

COS10031 – Computer Technology

Assignment 3: ARMLite Mastermind Game

8:30am Tuesday, 10:30am Wednesday with Dr. Sourabh Dani

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Due: 18 May 2025

Diploma IT – Swinburne College

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Stage 2 (stage2.txt)

- Vandy Aum & Marcus Mifsud

In stage 2 a function `getcode` was created to receive input of a code and validate that it follows the rules of the game. After receiving input, the value of each character is extracted from the string using `LDRB` before branching to `validateChar` where it is checked against all valid characters. The fifth character of the string is then checked and returns an error if it has any value.

File: stage2.txt

```
080: getcode:
081:     // store address of where the function was called from
082:     MOV R8, LR
083:     // branch here if the code entered is invalid
084:     getcodeNested:
085:         // Read input of code
086:         MOV R12, #tempcode
087:         STR R12, .ReadString
088:         // Validate Secret Code
089:         // First Character
090:         // Store the address of the first byte of R12 content
           (secret code) in R9
091:         LDRB R9, [R12]
092:         BL validateChar
093:         // Second Character
094:         // Store the address of the second byte of R12 content
           (secret code) in R9
095:         //one character is one byte so when adding one byte to R12
           it will be the address of the next character
096:         LDRB R9, [R12, #1]
097:         BL validateChar
098:         // Third Character
099:         // Store the address of the third byte of R12 content
           (secret code) in R9
100:         LDRB R9, [R12, #2]
101:         BL validateChar
102:         // Fourth Character
103:         // Store the address of the fourth byte of R12 content
           (secret code) in R9
104:         LDRB R9, [R12, #3]
105:         BL validateChar
106:         // Fifth Character
107:         // Store the address of the fifth byte of R12 content
           (secret code) in R9
108:         LDRB R9, [R12, #4]
109:         CMP R9, #0 //check if a character was not entered
110:         BNE overLimit //if a character was entered branch to
           'overLimit'
111:         //if a fifth character was not entered and all prior checks
           passed, input is valid, return to code
112:         // return address the function was called from to LR
113:         MOV LR, R8
114:         B Return
```

Program

```

59 // Print guess1 into R11
60 STR R11, #writeSignedNum
61 ///////////////////////////////////////////////////
62 // Stage 2 - A Code Entry Function - Vandy Aum
63 // Marcus - Consolidated into functions and split stage 2 and 3
64 // Display a prompt for secret code entry
65 MOV R10, #newlineMsg
66 STR R10, #writeString
67 MOV R10, #requestCodeMsg
68 STR R10, #writeString
69 BL getcode
70 ///////////////////////////////////////////////////
71 // continue stage 3 code from here
72 code:
73 MOV R10, #testMsg
74 STR R10, #writeString
75 WAIT
76 ///////////////////////////////////////////////////
77 // FUNCTIONS
78 // Stage 2 - A Code Entry Function - Vandy Aum
79 // Marcus - Consolidated into functions and split stage 2 and 3
80 getcode:
81 // store address of where the function was called from
82 MOV R8, LR
83 getcodeNested:
84 // Read input of code
85 MOV R12, #tempCode
86 STR R12, #readSecret
87 // Validate Secret Code
88 // First Character
89 // Store the address of the first byte of R12 content (secret code) in R9
90 LDRB R9, [R12]
91 BL validateChar
92 // Second Character
93 // Store the address of the second byte of R12 content (secret code) in R9
94 // one character is one byte so when adding one byte to R12 it will be the address of the next character
95 LDRB R9, [R12, #1]
96 BL validateChar
97 // Third Character
98 // Store the address of the third byte of R12 content (secret code) in R9

```

Processor

PC 0x00000058

LR 0x0000004c

SP 0x00100000

R12 0x0000003d

R11 0x00000038

R10 0x00000039

R9 0x00000000

R8 0x0000004c

R7 0x00000000

R6 0x00000000

R5 0x00000000

R4 0x00000000

R3 0x00000000

R2 0x00000000

R1 0x00000000

R0 0x00000000

Count

Current Instruction

Status bits N Z C V **0100**

Input/Output

Codemaker is: vandy

Codemaker is: marcus

Guess Limit: 1000

Enter the Code:

Memory

000	0x8	0x4	0x8	0xc
0x0000	0xe3a0afc	0xe50fa0ec	0xe30a010b	0xe50fa0b4
0x0001	0xe50fa0f8	0xe30a018b	0xe50fa100	0xe30a019d
0x0002	0xe50fa0fc	0xe50fa18c	0xe30a021d	0xe50fa114
0x0003	0xe51fa130	0xe30a02f5	0xe50fa130	0xe50fa14a
0x0004	0xe3a0a8fb	0xe50fa12c	0xe0a00002	0xe30a0329
0x0005	0xe50fa138	0xe1000070	0xe1a0000e	0xe30c023d
0x0006	0xe50fc144	0xe50c0000	0xe0b00013	0xe50c0901
0x0007	0xe0000011	0xe5dc5002	0xe2b0000f	0xe55c0003
0x0008	0xeb00000d	0xe5dc5004	0xe3500000	0xe1a00007
0x0009	0xe1a0e008	0xe0a00017	0xe30a02bd	0xe50fa184
0x000a	0xeafffffd	0xe30a02df	0xe50fa190	0xeafffffe
0x000b	0xe30a0305	0xe50fa19c	0xeaffffa7	0xe3500000
0x000c	0x0a0ffff7	0xe3500072	0x0a00000a	0xe3500067
0x000d	0x0a000000	0xe3500062	0x0a000006	0xe3500079
0x000e	0x0a000000	0xe3500070	0x0a000002	0xe3500063
0x000f	0x0a000000	0xeaffffa7	0xe1a0f00e	0xe55a66f3
0x0010	0x656b616d	0x73692072	0x6072003a	0x7964a6e1
0x0011	0x00000000	0x00000000	0x00000000	0x00000000
0x0012	0x00000000	0x00000000	0x00000000	0x00000000
0x0013	0x00000000	0x00000000	0x00000000	0x00000000
0x0014	0x00000000	0x00000000	0x00000000	0x00000000
0x0015	0x00000000	0x00000000	0x00000000	0x00000000
0x0016	0x00000000	0x00000000	0x00000000	0x00000000
0x0017	0x00000000	0x00000000	0x00000000	0x00000000
0x0018	0x00000000	0x00000000	0x00000000	0xe55a66f3
0x0019	0xe0165726	0x20725050	0x203a7359	0x70216000
0x001a	0xe0737563	0x00000000	0x00000000	0x00000000
0x001b	0x00000000	0x00000000	0x00000000	0x00000000
0x001c	0x00000000	0x00000000	0x00000000	0x00000000
0x001d	0x00000000	0x00000000	0x00000000	0x00000000
0x001e	0x00000000	0x00000000	0x00000000	0x00000000
0x001f	0x00000000	0x00000000	0x00000000	0x00000000

Hex Clear

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Load
Save
Edit

Stage 3 (stage3.txt)

- Marcus Mifsud & Vandy Aum

In stage 3 the 'codeToArray' function was created to convert the string 'tempcode' into an array. The getcode function was also modified to utilize .ReadSecret the first time it runs (always the code maker's turn) to hide the entered code from the code breaker.

File: stage3.txt - code to array function

```
170: // Store code to array function
171: // R12 - Address to tempcode is stored here
172: // R9 - Current Character
173: // R6 - Memory address of the array to fill
174: // R7 - Array index
175: secretCodeToArray:
176:     // load the address of the secret code into R6
177:     MOV R6, #secretcode
178:     B codeToArray
179: codeToArray:
180:     // initialize the array position to 0
181:     MOV R7, #0
182:     fillArrayLoop:
183:         // divide R7 (index) by 4
184:         LSR R7, R7, #2
185:         // load character into R9
186:         LDRB R9, [R12 + R7]
187:         // multiply R7 (index) by 4
188:         LSL R7, R7, #2
189:
190:         // store character into array element
191:         STR R9, [R6 + R7]
192:
193:         // increment index counter by 4
194:         ADD R7, R7, #4
195:
196:         CMP R7, #codeArraySize // repeat until 4 elements of the array have been
filled
197:         BLT fillArrayLoop
198:     B Return
```

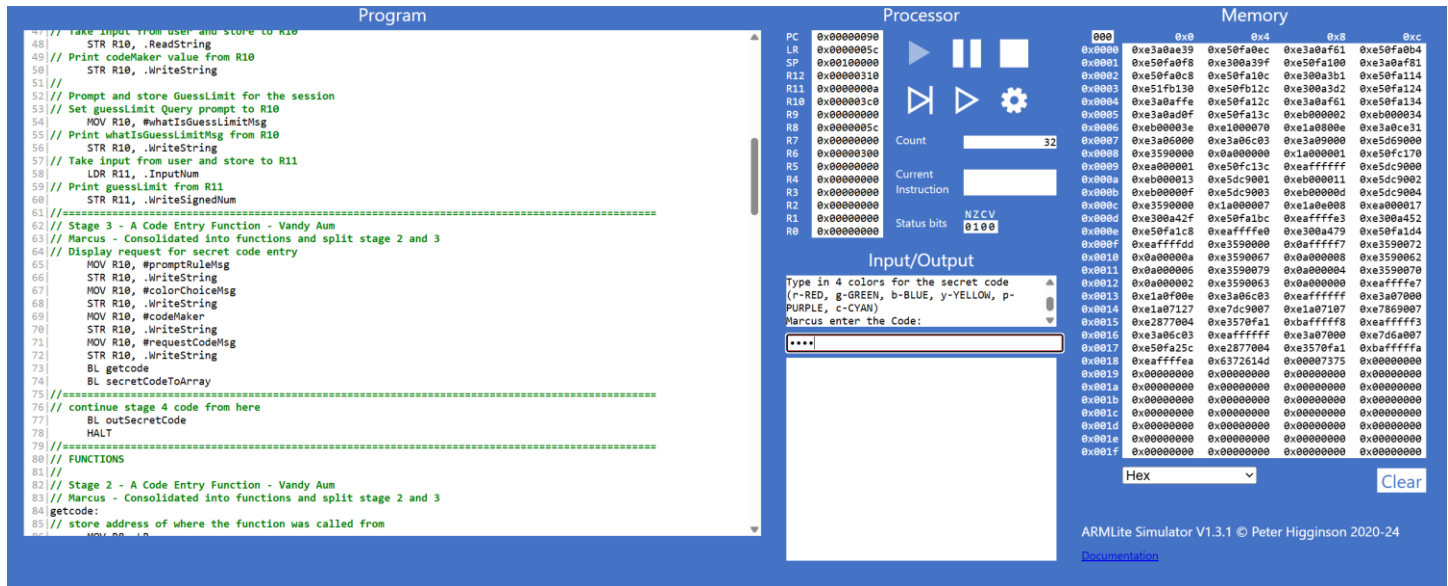
File: stage3.txt - exert from updated *getcode* function

```
088: getcodeNested:
089:     // Read input of code
090:     MOV R12, #tempcode
091:     // Initialize R6
092:     MOV R6, #0
093:     MOV R6, #secretcode
094:     MOV R9, #0
095:     LDRB R9, [R6]
096:     CMP R9, #0
097:     BEQ secretcodeentry
098:     BNE querycodeentry
099:     // If codemaker's turn
```

```

100:      secretcodeentry:
101:          STR R12, .ReadSecret
102:          B validateCharLoop
103:      // If codebreaker's turn
104:      querycodeentry:
105:          STR R12, .ReadString
106:          B validateCharLoop

```



Stage 3: Screenshot showing code maker code entry

Stage 4 (stage4.txt)

- Nicole Reichert & Marcus Mifsud

In stage 4 the queryloop function was created which increments the guess counter before checking if the code breaker has exceeded the guess limit. If not, the code breaker is requested to enter their guess using the *getcode* function. The code then branches back to the start of *queryloop* and continues looping until the guess limit is met.

File: stage4.txt - *queryloop* function

```
080: queryloop:
081:     // Initialize to currentGuessCount
082:     MOV R3, #0
083:     LDRB R3, currentGuessCount
084:     // Increment guess count by 1
085:     ADD R3, R3, #1
086:     STRB R3, currentGuessCount
087:     // Check if we are at guess limit
088:     CMP R3, R11
089:     BGT break
090:     // reset R3
091:     MOV R3, #0
092:     //
093:     // Continue to guess now that we've checked guess count
094:     // Print 'What is your guess'
095:     MOV R10, #requestGuessMsg
096:     STR R10, .WriteString
097:     // Print codebreaker name
098:     MOV R10, #codeBreaker
099:     STR R10, .WriteString
100:    // Print question mark
101:    MOV R10, #questionMarkMsg
102:    STR R10, .WriteString
103:    // End line
104:    MOV R10, #newLineMsg
105:    STR R10, .WriteString
106:    //
107:    // Print 'This is guess number: '
108:    MOV R10, #guessNumberCountMsg
109:    STR R10, .WriteString
110:    // Print guess number
111:    LDRB R10, currentGuessCount
112:    STR R10, .WriteUnsignedNum
113:    // End line
114:    MOV R10, #newLineMsg
115:    STR R10, .WriteString
116:    //
117:    // Get codebreaker's guess
118:    BL getcode
119:    BL queryCodeToArray
120:
121:    B query
122: // out of guesses
123: break:
```



```

124:      HALT
125:  //=====
126:  // Continue stage 5 here
127:      query:
128:
129:          B queryloop

```

Program		Processor	
808	b getCodeNested	PC	0x0000024c
809	tooFewChar:	LR	0x000001f4
810	MOV R10, #errorMsg2	SP	0x00100000
811	STR R10, .WriteString	R12	0x00000510
812	b getCodeNested	R11	0x00000004
813	overLimit:	R10	0x000006a3
814	MOV R10, #errorMsg3	R9	0x00000072
815	STR R10, .WriteString	R8	0x00000068
816	b getCodeNested	R7	0x00000000
817	// VALIDATE CHARACTER FUNCTION	R6	0x00000480
818	validateChar:	R5	0x00000000
819	CMP R9, #0 //check if a character was not entered	R4	0x00000000
820	BEQ tooFewChar	R3	0x00000000
821	CMP R9, #0x72 //check if the character is r(red)	R2	0x00000000
822	BEQ Return	R1	0x00000000
823	CMP R9, #0x67 //check if the character is g(green)	R0	0x00000000
824	BEQ Return		
825	CMP R9, #0x62 //check if the character is b(blue)		
826	BEQ Return		
827	CMP R9, #0x79 //check if the character is y(yellow)		
828	BEQ Return		
829	CMP R9, #0x70 //check if the character is p(purple)		
830	BEQ Return		
831	CMP R9, #0x63 //check if the character is c(cyan)		
832	BEQ Return		
833	b invalidChar //branch to 'invalidChar' if the character is invalid		
834	// Function to return from function		
835	Return: RET		
836	// STORE CODE TO ARRAY FUNCTION		
837	// R12 - Address to tempcode is stored here		
838	// R9 - Current Character		
839	// R6 - Memory address of the array to fill		

Input/Output	
Type in 4 colors for the secret code (r-RED, g-GREEN, b-BLUE, y-YELLOW, p-PURPLE, c-CYAN) Nicole enter the Code:	
Stopped on Breakpoint at PC = 0x0024c	
rgbr	

Stage 4: Functional Screenshot

Stage 5a (stage5a.txt)

- Nicole Reichert & Marcus Mifsud

In stage 5a we check the query code against the secret code. To achieve this we use a nested loop, where the outer loop iterates for each peg of the query code, that peg is checked against the secret code peg of the same position, and if they did not match, the inner loop iterates for each character of the secret code other than the current query code character, checking for a colour match in a different position.

Because this doesn't check for any prior Case 1 states (as we have not completed a state machine here), this gives back ALL Case 1 and Case 2 instances, even if Case 1 and Case 2 might collide (in example of double colours in a secret code).

File: stage5.txt - *comparecodes* function

```
128: comparecodes:
129:     // Initializing registers
130:     MOV R0, #0 // Case 1 Counter
131:     MOV R1, #0 // Case 2 Counter
132:     MOV R3, #0
133:     LDRB R3, arraySize // Array Size
134:     MOV R9, #0 // Query character
135:     MOV R4, #0 // Secret character
136:     MOV R5, #querycode // Query array address
137:     MOV R6, #secretcode // Secret array address
138:     MOV R7, #0 // array index / loop counter
139:     // R2 - Inner index
140:
141:     // Case 1
142:     case1start:
143:         // initialize R2 (inner index)
144:         MOV R2, #0
145:         // Load a char from query code into R9
146:         LDRB R9, [R5 + R7]
147:         //
148:         // Load a char from secret code into R4
149:         LDRB R4, [R6 + R7]
150:         //
151:         // Compare for Case 1 (BEQ)
152:         CMP R4, R9
153:         // If case 1 is true
154:         BEQ case1true
155:         // If case 1 is false
156:         B case2start
157:
158:     // Case 2
159:     case2start:
160:         // if main index = inner index, skip case2 check
161:         CMP R2, R7
162:         BEQ case2loopback
163:         // load secret char
164:         LDRB R4, [R6 + R2]
165:         // Compare secret char to query char
166:         CMP R4, R9
```

```

167:      // if case 2 is true
168:      BEQ case2true
169:      //
170:      // branch here to skip comparison of chars already done in case 1
171:      case2loopback:
172:      // increment inner index
173:      ADD R2, R2, #4
174:
175:      // loop until full array checked
176:      CMP R2, R3
177:      BLT case2start
178:      B charQueryEnd
179:
180:      //////////////////////////////////////
181:      // Case 1 success
182:      // Query char matches secret char in same position
183:      case1true:
184:      // Add 1 to case1 counter
185:      ADD R0, R0, #1
186:      B case2start
187:
188:
189:      // Case 2 success
190:      // Query char matches a secret char in a different position
191:      case2true:
192:      // Add 1 to case2 counter
193:      ADD R1, R1, #1
194:      // go back to case 2 start
195:      B case2loopback
196:
197:      // Loop back to main
198:      charQueryEnd:
199:      // Add 4 to main index
200:      ADD R7, R7, #4
201:      // Have we hit end of loop?
202:      CMP R7, R3
203:      // if not, loop back to start of char checks
204:      BLT case1start
205:      // if loop complete, display char check info
206:      B guessfeedback

```

Program

```

183 case2true:
184 // Add 1 to case2 counter
185 ADD R1, R1, #1
186 // go back to case 2 start
187 B case2loopback
188 // Loop back to main
189 charQueryEnd:
190 // Add 4 to main index
191 ADD R7, R7, #4
192 // Have we hit end of loop?
193 CMP R7, R3
194 // if not, loop back to start of char checks
195 BLT case1start
196 // if loop complete, display char check info
197 B guessfeedback
198 ///////////////////////////////////////////////////
199 //5(b)
200 guessfeedback:
201 HALT
202 // Display position matches message
203 MOV R10, #positionMatchesMsg
204 STR R10, .WriteString
205 // Display case 1 counter
206 STR R0, .WriteUnsignedNum
207 // Display colour matches message
208 MOV R10, #colourMatchesMsg
209 STR R10, .WriteString
210 // Display case 2 counter
211 STR R1, .WriteUnsignedNum
212 // If 4 position matches
213 CMP R0, #4
214 // Branch to winstate
215 BEQ winstate
216 //
217 // Initialize to currentGuessCount
218 MOV R3, #0
219 LDRB R3, currentGuessCount
220 // If this was final guess
221 CMP R3, R11

```

Load Save Edit

Processor

PC	0x00000138
LR	0x00000000
SP	0x00100000
R12	0x00000510
R11	0x00000005
R10	0x000006a3
R9	0x00000002
R8	0x000000ac
R7	0x00000010
R6	0x00000480
R5	0x00000500
R4	0x00000002
R3	0x00000010
R2	0x00000010
R1	0x00000002
R0	0x00000002

Count: 410

Current Instruction:

Status bits: NZCV 0110

Input/Output

What is your guess Luke?
This is guess number: 1
Program HALTED. STOP, LOAD or EDIT

rgyb

Memory

0x0	0x4	0x8	0xc
0x00000000	0xe300a591	0xe50fa0ec	0xe3a0afd2
0x00000001	0xe50fa0f8	0xe3a0ae5a	0xe50fa100
0x00000002	0xe50fa0c8	0xe50fa10c	0xe300a5b2
0x00000003	0xe51fb130	0xeb0000ad	0xe50fb12c
0x00000004	0xe50fa128	0xe300a624	0xe50fa130
0x00000005	0xe50fa138	0xe300a5ec	0xe50fa140
0x00000006	0xe50fa148	0xeb000054	0xeb000086
0x00000007	0xe50fa158	0xe3a0aff2	0xe50fa160
0x00000008	0xe50fa168	0xe300a6a3	0xe50fa170
0x00000009	0xe300a5d5	0xe50fa17c	0xe50fa190
0x0000000a	0xe300a6a3	0xe50fa18c	0xeb000043
0x0000000b	0xea000000	0xe3a00000	0xe3a01000
0x0000000c	0xe5df3380	0xe3a09000	0xe3a05c05
0x0000000d	0xe3a06d12	0xe3a07000	0xe3a02000
0x0000000e	0xe7d64007	0xe1540009	0xeb000009
0x0000000f	0xe1520007	0xeb000002	0xe7d64002
0x00000010	0xeb000005	0xe2812004	0xe1520003
0x00000011	0xea000003	0xe2800001	0xea000000
0x00000012	0xea000000	0xe2877004	0xe1570003
0x00000013	0xea000000	0xe1000070	0xe300a65b
0x00000014	0xe50fb234	0xe300a65e	0xe50fa224
0x00000015	0xe3500004	0xeb000004	0xe3a03000
0x00000016	0xe153000b	0xeb000007	0xea000000
0x00000017	0xe50fa258	0xe3a0aff2	0xe50fa260
0x00000018	0xe50fa268	0xeb000006	0xe300a6a3
0x00000019	0xe3a0aff2	0xe50fa27c	0xe300a68c
0x0000001a	0xea000000	0xeb000060	0xe300a6a3
0x0000001b	0xe300a698	0xe50fa29c	0xe1000070
0x0000001c	0xe3a0ce51	0xe3a06000	0xe3a06d12
0x0000001d	0xe5d69000	0xe3590000	0xeb000000
0x0000001e	0xe50fc2c4	0xea000001	0xe50fc290
0x0000001f	0xe5dc9000	0xeb000013	0xe5dc9001

Hex Clear

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Stage 5a: Screenshot showing 2 exact matches and 2 colour matches (stored in R0 & R1)

Stage 5b (stage5b.txt)

- Nicole Reichert & Marcus Mifsud

In stage 5 the *guessfeedback* function was created which displays the result of *comparecodes*. If the result of case 1 is 4 (the codes fully match) the code branches to *winstatement* which displays a win message and then branches to *gameover* which ends the game. The logic for incrementing the current guess count and checking the guess limit was also moved here from the start of *queryloop*, and branches to *losestate* if the guess limit has been exceeded without a full code match. If the code breaker neither wins or loses at this point, the code loops back to the start of *queryloop* to allow another guess.

```
File: stage5.txt
209: guessfeedback:
210:     // Display position matches message
211:     MOV R10, #positionMatchesMsg
212:     STR R10, .WriteString
213:     // Display case 1 counter
214:     STR R0, .WriteUnsignedNum
215:     // Display colour matches message
216:     MOV R10, #colourMatchesMsg
217:     STR R10, .WriteString
218:     // Display case 2 counter
219:     STR R1, .WriteUnsignedNum
220:     // If 4 position matches
221:     CMP R0, #4
222:     // Branch to winstate
223:     BEQ winstate
224:     //
225:     // Initialize to currentGuessCount
226:     MOV R3, #0
227:     LDRB R3, currentGuessCount
228:     // If this was final guess
229:     CMP R3, R11
230:     BEQ losestate
231:     // Else, loop back for another guess
232:     B queryloop
233:
234: winstate:
235:     MOV R10, #newLineMsg
236:     STR R10, .WriteString
237:     MOV R10, #winStateMsg1
238:     STR R10, .WriteString
239:     MOV R10, #codeBreaker
240:     STR R10, .WriteString
241:     MOV R10, #winStateMsg2
242:     STR R10, .WriteString
243:     B gameover
244:
245: losestate:
246:     MOV R10, #newLineMsg
247:     STR R10, .WriteString
248:     MOV R10, #loseStateMsg1
249:     STR R10, .WriteString
```

```

250:      MOV R10, #codeBreaker
251:      STR R10, .WriteString
252:      MOV R10, #loseStateMsg2
253:      STR R10, .WriteString
254:      B gameover
255:
256:      gameover:
257:      // clean our words if we wish to re-run
258:      BL clean
259:      MOV R10, #newLineMsg
260:      STR R10, .WriteString
261:      MOV R10, #gameOverMsg
262:      STR R10, .WriteString
263:      HALT

```

Program

```

250:      STR R10, .WriteString
251:      B gameover
252:      MOV R10, #newLineMsg
253:      STR R10, .WriteString
254:      MOV R10, #loseStateMsg1
255:      STR R10, .WriteString
256:      MOV R10, #codeBreaker
257:      STR R10, .WriteString
258:      MOV R10, #loseStateMsg2
259:      STR R10, .WriteString
260:      B gameover
261:
262:      gameover:
263:      // clean our words if we wish to re-run
264:      BL clean
265:      MOV R10, #newLineMsg
266:      STR R10, .WriteString
267:      MOV R10, #gameOverMsg
268:      STR R10, .WriteString
269:      HALT

```

Processor

PC: 0x000001f8
LR: 0x00000000
SP: 0x00100000
R12: 0x00000000
R11: 0x00000000
R10: 0x00000000
R9: 0x00000000
R8: 0x00000000
R7: 0x00000000
R6: 0x00000000
R5: 0x00000000
R4: 0x00000000
R3: 0x00000000
R2: 0x00000000
R1: 0x00000000
R0: 0x00000000

Count: 459
Current Instruction: 0x00000000
Status bits: NZCV 0000

Input/Output

This is guess number: 1
Position matches: 1, Colour matches: 1
What is your guess Nicole?
This is guess number: 2
Input expected

Memory

0x0	0x4	0x8	0xc
0x0000	0xe300a591	0xe50fa0ec	0xe300a5f5
0x0001	0xe50fa0f8	0xe300a5a5	0xe50fa100
0x0002	0xe50fa0c8	0xe50fa18c	0xe300a5b2
0x0003	0xe51fb130	0xeb00000b	0xe50fb12c
0x0004	0xe50fa128	0xe300a624	0xe50fa130
0x0005	0xe50fa138	0xe300a5ec	0xe50fa140
0x0006	0xe50fa148	0xeb000057	0xeb000009
0x0007	0xe50fa158	0xe300a5f5	0xe50fa160
0x0008	0xe50fa168	0xe300a6c7	0xe50fa170
0x0009	0xe300a5d5	0xe50fa17c	0xe50fa18c
0x000a	0xe300a6c7	0xe50fa18c	0xeb000046
0x000b	0xe50fa18c	0xe300a600	0xe300a600
0x000c	0xe50f338c	0xe300a600	0xe300a600
0x000d	0xe300a612	0xe300a700	0xe300a200
0x000e	0xe7d64007	0xe1540009	0x00000009
0x000f	0xe1520007	0x00000002	0xe7d64002
0x0010	0x00000005	0xe2820004	0xe1520003
0x0011	0xe0000003	0xe2800001	0xe0000003
0x0012	0xe0000003	0xe2877004	0xe1570003
0x0013	0xe0000003	0xe300a65b	0xe50fa220
0x0014	0xe300a65e	0xe50fa22c	0xe50fa12c
0x0015	0xe0000004	0xe300a600	0xe50f3430
0x0016	0x00000009	0xe0000000	0xe300a6c7
0x0017	0xe300a681	0xe50fa25c	0xe300a6ff5
0x0018	0xe300a694	0xe50fa26c	0xe0000000
0x0019	0xe50fa278	0xe300a69f	0xe50fa280
0x001a	0xe50fa288	0xe300a6eb	0xe50fa290
0x001b	0xeb000000	0xe300a6c7	0xe50fa2a0
0x001c	0xe50fa2a8	0xe1000070	0xe1a0800e
0x001d	0xe300a600	0xe300a6d12	0xe300a600
0x001e	0xe3590000	0x00000000	0x1a000001
0x001f	0xe0000001	0xe50fc29c	0xe0000001

Hex

Clear

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Stage 5b: Screenshot showing feedback for a guess

Program

```

250:      STR R10, .WriteString
251:      B gameover
252:      MOV R10, #newLineMsg
253:      STR R10, .WriteString
254:      MOV R10, #loseStateMsg1
255:      STR R10, .WriteString
256:      MOV R10, #codeBreaker
257:      STR R10, .WriteString
258:      MOV R10, #loseStateMsg2
259:      STR R10, .WriteString
260:      B gameover
261:
262:      gameover:
263:      // clean our words if we wish to re-run
264:      BL clean
265:      MOV R10, #newLineMsg
266:      STR R10, .WriteString
267:      MOV R10, #gameOverMsg
268:      STR R10, .WriteString
269:      HALT

```

Processor

PC: 0x000001c8
LR: 0x00000000
SP: 0x00100000
R12: 0x00000000
R11: 0x00000000
R10: 0x00000000
R9: 0x00000000
R8: 0x00000000
R7: 0x00000000
R6: 0x00000000
R5: 0x00000000
R4: 0x00000000
R3: 0x00000000
R2: 0x00000000
R1: 0x00000000
R0: 0x00000000

Count: 1054
Current Instruction: 0x00000000
Status bits: NZCV 0110

Input/Output

Out of guesses.
Nicole, you LOSE!
Game Over!
Program HALTED. STOP, LOAD or EDIT
rby

Memory

0x0	0x4	0x8	0xc
0x0000	0xe300a591	0xe50fa0ec	0xe300a5f5
0x0001	0xe50fa0f8	0xe300a5a5	0xe50fa100
0x0002	0xe50fa0c8	0xe50fa18c	0xe300a5b2
0x0003	0xe51fb130	0xeb00000b	0xe50fb12c
0x0004	0xe50fa128	0xe300a624	0xe50fa130
0x0005	0xe50fa138	0xe300a5ec	0xe50fa140
0x0006	0xe50fa148	0xeb000057	0xeb000009
0x0007	0xe50fa158	0xe300a5f5	0xe50fa160
0x0008	0xe50fa168	0xe300a6c7	0xe50fa170
0x0009	0xe300a5d5	0xe50fa17c	0xe50fa18c
0x000a	0xe300a6c7	0xe50fa18c	0xeb000046
0x000b	0xe50fa18c	0xe300a600	0xe300a600
0x000c	0xe50f338c	0xe300a600	0xe300a600
0x000d	0xe300a612	0xe300a700	0xe300a200
0x000e	0xe7d64007	0xe1540009	0x00000009
0x000f	0xe1520007	0x00000002	0xe7d64002
0x0010	0x00000005	0xe2820004	0xe1520003
0x0011	0xe0000003	0xe2800001	0xe0000003
0x0012	0xe0000003	0xe2877004	0xe1570003
0x0013	0xe0000003	0xe300a65b	0xe50fa220
0x0014	0xe300a65e	0xe50fa22c	0xe50fa12c
0x0015	0xe0000004	0xe300a600	0xe50f3430
0x0016	0x00000009	0xe0000000	0xe300a6c7
0x0017	0xe300a681	0xe50fa25c	0xe300a6ff5
0x0018	0xe300a694	0xe50fa26c	0xe0000000
0x0019	0xe50fa278	0xe300a69f	0xe50fa280
0x001a	0xe50fa288	0xe300a6eb	0xe50fa290
0x001b	0xeb000000	0xe300a6c7	0xe50fa2a0
0x001c	0xe50fa2a8	0xe1000070	0xe1a0800e
0x001d	0xe300a600	0xe300a6d12	0xe300a600
0x001e	0xe3590000	0x00000000	0x1a000001
0x001f	0xe0000001	0xe50fc29c	0xe0000001

Hex

Clear

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Stage 5b: Screenshot showing lose state

Assumptions

No restrictions for user submitted Guess Limit

Reasonable number of guesses will be submitted as input for the user without controls. The application does not constrict the user-entry value of the number of guesses to either a numerical entry limit, nor a theoretical mathematical limit of guesses needed to get the right answer. For example, as per the rules of Mastermind, the total sequences available to guess from is expressed by:

$$\text{Total Sequences} = \text{Number of options}^{\text{Number of places}}$$

$$\text{Total Sequences} = 6^4 = 1296$$

No Duplicate Guess controls

There are no validation checks for duplicate sequence submissions made by the user. This means that the user is burning an opportunity to guess within the specified limit, but also means that they have increased the number of guesses that could potentially be needed to obtain the correct outcome if there was no limit specified. That is, for each duplicate guess d , the number of total sequences increases by 1.

$$\text{Total guesses required} = \text{Total sequences} + \text{Duplicate Guesses}$$

$$\text{Total guesses required} = 1296 + d$$

Appendix - Full Code Stack

```
File: mastermind.asm
001: //=====
002: // COS10031 - Computer Technology | Assessment 3
003: // Vandy Aum, Marcus Mifsud, Nicole Reichert, Luke Byrnes
004: //
005: //      _ _ _ \_ _ _          _ _          _ _          _ _
006: //      | . . | _ _ _ _ _ | | _ _ _ _ _ | _ _ _ _ _ | _ _ _ _ _ |
007: //      | \| | / _ _ / _ _ | _ _ \_ _ \_ _ | _ _ \_ _ \_ _ | _ _ \_ _ \_ _ |
008: //      | | | | (| \_ _ \ || _ _ / | | | | | | | | | | | | | | | | (|
009: //      \_| |_/_\_,_|_\/_\_,_|_| |_| |_| |_| |_| |_| |_| |_| |_|_|_\_,_|
010: //
011: // Register Assignations
012:     // R0 (Compare Code of Correct Pos/Col)
013:     // R1 (Compare Code of (Correct Pos, Incorrect Col))
014:     // R2
015:     // R3
016:     // R4
017:     // R5
018:     // R6
019:     // R7
020:     // R8 Function Return (stores LR to return after a function is used within a
        function)
021:     // R9 Code character address
022:     // R10 String Handling
023:     // R11 Guess Limit
024:     // R12 Address to temp code
025: //=====
026: // Stage 1 - Game Setup - Luke Byrnes & Nicole Reichert
027: //
028: // Prompt and store Codemaker Name
029:     // Set whoIsCodeMakerMsg Query prompt to R10
030:     MOV R10, #whoIsCodeMakerMsg
031:     // print whoIsCodeMakerMsg Query from R10
032:     STR R10, .WriteString
033:     // Move codeMaker address to R10
034:     MOV R10, #codeMaker
035:     // Take input from user and store to R10
036:     STR R10, .ReadString
037:     // Print codeMaker value from R10
038:     STR R10, .WriteString
039: //
040: // Prompt and store CodeBreaker Name
041:     // Set whoIsCodeMakerMsg Query prompt to R10
042:     MOV R10, #whoIsCodeBreakerMsg
043:     // print whoIsCodeMakerMsg Query from R10
044:     STR R10, .WriteString
045:     // Move codeBreaker address to R10
046:     MOV R10, #codeBreaker
047:     // Take input from user and store to R10
048:     STR R10, .ReadString
049:     // Print codeMaker value from R10
```



```

050:     STR R10, .WriteString
051: //
052: // Prompt and store GuessLimit for the session
053: guesslimitprompt:
054:     // Set guessLimit Query prompt to R10
055:     MOV R10, #whatIsGuessLimitMsg
056:     // Print whatIsGuessLimitMsg from R10
057:     STR R10, .WriteString
058:     // Take input from user and store to R11
059:     LDR R11, .InputNum
060:     // BL to check we have a value between 1 and 100
061:     BL guesslimitcheck
062:     // Print guessLimit from R11
063:     STR R11, .WriteUnsignedNum
064: //=====
065: // Stage 3 - A Code Entry Function - Marcus Mifsud & Vandy Aum
066: // Marcus - Consolidated into functions and split stage 2 and 3
067: // Display request for secret code entry
068:     MOV R10, #promptRuleMsg
069:     STR R10, .WriteString
070:     MOV R10, #colorChoiceMsg
071:     STR R10, .WriteString
072:     MOV R10, #codeMaker
073:     STR R10, .WriteString
074:     MOV R10, #requestCodeMsg
075:     STR R10, .WriteString
076:     MOV R10, #newlineMsg
077:     STR R10, .WriteString
078:     BL getcode
079:     BL secretCodeToArray
080: //=====
081: // Stage 4 - Query Code Entry - Nicole Reichert & Marcus Mifsud
082: // Marcus - Consolidated Nicole's work into main code base
083: queryloop:
084:     // Initialize to currentGuessCount
085:     //MOV R3, #0
086:     //LDRB R3, currentGuessCount
087:     // Increment guess count by 1
088:     //ADD R3, R3, #1
089:     //STRB R3, currentGuessCount
090:     // reset R3
091:     //MOV R3, #0
092:     //
093:     // Continue to guess now that we've checked guess count
094:     // Print 'What is your guess'
095:     MOV R10, #requestGuessMsg
096:     STR R10, .WriteString
097:     // Print codebreaker name
098:     MOV R10, #codeBreaker
099:     STR R10, .WriteString
100:     // Print question mark
101:     MOV R10, #questionMarkMsg
102:     STR R10, .WriteString

```

```

103:    // End line
104:    MOV R10, #newlineMsg
105:    STR R10, .WriteString
106:    //
107:    // Perform guessCount check now
108:    BL guesscountcheck
109:    // Print 'This is guess number: '
110:    MOV R10, #guessNumberCountMsg
111:    STR R10, .WriteString
112:    // Print guess number
113:    LDRB R10, currentGuessCount
114:    STR R10, .WriteUnsignedNum
115:    // End line
116:    MOV R10, #newlineMsg
117:    STR R10, .WriteString
118:    //
119:    // Get codebreaker's guess
120:    BL getcode
121:    BL queryCodeToArray
122:
123:
124:    B comparecodes
125:    //=====
126:    // Stage 5 - Query Code Evaluation - Nicole Reichert
127:    // 5(a)
128:    comparecodes:
129:        // Initializing registers
130:        MOV R0, #0 // Case 1 Counter
131:        MOV R1, #0 // Case 2 Counter
132:        MOV R3, #0
133:        LDRB R3, arraySize // Array Size
134:        MOV R9, #0 // Query character
135:        MOV R4, #0 // Secret character
136:        MOV R5, #querycode // Query array address
137:        MOV R6, #secretcode // Secret array address
138:        MOV R7, #0 // array index / loop counter
139:        // R2 - Inner index
140:
141:        // Case 1
142:        case1start:
143:            // initialize R2 (inner index)
144:            MOV R2, #0
145:            // Load a char from query code into R9
146:            LDRB R9, [R5 + R7]
147:            //
148:            // Load a char from secret code into R4
149:            LDRB R4, [R6 + R7]
150:            //
151:            // Compare for Case 1 (BEQ)
152:            CMP R4, R9
153:            // If case 1 is true
154:            BEQ case1true
155:            // If case 1 is false

```

```

156:      B case2start
157:
158:  // Case 2
159:  case2start:
160:      // if main index = inner index, skip case2 check
161:      CMP R2, R7
162:      BEQ case2loopback
163:      // load secret char
164:      LDRB R4, [R6 + R2]
165:      // Compare secret char to query char
166:      CMP R4, R9
167:      // if case 2 is true
168:      BEQ case2true
169:      //
170:      // branch here to skip comparison of chars already done in case1
171:      case2loopback:
172:      // increment inner index
173:      ADD R2, R2, #4
174:
175:      // loop until full array checked
176:      CMP R2, R3
177:      BLT case2start
178:      B charQueryEnd
179:
180:  //////////////////////////////////////
181:  // Case 1 success
182:  // Query char matches secret char in same position
183:  case1true:
184:      // Add 1 to case1 counter
185:      ADD R0, R0, #1
186:      B case2start
187:
188:
189:  // Case 2 success
190:  // Query char matches a secret char in a different position
191:  case2true:
192:      // Add 1 to case2 counter
193:      ADD R1, R1, #1
194:      // go back to case 2 start
195:      B case2loopback
196:
197:  // Loop back to main
198:  charQueryEnd:
199:      // Add 4 to main index
200:      ADD R7, R7, #4
201:      // Have we hit end of loop?
202:      CMP R7, R3
203:      // if not, loop back to start of char checks
204:      BLT case1start
205:      // if loop complete, display char check info
206:      B guessfeedback
207:      //////////////////////////////////////
208:  //5(b)

```

```

209: guessfeedback:
210:     // Display position matches message
211:     MOV R10, #positionMatchesMsg
212:     STR R10, .WriteString
213:     // Display case 1 counter
214:     STR R0, .WriteUnsignedNum
215:     // Display colour matches message
216:     MOV R10, #colourMatchesMsg
217:     STR R10, .WriteString
218:     // Display case 2 counter
219:     STR R1, .WriteUnsignedNum
220:     // If 4 position matches
221:     CMP R0, #4
222:     // Branch to winstate
223:     BEQ winstate
224:     //
225:     // Initialize to currentGuessCount
226:     MOV R3, #0
227:     LDRB R3, currentGuessCount
228:     // If this was final guess
229:     CMP R3, R11
230:     BEQ losestate
231:     // Else, loop back for another guess
232:     B queryloop
233:
234: winstate:
235:     MOV R10, #newLineMsg
236:     STR R10, .WriteString
237:     MOV R10, #winStateMsg1
238:     STR R10, .WriteString
239:     MOV R10, #codeBreaker
240:     STR R10, .WriteString
241:     MOV R10, #winStateMsg2
242:     STR R10, .WriteString
243:     B gameover
244:
245: losestate:
246:     MOV R10, #newLineMsg
247:     STR R10, .WriteString
248:     MOV R10, #loseStateMsg1
249:     STR R10, .WriteString
250:     MOV R10, #codeBreaker
251:     STR R10, .WriteString
252:     MOV R10, #loseStateMsg2
253:     STR R10, .WriteString
254:     B gameover
255:
256: gameover:
257:     // clean our words if we wish to re-run
258:     BL clean
259:     MOV R10, #newLineMsg
260:     STR R10, .WriteString
261:     MOV R10, #gameOverMsg

```

```

262:      STR R10, .WriteString
263:      HALT
264:
265: //=====
266: // FUNCTIONS
267: //
268: // Stage 2 - A Code Entry Function - Vandy Aum & Marcus Mifsud
269: //
270: // GET CODE FUNCTION
271: getcode:
272:     // store address of where the function was called from
273:     MOV R8, LR
274:     // branch here if the code entered is invalid
275:     getcodeNested:
276:         // Read input of code
277:         MOV R12, #tempcode
278:         // Initialize R6
279:         MOV R6, #0
280:         MOV R6, #secretcode
281:         MOV R9, #0
282:         LDRB R9, [R6]
283:         CMP R9, #0
284:         BEQ secretcodeentry
285:         BNE querycodeentry
286:         // If codemaker's turn
287:         secretcodeentry:
288:             STR R12, .ReadSecret
289:             B validateCharLoop
290:         // If codebreaker's turn
291:         querycodeentry:
292:             STR R12, .ReadString
293:             B validateCharLoop
294:         // Validate Secret Code
295:         validateCharLoop:
296:         // First Character
297:             // Store the address of the first byte of R12 content (temp
                code) in R9
298:             LDRB R9, [R12]
299:             BL validateChar
300:         // Second Character
301:             // Store the address of the second byte of R12 content (temp
                code) in R9
302:             //one character is one byte so when adding one byte to R12
                it will be the address of the next character
303:             LDRB R9, [R12, #1]
304:             BL validateChar
305:         // Third Character
306:             // Store the address of the third byte of R12 content (temp
                code) in R9
307:             LDRB R9, [R12, #2]
308:             BL validateChar
309:         // Fourth Character
310:             // Store the address of the fourth byte of R12 content (temp

```

```

        code) in R9
311:        LDRB R9, [R12, #3]
312:        BL validateChar
313:        // Fifth Character
314:        // Store the address of the fifth byte of R12 content (temp
        code) in R9
315:        LDRB R9, [R12, #4]
316:        CMP R9, #0        //check if a character was not entered
317:        BNE overLimit    //if a character was entered branch to
        'overLimit'
318:        //if a fifth character was not entered and all prior checks
        passed, input is valid, return to code
319:        // return address the function was called from to LR
320:        MOV LR, R8
321:        B Return
322:
323: invalidChar:
324:        MOV R10, #errorMsg1
325:        STR R10, .WriteString
326:        b getcodeNested
327: tooFewChar:
328:        MOV R10, #errorMsg2
329:        STR R10, .WriteString
330:        b getcodeNested
331: overLimit:
332:        MOV R10, #errorMsg3
333:        STR R10, .WriteString
334:        b getcodeNested
335:
336: // VALIDATE CHARACTER FUNCTION
337: validateChar:
338:        CMP R9, #0        //check if a character was not entered
339:        BEQ tooFewChar
340:        CMP R9, #0x72    //check if the character is r(red)
341:        BEQ Return
342:        CMP R9, #0x67    //check if the character is g(green)
343:        BEQ Return
344:        CMP R9, #0x62    //check if the character is b(blue)
345:        BEQ Return
346:        CMP R9, #0x79    //check if the character is y(yellow)
347:        BEQ Return
348:        CMP R9, #0x70    //check if the character is p(purple)
349:        BEQ Return
350:        CMP R9, #0x63    //check if the character is c(cyan)
351:        BEQ Return
352:        b invalidChar    //branch to 'invalidChar' if the character was not
        matched by any of the above checks
353:
354: // Function to return from function
355: Return: RET
356:
357: // STORE CODE TO ARRAY FUNCTION
358: // R12 - Address to tempcode is stored here

```

```

359: // R9 - Current Character
360: // R6 - Memory address of the array to fill
361: // R7 - Array index
362: // R3 - Array Size
363: secretCodeToArray:
364:     // load the address of the secret code into R6
365:     MOV R6, #secretcode
366:     B codeToArray
367: queryCodeToArray:
368:     MOV R6, #querycode
369:     B codeToArray
370: codeToArray:
371:     // initialize the array position to 0
372:     MOV R7, #0
373:     // initialize array size
374:     LDRB R3, arraySize
375:     fillArrayLoop:
376:         // divide R7 (index) by 4
377:         LSR R7, R7, #2
378:         // load character into R9
379:         LDRB R9, [R12 + R7]
380:         // multiply R7 (index) by 4
381:         LSL R7, R7, #2
382:
383:         // store character into array element
384:         STR R9, [R6 + R7]
385:
386:         // increment index counter by 4
387:         ADD R7, R7, #4
388:
389:         CMP R7, R3 // repeat until 4 elements of the array have been
                        filled
390:         BLT fillArrayLoop
391:     B Return
392:
393: // OUTPUT ARRAY FUNCTION (only used for testing)
394: // output secret code
395: outSecretCode:
396:     MOV R6, #secretcode
397:     B outCodeArray
398: // output query code
399: outQueryCode:
400:     MOV R6, #querycode
401:     B outCodeArray
402: outCodeArray:
403:     // initialize index counter
404:     MOV R7, #0
405:     // initialize array size
406:     LDRB R3, arraySize
407:     // output the 4 digit code from an array
408:     outCodeArrayLoop:
409:         LDRB R10, [R6 + R7]
410:         STR R10, .WriteChar

```

```

411:
412:     // increment index
413:     ADD R7, R7, #4
414:
415:     // loop until 4 elements have been output
416:     CMP R7, R3
417:     BLT outCodeArrayLoop
418:     B Return
419:
420: //=====
421: //HELPER FUNCTIONS - Nicole Reichert
422: // Checking bounds of functions - we could be inputting something over a
    word or over a hard limit of 1-255.
423: guesslimitcheck:
424: CMP R11, #0xFF
425: BGT exceedlimit
426: CMP R11, #0x1
427: BLT exceedlimit
428: RET
429:
430: exceedlimit:
431: MOV R10, #errorMsg4
432: STR R10, .WriteString
433: MOV R11, #0
434: B guesslimitprompt
435:
436: guesscountcheck:
437: // Initialize to currentGuessCount
438:     MOV R3, #0
439:     LDRB R3, currentGuessCount
440:     // Increment guess count by 1
441:     ADD R3, R3, #1
442:     STRB R3, currentGuessCount
443:     // reset R3
444:     MOV R3, #0
445:     RET
446: clean:
447: // wipe currentguesscount
448:     LDRB R8, currentGuessCount
449:     MOV R8, #0
450:     STRB R8, currentGuessCount
451:     MOV R8, #secretcode
452:     MOV R7, #0
453:     STR R7, [R8]
454:
455:     RET
456:
457: //=====
458: // STORAGE =====
459: // Store block of memory of 128 bytes to store the codemaker's name
460: codeMaker: .BLOCK 128
461: // Store block of memory of 128 bytes to store the codebreaker's name
462: codeBreaker: .BLOCK 128

```



```

463: // Array Size
464: arraySize: .BYTE 16 // 4 elements * 4 bytes
465: // secret code array
466: .ALIGN 128
467: secretcode: .BYTE 0
468:             0
469:             0
470:             0
471: //
472: // query code array
473: .ALIGN 128
474: querycode: .BYTE 0
475:            0
476:            0
477:            0
478: //
479: // temp code string
480: tempcode: .BLOCK 128
481: //
482: currentGuessCount: .BYTE 0
483: //
484: // MESSAGES =====
485: // Display whoIsCodeMakerMsg Query prompt:
486: whoIsCodeMakerMsg: .ASCIZ "Codemaker is: "
487: // Display whoIsCodeBreakerMsg Query prompt:
488: whoIsCodeBreakerMsg: .ASCIZ "\nCodebreaker is: "
489: // Display guessLimit Query prompt:
490: whatIsGuessLimitMsg: .ASCIZ "\nGuess Limit: "
491: requestGuessMsg: .ASCIZ "What is your guess "
492: guessNumberCountMsg: .ASCIZ "This is guess number: "
493: //Display the prompt for user to input the secret code
494: requestCodeMsg: .ASCIZ " enter the Code: "
495: promptRuleMsg: .ASCIZ "\nType in 4 colors for the secret code"
496: colorChoiceMsg: .ASCIZ "\n(r-RED, g-GREEN, b-BLUE, y-YELLOW, p-PURPLE,
                        c-CYAN)\n"
497: // Outcome of guess messages
498: positionMatchesMsg: .ASCIZ "Position matches: "
499: colourMatchesMsg: .ASCIZ ", Colour matches: "
500: // Win/Lose States/GameOver
501: winStateMsg1: .ASCIZ "Exact code match.\n"
502: winStateMsg2: .ASCIZ ", you WIN!"
503: loseStateMsg1: .ASCIZ "Out of guesses.\n"
504: loseStateMsg2: .ASCIZ ", you LOSE!"
505: gameOverMsg: .ASCIZ "Game Over!"
506: // General use Messages
507: newLineMsg: .ASCIZ "\n"
508: questionMarkMsg: .ASCIZ "?"
509: // Error Messages
510: errorMsg1: .ASCIZ "\nError: Invalid character entered!\n"
511: errorMsg2: .ASCIZ "\nError: Not enough characters entered!\n"
512: errorMsg3: .ASCIZ "\nError: Too many characters entered!\n"
513: errorMsg4: .ASCIZ "\n--Please enter a value from 1 to 255!--\n"
514: // Test Message

```

```
515: testMsg: .ASCIZ "\nTEST\n"
```