What does this C code do?

```c
int foo(char *s) {
    int L = 0;
    while (*s++) {
        ++L;
    }
    return L;
}
```
Machine Language and Pointers

- Array Indexing vs. Pointers
  - Pointer arithmetic, in particular
Representing strings

- A C-style string is represented by an array of bytes.
  - Elements are one-byte ASCII codes for each character.
  - A 0 value marks the end of the array.
Null-terminated Strings

- For example, “Harry Potter” can be stored as a 13-byte array.

<table>
<thead>
<tr>
<th>72</th>
<th>97</th>
<th>114</th>
<th>114</th>
<th>121</th>
<th>32</th>
<th>80</th>
<th>111</th>
<th>116</th>
<th>116</th>
<th>101</th>
<th>114</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>a</td>
<td>r</td>
<td>r</td>
<td>y</td>
<td>P</td>
<td>o</td>
<td>t</td>
<td>t</td>
<td>e</td>
<td>r</td>
<td>\0</td>
<td></td>
</tr>
</tbody>
</table>

- Since strings can vary in length, we put a 0, or null, at the end of the string.
  - This is called a null-terminated string

- Computing string length
  - We’ll look at two ways.
Array Indexing Implementation of strlen

```c
int strlen(char *string) {
    int len = 0;
    while (string[len] != 0) {
        len ++;
    }
    return len;
}
```
Pointers & Pointer Arithmetic

- Many programmers have a vague understanding of pointers
  - Looking at assembly code is useful for their comprehension.

```c
int strlen(char *string) {
    int len = 0;
    while (string[len] != 0) {
        len ++;
    }
    return len;
}
```

```c
int strlen(char *string) {
    int len = 0;
    while (*string != 0) {
        string ++;
        len ++;
    }
    return len;
}
```
What is a Pointer?

- A pointer is an address.
- Two pointers that point to the same thing hold the same address
- Dereferencing a pointer means loading from the pointer’s address
- A pointer has a type; the type tells us what kind of load to do
  - Use load byte (lb) for char *
  - Use load half (lh) for short *
  - Use load word (lw) for int *
  - Use load single precision floating point (l.s) for float *
- Pointer arithmetic is often used with pointers to arrays
  - Incrementing a pointer (i.e., ++) makes it point to the next element
  - The amount added to the point depends on the type of pointer
    - pointer = pointer + sizeof(pointer’s type)
      - 1 for char *, 4 for int *, 4 for float *, 8 for double *
What is really going on here...

```c
int strlen(char *string) {
    int len = 0;
    
    while (*string != 0) {
        string ++;
        len ++;
    }
    
    return len;
}
```
Structs

- Structs are like arrays, but the elements can be different types.
  - Same with objects

- Compiler/assembler inserts padding to “naturally align” data
  - Sometimes you can reorganize fields to eliminate padding.

- Consider:
Summary

- Machine language is the binary representation of instructions:
  - The format in which the machine actually executes them
- MIPS machine language is designed to simplify processor implementation
  - Fixed length instructions
  - 3 instruction encodings: R-type, I-type, and J-type
  - Common operations fit in 1 instruction
    - Uncommon (e.g., long immediates) require more than one
- Pointers are just addresses!!
  - “Pointees” are locations in memory
- Pointer arithmetic updates the address held by the pointer
  - “string ++” points to the next element in an array
  - Pointers are typed so address is incremented by sizeof(pointee)