1. Fill in the blanks with the appropriate word(s) taken from this list: constructs, bounds checking, instructions, multiple, attacks, registers, data types, compiler.

Machine-level programs, and their representation by assembly code, differ in many ways from C programs.

- There is minimal distinction between different ___ data types ___.
- The program is expressed as a sequence of ___ instructions ___, each of which performs a single operation.
- Parts of the program state, such as ___ registers ____ and the run-time stack, are directly visible to the programmer.
- Only low-level operations are provided to support data manipulation and program control. The compiler must use ___ multiple ___ instructions to generate and operate on different data structures and to implement control ___ constructs ___ such as conditionals, loops, and procedures.
We have covered many different aspects of C and how it gets compiled. We have seen that the lack of bounds checking in C makes many programs prone to buffer overflows. This has made many systems vulnerable to attacks by malicious intruders, although recent safeguards provided by the run-time system and the compiler help make programs more secure.

Participation Activity 6 – Solution
2. Consider the following array declaration and fill in the blanks:

In C:

\[ \text{short } A[4]; \]

\[ \begin{array}{cccc}
1 & 5 & 2 & 1 \\
\end{array} \]

\[ \text{A} \]

\[ \text{A} + 2 * _____ \]

In x86-64:

\[ \text{A + 2 * 3} \]

- In C, array \( A \) has 4 elements of data type \( T \).
- In x86-64 assembly, we compute the address of each element using \( A + i * L \):
  - where \( A \) is the base address (i.e., address of first element of \( A \rightarrow A[0] \))
  - where \( i \) is the index (position) of element we are focusing on (here, the 4\textsuperscript{th} element of \( A \))
  - where \( L \) is the \text{sizeof}(T)
- We are already given "\( A + 2 * _____ \)"
  - 2 can either be \( i \) or \( L \)
  - Since we are looking for the address of the 4\textsuperscript{th} element of \( A \), i.e., \( A[3] \), \( i \) must be 3, therefore 2 must be \( L \)
  - Since \( L \) is the \text{sizeof}(T) = 2, \text{i.e.,} 2 \text{ bytes then } T \text{ must be a short}