In order to write software a programmer will use a programming language to write code in a way that is understandable to the programmer.

However, the processor will not be able to run the programmer's code and therefore it has to be translated into machine code that can be processed.

Translators are software that convert programs from one language to another. There are three types of translator: compiler, interpreter and assembler.

Term	Definition
Compiler	A compiler is a program that converts high level language programs into machine code for execution at a later time. The entire program is converted at one time.
Interpreter	An interpreter is a program which converts code one line at a time, into machine code and executes it.
Assembler	An assembler is a program which converts the low-level assembly programming language into machine code.

Interpreters and compilers are used to translate high level language programs.

Term	Definition
High level Language	A high level language allows programmers to write programs that are independent of a particular type of computer. Such languages are considered high level because they are closer to spoken language and further away from machine code.

```
2  if age > 11 then
3      print "Secondary school"
4  else
5      print "Primary School"
6      end if
7
```

Term	Definition
Source code	Programming code that has not yet been translated into an executable file.
Object code	Translated code that can be executed by a computer.

Interpreter

An interpreter reads a statement from the high level code and converts that line of the source code into object code and executes it straight away. If there is an error in a line of source code the interpreter will stop the translation process.

Interpreters are often used in the development of a program as they make debugging the code easier.

No executable file is produced, and the program is translated from the beginning each time it is run.

Compiler

A compiler translates the entire source code program into object code before the program is executed producing an executable file.

An advantage of a compiler is that once the code has been translated it can be run many times without having to be translated again.

A disadvantage of a compiler is that if there is an error in the code the translation will carry on and the error is not reported until the end of the process.

The compilation process involves the following steps:

Lexical analysis:

- Comments (annotations) and unneeded spaces are removed.
- Keywords, constants and identifiers are replaced by tokens.

Term	Examples
Keywords	IF, WHILE, DO, REPEAT
Constants	100, 3.1429, -73
Identifiers	Variable names, subroutine names

Symbol table construction

- A symbol table is created which holds the addresses of variables, labels and subroutines.

Syntax analysis

- Tokens are checked to see if they match the spelling and grammar expected, using standard language definitions. This is done by parsing each token to see if it uses the correct syntax for the programming language.

- If syntax errors are found, error messages will be produced.

Term	Definition
Parsing	Analysing a string of tokens
Syntax	The rules for the structure of statements in a programming language

Semantic analysis

- Variables are checked to ensure that they have been properly declared and used.

- Variables are checked to ensure that they are of the correct data type – real values are not being assigned to integers.

- Operators are checked to ensure that they are valid for the type of variable being used.

Code generation and optimisation

- Machine code is generated.

- Code optimisation may be used to ensure that the object code is as efficient, fast and less resource intense as possible.

op	target address	
2	1024	decimal
000010	00000 00000 00000 10000 000000	binary

Programming errors

When an error occurs in code, the program fails to compile or to run. Error messages are displayed to help the programmer diagnose what has gone wrong.

```
Python 3.8.1 Shell
Python 3.8.1 (v3.8.1:1b293b6006, Dec 18 2019, 14:08:53)
[Clang 6.0 (clang-600.0.57)] on darwin
Type "help", "copyright", "credits" or "license()" for more information.
>>>
=========== RESTART: /Users/jengillies/Downloads/program 2/program.py ===========
Welcome to Parkwood Vale Athletics Club.
Main Menu, type in which option you would like:
Option 1: Create new member
Option 2: Renew membership
Option 3: How many days left until member needs to pay
Option 4: Reminder for renewal
Option 5: Check for overdue membership
Option 6: Cancel membership.
ValueError: invalid literal for int() with base 10: 'A'
>>>
```

Syntax errors

A syntax error is an error in the source code of a program. As the code in a computer programs must follow strict syntax rules to compile correctly, any aspects of the code that do not follow the syntax of the programming language will cause a syntax error.

Incorrect: Whale x < 6   Correct: While x < 6

Runtime / execution error

A runtime error only happens when the code is run. It is an error that is difficult to foresee before the code is run.

A typical runtime error is an attempt to divide a number by zero which will cause the program to crash.

Logical error

A logical (logic) error is a mistake in a program's source code that results in incorrect or unexpected behaviour.

An example would be using the wrong operator in a calculation.

Linking error

An error that occurs when a programmer calls a function within a program, but the correct library has not been linked to the program.

An example would be when the code uses the square root function that has not been linked to the program.

Rounding error

A rounding error is the difference between a rounded-off numerical value and the actual value. A rounded quantity is represented by a numeral with a fixed number of allowed digits.

Actual value: 3.1429   Rounded value: 3.14

Truncation error

Truncation error is the difference between a truncated value and the actual value. A truncated quantity is represented by a numeral with a fixed number of allowed digits, with any excess digits "chopped off".

Actual value: 7.99   Truncated value: 7

This creates an error of - 0.99.

Example Question

The following program is intended to calculate a total mark achieved by one student who has taken 4 tests. The program contains two errors.

```
total is integer
count is integer
mark is integer

total = 0

for count = 1 to 4
  input mark
  total = total – mark
next count
```

Name the errors and write down the correct code.

Syntax error – input Mark

Logic error – Total = Total + Mark