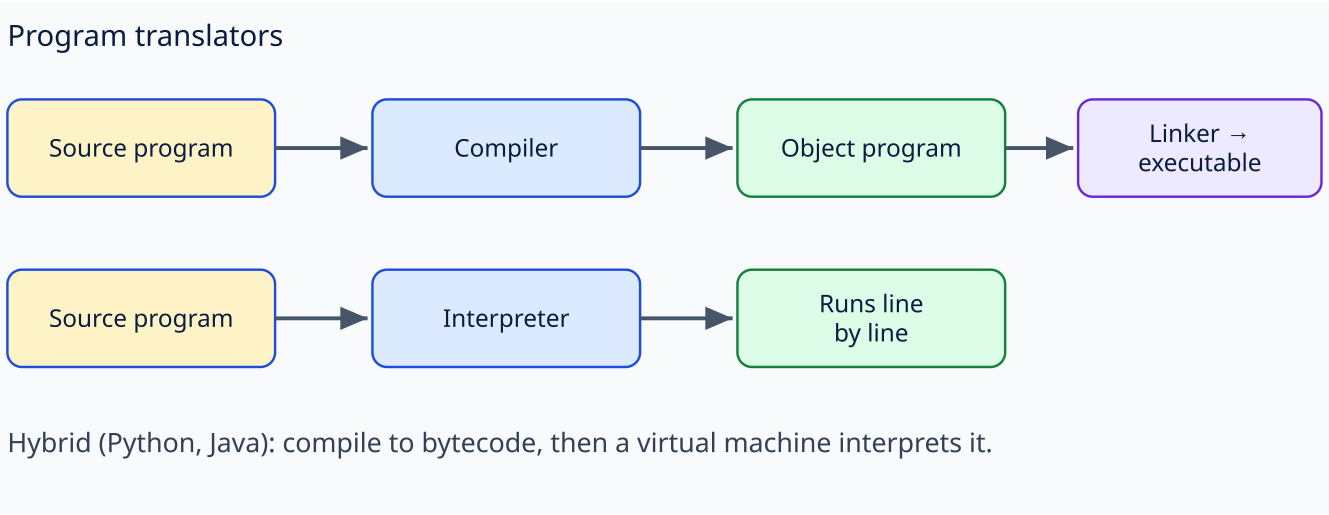
Grade 13 A/L ICT · Lesson 9

9.5 Program Translation: Compilers, Interpreters and Linkers

Syllabus 9.5. A CPU understands only machine code, so a **source program** written in a high-level language must be **translated**. **Compilers** translate the whole program into an **object program**; **interpreters** translate and run one statement at a time; the **hybrid approach** compiles to bytecode that a virtual machine interprets. **Linkers** join object code and libraries into one executable.

1. Translators



Compiler, interpreter, linker and hybrid

Feature	Compiler	Interpreter
Translates	Whole program at once	One statement at a time
Output	Object/executable file	No separate file
Speed of running	Fast after compiling	Slower
Errors	Listed after translation	Stops at the first error
Examples	C, C++	JavaScript (classic), BASIC

2. Python uses the hybrid approach

🐍 Syntax error found before running vs runtime error

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```
good = "x = 10\nprint(x * 2)"
bad = "print(10 +)"
code = compile(good, "good.py", "exec")   # translate to bytecode
exec(code)
try:
    compile(bad, "bad.py", "exec")
except SyntaxError:
    print("Syntax error: not translated")
try:
    print(10 / 0)
except ZeroDivisionError:
    print("Runtime error: division by zero")
```

▶ Output

```
20
Syntax error: not translated
Runtime error: division by zero
```

🧱 **Worked example: Why does the bad program never run, while the division error appears only when running?**
compile() translates source to **bytecode** first. "print(10 +)" breaks the grammar, so translation fails with a **syntax error** and nothing runs. 10 / 0 is grammatically correct, so it is translated, but fails at **run time**.

💡 Source program = what you write; object program = translated machine code.

🚀 **Beyond the syllabus (2026 update)** *Not required for the exam – read for interest.* In 2026 JavaScript engines and Python 3.13+ use just-in-time (JIT) compilation to speed up hot code while it runs.

Key Words

Source program – Program written by a programmer in a high-level language.

Object program – Machine code produced by translating source code.

Translator – Program that converts source code into machine code.

Compiler – Translates the whole program before running.

Interpreter – Translates and runs one statement at a time.

Hybrid approach – Compile to bytecode then interpret it on a virtual machine.

Bytecode – Intermediate code run by a virtual machine.

Linker – Joins object files and libraries into one executable.

Assembler – Translates assembly language into machine code.

Syntax error – Error in the grammar of the language found during translation.

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Runtime error – Error that happens while the program is running.

Executable file – File that the operating system can run directly.

Sample Q&A

1. Why is translation needed?

> **Answer:** The CPU understands only machine code.

2. Compiler vs interpreter?

> **Answer:** Compiler translates all first; interpreter one statement at a time.

3. What is the hybrid approach?

> **Answer:** Compile to bytecode, then a virtual machine interprets it (Python, Java).

4. What does a linker do?

> **Answer:** Joins object files and libraries into an executable.

5. Which line of the translate program is never run?

> **Answer:** print(10 +) – it has a syntax error.

6. Source vs object program?

> **Answer:** Source is written by people; object is translated machine code.

MCQ

1. A translator that converts the whole program before running is a

A. compiler
B. loader
C. interpreter
D. linker
E. editor

2. A translator that runs one statement at a time is an

A. interpreter
B. assembler
C. debugger
D. linker
E. compiler

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3. Joining object code with libraries is done by a

A. compiler
B. linker
C. editor
D. interpreter
E. debugger

4. Python and Java translate to bytecode first; this is the

A. pure compiler approach
B. assembly approach
C. linker approach
D. machine approach
E. hybrid approach

5. print(10 +) produces a

A. logic error
B. syntax error
C. runtime error
D. no error
E. linker error

6. 10 / 0 in Python produces a

A. runtime error
B. no error
C. syntax error
D. compile error
E. linker error

7. The program written by the programmer is the

A. bytecode only
B. source program
C. executable
D. object program
E. library

8. Assembly language is translated by an

A. browser
B. interpreter
C. assembler
D. editor
E. linker

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9. Which term means: “Program written by a programmer in a high-level language”?

A. Translator
B. Linker
C. Hybrid approach
D. Source program
E. Runtime error

10. Which term means: “Machine code produced by translating source code”?

A. Assembler
B. Bytecode
C. Object program
D. Compiler
E. Executable file

11. Which term means: “Program that converts source code into machine code”?

A. Source program
B. Linker
C. Interpreter
D. Translator
E. Syntax error

12. Which term means: “Translates the whole program before running”?

A. Runtime error
B. Compiler
C. Object program
D. Hybrid approach
E. Assembler

13. Which term means: “Translates and runs one statement at a time”?

A. Executable file
B. Bytecode
C. Translator
D. Interpreter
E. Syntax error

14. Which term means: “Compile to bytecode then interpret it on a virtual machine”?

A. Runtime error
B. Source program
C. Compiler
D. Linker
E. Hybrid approach

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15. Which term means: “Intermediate code run by a virtual machine”?

A. Object program
B. Interpreter
C. Bytecode
D. Assembler
E. Executable file

16. Which term means: “Joins object files and libraries into one executable”?

A. Source program
B. Hybrid approach
C. Linker
D. Syntax error
E. Translator

17. Which term means: “Translates assembly language into machine code”?

A. Bytecode
B. Object program
C. Compiler
D. Runtime error
E. Assembler

18. Which term means: “Error in the grammar of the language found during translation”?

A. Syntax error
B. Executable file
C. Translator
D. Interpreter
E. Linker

19. Which term means: “Error that happens while the program is running”?

A. Compiler
B. Assembler
C. Hybrid approach
D. Source program
E. Runtime error

20. Which term means: “File that the operating system can run directly”?

A. Bytecode
B. Object program
C. Syntax error
D. Executable file
E. Interpreter

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Structured Questions

1. Explain why program translation is needed. *(2 marks)*

> CPU understands machine code only; high-level code must be converted.

2. Compare compilers and interpreters (three points). *(3 marks)*

> Whole vs line; object file vs none; error reporting/speed.

3. Describe the hybrid approach used by Python. *(3 marks)*

> Source to bytecode; virtual machine interprets; portable.

4. Explain the function of a linker. *(3 marks)*

> Combines object modules and libraries; resolves calls; makes executable.

5. Distinguish syntax and runtime errors with Python examples. *(2 marks)*

> print(10 +) syntax; 10 / 0 runtime.

Summary

- Source code must be translated to machine code.
- Compilers translate the whole program.
- Interpreters translate statement by statement.
- Python is hybrid: bytecode + virtual machine.
- Linkers build the final executable.

MCQ answer key – 9.5

1. **A** – Compiler.
2. **A** – Interpreter.
3. **B** – Linker.
4. **E** – Hybrid.
5. **B** – Grammar.
6. **A** – At run time.
7. **B** – Source.
8. **C** – Assembler.
9. **D** – Source program – Program written by a programmer in a high-level language.
10. **C** – Object program – Machine code produced by translating source code.
11. **D** – Translator – Program that converts source code into machine code.
12. **B** – Compiler – Translates the whole program before running.
13. **D** – Interpreter – Translates and runs one statement at a time.
14. **E** – Hybrid approach – Compile to bytecode then interpret it on a virtual machine.
15. **C** – Bytecode – Intermediate code run by a virtual machine.

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16. **C** – Linker – Joins object files and libraries into one executable.
17. **E** – Assembler – Translates assembly language into machine code.
18. **A** – Syntax error – Error in the grammar of the language found during translation.
19. **E** – Runtime error – Error that happens while the program is running.
20. **D** – Executable file – File that the operating system can run directly.

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