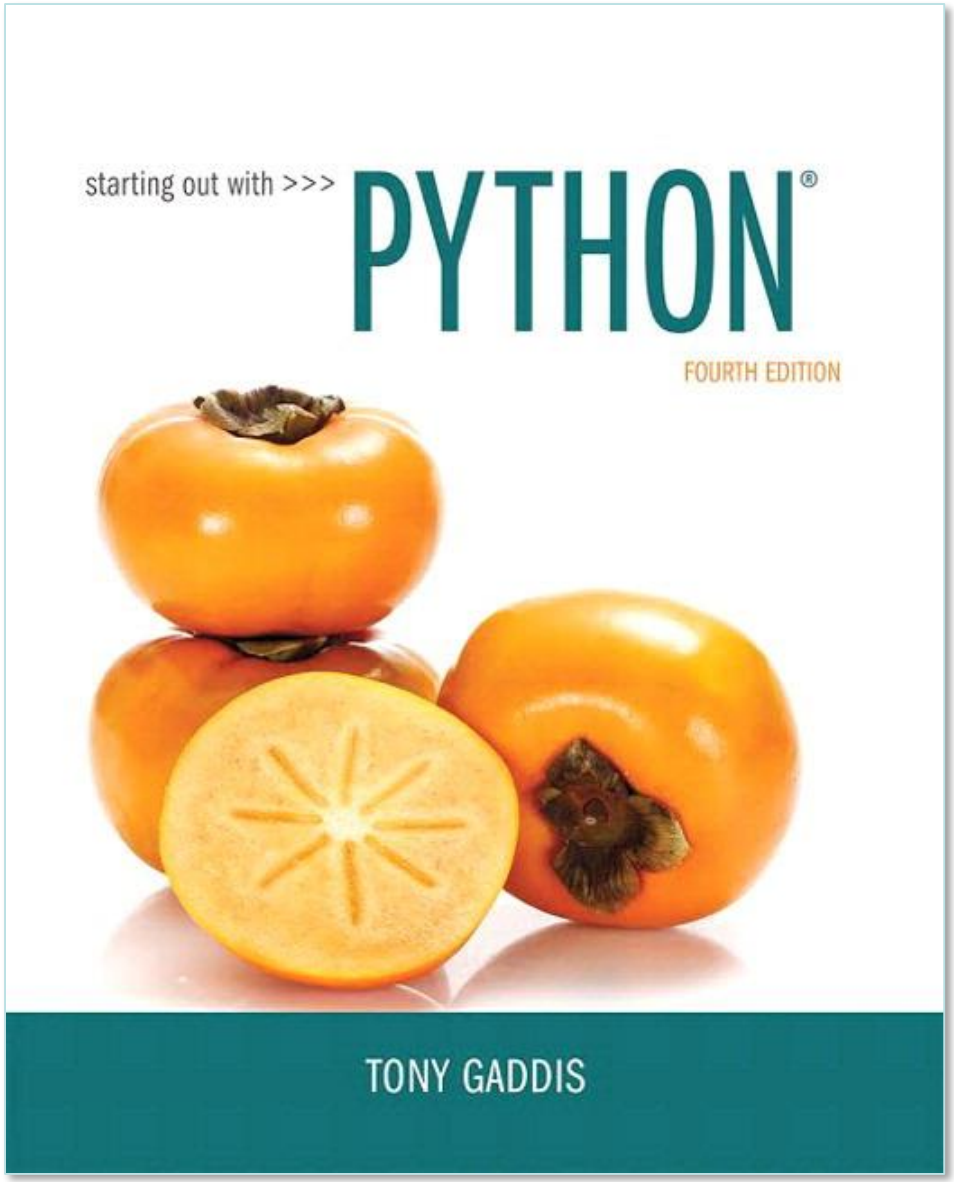
CHAPTER 3

Decision Structures and Boolean Logic



Topics

- The `if` Statement
- The `if-else` Statement
- Comparing Strings
- Nested Decision Structures and the `if-elif-else` Statement
- Logical Operators
- Boolean Variables
- Turtle Graphics: Determining the State of the Turtle

The `if` Statement

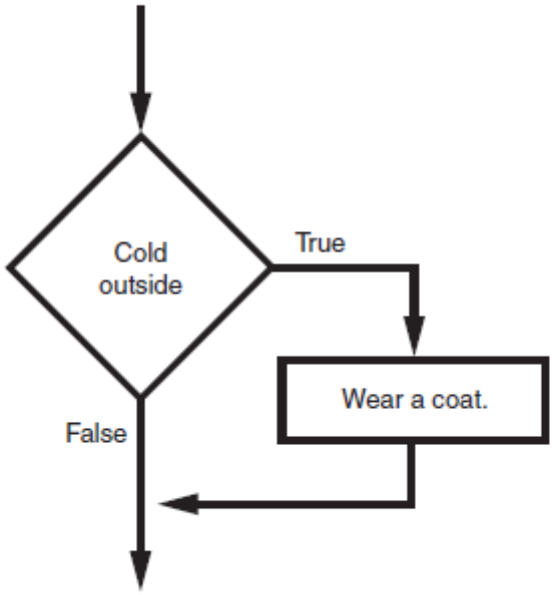
- **Control structure: logical design that controls order in which set of statements execute**
- **Sequence structure: set of statements that execute in the order they appear**
- **Decision structure: specific action(s) performed only if a condition exists**
  - Also known as selection structure

The `if` Statement (cont'd.)

- **In flowchart, diamond represents true/false condition that must be tested**
- **Actions can be *conditionally executed***
  - Performed only when a condition is true
- **Single alternative decision structure: provides only one alternative path of execution**
  - If condition is not true, exit the structure

The `if` Statement (cont'd.)

Figure 3-1 A simple decision structure



The `if` Statement (cont'd.)

- **Python syntax:**

```
if condition:
    Statement
    Statement
```

- **First line known as the `if` clause**
  - Includes the keyword `if` followed by condition
    - The condition can be true or false
    - When the `if` statement executes, the condition is tested, and if it is true the block statements are executed. otherwise, block statements are skipped

Boolean Expressions and Relational Operators

- **Boolean expression: expression tested by if statement to determine if it is true or false**
  - Example: a > b
    - `true` if a is greater than b; `false` otherwise
- **Relational operator: determines whether a specific relationship exists between two values**
  - Example: greater than (>)

Boolean Expressions and Relational Operators (cont'd.)

- **>= and <= operators test more than one relationship**
  - It is enough for one of the relationships to exist for the expression to be true
- **== operator determines whether the two operands are equal to one another**
  - Do not confuse with assignment operator (=)
- **!= operator determines whether the two operands are not equal**

Boolean Expressions and Relational Operators (cont'd.)

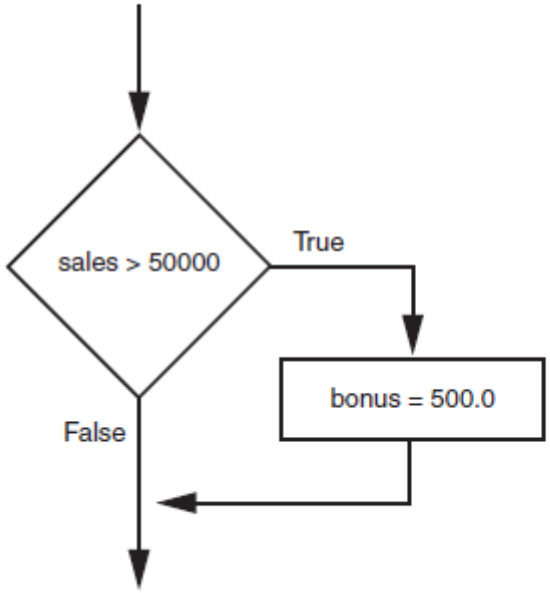
Table 3-2 Boolean expressions using relational operators

Expression	Meaning
`x > y`	Is x greater than y?
`x < y`	Is x less than y?
`x >= y`	Is x greater than or equal to y?
`x <= y`	Is x less than or equal to y?
`x == y`	Is x equal to y?
`x != y`	Is x not equal to y?

Boolean Expressions and Relational Operators (cont'd.)

- **Using a Boolean expression with the > relational operator**

Figure 3-3 Example decision structure



Boolean Expressions and Relational Operators (cont'd.)

- **Any relational operator can be used in a decision block**
  - Example: `if balance == 0`
  - Example: `if payment != balance`
- **It is possible to have a block inside another block**
  - Example: `if` statement inside a function
  - Statements in inner block must be indented with respect to the outer block

The `if-else` Statement

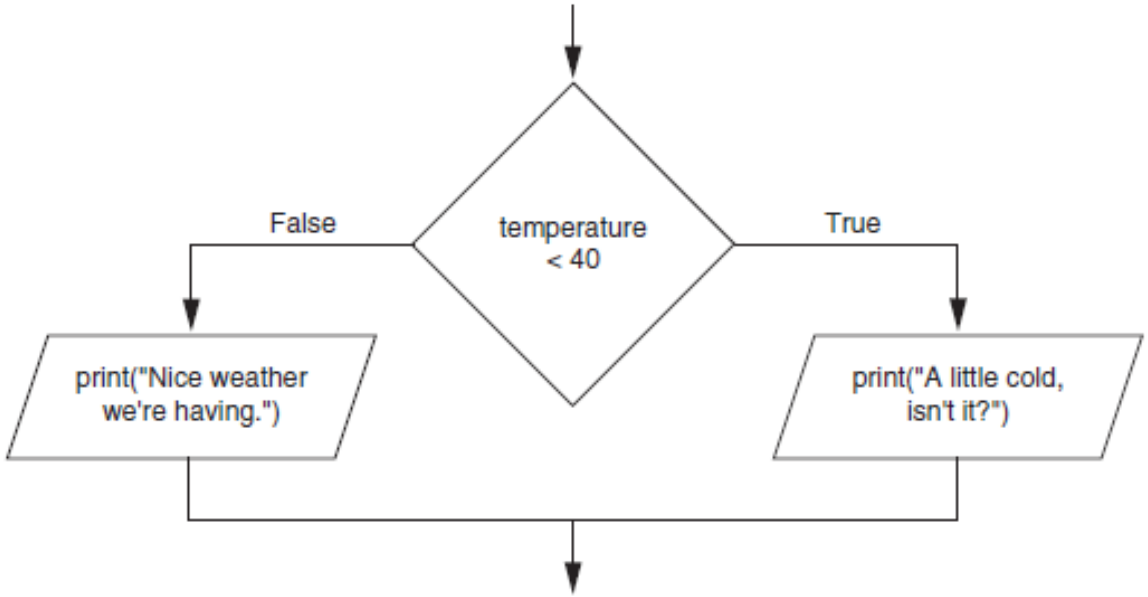
- **Dual alternative decision structure: two possible paths of execution**
  - One is taken if the condition is true, and the other if the condition is false
  - Syntax:

```
if condition:
        statements
else:
        other statements
```

  - `if` clause and `else` clause must be aligned
  - Statements must be consistently indented

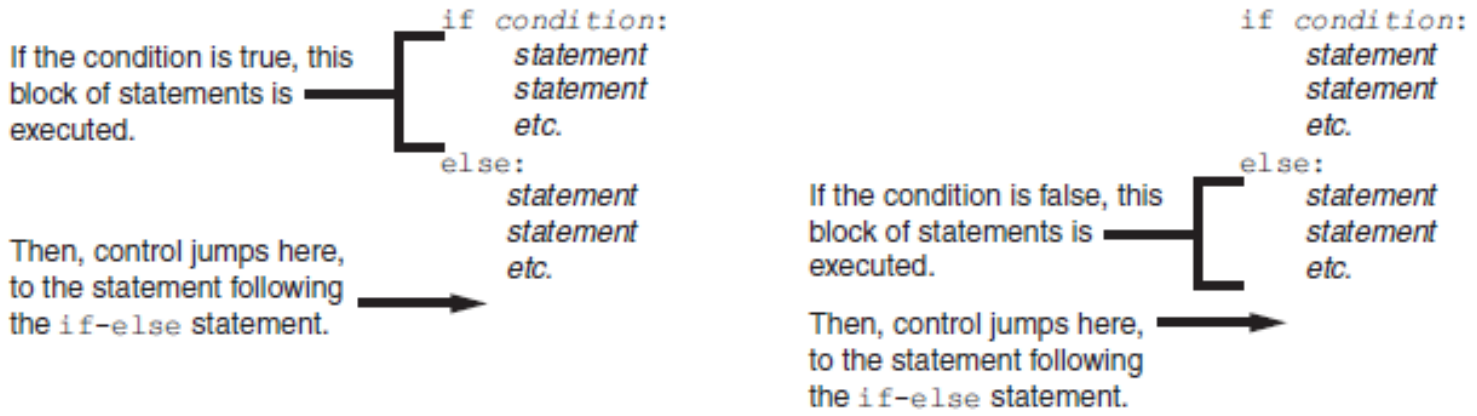
The `if-else` Statement (cont'd.)

Figure 3-5 A dual alternative decision structure



The `if-else` Statement (cont'd.)

Figure 3-6 Conditional execution in an `if-else` statement

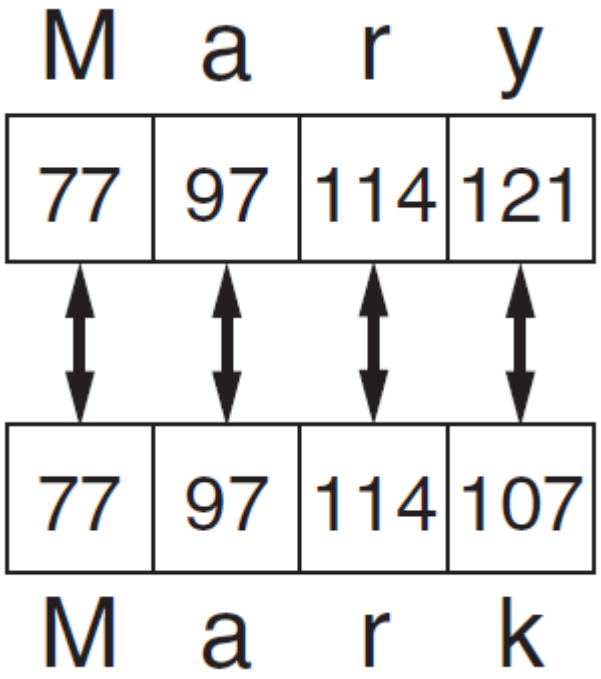


Comparing Strings

- **Strings can be compared using the == and != operators**
- **String comparisons are case sensitive**
- **Strings can be compared using >, <, >=, and <=**
  - Compared character by character based on the ASCII values for each character
  - If shorter word is substring of longer word, longer word is greater than shorter word

Comparing Strings (cont'd.)

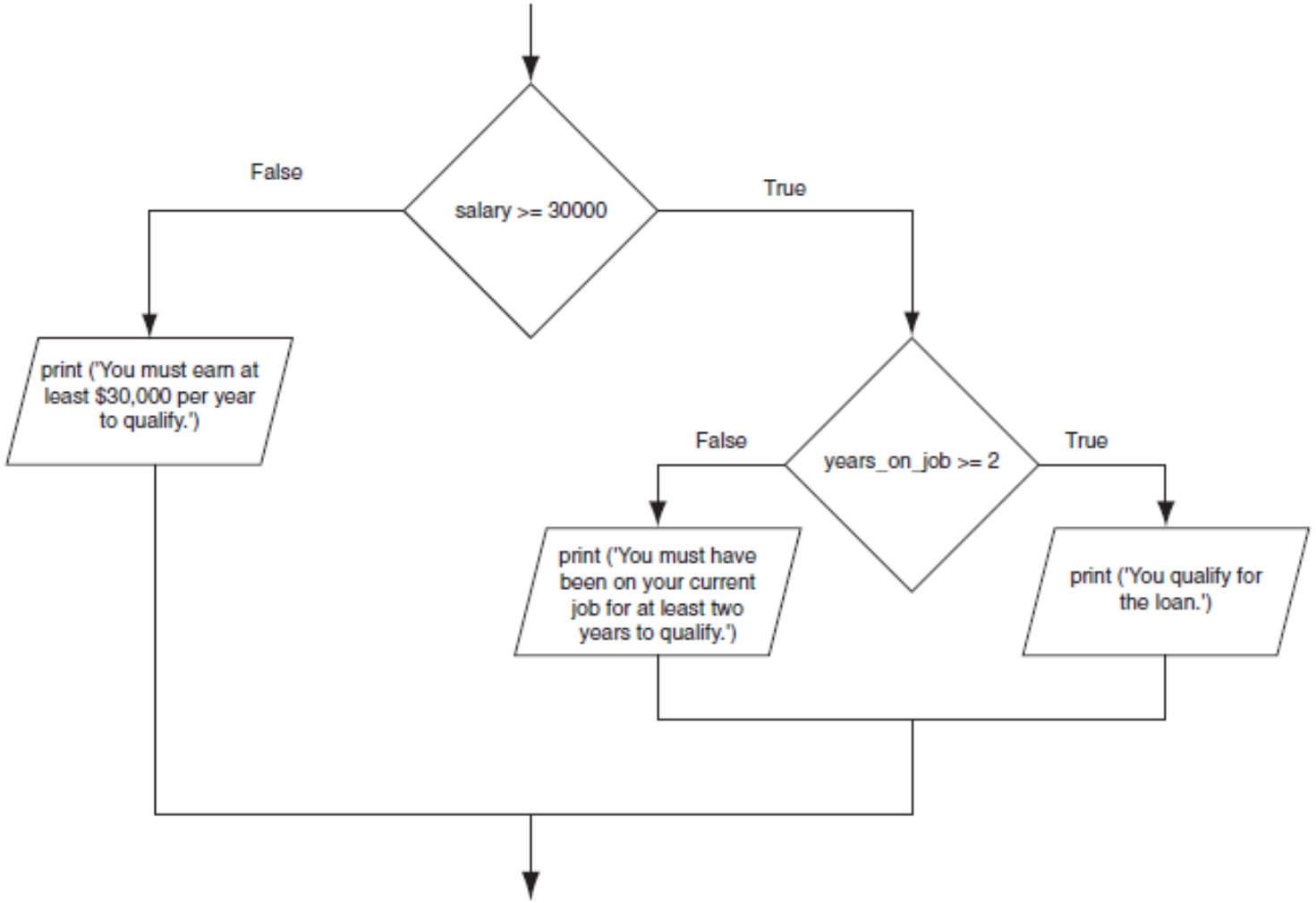
Figure 3-9 Comparing each character in a string



Nested Decision Structures and the `if-elif-else` Statement

- **A decision structure can be nested inside another decision structure**
  - Commonly needed in programs
  - Example:
    - Determine if someone qualifies for a loan, they must meet two conditions:
      - Must earn at least $30,000/year
      - Must have been employed for at least two years
    - Check first condition, and if it is true, check second condition

Figure 3-12 A nested decision structure



Nested Decision Structures and the `if-elif-else` Statement (cont'd.)

- **Important to use proper indentation in a nested decision structure**
  - Important for Python interpreter
  - Makes code more readable for programmer
  - Rules for writing nested if statements:
    - `else` clause should align with matching `if` clause
    - Statements in each block must be consistently indented

The `if-elif-else` Statement

- **`if-elif-else` statement: special version of a decision structure**
  - Makes logic of nested decision structures simpler to write
    - Can include multiple `elif` statements
  - Syntax:

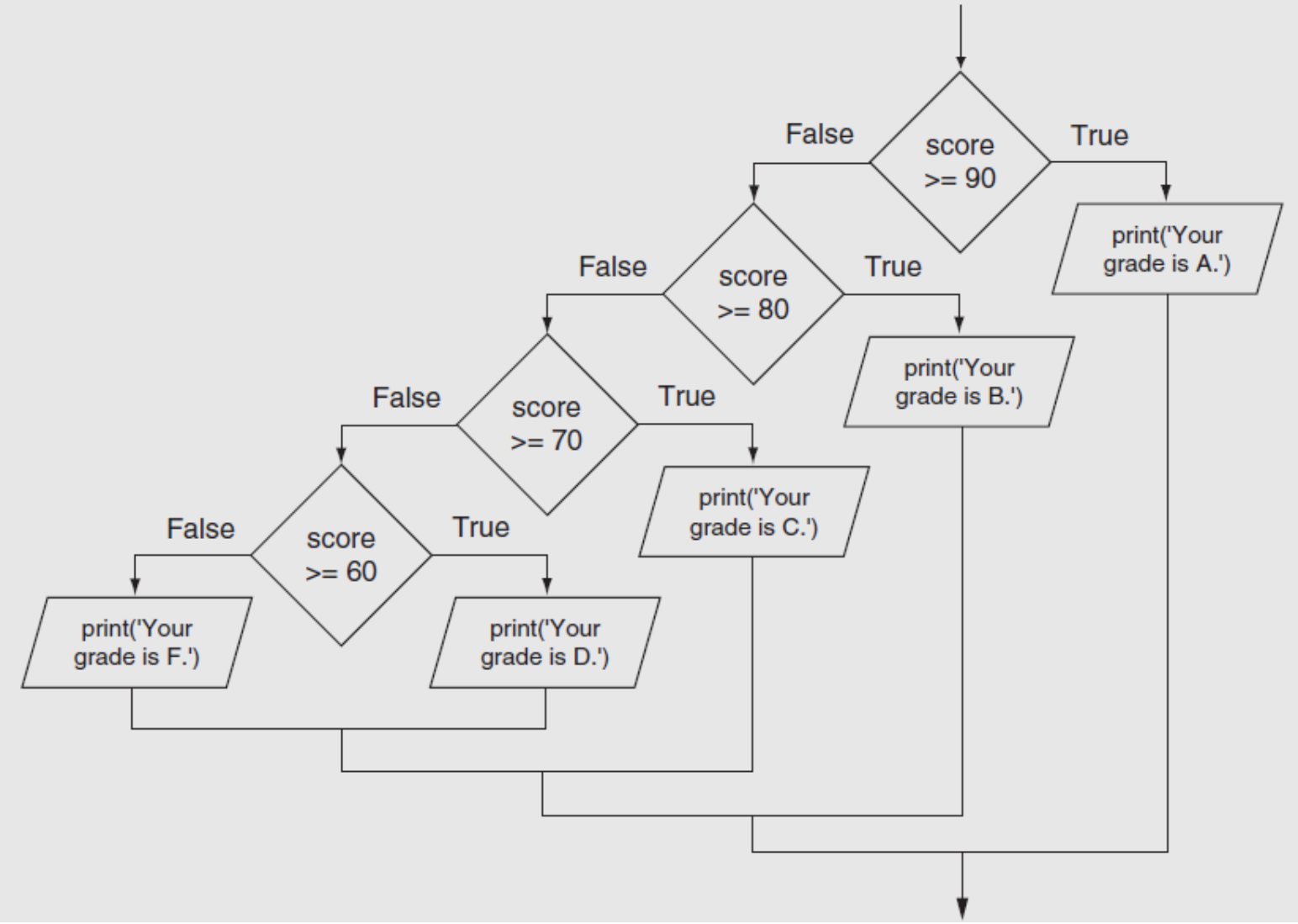
```
if condition_1:
    statement(s)
elif condition_2:
    statement(s)
elif condition_3:
    statement(s)
else
    statement(s)
```

Insert as many `elif` clauses as necessary.

The `if-elif-else` Statement (cont'd.)

- **Alignment used with `if-elif-else` statement:**
  - `if`, `elif`, and `else` clauses are all aligned
  - Conditionally executed blocks are consistently indented
- **`if-elif-else` statement is never required, but logic easier to follow**
  - Can be accomplished by nested `if-else`
    - Code can become complex, and indentation can cause problematic long lines

Figure 3-15 Nested decision structure to determine a grade



Logical Operators

- **Logical operators: operators that can be used to create complex Boolean expressions**
  - `and` operator and `or` operator: binary operators, connect two Boolean expressions into a compound Boolean expression
  - `not` operator: unary operator, reverses the truth of its Boolean operand

The `and` Operator

- **Takes two Boolean expressions as operands**
  - Creates compound Boolean expression that is true only when both sub expressions are true
  - Can be used to simplify nested decision structures
- **Truth table for the `and` operator**

Expression	Value of the Expression
false and false	false
false and true	false
true and false	false
true and true	true

The `or` Operator

- **Takes two Boolean expressions as operands**
  - Creates compound Boolean expression that is true when either of the sub expressions is true
  - Can be used to simplify nested decision structures
- **Truth table for the `or` operator**

Expression	Value of the Expression
false and false	false
false and true	true
true and false	true
true and true	true

Short-Circuit Evaluation

- **Short circuit evaluation: deciding the value of a compound Boolean expression after evaluating only one sub expression**
  - Performed by the `or` and `and` operators
    - For `or` operator: If left operand is true, compound expression is true. Otherwise, evaluate right operand
    - For `and` operator: If left operand is false, compound expression is false. Otherwise, evaluate right operand

The `not` Operator

- **Takes one Boolean expressions as operand and reverses its logical value**
  - Sometimes it may be necessary to place parentheses around an expression to clarify to what you are applying the not operator
- **Truth table for the `not` operator**

Expression	Value of the Expression
true	false
false	true

Checking Numeric Ranges with Logical Operators

- **To determine whether a numeric value is within a specific range of values, use `and`**
  - Example: `x >= 10 and x <= 20`
- **To determine whether a numeric value is outside of a specific range of values, use `or`**
  - Example: `x < 10 or x > 20`

Boolean Variables

- **Boolean variable: references one of two values, `True` or `False`**
  - Represented by `bool` data type
- **Commonly used as flags**
  - Flag: variable that signals when some condition exists in a program
    - Flag set to `False` → condition does not exist
    - Flag set to `True` → condition exists

Turtle Graphics: Determining the State of the Turtle

- **The `turtle.xcor()` and `turtle.ycor()` functions return the turtle's *X* and *Y* coordinates**
- **Examples of calling these functions in an `if` statement:**

```
if turtle.ycor() < 0:
    turtle.goto(0, 0)
```

```
if turtle.xcor() > 100 and turtle.xcor() < 200:
    turtle.goto(0, 0)
```

Turtle Graphics: Determining the State of the Turtle

- **The `turtle.heading()` function returns the turtle's heading. (By default, the heading is returned in degrees.)**
- **Example of calling the function in an `if` statement:**

```
if turtle.heading() >= 90 and turtle.heading() <= 270:
    turtle.setheading(180)
```

Turtle Graphics: Determining the State of the Turtle

- **The `turtle.isdown()` function returns `True` if the pen is down, or `False` otherwise.**
- **Example of calling the function in an `if` statement:**

```
if turtle.isdown():
    turtle.penup()

if not(turtle.isdown()):
    turtle.pendown()
```

Turtle Graphics: Determining the State of the Turtle

- **The `turtle.isvisible()` function returns `True` if the turtle is visible, or `False` otherwise.**
- **Example of calling the function in an `if` statement:**

```
if turtle.isvisible():
    turtle.hideturtle()
```

Turtle Graphics: Determining the State of the Turtle

- **When you call `turtle.pencolor()` without passing an argument, the function returns the pen's current color as a string. Example of calling the function in an `if` statement:**

```
if turtle.pencolor() == 'red':
    turtle.pencolor('blue')
```

- **When you call `turtle.fillcolor()` without passing an argument, the function returns the current fill color as a string. Example of calling the function in an `if` statement:**

```
if turtle.fillcolor() == 'blue':
    turtle.fillcolor('white')
```

Turtle Graphics: Determining the State of the Turtle

- **When you call `turtle.bgcolor()` without passing an argument, the function returns the current background color as a string. Example of calling the function in an `if` statement:**

```
if turtle.bgcolor() == 'white':
    turtle.bgcolor('gray')
```

Turtle Graphics: Determining the State of the Turtle

- **When you call `turtle.pensize()` without passing an argument, the function returns the pen's current size as a string. Example of calling the function in an `if` statement:**

```
if turtle.pensize() < 3:
    turtle.pensize(3)
```

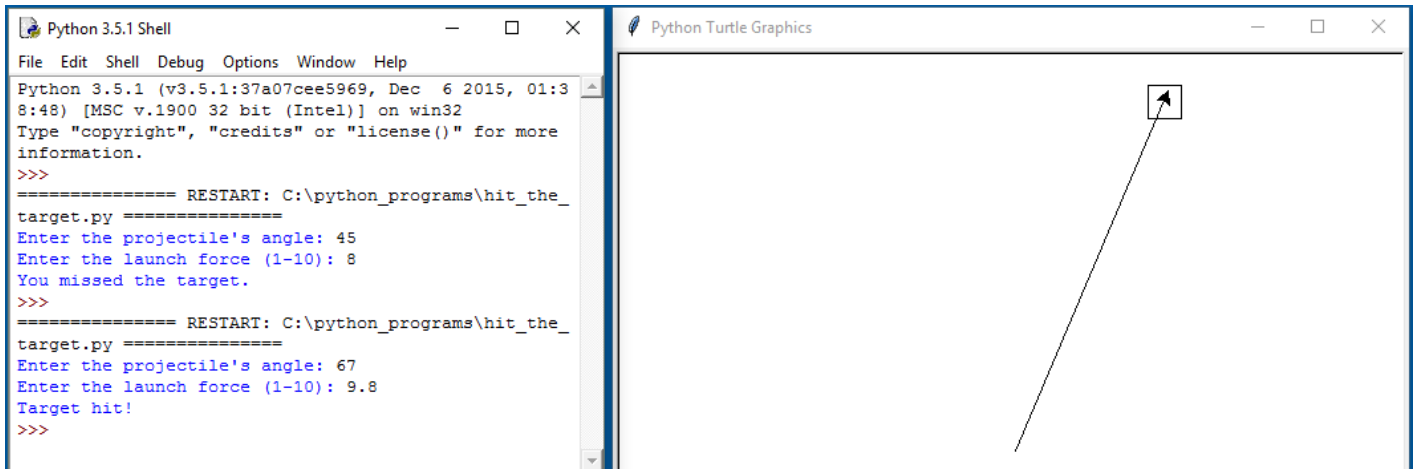
Turtle Graphics: Determining the State of the Turtle

- **When you call `turtle.speed()` without passing an argument, the function returns the current animation speed. Example of calling the function in an `if` statement:**

```
if turtle.speed() > 0:
    turtle.speed(0)
```

Turtle Graphics: Determining the State of the Turtle

- **See *In the Spotlight: The Hit the Target Game* in your textbook for numerous examples of determining the state of the turtle.**



Summary

- **This chapter covered:**
  - Decision structures, including:
    - Single alternative decision structures
    - Dual alternative decision structures
    - Nested decision structures
  - Relational operators and logical operators as used in creating Boolean expressions
  - String comparison as used in creating Boolean expressions
  - Boolean variables
  - Determining the state of the turtle in Turtle Graphics