1. Lexical Errors:

  - Detected by the scanner (lexical analyzer).

  - Occur when the input source code contains invalid characters or tokens that don't conform to the language's lexical rules.

  - Examples include misspelled keywords, undefined symbols, and characters that are not allowed in identifiers.

  - These errors are the first step in the compilation process and are typically reported early during tokenization.

2. Syntax Errors:

  - Detected by the parser (syntax analyzer).

  - Arise when the structure of the code violates the language's syntax rules.

  - Examples include missing or misplaced parentheses, incorrect usage of operators, and improper statement sequencing.

  - Syntax errors prevent the parser from generating a valid parse tree or abstract syntax tree.

3. Static Semantic Errors:

  - Detected during the analysis phase of compilation.

  - These errors involve violations of semantic rules that can be identified without executing the program.

  - Examples include type mismatches, undeclared variables, and accessing array elements with out-of-bounds indices.

  - Static semantic errors can be caught by a sophisticated compiler's type checker or symbol table analysis.

4. Dynamic Semantic Errors:

  - Detected during the runtime or execution phase.

  - These errors involve issues that can only be identified while the program is running.

  - Examples include division by zero, null pointer dereferences, and array index out-of-bounds errors.

  - Dynamic semantic errors require running the program on inputs that trigger the problematic behavior.

Key Differences:

- Lexical errors are detected by the scanner, syntax errors by the parser, and both static and dynamic semantic errors involve more complex analysis.

- Lexical and syntax errors prevent the compiler from producing a valid intermediate representation, while semantic errors may lead to incorrect program behavior or crashes.

- Static semantic errors are detected before program execution, while dynamic semantic errors occur during program execution.

- Static semantic errors are usually caught by analyzing the program's structure and types, while dynamic semantic errors require specific inputs to manifest.

- Fixing lexical and syntax errors often involves correcting code formatting and structure, while fixing semantic errors requires understanding the program's logic and intent.