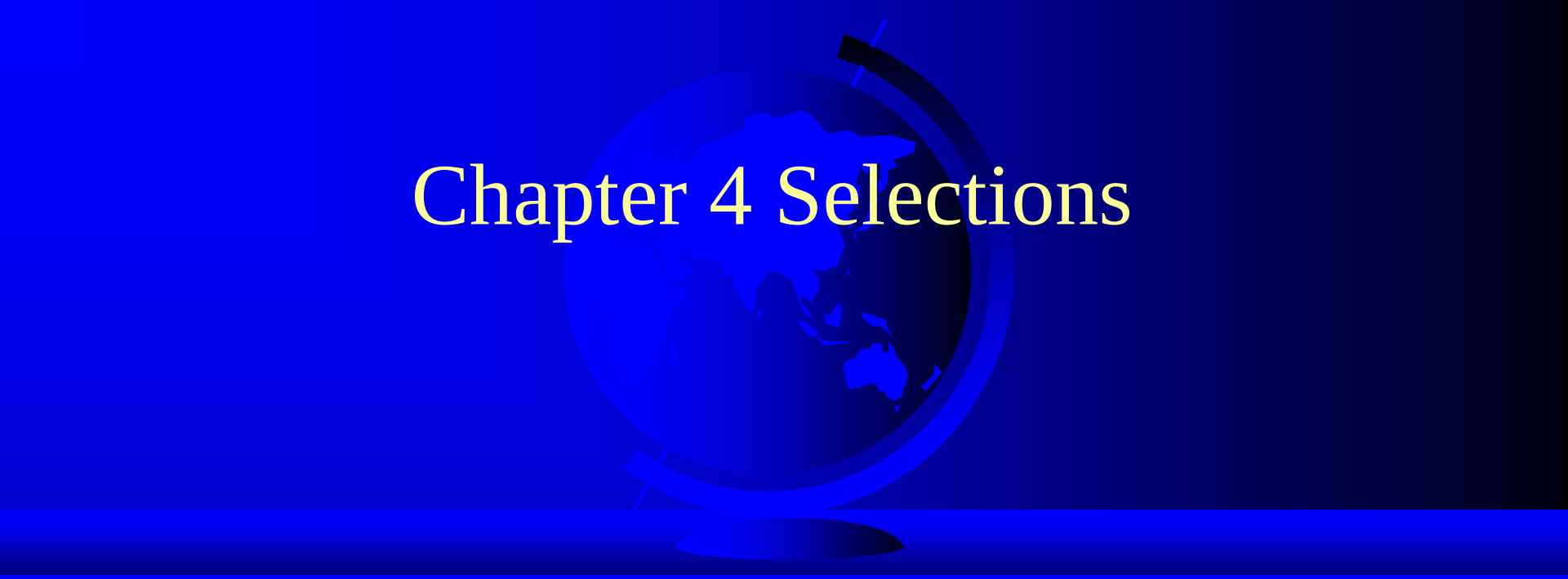


Chapter 4 Selections

Motivations

If you assigned a negative value for radius in Listing 2.1, ComputeArea.py, the program would print an invalid result. If the radius is negative, you don't want the program to compute the area. How can you deal with this situation?

Objectives

- To write Boolean expressions by using comparison operators (§4.2).
- To generate random numbers by using the **random.randint(a, b)** or **random.random()** functions (§4.3).
- To program with Boolean expressions (**AdditionQuiz**) (§4.3).
- To implement selection control by using one-way if statements (§4.4)
- To program with one-way if statements (**GuessBirthday**) (§4.5).
- To implement selection control by using two-way **if .. else** statements (§4.6).
- To implement selection control with nested **if ... elif ... else** statements (§4.7).
- To avoid common errors in **if** statements (§4.8).
- To program with selection statements (§4.9–4.10).
- To combine conditions by using logical operators (**and**, **or**, and **not**) (§4.11).
- To use selection statements with combined conditions (**LeapYear**, **Lottery**) (§§4.12–4.13).
- To write expressions that use the conditional expressions (§4.14).
- To understand the rules governing operator precedence and associativity (§4.15).

Boolean Data Types

Often in a program you need to compare two values, such as whether i is greater than j. There are six comparison operators (also known as relational operators) that can be used to compare two values. The result of the comparison is a Boolean value: True or False.

```
b = (1 > 2)
```

Comparison Operators

Operator	*Name*
<	less than
<=	less than or equal to
>	greater than
>=	greater than or equal to
==	equal to
!=	not equal to

Comparison Operators

```
x = 5
y = 8

print("x == y:", x == y)
print("x != y:", x != y)
print("x < y:", x < y)
print("x > y:", x > y)
print("x <= y:", x <= y)
print("x >= y:", x >= y)
```

Output

```
x == y: False
x != y: True
x < y: True
x > y: False
x <= y: True
x >= y: False
```

Problem: A Simple Math Learning Tool

This example creates a program to let a first grader practice additions. The program randomly generates two single-digit integers number1 and number2 and displays a question such as “What is 7 + 9?” to the student. After the student types the answer, the program displays a message to indicate whether the answer is true or false.

AdditionQuiz

Run

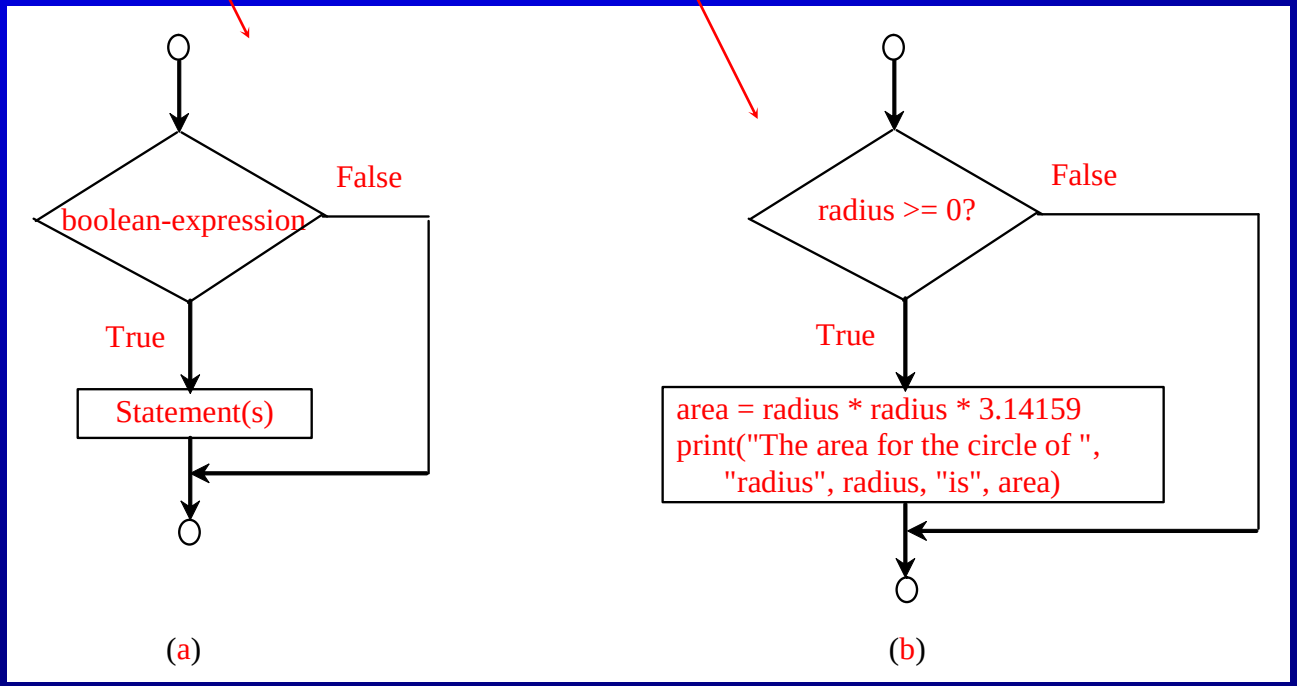
if Statements

- Python has several types of selection statements:
  - one-way **if** statements,
  - two-way **if-else** statements,
  - nested **if** statements,
  - multi-way **if-elif-else** statements and
  - conditional expressions

One-way `if` Statements

```
if boolean-expression:
    statement(s)
```

```
if radius >= 0:
    area = radius * radius * 3.14159
    print("The area for the circle of radius“,
          radius, "is“, area)
```



A one-way **if** *statement executes the statements if the condition is true.*

Note

```
if i > 0:
print("i is positive")
```

(a) Wrong

```
if i > 0:
    print("i is positive")
```

(b) Correct

- The statement(s) must be indented at least one space to the right of the if keyword and each statement must be indented using the same number of spaces.
- For consistency, we indent it four spaces in this book.

Simple if Demo

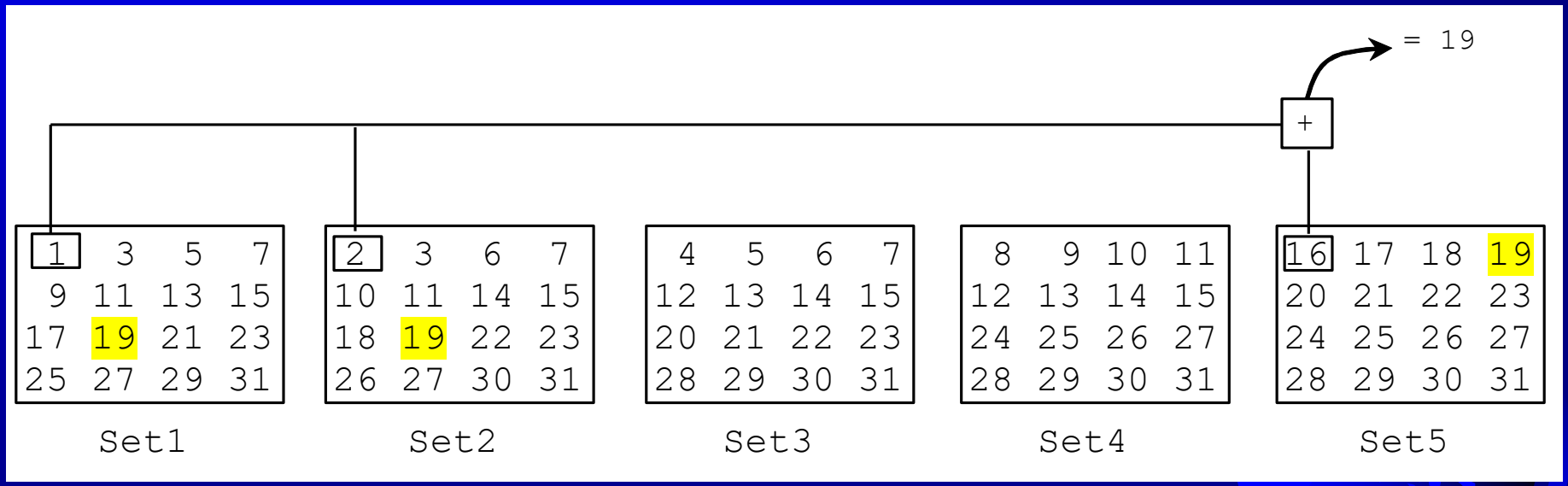
Write a program that prompts the user to enter an integer. If the number is a multiple of 5, print HiFive. If the number is divisible by 2, print HiEven.

SimpleIfDemo

Run

Problem: Guessing Birthday

- You can find out the date of the month when your friend was born by asking five questions.
- Each question asks whether the day is in one of the five sets of numbers.
- The birthday is the sum of the first numbers in the sets where the date appears.
- The program can guess your birth date. Run to see how it works.



GuessBirthday

Run

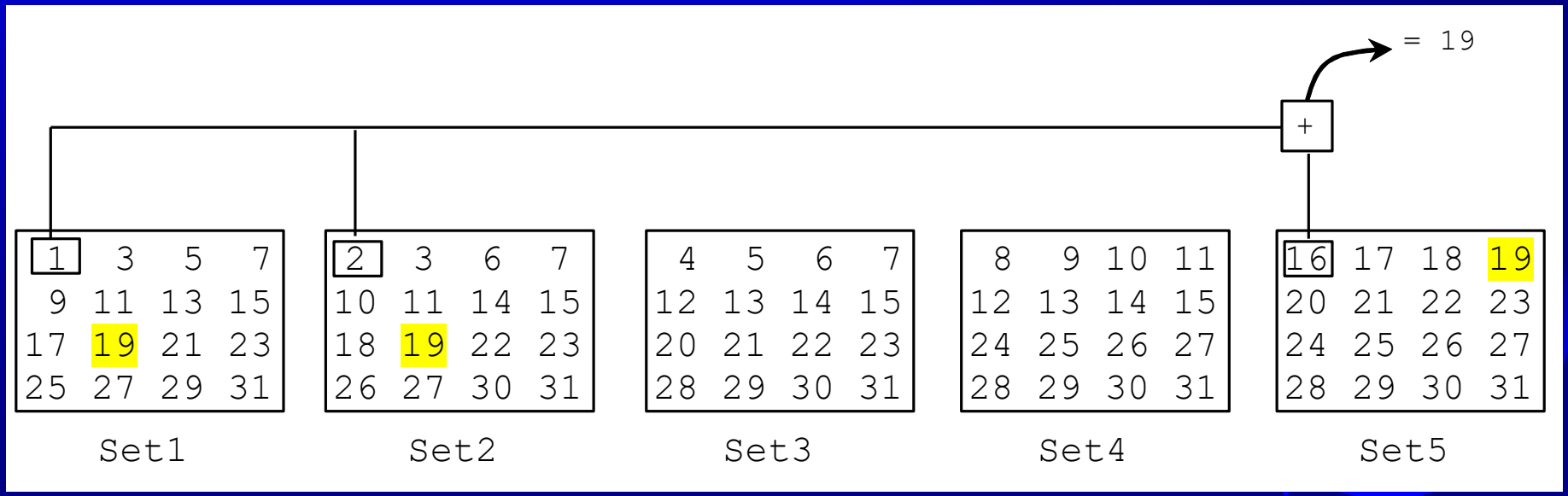
Mathematics Basis for the Game

19 is 10011 in binary. 7 is 111 in binary. 23 is 11101 in binary

```
   10000          00100          10000
      10             10           1000
+      1      +       1           100
-------        -------      +      1
   10011          00111        -------
                               11101

    19             7             23
```

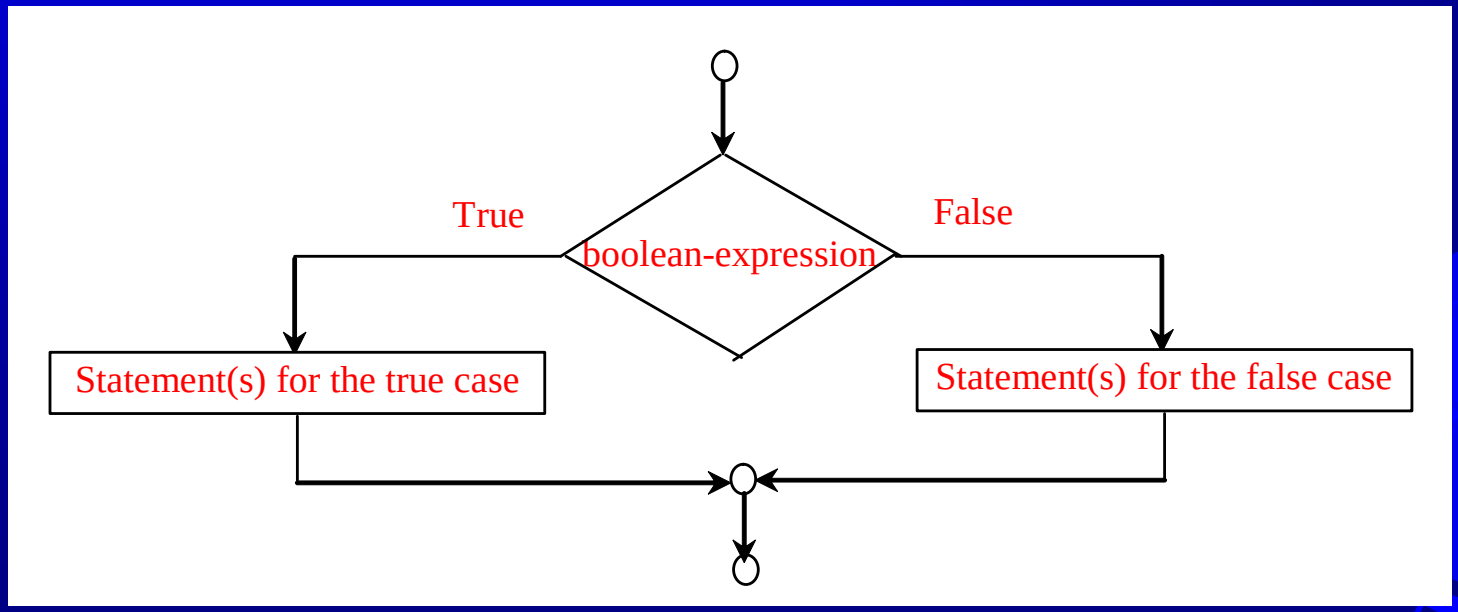
Decimal	Binary
1	00001
2	00010
3	00011
...	
19	10011
...	
31	11111

$b_5 0000$		10000
$b_4 000$		1000
$b_3 00$	10000	100
$b_2 0$	10	10
$+ \ b_1$	+ 1	+ 1
$b_5 b_4 b_3 b_2 b_1$	10011	11111
	19	31



The Two-way `if` Statement

```
if boolean-expression:
    statement(s)-for-the-true-case
else:
    statement(s)-for-the-false-case
```



`if...else` Example

```
if radius >= 0:
    area = radius * radius * math.pi
    print("The area for the circle of radius", radius, "is", area)
else:
    print("Negative input")
```

Problem: An Improved Math Learning Tool

This example creates a program to teach a first grade child how to learn subtractions. The program randomly generates two single-digit integers number1 and number2 with number1 > number2 and displays a question such as "What is 9 – 2?" to the student. After the student types the answer in the input dialog box, the program displays a message dialog box to indicate whether the answer is correct.

SubtractionQuiz

Run

Nested if

- *One* **if** *statement can be placed inside another* **if** *statement to form a nested* **if** *statement.*

```
if i > k:
        if j > k:
                print("i and j are greater than k")
else:
        print("i is less than or equal to k")
```

Multiple Alternative (MultiWay) if Statements

```
if score >= 90.0:
    grade = 'A'
else:
    if score >= 80.0:
        grade = 'B'
    else:
        if score >= 70.0:
            grade = 'C'
        else:
            if score >= 60.0:
                grade = 'D'
            else:
                grade = 'F'
```

(a)

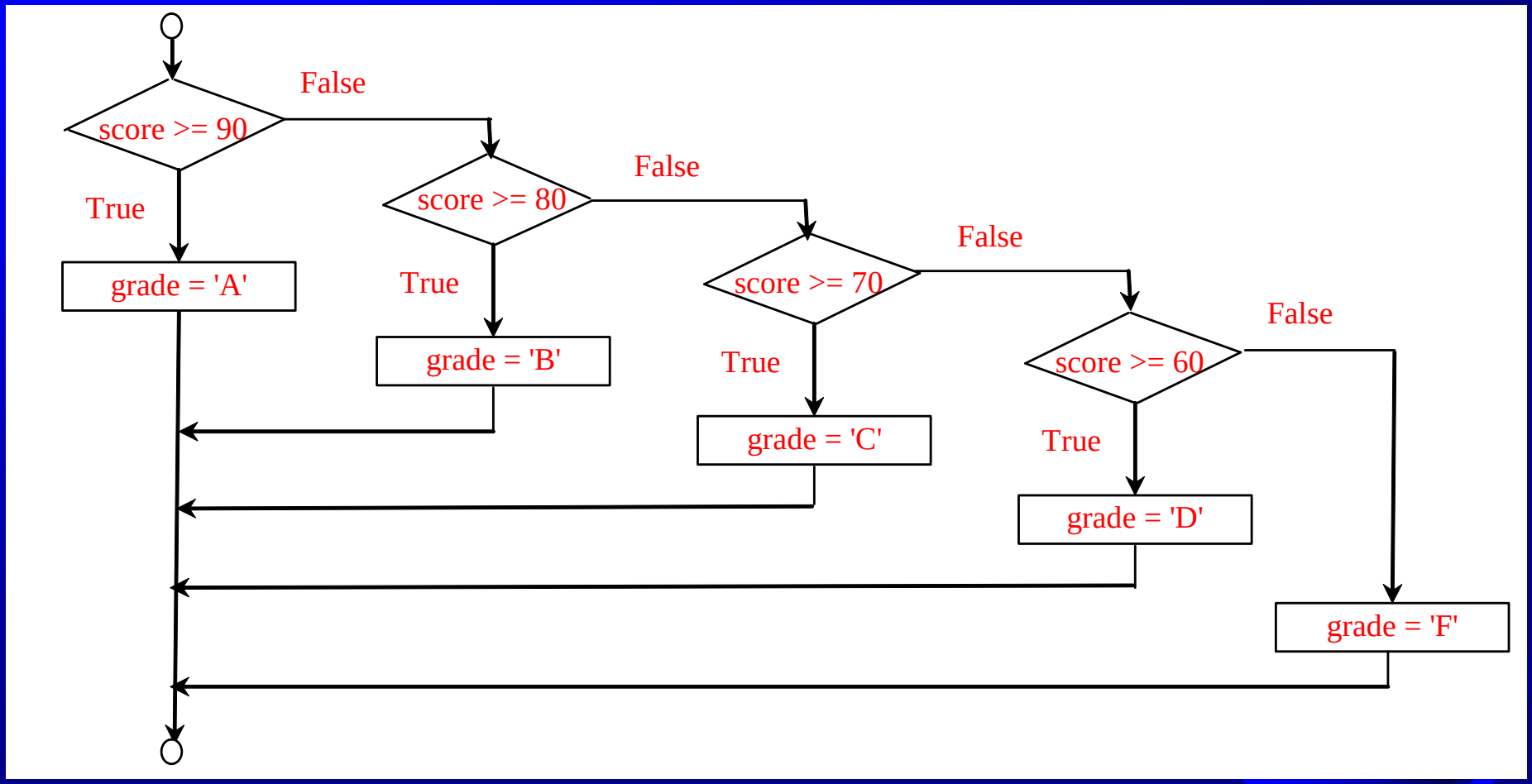
Equivalent

This is better

```
if score >= 90.0:
    grade = 'A'
elif score >= 80.0:
    grade = 'B'
elif score >= 70.0:
    grade = 'C'
elif score >= 60.0:
    grade = 'D'
else:
    grade = 'F'
```

(b)

Flowchart



animation

Trace if-else statement

Suppose score is 70.0

The condition is false

```
if score >= 90.0:
    grade = 'A'
elif score >= 80.0:
    grade = 'B'
elif score >= 70.0:
    grade = 'C'
elif score >= 60.0:
    grade = 'D'
else:
    grade = 'F'
```

animation

Trace if-else statement

Suppose score is 70.0

The condition is false

```
if score >= 90.0:
    grade = 'A'
elif score >= 80.0:
    grade = 'B'
elif score >= 70.0:
    grade = 'C'
elif score >= 60.0:
    grade = 'D'
else:
    grade = 'F'
```

animation

Trace if-else statement

Suppose score is 70.0

The condition is true

```
if score >= 90.0:
    grade = 'A'
elif score >= 80.0:
    grade = 'B'
elif score >= 70.0:
    grade = 'C'
elif score >= 60.0:
    grade = 'D'
else:
    grade = 'F'
```

animation

Trace if-else statement

Suppose score is 70.0

grade is C

```
if score >= 90.0:
    grade = 'A'
elif score >= 80.0:
    grade = 'B'
elif score >= 70.0:
    grade = 'C'
elif score >= 60.0:
    grade = 'D'
else:
    grade = 'F'
```

animation

Trace if-else statement

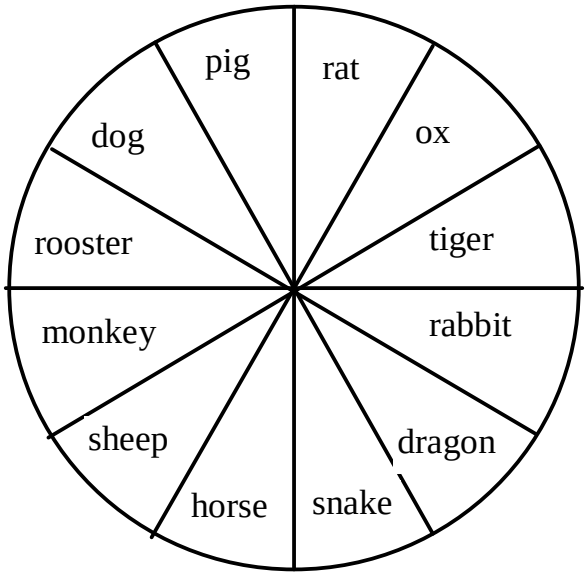
Suppose score is 70.0

Exit the if statement

```
if score >= 90.0:
    grade = 'A'
elif score >= 80.0:
    grade = 'B'
elif score >= 70.0
    grade = 'C'
elif score >= 60.0:
    grade = 'D'
else:
    grade = 'F'
```

Example

Now let us write a program to find out the Chinese Zodiac sign for a given year. The Chinese Zodiac sign is based on a 12-year cycle, each year being represented by an animal: rat, ox, tiger, rabbit, dragon, snake, horse, sheep, monkey, rooster, dog, and pig, in this cycle.



year % 12 =

0: monkey
1: rooster
2: dog
3: pig
4: rat
5: ox
6: tiger
7: rabbit
8: dragon
9: snake
10: horse
11: sheep

ChineseZodiac

Run

Common Errors

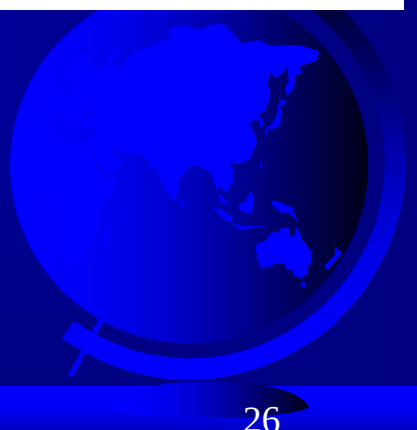
Most common errors in selection statements are caused by incorrect indentation. Consider the following code in (a) and (b).

```
radius = -20

if radius >= 0:
    area = radius * radius * 3.14
print("The area is", area)
```

(a) Wrong

```
radius = -20

if radius >= 0:
    area = radius * radius * 3.14
    print("The area is", area)
```

(b) Correct



Nested If

Which **if** clause is matched by the **else** clause? The indentation indicates that the **else** clause matches the first **if** clause in (a) and the second **if** clause in (b).

```
i = 1
j = 2
k = 3

if i > j:
    if i > k:
        print('A')
else:
    print('B')
```

(a)

```
i = 1
j = 2
k = 3

if i > j:
    if i > k:
        print('A')
    else:
        print('B')
```

(b)

TIP: The code can be simplified by assigning the test value directly to the variable, as shown in (b)

```
if number % 2 == 0:
    even = True
else:
    even = False
```

(a)

Equivalent

This is shorter

```
even = number % 2 == 0
```

(b)

Problem: Body Mass Index

Body Mass Index (BMI) is a measure of health on weight. It can be calculated by taking your weight in kilograms and dividing by the square of your height in meters. The interpretation of BMI for people 16 years or older is as follows:

Formula: weight (kg) / [height (m)]^2

BMI	Interpretation
Below 18.5	Underweight
18.5-24.9	Normal
25.0-29.9	Overweight
Above 30.0	Obese

ComputeBMI

Run

Problem: Computing Taxes

The US federal personal income tax is calculated based on the filing status and taxable income. There are four filing statuses: single filers, married filing jointly, married filing separately, and head of household. The tax rates for 2009 are shown below.

If you are, say, single with a taxable income of $10,000, the first $8,350 is taxed at 10% and the other $1,650 is taxed at 15%. So, your tax is $1,082.50.

Marginal Tax Rate	Single	Married Filing Jointly or Qualified Widow(er)	Married Filing Separately	Head of Household
10%	$0 – $8,350	$0 – $16,700	$0 – $8,350	$0 – $11,950
15%	$8,351– $33,950	$16,701 – $67,900	$8,351 – $33,950	$11,951 – $45,500
25%	$33,951 – $82,250	$67,901 – $137,050	$33,951 – $68,525	$45,501 – $117,450
28%	$82,251 – $171,550	$137,051 – $208,850	$68,525 – $104,425	$117,451 – $190,200
33%	$171,551 – $372,950	$208,851 – $372,950	$104,426 – $186,475	$190,201 - $372,950
35%	$372,951+	$372,951+	$186,476+	$372,951+

Problem: Computing Taxes, cont.

```
if status == 0:
    # Compute tax for single filers
elif status == 1:
    # Compute tax for married filing jointly
elif status == 2:
    # Compute tax for married filing separately
elif status == 3:
    # Compute tax for head of household
else:
    # Display wrong status
```

ComputeTax

Run

Logical Operators

Operator	Description
`not`	`logical negation`
`and`	`logical conjunction`
`or`	`logical disjunction`

Truth Table for Operator not

p	not p	Example (assume age = 24, gender = 'F')
True	False	not (age > 18) is False, because (age > 18) is True.
False	True	not (gender == 'M') is True, because (grade == 'M') is False.

Truth Table for Operator and

p1	p2	p1 and p2	Example (assume age = 24, gender = 'F')
False	False	False	(age > 18) and (gender == 'F') is True, because (age > 18) and (gender == 'F') are both True.
False	True	False	
True	False	False	(age > 18) and (gender != 'F') is False, because (gender != 'F') is False.
True	True	True	

Truth Table for Operator or

p1	p2	p1 or p2	Example (assume age = 24, gender = 'F')
False	False	False	(age > 34) or (gender == 'F') is true, because (gender == 'F') is True.
False	True	True	
True	False	True	(age > 34) or (gender == 'M') is False, because (age > 34) and (gender == 'M') are both Talse.
True	True	True	

Boolean/Logical Expressions

```
a = 6
b = 7
c = 42
print(1, a == 6)
print(2, a == 7)
print(3, a == 6 and b == 7)
print(4, a == 7 and b == 7)
print(5, not a == 7 and b == 7)
print(6, a == 7 or b == 7)
print(7, a == 7 or b == 6)
print(8, not (a == 7 and b == 6))
print(9, not a == 7 and b == 6)
```

Output

```
1 True
2 False
3 True
4 False
5 True
6 True
7 False
8 True
9 False
```

Examples

Here is a program that checks whether a number is divisible by 2 and 3, whether a number is divisible by 2 or 3, and whether a number is divisible by 2 or 3 but not both:

TestBooleanOperators

Run

Problem: Determining Leap Year?

This program first prompts the user to enter a year as an int value and checks if it is a leap year.

A year is a leap year if it is divisible by 4 but not by 100, or it is divisible by 400.

(year % 4 == 0 and year % 100 != 0) or (year % 400 == 0)

LeapYear

Run

Problem: Lottery

Write a program that randomly generates a lottery of a two-digit number, prompts the user to enter a two-digit number, and determines whether the user wins according to the following rule:

- If the user input matches the lottery in exact order, the award is $10,000.
- If the user input matches the lottery in any order, the award is $3,000.
- If one digit in the user input matches a digit in the lottery, the award is $1,000.

Lottery

Run

Conditional Operator

```
if x > 0:
    y = 1
else:
    y = -1
```

is equivalent to

```
y = 1 if x > 0 else -1
```

expression1 **if** boolean-expression **else** expression2

Conditional Operator

```
if num % 2 == 0:
   print(str(num) + “is even”)
else:
   print(str(num) + “is odd”);
```

print("number is even" **if** (number % 2 == 0)
else "number is odd")

Operator Precedence

- +, - (Unary plus and minus)
- ** (Exponentiation)
- not
- *, /, //, % (Multiplication, division, integer division, and remainder)
- +, - (Binary addition and subtraction)
- <, <=, >, >= (Comparison)
- ==, != (Equality)
- and
- or
- =, +=, -=, *=, /=, //=, %= (Assignment operator)

Operator Precedence and Associativity

The expression in the parentheses is evaluated first. (Parentheses can be nested, in which case the expression in the inner parentheses is executed first.) When evaluating an expression without parentheses, the operators are applied according to the precedence rule and the associativity rule.

If operators with the same precedence are next to each other, their associativity determines the order of evaluation. All binary operators except assignment operators are left-associative.

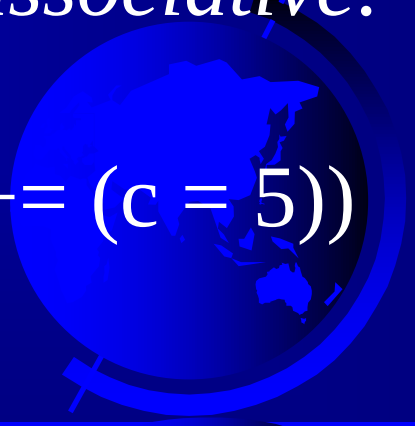
Operator Associativity

When two operators with the same precedence are evaluated, the *associativity* of the operators determines the order of evaluation. All binary operators except assignment operators are *left-associative*.

a – b + c – d is equivalent to ((a – b) + c) – d

Assignment operators are *right-associative*. Therefore, the expression

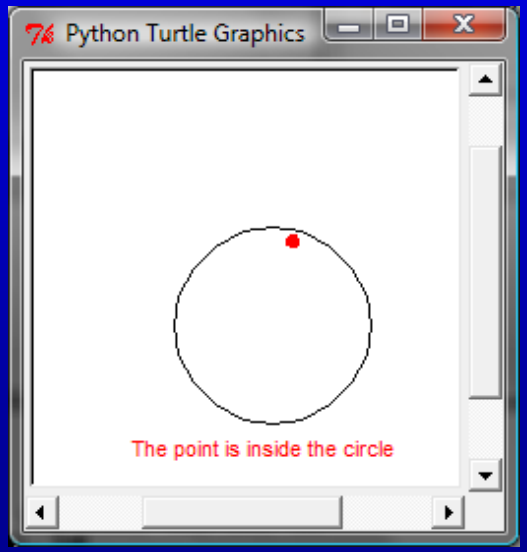
a = b += c = 5 is equivalent to a = (b += (c = 5))

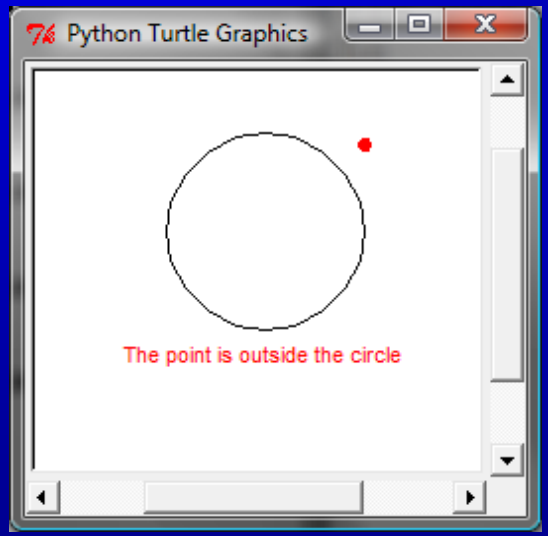


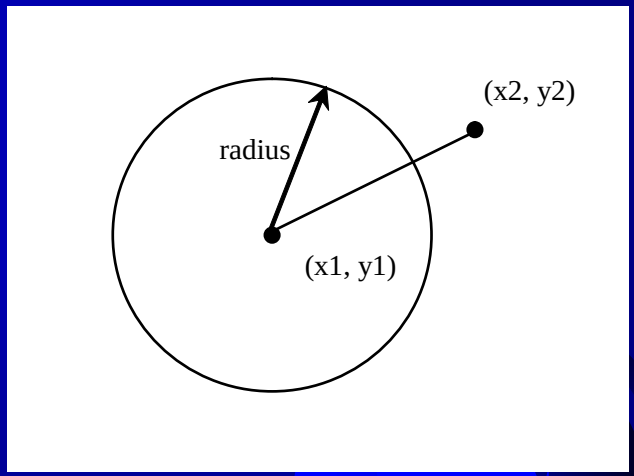
Turtle: Location of an Object

Test whether a point is inside a circle. The program prompts the user to enter the center of a circle, the radius, and a point.

A point is in the circle if its distance to the center of the circle is less than or equal to the radius of the circle, as shown in Figure 4.7c. The formula for computing the distance is $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$. Listing 4.11 gives the program.







PointInCircle

Run