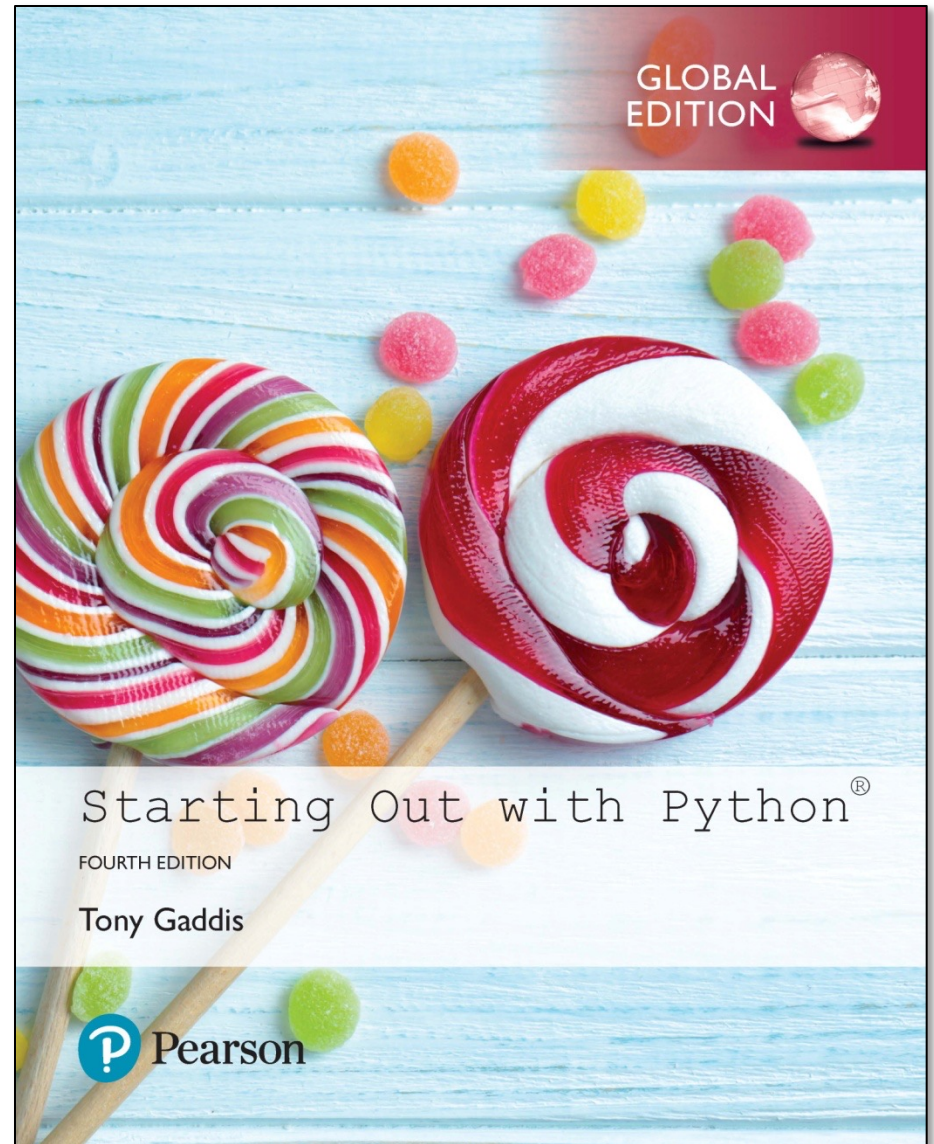


CHAPTER 3

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

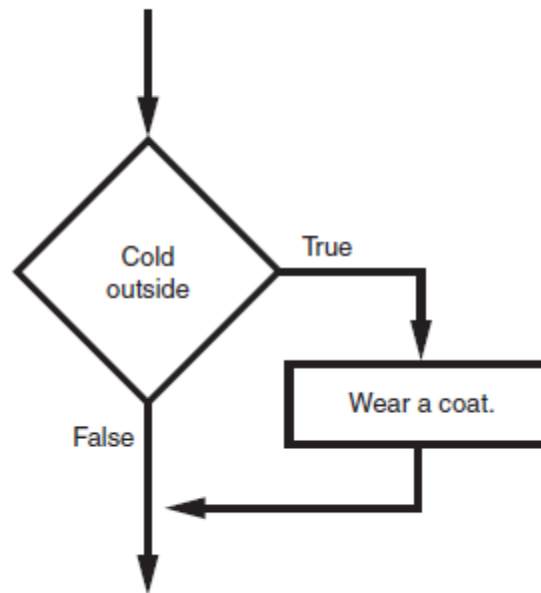
- **Control structure**: logical design that controls order in which set of statements execute
- **Sequence structure**: set of statements that execute in the order they appear
- **Decision structure**: specific action(s) performed only if a condition exists
 - Also known as selection structure

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.)

- **\geq and \leq 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 ($=$)
- **\neq operator determines whether the two operands are not equal**



Boolean Expressions and Relational Operators (cont'd.)

Table 3-2 Boolean expressions using relational operators

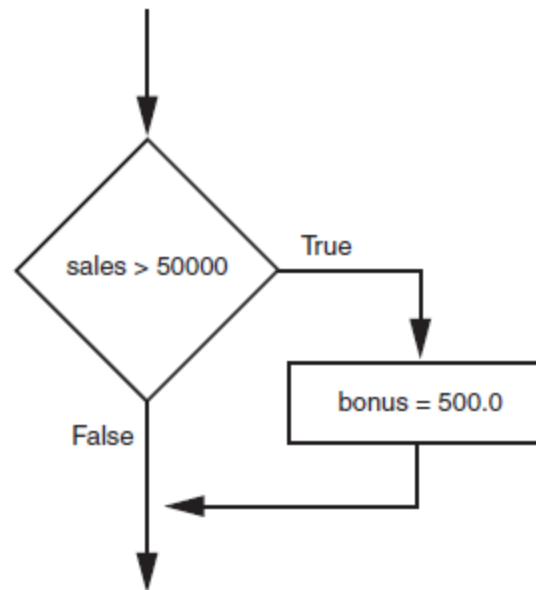
Expression	Meaning
$x > y$	Is x greater than y?
$x < y$	Is x less than y?
$x \geq y$	Is x greater than or equal to y?
$x \leq y$	Is x less than or equal to y?
$x == y$	Is x equal to y?
$x != y$	Is x not equal to y?



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

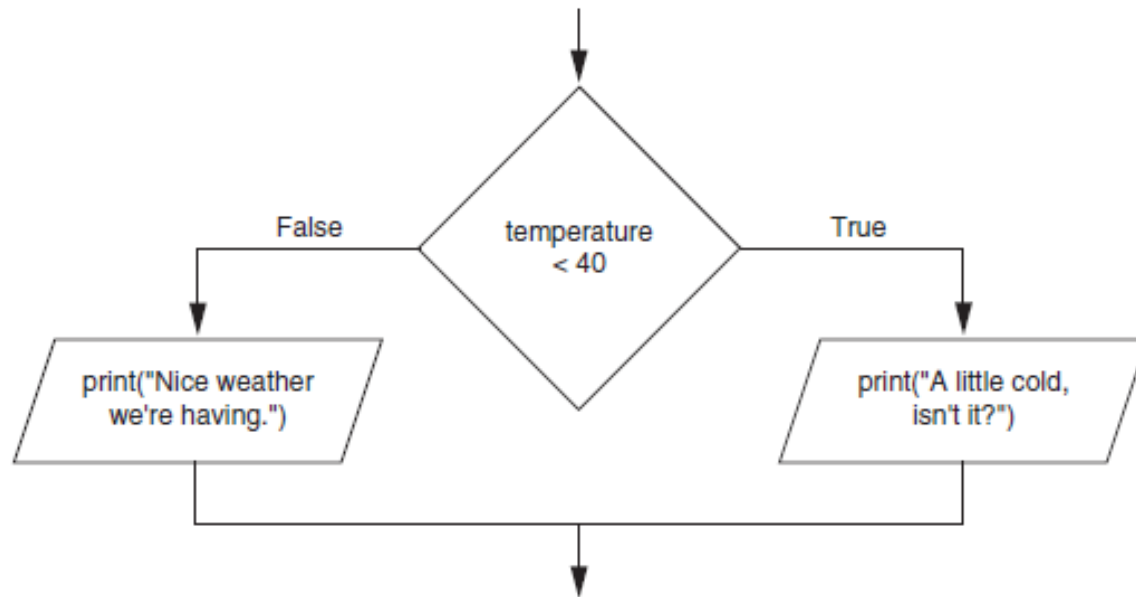
- **Dual alternative decision structure: two possible paths of execution**
 - One is taken if the condition is true, and the other if the condition is false
- Syntax:

```
if condition:
    statements
else:
    other statements
```
- `if` clause and `else` clause must be aligned
- Statements must be consistently indented



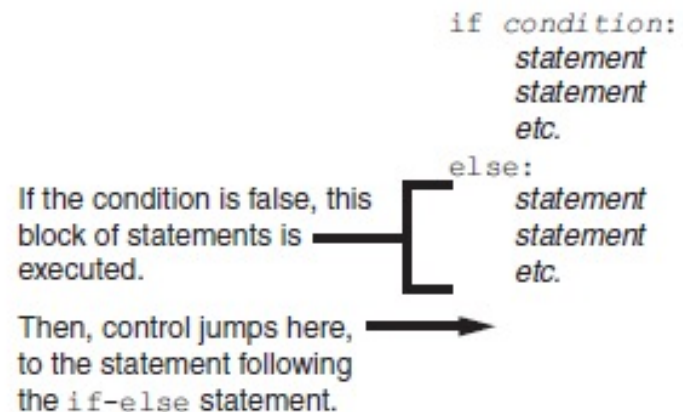
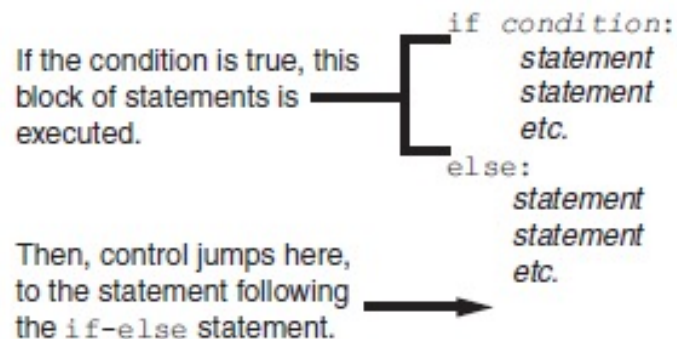
The `if-else` Statement (cont'd.)

Figure 3-5 A dual alternative decision structure



The if-else Statement (cont'd.)

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



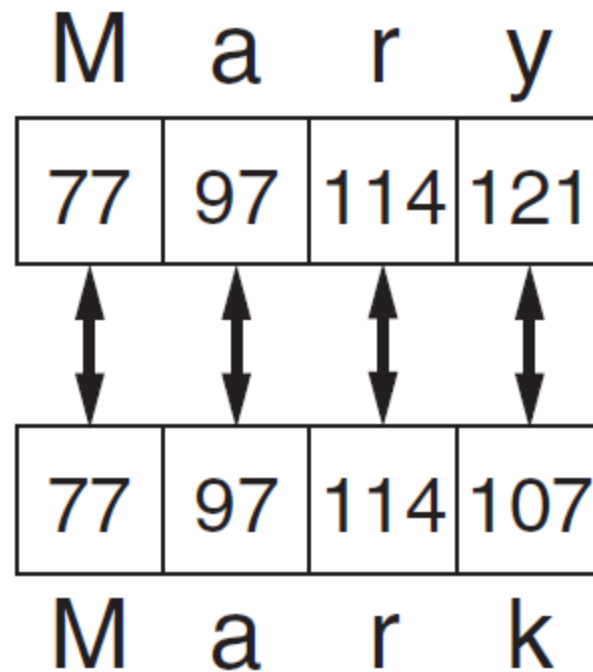
Comparing Strings

- **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.)

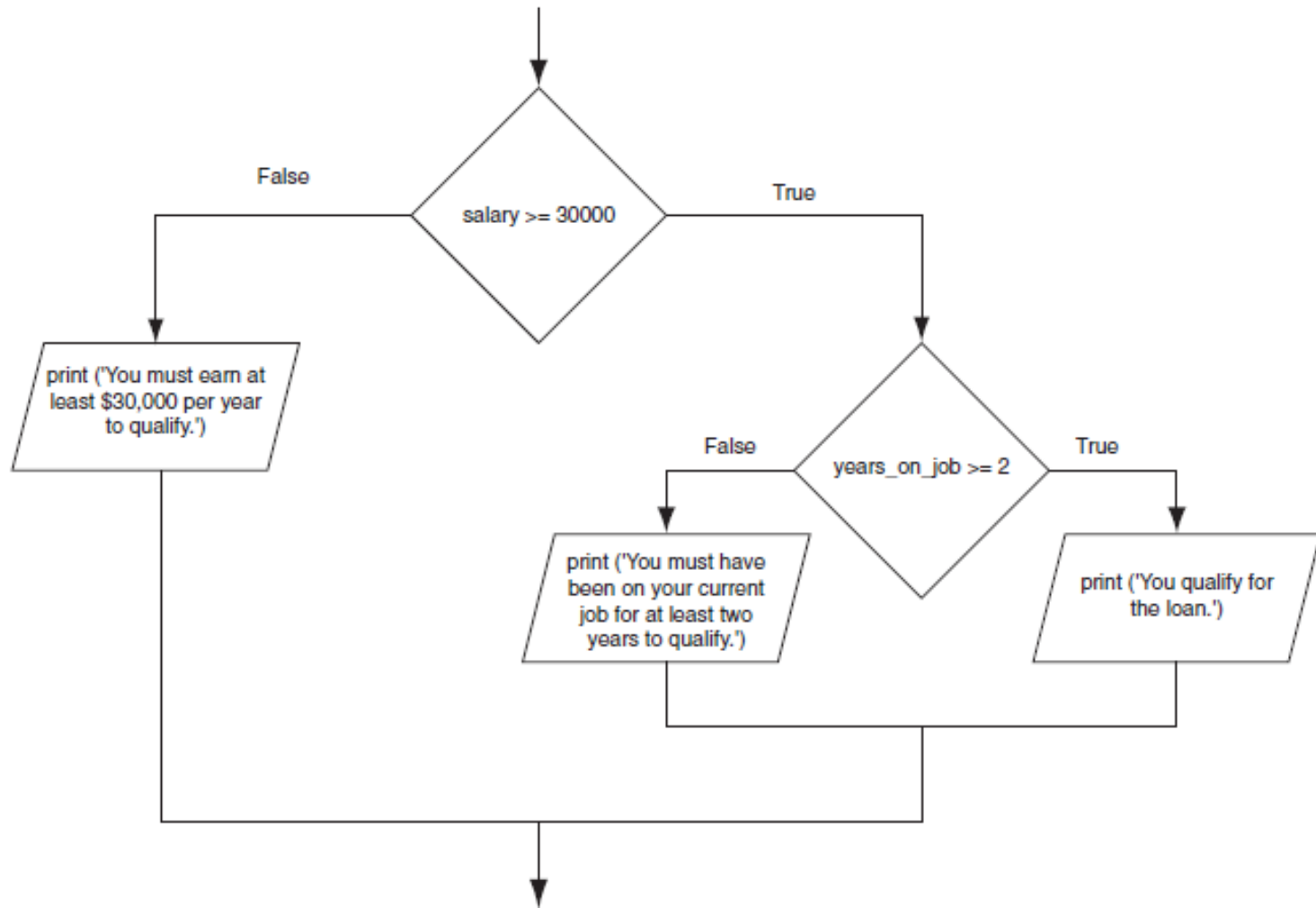
Figure 3-9 Comparing each character in a string



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:

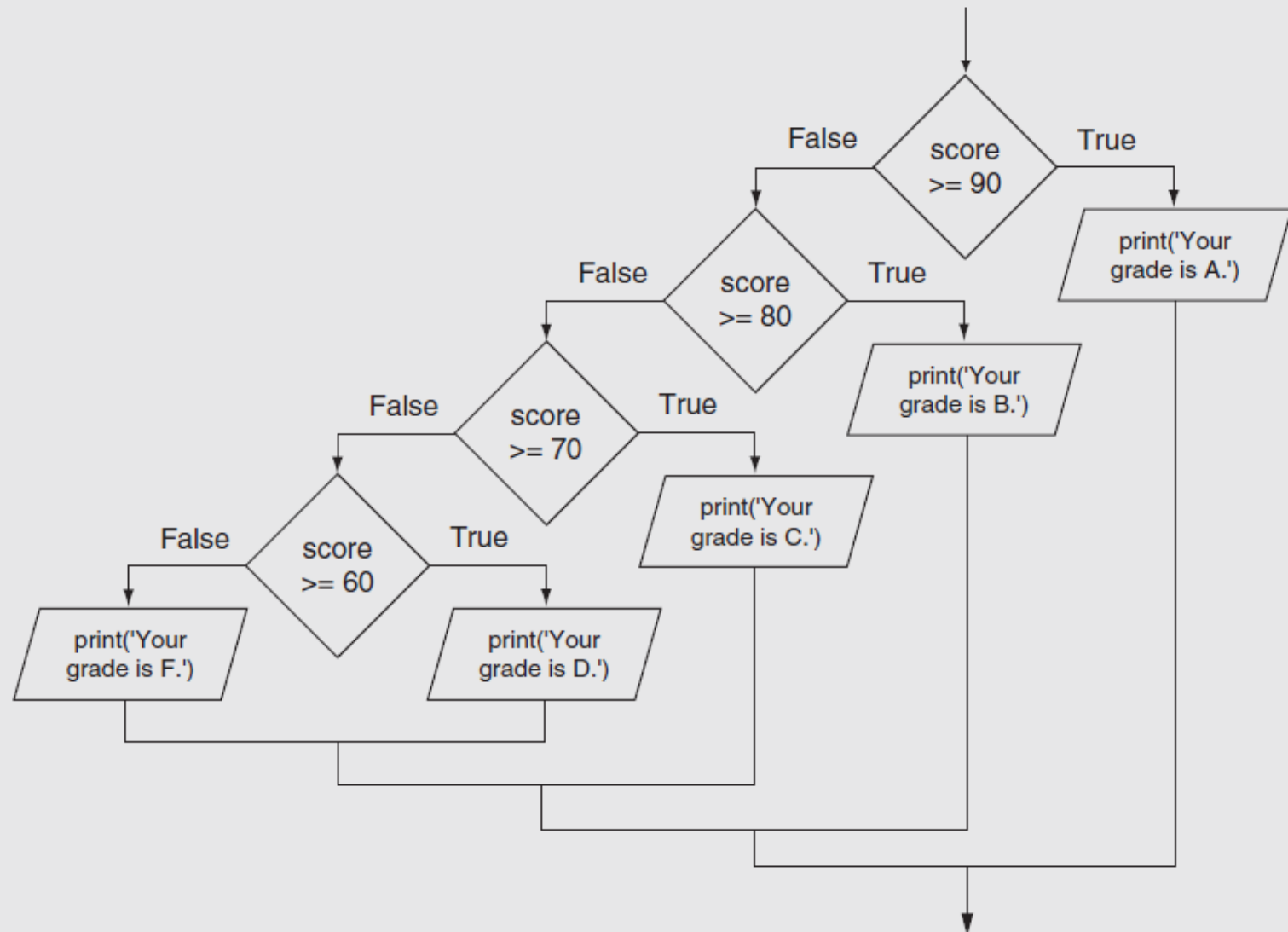
```
if condition_1:
    statement(s)
elif condition_2:
    statement(s)
elif condition_3:
    statement(s)
else
    statement(s)
```

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: $x \geq 10$ and $x \leq 20$
- **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)
```

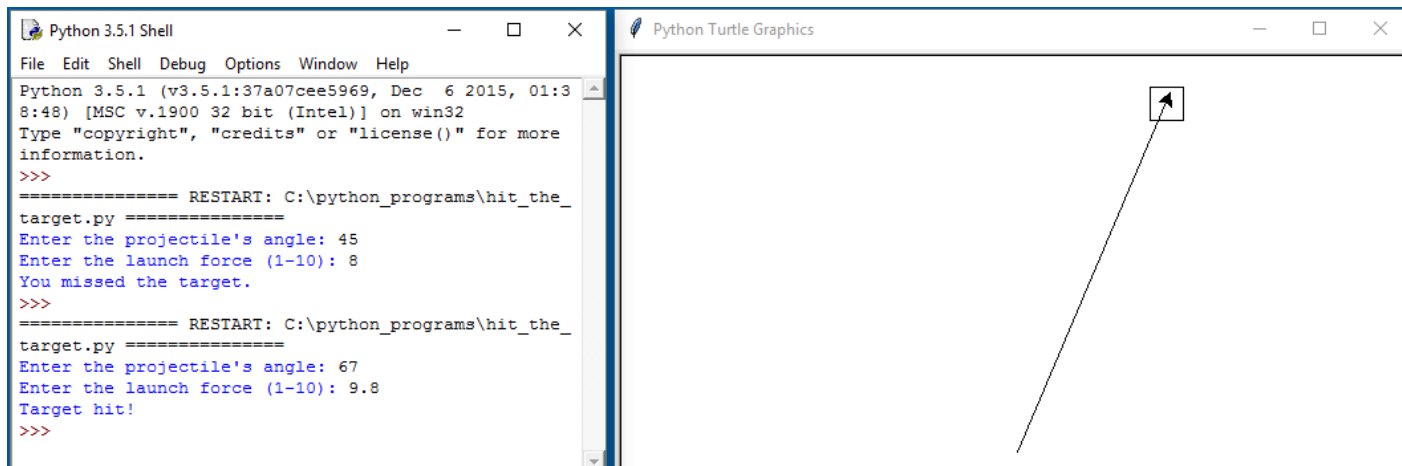
Turtle Graphics: Determining the State of the Turtle

- 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

