

**Bug Free Coding with SPARK**  
**Ada**  
*Release 2024-09*

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**Sep 27, 2024**



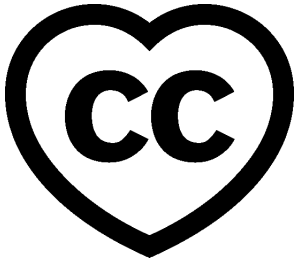
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Workshop project: Learn to write maintainable bug-free code with SPARK Ada.

This document was written by Robert Tice.

**Note**

The code examples in this course use an 80-column limit, which is a typical limit for Ada code. Note that, on devices with a small screen size, some code examples might be difficult to read.

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## LET'S BUILD A STACK

In this lab we will build a stack data structure and use the SPARK provers to find the errors in the below implementation.

### 1.1 Background

#### So, what is a stack?

A stack is like a pile of dishes...



1. The pile starts out empty.
2. You add ( push ) a new plate ( data ) to the stack by placing it on the top of the pile.
3. To get plates ( data ) out, you take the one off the top of the pile ( pop ).
4. Our stack has a maximum height ( size ) of 9 dishes

#### Pushing items onto the stack

Here's what should happen if we pushed the string MLH onto the stack.

Step 0:

Empty

1:	
2:	
3:	
4:	
5:	

Last = 0

Step 1:

Push("M")

1:	M
2:	
3:	
4:	
5:	

Last = 1

Step 2:

Push("L")

1:	M
2:	L
3:	
4:	
5:	

Last = 2

Step 3:

Push("H")

1:	M
2:	L
3:	H
4:	
5:	

Last = 3

Step 4:

Top()

1:	M
2:	L
3:	H
4:	
5:	

Last = 3

returns:

'H'

The list starts out empty. Each time we push a character onto the stack, Last increments by 1.

### Popping items from the stack



Here's what should happen if we popped 2 characters off our stack & then clear it.

Step 0:

Start

1:	M
2:	L
3:	H
4:	
5:	

Last = 3

Step 1:

Pop()

1:	M
2:	L
3:	H
4:	
5:	

Last = 2

returns:

'H'

Step 2:

Pop()

1:	M
2:	L
3:	H
4:	
5:	

Last = 1

returns:

'L'

Step 3:

Clear()

1:	M
2:	L
3:	H
4:	
5:	

Last = 0

Note that pop and clear don't unset the Storage array's elements, they just change the value of Last.

## 1.2 Input Format

N inputs will be read from stdin/console as inputs, C to the stack.

## 1.3 Constraints

$1 \leq N \leq 1000$

C is any character. Characters d and p will be special characters corresponding to the below commands:

p => Pops a character off the stack

d => Prints the current characters in the stack

## 1.4 Output Format

If the stack currently has the characters "M", "L", and "H" then the program should print the stack like this:

[M, L, H]

## 1.5 Sample Input

M L H d p d p d p d

## 1.6 Sample Output

[M, L, H] [M, L] [M] []

---

Listing 1: stack.ads

```
1 package Stack with SPARK_Mode => On is
2
3   procedure Push (V : Character)
4     with Pre => not Full,
5           Post => Size = Size'Old + 1;
6
7   procedure Pop (V : out Character)
8     with Pre => not Empty,
9           Post => Size = Size'Old - 1;
10
11  procedure Clear
12    with Post => Size = 0;
13
14  function Top return Character
15    with Post => Top'Result = Tab>Last);
16
17  Max_Size : constant := 9;
```

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```

18  -- The stack size.
19
20  Last : Integer range 0 .. Max_Size := 0;
21  -- Indicates the top of the stack. When 0 the stack is empty.
22
23  Tab : array (1 .. Max_Size) of Character;
24  -- The stack. We push and pop pointers to Values.
25
26  function Full return Boolean is (Last = Max_Size);
27
28  function Empty return Boolean is (Last < 1);
29
30  function Size return Integer is (Last);
31
32  end Stack;

```

Listing 2: stack.adb

```

1  package body Stack with SPARK_Mode => On is
2
3      -----
4      -- Clear --
5      -----
6
7      procedure Clear
8      is
9      begin
10         Last := Tab'First;
11     end Clear;
12
13     -----
14     -- Push --
15     -----
16
17     procedure Push (V : Character)
18     is
19     begin
20         Tab (Last) := V;
21     end Push;
22
23     -----
24     -- Pop --
25     -----
26
27     procedure Pop (V : out Character)
28     is
29     begin
30         Last := Last - 1;
31         V := Tab (Last);
32     end Pop;
33
34     -----
35     -- Top --
36     -----
37
38     function Top return Character
39     is
40     begin
41         return Tab (1);
42     end Top;
43

```

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```
44 end Stack;
```

Listing 3: main.adb

```

1 with Ada.Command_Line; use Ada.Command_Line;
2 with Ada.Text_IO;      use Ada.Text_IO;
3 with Stack;           use Stack;
4
5 procedure Main with SPARK_Mode => Off
6 is
7
8     -----
9     -- Debug --
10    -----
11
12    procedure Debug
13    is
14    begin
15
16        if not Stack.Empty then
17
18            Put ("[";
19            for I in Stack.Tab'First .. Stack.Size - 1 loop
20                Put (Stack.Tab (I) & ", ");
21            end loop;
22            Put_Line (Stack.Tab (Stack.Size) & "]");
23        else
24            Put_Line ("[]");
25        end if;
26
27    end Debug;
28
29    S : Character;
30
31 begin
32
33     -----
34     -- Main --
35     -----
36
37    for Arg in 1 .. Argument_Count loop
38        if Argument (Arg)'Length /= 1 then
39            Put_Line (Argument (Arg) & " is an invalid input to the stack.");
40        else
41            S := Argument (Arg)(Argument (Arg)'First);
42
43            if S = 'd' then
44                Debug;
45            elsif S = 'p' then
46                if not Stack.Empty then
47                    Stack.Pop (S);
48                else
49                    Put_Line ("Nothing to Pop, Stack is empty!");
50                end if;
51            else
52                if not Stack.Full then
53                    Stack.Push (S);
54                else
55                    Put_Line ("Could not push '" & S & "', Stack is full!");
56                end if;
57            end if;

```

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```
58     end if;  
59  
60     end loop;  
61  
62 end Main;
```