         0029         S16           010         8000         S19           011         8000         S19           012         8000         S19           015         104A         S19           016         014A									
00B         104A           00C         4051           00D         204D           00E         8000           00F         0029           010         104A           011         4052           012         204D           013         8000           014         0029           015         104A           016         4053           017         204D           018         8000           019         0029           01A         104A           01B         4054           01C         204D           01B         4054           01C         204D           01E         0029           01F         104A           020         4055           021         204D           022         8000           023         0029           024         104B           025         6000           026         104C           027         6000           028         9000           029         0000           020         0025 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
00C         4051           00D         204D           00E         8000           00F         0029           010         104A           011         4052           012         204D           013         8000           014         0029           015         104A           016         4053           017         204D           018         8000           019         0029           01A         104A           01B         4054           01C         204D           01D         8000           01E         0029           01F         104A           020         4055           021         204D           022         8000           023         0029           024         104B           025         6000           026         104C           027         6000           028         9000           029         0000           029         0000           02B         204A           02C         002F <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
00D         204D         S14           00E         8000         S15           00F         0029         S16           010         104A         S17           011         4052         S18           012         204D         S19           013         8000         S19           014         0029         S19           015         104A         S19           016         4053         S19           018         8000         S19           018         4054         S19           019         0029         S19           010         010         S19           011         010         S19           012         014A         S19           013         019         S19           014         S19         S19           015         014A         S19           016         014A									
00E         8000         S15           00F         0029         S16           010         104A         S17           S11         4052         S18           012         204D         S19           013         8000         S19           014         0029         S19           015         104A         S19           016         4053         S19           017         204D         S19           018         8000         S01           019         0029         S01           010         0029         S01           011         0029         S01           011         8000         S01           012         204D         S01           015         104A         S01           016         4054         S01           017         204D         S01           018         8000         S01           019         0029         S01           010         8000         S01           011         104A         S02           021         204D         S02           022         8000									
00F         0029         S16           010         104A         S17           011         4052         S18           012         204D         S19           013         8000         S19           014         0029         S19           015         104A         S19           016         4053         S19           018         8000         S19           019         0029         S19           01A         104A         S19           01B         4053         S19           01B         8000         S19           01P         0029         S19           01D         8000         S19           01E         0029         S19           01F         104A         S19           021         204D         S19           022         8000         S19           023         0029         S19           024         104B         S19           025         6000         S19           028         9000         S19           028         9000         S19           028         9000									
O10									
011       4052       S18         012       204D       S19         013       8000       S19         014       0029       S18         015       104A       S10         016       4053       S10         017       204D       S18         018       8000       S10         019       0029       S10         01A       104A       S10         01B       4054       S10         01C       204D       S10         01E       0029       S10         01F       104A       S10         021       204D       S10         022       8000       S10         023       0029       S10         024       104B       S10         025       6000       S10         026       104C       S10         027       6000       S10         028       9000       S10         029       0000       S10         028       9000       S10         029       0005       S10         020       0025       S10         020									
012         204D           013         8000           014         0029           015         104A           016         4053           017         204D           018         8000           019         0029           01A         104A           01B         4054           01C         204D           01D         8000           01E         0029           01F         104A           020         4055           021         204D           022         8000           023         0029           024         104B           025         6000           026         104C           027         6000           028         9000           029         0000           02A         104D           02B         204A           02B         204A           02C         002F           02D         0035           02E         C029									
013       8000         014       0029         015       104A         016       4053         017       204D         018       8000         019       0029         01A       104A         01B       4054         01C       204D         01D       8000         01E       0029         01F       104A         020       4055         021       204D         022       8000         023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         029       0000         02A       104D         02B       204A         02C       002F         02D       0035         02E       C029									
014         0029           015         104A           016         4053           017         204D           018         8000           019         0029           01A         104A           01B         4054           01C         204D           01D         8000           01E         0029           01F         104A           020         4055           021         204D           022         8000           023         0029           024         104B           025         6000           026         104C           027         6000           028         9000           029         0000           02A         104D           02B         204A           02C         002F           02D         0035           02E         C029							319		
015       104A         016       4053         017       204D         018       8000         019       0029         01A       104A         01B       4054         01C       204D         01D       8000         01E       0029         01F       104A         020       4055         021       204D         022       8000         023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         029       0000         02A       104D         02B       204A         02C       002F         02D       0035         02E       C029									
016       4053         017       204D         018       8000         019       0029         01A       104A         01B       4054         01C       204D         01D       8000         01E       0029         01F       104A         020       4055         021       204D         022       8000         023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         029       0000         028       204A         02C       002F         02D       0035         02E       C029									
017       204D         018       8000         019       0029         01A       104A         01B       4054         01C       204D         01D       8000         01E       0029         01F       104A         020       4055         021       204D         022       8000         023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         029       0000         02A       104D         02B       204A         02C       002F         02D       0035         02E       C029									
018       8000         019       0029         01A       104A         01B       4054         01C       204D         01D       8000         01E       0029         01F       104A         020       4055         021       204D         022       8000         023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         029       0000         02A       104D         02B       204A         02C       002F         02D       0035         02E       C029									
019       0029         01A       104A         01B       4054         01C       204D         01D       8000         01E       0029         01F       104A         020       4055         021       204D         022       8000         023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         029       0000         02A       104D         02B       204A         02C       002F         02D       0035         02E       C029									
01A       104A         01B       4054         01C       204D         01D       8000         01E       0029         01F       104A         020       4055         021       204D         022       8000         023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         029       0000         02A       104D         02B       204A         02C       002F         02D       0035         02E       C029									
01B       4054         01C       204D         01D       8000         01E       0029         01F       104A         020       4055         021       204D         022       8000         023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         029       0000         02A       104D         02B       204A         02C       002F         02D       0035         02E       C029									
01C       204D         01D       8000         01E       0029         01F       104A         020       4055         021       204D         022       8000         023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         02A       104D         02B       204A         02C       002F         02D       0035         02E       C029									
01D       8000         01E       0029         01F       104A         020       4055         021       204D         022       8000         023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         029       0000         02A       104D         02B       204A         02C       002F         02D       0035         02E       C029									
01E         0029           01F         104A           020         4055           021         204D           022         8000           023         0029           024         104B           025         6000           026         104C           027         6000           028         9000           029         0000           02A         104D           02B         204A           02C         002F           02D         0035           02E         C029									
01F         104A           020         4055           021         204D           022         8000           023         0029           024         104B           025         6000           026         104C           027         6000           028         9000           029         0000           02A         104D           02B         204A           02C         002F           02D         0035           02E         C029									
020     4055       021     204D       022     8000       023     0029       024     104B       025     6000       026     104C       027     6000       028     9000       029     0000       02A     104D       02B     204A       02C     002F       02D     0035       02E     C029									
021     204D       022     8000       023     0029       024     104B       025     6000       026     104C       027     6000       028     9000       029     0000       02A     104D       02B     204A       02C     002F       02D     0035       02E     C029									
022     8000       023     0029       024     104B       025     6000       026     104C       027     6000       028     9000       029     0000       02A     104D       02B     204A       02C     002F       02D     0035       02E     C029									
023       0029         024       104B         025       6000         026       104C         027       6000         028       9000         029       0000         02A       104D         02B       204A         02C       002F         02D       0035         02E       C029									
024     104B       025     6000       026     104C       027     6000       028     9000       029     0000       02A     104D       02B     204A       02C     002F       02D     0035       02E     C029									
025     6000       026     104C       027     6000       028     9000       029     0000       02A     104D       02B     204A       02C     002F       02D     0035       02E     C029			1						
026     104C       027     6000       028     9000       029     0000       02A     104D       02B     204A       02C     002F       02D     0035       02E     C029	024		104B						
027     6000       028     9000       029     0000       02A     104D       02B     204A       02C     002F       02D     0035       02E     C029	025		6000						
028     9000       029     0000       02A     104D       02B     204A       02C     002F       02D     0035       02E     C029	026		104C						
029         0000           02A         104D           02B         204A           02C         002F           02D         0035           02E         C029	027		6000						
02A     104D       02B     204A       02C     002F       02D     0035       02E     C029	028		9000						
02B         204A           02C         002F           02D         0035           02E         C029	029		0000						
02B         204A           02C         002F           02D         0035           02E         C029			104D						
02C         002F           02D         0035           02E         C029									
02D         0035           02E         C029			002F						
02E C029									
	02F		0000						

Pass (1) Symbol Page 2 table

				table		
Address	Label	Machine code	Assembly code (best guess)	Hash to	Address	Symbol
030		104B	(See guess)		03F	S1
031		304E			04A	S2
032		204B			04F	S3
033		A000			04D	S4
034		C02F			0.12	S5
035	<del> </del>	0000				S6
036		104C				S7
037		8800				S8
038		903B				S9
039		A000				S10
03A		903C				S11
03B		104E				S12
03C		204C				S13
03D		A000				S14
03E		C035				S15
03F		0000				S16
040		A000				S17
041		204B				S18
042		A000				S19
043		204C				
044		A000				
045		204D				
046		5000				
047		204A				
048		6000				
049		C03F				
04A		0000				
04B		0000				
04C		0000				
04D		0000				
04E		0001				
04F		0040				
050		0020				
051		0010				
052		8000				
053		0004				
054		0002				
055		0001				
056		DEAD	Hex dead			
057		CODE	Hex c0de			

Note: It is a common practice for programmers to put the bit string <code>0xdeadc0de</code> into memory locations that are empty or unused. The purpose of this is to help programmers distinguish between unused spaces from used spaces that are initialized to value 0.

Insert symbols into the label column according to the addresses listed in the symbol table. Then erase the addresses in the assembly code.

Pass (2)	Symbol	Page 1
	table	

						table		
Address	Label	Machine code	Assembly code (best guess)	Hash to	Address	Symbol		
000		003F	JNS	S1	03F	S1		
001		104A	LOAD	S2	04A	S2		
002		404F	SUBT	S3	04F	S3		
003		204D	STORE	S4	04D	S4		
004		8000	SKIPCOND 000			S5		
005		0029				S6		
006		104A				S7		
007		4050				S8		
008		204D				S9		
009		8000				S10		
00A		0029				S11		
00B		104A				S12		
00C		4051				S13		
00D		204D				S14		
00E		8000				S15		
00F		0029				S16		
010		104A				S17		
011		4052				S18		
012		204D				S19		
013		8000						
014		0029						
015		104A						
016		4053						
017		204D						
018		8000						
019		0029						
01A		104A						
01B		4054						
01C		204D						
01D		8000						
01E		0029						
01F		104A						
020		4055						
021		204D						
022		8000						
023		0029						
024		104B						
025		6000						
026		104C						
027		6000						
028		9000						
029		0000						
02A		104D						
02B		204A						
02C		002F						
02D		0035						
02E		C029						
02F		0000						

Pass (2)	Symbol	Page 2
	table	

					table		
Address	Label	Machine	Assembly code	Hash	Address	Symbol	
		code	(best guess)	to			
030		104B			03F	S1	
031		304E			04A	S2	
032		204B			04F	S3	
033		A000			04D	S4	
034		C02F				S5	
035		0000				S6	
036		104C				S7	
037		8800				S8	
038		903B				S9	
039		A000				S10	
03A		903C				S11	
03B		104E				S12	
03C		204C				S13	
03D		A000				S14	
03E		C035				S15	
03F	S1	0000				S16	
040		A000				S17	
041		204B				S18	
042		A000				S19	
043		204C					
044		A000					
045		204D					
046		5000					
047		204A					
048		6000					
049		C03F					
04A	S2	0000					
04B		0000					
04C		0000					
04D	S4	0000					
04E		0001					
04F	S3	0040					
050		0020					
051	1	0010					
052		0008					
053		0004					
054		0002					
055		0001					
056		DEAD	Hex dead				
057		CODE	Hex c0de				

Note: It is a common practice for programmers to put the bit string <code>0xdeadc0de</code> into memory locations that are empty or unused. The purpose of this is to help programmers distinguish between unused spaces from used spaces that are initialized to value 0.