**F.10 Chapter 8 Solutions**

8.1 The defining characteristic of a stack is the unique specification of how it is to be accessed. Stack is a LIFO (Last in First Out) structure. This means that the last thing that is put in the stack will be the first one to get out from the stack.

8.3 (a) PUSH R1

* + 1. POP R0
    2. PUSH R3
    3. POP R7

8.5 One way to check for overflow and underflow conditions is to keep track of a pointer that tracks the bottom of the stack. This pointer can be compared with the address of the first and last addresses of the space allocated for the stack.

;

; Subroutines for carrying out the PUSH and POP functions. This

; program works with a stack consisting of memory locations x3FFF

; (BASE) through x3FFB (MAX). R6 is the bottom of the stack.

;

POP ST R1, Save1 ; are needed by POP. ST R2, Save2

ST R3, Save3

LD R1, NBASE ; BASE contains -x3FFF. ADD R1, R1, #-1 ; R1 contains -x4000.

ADD R2, R6, R1 ; Compare bottom of stack to x4000 BRz fail\_exit ; Branch if stack is empty.

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| --- | --- | --- | --- | --- |
| LD | R1, | BASE |  | ;Iterate from the top of |
|  |  |  |  | ;the stack |
| LDI | R0, | BASE |  | ;Load the value from the |
| NOT | R3, | R6 |  | ;top of stack |
| ADD | R3, | R3, | #1 | ;Generate the |
|  |  |  |  | ;negative of the |
|  |  |  |  | ;bottom-of-stack pointer |
| ADD | R6, | R6, | #1 | ;Increment the |
|  |  |  |  | ;bottom-of-stack |
|  |  |  |  | ;pointer |

pop\_loop ADD R2, R1, R3 ;Compare iterating

;pointer to

;bottom-of-stack pointer BRz success\_exit;Branch if no more

;entries to shift

LDR R2, R1, #-1 ;Load the entry to shift STR R2, R1, #0 ;Shift the entry

ADD R1, R1, #-1 ;Increment the

;iterating pointer

BRnzp pop\_loop

PUSH ST R1, Save1 ; Save registers that ST R2, Save2 ; are needed by PUSH. ST R3, Save3

LD R1, MAX ; MAX contains -x3FFB

ADD R2, R6, R1 ; Compare stack pointer to -x3FFB BRz fail\_exit ; Branch if stack is full.

ADD R1, R6, #0 ;Iterate from the bottom

;of stack

LD R3, NBASE ;NBASE contains

;-x3FFF

ADD R3, R3, #-1 ; R3 = -x4000

push\_loop ADD R2, R1, R3 ;Compare iterating

;pointer to

;bottom-of-stack pointer BRz push\_entry ;Branch if no more

;entries to shift

LDR R2, R1, #0 ;Load the entry to shift STR R2, R1, #-1 ;Shift the entry

ADD R1, R1, #1 ;Decrement the

;iterating pointer

BRnzp push\_loop

push\_entry ADD R6, R6, #-1 ;Increment the

;bottom-of-stack pointer STI R0, BASE ;Push a value onto stack BRnzp success\_exit

success\_exit LD R1, Save1 ;Restore original

LD R2, Save2 ;register values LD R3, Save3

AND R5, R5, #0 ;R5 <--- success RET

fail\_exit LD R1, Save1 ;Restore original

LD R2, Save2 ;register values LD R3, Save3

AND R5, R5, #0

ADD R5, R5, #1 ;R5 <--- failure RET

BASE .FILL x3FFF

NBASE .FILL xC001 ; NBASE contains -x3FFF.

MAX .FILL xC005

Save1 .FILL x0000

Save2 .FILL x0000

Save3 .FILL x0000

8.6 ;PUSH:   
ADD R6, R6, #-2   
STR R0, R6, #0   
STR R1, R6, #1   
  
POP:   
LDR R0, R6, #0   
LDR R1, R6, #1   
ADD R6, R6, #2

8.7 ; Subroutines for carrying out the PUSH and POP functions. This

; program works with a stack consisting of memory locations x3FFF

; (BASE) through x3FFB (MAX). R6 is the stack pointer. R3 contains

; the size of the stack element. R4 is a pointer specifying the

; location of the element to PUSH from or the space to POP to

;

POP ST R2, Save2 ; are needed by POP. ST R1, Save1

ST R0, Save0

LD R1, BASE ; BASE contains -x3FFF. ADD R1, R1, #-1 ; R1 contains -x4000.

ADD R2, R6, R1 ; Compare stack pointer to x4000 BRz fail\_exit ; Branch if stack is empty.

ADD R0, R4, #0

ADD R1, R3, #0

ADD R5, R6, R3

ADD R5, R5, #-1

ADD R6, R6, R3

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| --- | --- | --- |
| pop\_loop | LDR  STR | R2, R5, #0  R2, R0, #0 |
|  | ADD | R0, R0, #1 |
|  | ADD | R5, R5, #-1 |
|  | ADD  BRp BRnzp | R1, R1, #-1  pop\_loop success\_exit |
| PUSH | ST | R2, Save2 ; Save registers that |
|  | ST | R1, Save1 ; are needed by PUSH. |
|  | ST | R0, Save0 |
|  | LD | R1,MAX ; MAX contains -x3FFB |
|  | ADD  BRz ADD ADD ADD | R2,R6,R1 ; Compare stack pointer to -x3FFB fail\_exit ; Branch if stack is full.  R0, R4, #0  R1, R3, #0  R5, R6, #-1 |
|  | NOT | R2, R3 |
|  | ADD | R2, R2, #1 |
|  | ADD | R6, R6, R2 |
| push\_loop | LDR | R2, R0, #0 |
|  | STR | R2, R5, #0 |
|  | ADD | R0, R0, #1 |
|  | ADD | R5, R5, #-1 |
|  | ADD  BRp | R1, R1, #-1  push\_loop |
| success\_exit | LD | R0, Save0 |
|  | LD | R1, Save1 ; Restore original |
|  | LD | R2, Save2 ; register values. |
| fail\_exit | AND RET  LD | R5, R5, #0 ; R5 <-- success.  R0, Save0 |
|  | LD | R1, Save1 ; Restore original |
|  | LD | R2, Save2 ; register values. |
|  | AND | R5, R5, #0 |
| BASE | ADD RET  .FILL | R5, R5, #1 ; R5 <-- failure.  xC001 ; BASE contains -x3FFF. |
| MAX | .FILL | xC005 |
| Save0 | .FILL | x0000 |

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| --- | --- | --- |
| Save1 | .FILL | x0000 |
| Save2 | .FILL | x0000 |

8.9 (a) BDECJKIHLG

* + - 1. Push Z

Push Y Pop Y Push X Pop X Push W Push V Pop V Push U Pop U Pop W Pop Z Push T Push S Pop S Push R Pop R Pop T

* + - 1. 14 different output streams.

8.11 16 memory locations are needed for the assembled program.  
 Address of C = **x400F**  
 After execution, C contains the **average** of the four consecutive values starting at memory location specified in B.

8.13 FACT ST R1, SAVE\_R1  
 ADD R1, R0, #0  
 **BRnp SKIP  
 ADD R1, R1, #1  
 BRnzp DONE**  
 **SKIP** ADD R0, R0, #-1  
 BRz DONE  
 AGAIN MUL R1, R1, R0  
 ADD R0, R0, #-1  
 BRnp AGAIN  
 DONE ADD R0, R1, #0  
 LD R1, SAVER1  
 RET  
 SAVE\_R1 .BLKW 1

8.15 NOTE: There is an error in the statement of this problem. See Errata Sheet for question. Additionally, this problem would belong in Chapter 9 rather than Chapter 8.

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| **MAR** | **MDR** |
| **x400E** | x5020 |
| **x400F** | xF0F0 |
| **x1FFF** | **x8002** |
| **x1FFE** | x4010 |
| **x00F0** | **x2000** |
| x2000 | x71BF |
| x1FFD | **x0000** |
| **x2001** | x8000 |
| **x1FFE** | **x4010** |
| **x1FFF** | **x8002** |
| **x4010** | xF025 |