

PYTHON PROGRAMMING

USING PROBLEM SOLVING APPROACH

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Preface

Computers are so widely used in our day-to-day lives that imagining a life without them has become almost impossible. They are not only used by professionals but also by children for interactively learning lessons, playing games, and doing their homework. Applications of the computer and its users are increasing by the day. Learning computer and programming basics is a stepping stone to having an insight into how the machines work. Once the reader is aware of the basic terminologies and problem solving strategies that are commonly used in computer science, he/she can then go on to develop efficient and effective computer programs that may help solve a user's problems.

Since computers cannot understand human languages, special programming languages are designed for this purpose. Python is one such language. It is an open-source, easy, high-level, interpreted, interactive, object-oriented and reliable language that uses English-like words. It can run on almost all platforms including Windows, Mac OS X, and Linux. Python is also a versatile language that supports development of a wide range of applications ranging from simple text processing to WWW browsers to games. Moreover, programmers can embed Python within their C, C++, COM, ActiveX, CORBA, and Java programs to give 'scripting' capabilities to the users.

Python uses easy syntax and short codes as well as supports multiple programming paradigms, including object oriented programming, functional Python programming, and parallel programming models. Hence, it has become an ideal choice for the programmers and even the novices in computer programming field find it easy to learn and implement. It has encompassed a huge user base that is constantly growing and this strength of Python can be understood from the fact that it is the most preferred programming language in companies such as Nokia, Google, YouTube, and even NASA for its easy syntax and short codes.

About the Book

This book is designed as a textbook to cater to the requirements of the first course in Python programming. It is suited for undergraduate degree students of computer science engineering and information technology as well as postgraduate students of computer applications. The objective of this book is to introduce the students to the fundamentals of computers and the concepts of Python programming language, and enable them to apply these concepts for solving real-world problems.

The book is organized into 12 chapters that provide comprehensive coverage of all the relevant topics using simple language. It also contains useful annexures to various chapters including for additional information. Case studies and appendices are also provided to supplement the text.

Programming skill is best developed by rigorous practice. Keeping this in mind, the book provides a number of programming examples that would help the reader learn how to write efficient programs. These programming examples have already been compiled and tested using Python 3.4.1 version and can be also executed on Python 3.5 and 3.6 versions. To further enhance the understanding of the subject, there are numerous chapter-end exercises provided in the form of objective-type questions, review questions, and programming problems.

Key Features of the Book

The following are the important features of the book:

- Offers **simple** and **lucid** treatment of concepts supported with illustrations for easy understanding.
- Contains **separate chapters** on Strings, Files, Exception Handling, and Operator Overloading

- Provides **numerous programming examples** along with their outputs to help students master the art of writing efficient Python programs.
- Includes **notes** and **programming tips** to highlight the important concepts and help readers avoid common programming errors.
- Offers **rich chapter-end pedagogy** including plenty of objective-type questions (with answers), review questions, programming and debugging exercises to facilitate revision and practice of concepts learnt.
- Includes **7 Annexures** and **5 appendices** covering types of operating systems, differences between Python 2.x and 3.x, installing Python, debugging and testing, iterators, generators, getters, setters, `@property`, `@deleter`, Turtle graphics, plotting graphs, multi-threading, GUI and Web Programming provided to supplement the text. Exercises are also added at the end of several annexures and appendices.
- Provides **case studies** on creating calculator, calendar, hash files, compressing strings and files, tower of Hanoi, image processing, shuffling a deck of cards, and mail merge that are linked to various chapters to demonstrate the application of concepts.
- Point-wise **summary** and **glossary** of keyterms to aid quick recapitulation to concepts.

Organization of the Book

The book contains 12 chapters, 7 annexures, 8 case studies, and 5 appendices. The details of the book are presented as follows.

Chapter 1 provides an introduction to computer hardware and software. It covers the concept of memory and its storage units, application software, and system software. The chapter provides an insight into the different stages of software development life cycle and discusses the various strategies used for problem solving. Topics such as algorithms, flowcharts, and pseudocodes are discussed in this chapter.

Annexure 1 given after Chapter 1 discusses the classification of operating systems.

Chapter 2 discusses about programming languages and their evolution through generations. It describes different programming paradigms, features of OOP, and merits and demerits of object oriented programming languages. The chapter also gives a comparative study Python and other OOP languages, and highlights the applications of OOP paradigm.

Chapter 3 details the history, important features and applications of Python. It also presents the various building blocks (such as keywords, identifiers, constants variables, operators, expressions, statements and naming conventions) supported by the language.

The chapter is followed 3 annexures – **Annexure 2** provides instructions for installing Python. **Annexure 3** provides the comparison between Python 2.x and Python 3.x versions. **Annexure 4** discusses testing and debugging of Python programs using IDLE.

Chapter 4 deals with the different types of decision control statements such as selection/ conditional branching, iterative, break, continue, pass, and else statements.

Case studies 1 and 2 on simple calculator and generating a calendar show the implementation of concepts discussed in Chapters 3 and 4.

Chapter 5 provides a detailed explanation of defining and calling functions. It also explains the important concepts such as variable length arguments, recursive functions, modules, and packages in Python.

Annexure 5 explains how functions are objects in Python. **Case studies 3 and 4** on tower of Hanoi and shuffling a deck of cards demonstrates the concepts of functions as well as recursion.

Chapter 6 unleashes the concept of strings. The chapter lays special focus on the operators used with strings, slicing operation, built-in string methods and functions, comparing and iterating through strings, and the string module.

Chapter 7 discusses how data can be stored in files. The chapter deals with opening, processing (like reading, writing, appending, etc.), and closing of files through a Python program. These files are handled in text mode as well as binary mode for better clarity of the concepts. The chapter also explains the concept of file, directory, and the os module.

Case studies 5, 6, and 7 on creating a hash file, mail merge, and finding the resolution of an image demonstrate the applications of concepts related strings and file handling.

Chapter 8 details the different data structures (such as list, tuple, dictionary, sets, etc.) that are extensively used in Python. It deals with creating, accessing, cloning, and updating of lists as well as list methods and functions. It also describes functional programming and creating, accessing, and updating tuples. It also includes the concepts related to sets, dictionaries, nested lists, nested tuples, nested sets, nested dictionaries, list comprehensions, and dictionary comprehensions.

Annexure 6 discusses the concepts of iterator and generator.

Chapter 9 introduces the concept of classes, objects, public and private classes, and instance variables. It also talks about special methods, built-in attributes, built-in methods, garbage collection, class method, and static method.

Annexure 7 discusses the `getter` and `setter` methods as well as `@property` and `@deleter` decorators facilitate data encapsulation in Python.

Chapter 10 introduces inheritance and its various forms. It gives a detail explanation on method overriding, containership, abstract class, interface, and metaclass.

Chapter 11 is all about overloading arithmetic and logical operators. It also discusses reverse adding and overriding `__getitem__()`, `__setitem__()`, and `__call__()` methods, in operator, as well as other miscellaneous functions.

Chapter 12 elucidates the concepts of exception handling that can be used to make your programs robust. Concepts such as `try`, `except`, and `finally` blocks, raising and re-raising exceptions, built-in and user-defined exceptions, assertions, and handling invoked functions, used for handling exceptions are demonstrated in this chapter.

Case study 8 shows how to compress strings and files using exception handling concepts.

The **5 appendices** included in the book discuss about multi-threading, GUI programming, usage of Turtle graphics, plotting graphs and web programming in Python.

Online Resources

For the benefit of faculty and students reading this book, additional resources are available online at india.oup.com/orcs//9780199480173

For Faculty

- Solutions manual (for programming exercises)
- Chapter-wise PPTs

For Students

- Lab exercises
- Test generator
- Projects
- Solutions to find the output and error exercises
- Model question papers
- Extra reading material on number systems, unit testing in Python, sorting and searching methods, network programming, event-driven programming and accessing databases using Python

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Comments and suggestions for the improvement of the book are welcome. Please send them to me at reemathareja@gmail.com.

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Brief Contents

Preface iv

Detailed Contents ix

1	Introduction to Computers and Problem Solving Strategies	1
	<i>Annexure 1 — Types of Operating Systems</i>	52
2	Introduction to Object Oriented Programming (OOP)	63
3	Basics of Python Programming	83
	<i>Annexure 2 — Installing Python</i>	125
	<i>Annexure 3 — Comparison between Python 2.x and Python 3.x Versions</i>	127
	<i>Annexure 4 — Testing and Debugging</i>	130
4	Decision Control Statements	137
	<i>Case Study 1 — Simple Calculator</i>	180
	<i>Case Study 2 — Generating a Calendar</i>	183
5	Functions and Modules	185
	<i>Annexure 5 — Functions as Objects</i>	237
	<i>Case Study 3 — Tower of Hanoi</i>	239
	<i>Case Study 4 — Shuffling a Deck of Cards</i>	241
6	Python Strings Revisited	242
7	File Handling	289
	<i>Case Study 5 — Creating a Hash File (or a message digest of a file)</i>	317
	<i>Case Study 6 — Mail Merge Program</i>	319
	<i>Case Study 7 — Finding Resolution of an Image</i>	321
8	Data Structures	322
	<i>Annexure 6 — Iterator and Generator</i>	392
9	Classes and Objects	400
	<i>Annexure 7 — Getters, Setters, @property, and @deleter</i>	432
10	Inheritance	436
11	Operator Overloading	460
12	Error and Exception Handling	480
	<i>Case Study 8 — Compressing String and Files</i>	505

Appendix A — Multi-threading 508

Appendix B — GUI Programming With tkinter Package 514

Appendix C — Simple Graphics Using Turtle 524

Appendix D — Plotting Graphs in Python 530

Appendix E — CGI/Web Programming Using Python 536

Detailed Contents

Preface iv
Brief Contents viii

1 Introduction to Computers and Problem Solving Strategies 1

- 1.1 Introduction 1
- 1.2 What is a Computer? 1
- 1.3 History of Computers 2
- 1.4 Characteristics of Computers 4
- 1.5 Classification of Computers 5
- 1.6 Basic Applications of Computers 9
- 1.7 Stored Program Concept 11
 - 1.7.1 Types of Stored Program Computers 12
- 1.8 Components and Functions of a Computer System 12
- 1.9 Concept of Hardware and Software 14
 - 1.9.1 Hardware 14
 - 1.9.2 Software 14
- 1.10 Central Processing Unit (CPU): Basic Architecture 14
- 1.11 Input and Output devices 16
- 1.12 Computer Memory 17
 - 1.12.1 Memory Hierarchy 18
 - 1.12.2 Primary Memory 18
 - 1.12.3 Secondary Storage Devices 20
- 1.13 Classification of Computer Software 20
 - 1.13.1 System Software 22
 - 1.13.2 Application Software 27
- 1.14 Representation of Data: Bits and Bytes 29
- 1.15 Problem Solving Strategies 31
- 1.16 Program Design Tools: Algorithms, Flowcharts, Pseudocodes 32
 - 1.16.1 Algorithms 32
 - 1.16.2 Flowcharts 37
 - 1.16.3 Pseudocodes 39
- 1.17 Types of Errors 41
- 1.18 Testing and Debugging Approaches 42

Annexure 1 — Types of Operating Systems 52

2 Introduction to Object Oriented Programming (OOP) 63

- 2.1 Computer Programming and Programming Languages 63
- 2.2 Generations of Programming Languages 64
 - 2.2.1 First Generation: Machine Language 64
 - 2.2.2 Second Generation: Assembly Language 65
 - 2.2.3 Third Generation: High-level Language 66
 - 2.2.4 Fourth Generation: Very High-level Languages 67
 - 2.2.5 Fifth Generation Programming Language 68
- 2.3 Programming Paradigms 69
 - 2.3.1 Monolithic Programming 69
 - 2.3.2 Procedural Programming 69
 - 2.3.3 Structured Programming 70
 - 2.3.4 Object Oriented Programming (OOP) 71
- 2.4 Features of Object Oriented Programming 72
 - 2.4.1 Classes 72
 - 2.4.2 Objects 73
 - 2.4.3 Method and Message Passing 73
 - 2.4.4 Inheritance 74
 - 2.4.5 Polymorphism 75
 - 2.4.6 Containership 75
 - 2.4.7 Reusability 75
 - 2.4.8 Delegation 76
 - 2.4.9 Data Abstraction and Encapsulation 76
- 2.5 Merits and Demerits of Object Oriented Programming Language 77
- 2.6 Applications of Object Oriented Programming 77
- 2.7 Differences Between Popular Programming Languages 78

3 Basics of Python Programming 83

- 3.1 Features of Python 83
- 3.2 History of Python 85
- 3.3 The Future of Python 87
- 3.4 Writing and Executing First Python Program 87
- 3.5 Literal Constants 88
 - 3.5.1 Numbers 88
 - 3.5.2 Strings 90
- 3.6 Variables and Identifiers 94
- 3.7 Data Types 94
 - 3.7.1 Assigning or Initializing Values to Variables 94
 - 3.7.2 Multiple Assignment 96
 - 3.7.3 Multiple Statements on a Single Line 97
 - 3.7.4 Boolean 97
- 3.8 Input Operation 97
- 3.9 Comments 98
- 3.10 Reserved Words 98
- 3.11 Indentation 98
- 3.12 Operators and Expressions 99
 - 3.12.1 Arithmetic Operators 99
 - 3.12.2 Comparison Operators 100
 - 3.12.3 Assignment and In-place or Shortcut Operators 101
 - 3.12.4 Unary Operators 102
 - 3.12.5 Bitwise Operators 102
 - 3.12.6 Shift Operators 103
 - 3.12.7 Logical Operators 103
 - 3.12.8 Membership Operators 104
 - 3.12.9 Identity Operators 104
 - 3.12.10 Operators Precedence and Associativity 105
- 3.13 Expressions in Python 106
- 3.14 Operations on Strings 106
 - 3.14.1 Concatenation 107
 - 3.14.2 Multiplication (or String Repetition) 107
 - 3.14.3 Slice a String 108
- 3.15 Other Data Types 109
 - 3.15.1 Tuples 109
 - 3.15.2 Lists 109
 - 3.15.3 Dictionary 110
- 3.16 Type Conversion 110

Annexure 2 — Installing Python 125

*Annexure 3 — Comparison between
Python 2.x and Python 3.x
Versions 127*

Annexure 4 — Testing and Debugging 130

4 Decision Control Statements 137

- 4.1 Introduction to Decision Control Statements 137
- 4.2 Selection/Conditional Branching Statements 138
 - 4.2.1 if Statement 138
 - 4.2.2 if-else Statement 139
 - 4.2.3 Nested if Statements 142
 - 4.2.4 if-elif-else Statement 142
- 4.3 Basic Loop Structures/ Iterative Statements 147
 - 4.3.1 while loop 147
 - 4.3.2 for Loop 155
 - 4.3.3 Selecting an appropriate loop 156
- 4.4 Nested Loops 164
- 4.5 The break Statement 167
- 4.6 The continue Statement 168
- 4.7 The pass Statement 171
- 4.8 The else Statement used with Loops 172
- Case Study 1 — Simple Calculator 180*
- Case Study 2 — Generating a Calendar 183*

5 Functions and Modules 185

- 5.1 Introduction 185
 - 5.1.1 Need for Functions 186
- 5.2 Function Definition 187
- 5.3 Function Call 189
 - 5.3.1 Function Parameters 189
- 5.4 Variable Scope and Lifetime 191
 - 5.4.1 Local and Global Variables 192
 - 5.4.2 Using the Global Statement 193
 - 5.4.3 Resolution of Names 195
- 5.5 The return statement 196
- 5.6 More on Defining Functions 198
 - 5.6.1 Required Arguments 198
 - 5.6.2 Keyword Arguments 198
 - 5.6.3 Default Arguments 199

5.6.4 Variable-length Arguments	201
5.7 Lambda Functions or Anonymous Functions	201
5.8 Documentation Strings	205
5.9 Good Programming Practices	206
5.10 Recursive Functions	211
5.10.1 Greatest Common Divisor	213
5.10.2 Finding Exponents	214
5.10.3 The Fibonacci Series	214
5.10.4 Recursion vs Iteration	216
5.11 Modules	217
5.11.1 The from...import statement	218
5.11.2 Name of Module	220
5.11.3 Making your own Modules	220
5.11.4 The dir() function	221
5.11.5 The Python Module	223
5.11.6 Modules and Namespaces	223
5.12 Packages in Python	225
5.13 Standard Library modules	226
5.14 Globals(), Locals(), and Reload()	227
5.15 Function Redefinition	228
<i>Annexure 5 — Functions as Objects</i>	237
<i>Case Study 3 — Tower of Hanoi</i>	239
<i>Case Study 4 — Shuffling a Deck of Cards</i>	241

6 Python Strings Revisited 242

Introduction	242
6.1 Concatenating, Appending, and Multiplying Strings	243
6.2 Strings are Immutable	245
6.3 String Formatting Operator	246
6.4 Built-in String Methods and Functions	249
6.5 Slice Operation	254
6.5.1 Specifying Stride While Slicing Strings	256
6.6 ord() and chr() Functions	257
6.7 in and not in operators	257
6.8 Comparing Strings	258
6.9 Iterating String	259
6.10 The String Module	265
6.11 Regular Expressions	268
6.11.1 The match() Function	268
6.11.2 The search() Function	269
6.11.3 The sub() Function	270

6.11.4 The findall() and finditer() Functions	270
6.11.5 Flag Options	271
6.12 Metacharacters in Regular Expression	272
6.12.1 Character Classes	273
6.12.2 Groups	276
6.12.3 Application of Regular Expression to Extract Email	277

7 File Handling 289

7.1 Introduction	289
7.2 File Path	289
7.3 Types of Files	290
7.3.1 ASCII Text Files	291
7.3.2 Binary Files	291
7.4 Opening and Closing Files	292
7.4.1 The open() Function	292
7.4.2 The File Object Attributes	293
7.4.3 The close() Method	294
7.5 Reading and Writing Files	295
7.5.1 write() and writelines() Methods	295
7.5.2 append() Method	295
7.5.3 The read() and readline() Methods	296
7.5.4 Opening Files using with Keyword	298
7.5.5 Splitting Words	299
7.5.6 Some Other Useful File Methods	300
7.6 File Positions	300
7.7. Renaming and Deleting Files	303
7.8 Directory Methods	304
7.8.1 Methods from the os Module	307
<i>Case Study 5 — Creating a Hash File (or a message digest of a file)</i>	317
<i>Case Study 6 — Mail Merge Program</i>	319
<i>Case Study 7 — Finding Resolution of an Image</i>	321

8 Data Structures 322

8.1 Sequence	322
8.2 Lists	322
8.2.1 Access Values in Lists	323

8.2.2	Updating Values in Lists	323
8.2.3	Nested Lists	325
8.2.4	Cloning Lists	326
8.2.5	Basic List Operations	326
8.2.6	List Methods	327
8.2.7	Using Lists as Stack	330
8.2.8	Using Lists as Queues	331
8.2.9	List Comprehensions	332
8.2.10	Looping in Lists	334
8.3	Functional Programming	335
8.3.1	<code>filter()</code> Function	335
8.3.2	<code>map()</code> Function	336
8.3.3	<code>reduce()</code> Function	337
8.4	Tuple	346
8.4.1	Creating Tuple	346
8.4.2	Utility of Tuples	347
8.4.3	Accessing Values in a Tuple	347
8.4.4	Updating Tuple	348
8.4.5	Deleting Elements in Tuple	348
8.4.6	Basic Tuple Operations	349
8.4.7	Tuple Assignment	349
8.4.8	Tuples for Returning Multiple Values	350
8.3.9	Nested Tuples	351
8.4.10	Checking the Index: <code>index()</code> method	351
8.4.11	Counting the Elements: <code>count()</code> Method	352
8.4.12	List Comprehension and Tuples	352
8.4.13	Variable-length Argument Tuples	353
8.4.14	The <code>zip()</code> Function	354
8.4.16	Advantages of Tuple over List	356
8.5	Sets	359
8.5.1	Creating a Set	359
8.6	Dictionaries	366
8.6.1	Creating a Dictionary	367
8.6.2	Accessing Values	368
8.6.2	Adding and Modifying an Item in a Dictionary	369
8.6.3	Modifying an Entry	369
8.6.4	Deleting Items	370
8.6.5	Sorting Items in a Dictionary	373
8.6.6	Looping over a Dictionary	373
8.6.7	Nested Dictionaries	373

8.6.8	Built-in Dictionary Functions and Methods	374
8.6.9	Difference between a List and a Dictionary	376
8.6.10	String Formatting with Dictionaries	377
8.6.11	When to use which Data Structure?	377
8.6.12	List vs Tuple vs Dictionary vs Set	377

Annexure 6 — Iterator and Generator 392

9 Classes and Objects 400

9.1	Introduction	400
9.2	Classes and Objects	400
9.2.1	Defining Classes	400
9.2.2	Creating Objects	401
9.2.3	Data Abstraction and Hiding through Classes	401
9.3	Class Method and <code>self</code> Argument	402
9.4	The <code>__init__()</code> Method (The Class Constructor)	403
9.5	Class Variables and Object Variables	403
9.6	The <code>__del__()</code> Method	406
9.7	Other Special Methods	407
9.8	Public and Private Data Members	408
9.9	Private Methods	409
9.10	Calling a Class Method from Another Class Method	410
9.11	Built-in Functions to Check, Get, Set, and Delete Class Attributes	412
9.12	Built-in Class Attributes	413
9.13	Garbage Collection (Destroying Objects)	414
9.14	Class Methods	425
9.15	Static Methods	426

Annexure 7 — Getters, Setters, `@property`, and `@deleter` 432

10 Inheritance 436

10.1	Introduction	436
10.2	Inheriting Classes in Python	437
10.2.1	Polymorphism and Method Overriding	438

10.3	Types of Inheritance	441
10.3.1	Multiple Inheritance	441
10.3.2	Multi-level Inheritance	442
10.3.3	Multi-path Inheritance	443
10.4	Composition or Containership or Complex Objects	444
10.5	Abstract Classes and Interfaces	446
10.6	Metaclass	447

11 Operator Overloading 460

11.1	Introduction	460
11.1.1	Concept Of Operator Overloading	460
11.1.2	Advantage of Operator Overloading	461
11.2	Implementing Operator Overloading	461
11.3	Reverse Adding	470
11.4	Overriding <code>__getitem__()</code> and <code>__setitem__()</code> Methods	471
11.5	Overriding the <code>in</code> Operator	472
11.6	Overloading Miscellaneous Functions	473
11.7	Overriding the <code>__call__()</code> Method	474

Appendix A — Multi-threading 508

Appendix B — GUI Programming with tkinter Package 514

Appendix C — Simple Graphics Using Turtle 524

Appendix D — Plotting Graphs in Python 530

Appendix E — CGI/Web Programming Using Python 536

12 Error and Exception Handling 480

12.1	Introduction to Errors and Exceptions	480
12.1.1	Syntax Errors	480
12.1.2	Logic Error	481
12.1.3	Exceptions	481
12.2	Handling Exceptions	482
12.3	Multiple Except Blocks	483
12.4	Multiple Exceptions in a Single Block	484
12.5	Except Block Without Exception	484
12.6	The <code>else</code> Clause	485
12.7	Raising Exceptions	486
12.8	Instantiating Exceptions	486
12.9	Handling Exceptions in Invoked Functions	487
12.10	Built-in and User-defined Exceptions	489
12.11	The <code>finally</code> Block	491
12.12	Pre-defined Clean-up Action	493
12.13	Re-raising Exception	494
12.14	Assertions in Python	494
	<i>Case Study 8 — Compressing String and Files</i>	505

Operator Overloading



Basic Concepts of Operator Overloading • Advantages • Overloading Arithmetic and Logical Operators • Reverse Adding • Overriding `__getitem__()`, `__setitem__()`, `in` operator, and `__call__()` • Overloading Miscellaneous Functions

11.1 INTRODUCTION

Till now, we have seen that Python is an interesting and easy language. You can build classes with desired attributes and methods. But just think, if you want to add two Time values, where Time is a user-defined class, then how good it would be if we write `T3 = T1 + T2`, where T1, T2, and T3 are all objects of the class Time. As of now, we need to write the same statement as `T3 = T1.add(T2)`.

Basically, the meaning of operators like `+`, `=`, `*`, `/`, `>`, `<`, etc. are pre-defined in any programming language. Programmers can use them directly on built-in data types to write their programs. But, for user-defined types like objects, these operators do not work. Therefore, Python allows programmers to redefine the meaning of operators when they operate on class objects. This feature is called operator overloading. *Operator overloading* allows programmers to extend the meaning of existing operators so that in addition to the basic data types, they can be also applied to user-defined data types.

You already have a clue of operator overloading. Just give a thought, if you write `5 + 2`, then the integers are added, when you write `str1 + str2`, two strings are concatenated, when you write `List1 + List2`, the two lists are merged, so on and so forth. Thus, we see that the same operator behaves differently with different types.

11.1.1 Concept Of Operator Overloading

With operator overloading, a programmer is allowed to provide his own definition for an operator to a class by overloading the built-in operator. This enables the programmer to perform some specific computation when the operator is applied on class objects and to apply a standard definition when the same operator is applied on a built-in data type.

This means that while evaluating an expression with operators, Python looks at the operands around the operator. If the operands are of built-in types, Python calls a built-in routine. In case, the operator is being applied on user-defined operand(s), the Python compiler checks to see if the programmer has an overloaded operator function that it can call. If such a function whose parameters match the type(s) and number of the operands exists in the program, the function is called, otherwise a compiler error is generated.

Another form of Polymorphism

Like function overloading, operator overloading is also a form of compile-time polymorphism. Operator overloading, is therefore less commonly known as operator *ad hoc polymorphism* since different operators have different implementations depending on their arguments. Operator overloading is generally defined by the language, the programmer, or both.

Note Ad hoc polymorphism is a specific case of polymorphism where different operators have different implementations depending on their arguments.

11.1.2 Advantage of Operator Overloading

We can easily write our Python programs without the knowledge of operator overloading, but the knowledge and use of this feature can help us in many ways. Some of them are:

- With operator overloading, programmers can use the same notations for user-defined objects and built-in objects. For example, to add two complex numbers, we can simply write $C1 + C2$.
- With operator overloading, a similar level of syntactic support is provided to user-defined types as provided to the built-in types.
- In scientific computing where computational representation of mathematical objects is required, operator overloading provides great ease to understand the concept.
- Operator overloading makes the program clearer. For example, the statement

$(C1.mul(C2).div(C1.add(C2)))$ can be better written as $C1 * C2 / C1 + C2$

11.2 IMPLEMENTING OPERATOR OVERLOADING

Just consider the code given below which is trying to add two complex numbers and observe the result.

Example 11.1 Program to add two complex numbers without overloading the + operator

```
class Complex:
    def __init__(self):
        self.real = 0
        self.imag = 0
    def setValue(self, real, imag):
        self.real = real
        self.imag = imag
    def display(self):
        print("(", self.real, " + ", self.imag, "i)")
C1 = Complex()
C1.setValue(1,2)
C2 = Complex()
C2.setValue(3,4)
C3 = Complex()
C3 = C1 + C2
C3.display()
```

OUTPUT

Traceback (most recent call last):

```
File "C:\Python34\Try.py", line 15, in <module>
    C3 = C1 + C2
TypeError: unsupported operand type(s) for +: 'instance' and 'instance'
```

So, the reason for this error is simple. + operator does not work on user-defined objects. Now, to do the same concept, we will add an operator overloading function in our code. For example, look at the code given below which has the overloaded add function specified as `__add__()`.

Example 11.2 Program to overload the + operator on a complex object

```
class Complex:
    def __init__(self):
        self.real = 0
        self.imag = 0
    def setValue(self, real, imag):
        self.real = real
        self.imag = imag
    def __add__(self, C):
        Temp = Complex()
        Temp.real = self.real + C.real
        Temp.imag = self.imag + C.imag
        return Temp
    def display(self):
        print("(", self.real, " + ", self.imag, "i)")

C1 = Complex()
C1.setValue(1,2)
C2 = Complex()
C2.setValue(3,4)
C3 = Complex()
C3 = C1 + C2
Print("RESULT = ")
C3.display()
```

OUTPUT

```
RESULT = ( 4 + 6 i)
```

In the program, when we write `C1 + C2`, the `__add__()` function is called on `C1` and `C2` is passed as an argument. Remember that, user-defined classes have no + operator defined by default. The only exception is when you inherit from an existing class that already has the + operator defined.

Note The `__add__()` method returns the new combined object to the caller.

We can also overload the comparison operators to work with class objects. But before we write further programs, let us first have a look at Table 11.1 to know the name of the function for each operator.

Table 11.1 Operators and their corresponding function names

Operator	Function Name	Operator	Function Name
+	<code>__add__</code>	+=	<code>__iadd__</code>
-	<code>__sub__</code>	-=	<code>__isub__</code>
*	<code>__mul__</code>	*=	<code>__imul__</code>
/	<code>__truediv__</code>	/=	<code>__idiv__</code>
**	<code>__pow__</code>	**=	<code>__ipow__</code>
%	<code>__mod__</code>	%=	<code>__imod__</code>
>>	<code>__rshift__</code>	>>=	<code>__irshift__</code>
&	<code>__and__</code>	&=	<code>__iand__</code>
	<code>__or__</code>	=	<code>__ior__</code>
^	<code>__xor__</code>	^=	<code>__ixor__</code>
~	<code>__invert__</code>	~=	<code>__iinvert__</code>
<<	<code>__lshift__</code>	<<=	<code>__ilshift__</code>
>	<code>__gt__</code>	<=	<code>__le__</code>
<	<code>__lt__</code>	=	<code>__eq__</code>
>=	<code>__ge__</code>	!=	<code>__ne__</code>

The program given below compares two `Book` objects. Although the class `Book` has three attributes, comparison is done based on its price. However, this is not mandatory. You can compare two objects based on any of the attributes.

Example 11.3 Program to compare two objects of user-defined class type

```
class Book:
    def __init__(self):
        title = ""
        publisher = ""
        price = 0
    def set(self, title, publisher, price):
        self.title = title
        self.publisher = publisher
        self.price = price
    def display(self):
        print("TITLE : ", self.title)
        print("PUBLISHER : ", self.publisher)
        print("PRICE : ", self.price)
    def __gt__(self, B):
        if self.price > B.price:
            return True
        else:
            return False
B1 = Book()
```



```
B1.set("OOP with C++", "Oxford University Press", 525)
B2 = Book()
B2.set("Let us C++", "BPB", 300)
if B1>B2:
    print("This book has more knowledge so I will buy")
    B1.display()
```

OUTPUT

```
This book has more knowledge so I will buy
TITLE : OOP with C++ PUBLISHER : Oxford University Press PRICE : 525
```

PROGRAMMING EXAMPLES

Program 11.1 Write a program that overloads the + operator on a class Student that has attributes name and marks.

```
class Student:
    def __init__(self, name, marks):
        self.name = name
        self.marks = marks
    def display(self):
        print(self.name, self.marks)
    def __add__(self, S):
        Temp = Student(S.name, [])
        for i in range(len(self.marks)):
            Temp.marks.append(self.marks[i] + S.marks[i])
        return Temp
S1 = Student("Nikhil", [87, 90, 85])
S2 = Student("Nikhil", [83, 86, 88])
S1.display()
S2.display()
S3 = Student("", [])
S3 = S1 + S2
S3.display()
```

OUTPUT

```
Nikhil [87, 90, 85]
Nikhil [83, 86, 88]
Nikhil [170, 176, 173]
```

Program 11.2 Write a program that overloads the + operator to add two objects of class Matrix.

```
class Matrix:
    def __init__(self, List):
```

```

        self.List = List
    def display(self):
        print(self.List)
    def __add__(self, M):
        Temp = Matrix([])
        for i in range(len(self.List)):
            for j in range(len(self.List[0])):
                Temp.List.append(self.List[i][j] + M.List[i][j])
        return Temp
M1 = Matrix([[1,2],[3,4]])
M2 = Matrix([[3,4],[5,1]])
M3 = Matrix([])
M3 = M1 + M2
print("RESULTANT MATRIX IS : ")
M3.display()

```

OUTPUT

RESULTANT MATRIX IS : [4, 6, 8, 5]

Program 11.3 Write a program that overloads the + operator so that it can add two objects of class Fraction.

```

def GCD(num, deno):
    if(deno == 0):
        return num
    else:
        return GCD(deno, num%deno)
class Fraction:
    def __init__(self):
        self.num = 0
        self.deno = 1
    def get(self):
        self.num = int(input("Enter the numerator : "))
        self.deno = int(input("Enter the denominator : "))
    def simplify(self):
        common_divisor = GCD(self.num, self.deno)
        self.num //= common_divisor
        self.deno //= common_divisor
    def __add__(self, F):
        Temp = Fraction()
        Temp.num = (self.num * F.deno) + (F.num * self.deno)
        Temp.deno = self.deno * F.deno
        return Temp
    def display(self):
        self.simplify()
        print(self.num, "/", self.deno)
F1 = Fraction()

```

```

F1.get()
F2 = Fraction()
F2.get()
F3 = Fraction()
F3 = F1 + F2
print("RESULTANT FRACTION IS : ")
F3.display()

```

OUTPUT

```

Enter the numerator : 4
Enter the denominator : 10
Enter the numerator : 2
Enter the denominator : 5
RESULTANT FRACTION IS :  4 / 5

```

Program 11.4 Write a program that overloads the + operator so that it can add a specified number of days to a given date.

```

Dict = {1:31, 3:31, 4:30, 5:31, 6:30, 7:31, 8:31, 9:30, 10:31, 11:30, 12:31}
def chk_Leap_Year(year):
    if (year%4 == 0 and year%100 != 0) or (year%400 == 0):
        return 1
    else:
        return 0
class Date:
    def __init__(self):
        d = m = y = 0
    def get(self):
        self.d = int(input("Enter the day : "))
        self.m = int(input("Enter the month : "))
        self.y = int(input("Enter the year : "))
    def __add__(self, num):
        self.d += num
        if self.m != 2:
            max_days = Dict[self.m]
        elif self.m == 2:
            isLeap = chk_Leap_Year(self.y)
            if isLeap == 1:
                max_days = 29
            else:
                max_days = 28
        while self.d > max_days:
            self.d -= max_days
            self.m += 1
        while self.m > 12:
            self.m -= 12
            self.y += 1

```

```

    def display(self):
        print(self.d, "-", self.m, "-", self.y)
D = Date()
D.get()
num = int(input("How many days to add : "))
D + num
D.display()

```

OUTPUT

```

Enter the day : 25
Enter the month : 2
Enter the year : 2016
How many days to add : 10
6 - 3 - 2016

```

Program 11.5 Write a program that has an overloads the *, /, and > operators so that it can multiply, divide, and compare two objects of class Fraction.

```

Dict = {1:31, 3:31, 4:30, 5:31, 6:30, 7:31, 8:31, 9:30, 10:31, 11:30, 12:31}
def chk_Leap_Year(year):
    if (year%4 == 0 and year%100 != 0) or (year%400 == 0):
        return 1
    else:
        return 0
class Date:
    def __init__(self):
        d = m = y = 0
    def get(self):
        self.d = int(input("Enter the day : "))
        self.m = int(input("Enter the month : "))
        self.y = int(input("Enter the year : "))
    def __add__(self, num):
        self.d += num
        if self.m != 2:
            max_days = Dict[self.m]
        elif self.m == 2:
            isLeap = chk_Leap_Year(self.y)
            if isLeap == 1:
                max_days = 29
            else:
                max_days = 28
        while self.d > max_days:
            self.d -= max_days
            self.m += 1
        while self.m > 12:
            self.m -= 12
            self.y += 1

```

```

    def display(self):
        print(self.d, "-", self.m, "-", self.y)
D = Date()
D.get()
num = int(input("How many days to add : "))
D + num
D.display()

```

OUTPUT

```

Enter the numerator : 2
Enter the denominator : 3
Enter the numerator : 4
Enter the denominator : 9
F1 > F2 True
F1 * F2 IS : 8 / 27
F1 / F2 IS : 3 / 2

```

Program 11.6 Write a program that overloads the + operator so that it can add two objects of class Binary.

```

class Binary:
    number = []
    def set(self, bnum):
        self.number = bnum
    def display(self):
        print(self. Number)
    def __add__(self, B):
        Temp = Binary()
        index = len(self.number)
        carry = []
        while len(Temp.number) != index:
            Temp.number.append(-1)
            carry.append(0)
        index -= 1
        while (index)>=0:
            if self.number[index] == 0 and B.number[index] == 0:
                Temp.number[index] = 0 + int(carry[index])
            if self.number[index] == 0 and B.number[index] == 1:
                Temp.number[index] = 1 + int(carry[index])
            if self.number[index] == 1 and B.number[index] == 0:
                Temp.number[index] = 1 + int(carry[index])
            if self.number[index] == 1 and B.number[index] == 1:
                Temp.number[index] = 0 + int(carry[index])
                carry[index-1] = 1
            if Temp.number[index] == 2:
                Temp.number[index] = 0
                if (index-1)>=0:

```

```

        carry[index-1] = 1
    index -= 1
    return Temp
B1 = Binary()
B1.set([1,1,0,1,1])
B2 = Binary()
B2.set([0,1,1,0,1])
B3 = B1 + B2
B3.display()

```

OUTPUT

```
[0, 1, 0, 0, 0]
```

Program 11.7 Write a program to compare two Date objects.

```

class Date:
    def __init__(self):
        d = m = y = 0
    def get(self):
        self.d = int(input("Enter the day : "))
        self.m = int(input("Enter the month : "))
        self.y = int(input("Enter the year : "))
    def __eq__(self, D):
        Flag = False
        if self.d == D.d:
            if self.m == D.m:
                if self.y == D.y:
                    Flag = True
        return Flag
    def __lt__(self, D):
        Flag = False
        if self.y < D.y:
            if self.m < D.m:
                if self.d < D.d:
                    Flag = True
        return Flag
D1 = Date()
D1.get()
D2 = Date()
D2.get()
print("D1 == D2", D1 == D2)
print("D1 < D2", D1 < D2)

```

Programming Tip: The `__eq__` function gives `NotImplemented` as result when left hand argument does not know how to test for equality with given right hand argument.

OUTPUT

```

Enter the day : 21
Enter the month : 3

```

```

Enter the year : 2017
Enter the day : 21
Enter the month : 3
Enter the year : 2017
D1 == D2 True
D1 < D2 False

```

Program 11.8 Write a program to overload the -= operator to subtract two Distance objects.

```

class Distance:
    def __init__(self):
        self.km = 0
        self.m = 0
    def set(self, km, m):
        self.km = km
        self.m = m
    def __isub__(self, D):
        self.m = self.m - D.m
        if self.m < 0:
            self.m += 1000
            self.km -= 1
        self.km = self.km - D.km
        return self
    def convert_to_meters(self):
        return (self.km*1000 + self.m)
    def display(self):
        print(self.km, "kms", self.m, "mtrs")

D1 = Distance()
D1.set(21, 70)
D2 = Distance()
D2.set(18, 123)
D1 -= D2
print("D1 - D2 = ")
D1.display(),
print("that is", D1.convert_to_meters(), "meters")

```

OUTPUT

```
D1 - D2 = 2 kms 947 mtrs that is 2947 meters
```

11.3 REVERSE ADDING

In a program, we have added a certain number of days to our `Date` object by writing `d + num`. In this case, it is compulsory that the class object will invoke the `__add__()`. But, to provide greater flexibility, we should also be able to perform the addition in reverse order, that is, adding a non-class object to the class object. For this, Python provides the concept of reverse adding. The function to do normal addition on `Date` object is discussed in the following example.

Example 11.4 Program to illustrate adding on Date object

```
def __add__(self, num):
    self.d += num
    if self.m != 2:
        max_days = Dict[self.m]
    elif self.m == 2:
        isLeap = chk_Leap_Year(self.y)
        if isLeap == 1:
            max_days = 29
        else:
            max_days = 28
    while self.d > max_days:
        self.d -= max_days
        self.m += 1
    while self.m > 12:
        self.m -= 12
        self.y += 1
```

Programming Tip: Special methods are used for performing operator overloading.

But, had we written the same statement as `num + d`, then the desired task would not have been performed. The simple reason for this is that the `__add__()` takes `self` as the first argument, so the `+` operator has to be invoked using the `Date` object. But this is not the case when you work with numbers. You can either write `10 + 20` or `20 + 10`, it means the same and the correct result is produced. So, we should also have the same result when we write `d + num` or `num + d`. Python has a solution to this. It has the feature of reverse adding. As you write the `__add__()` function, just write the `__radd__()` function which will do the same task.

Note To overload the `+=` or `-=` operators, use the `__iadd__()` or `__isub__()` functions.

11.4 OVERRIDING `__getitem__()` AND `__setitem__()` METHODS

Python allows you to override `__getitem__()` and `__setitem__()` methods. We have already seen in Chapter 9 that `__getitem__()` is used to retrieve an item at a particular index. Similarly, `__setitem__()` is used to set value for a particular item at the specified index. Although they are well defined for built-in types like list, tuple, string, etc. but for user-defined classes we need to explicitly write their codes. Consider the program given below which has a list defined in a class. By default, Python does not allow you to apply indexes on class objects but if you have defined the `__getitem__()` and `__setitem__()` methods in the class, then you can simply work with indices as with any other built-in type as shown in the following example.

Example 11.5 Program that overrides `__getitem__()` and `__setitem__()` methods in a class

```
class myList:
    def __init__(self, List):
        self.List = List
    def __getitem__(self, index):
        return self.List[index]
```



```

def __setitem__(self, index, num):
    self.List[index] = num
def __len__(self):
    return len(self.List)
def display(self):
    print(self.List)
L = myList([1,2,3,4,5,6,7])
print("LIST IS : ")
L.display()
index = int(input("Enter the index of List you want to access : "))
print(L[index])
index = int(input("Enter the index at which you want to modify : "))
num = int(input("Enter the correct number : "))
L[index] = num
L.display()
print("The length of my list is : ", len(L))

```

OUTPUT

```

LIST IS : [1, 2, 3, 4, 5, 6, 7]
Enter the index of List you want to access : 3
4
Enter the index at which you want to modify : 3
Enter the correct number : 40
[1, 2, 3, 40, 5, 6, 7]
The length of my list is : 7

```

11.5 OVERRIDING THE `in` OPERATOR

We have seen that `in` is a membership operator that checks whether the specified item is in the variable of built-in type or not (like string, list, dictionary, tuple, etc.). We can overload the same operator to check whether the given value is a member of a class variable or not. To overload the `in` operator we have to use the function `__contains__()`. In the program given in the following example, we have created a dictionary that has name of the subjects as *key* and their maximum weightage as *value*. In the main module, we are asking the user to input a subject. If the subject is specified in our dictionary, then its maximum weightage is displayed.

Example 11.6 Program to override the `in` operator

```

class Marks:
    def __init__(self):
        self.max_marks = {"Maths":100, "Computers":50, "SST":100, "Science":75}
    def __contains__(self, sub):
        if sub in self.max_marks:
            return True
        else:
            return False
    def __getitem__(self, sub):

```

```

        return self.max_marks[sub]
    def __str__(self):
        return "The Dictionary has name of subjects and maximum marks allotted to them"
M = Marks()
print(str(M))
sub = input("Enter the subject for which you want to know extra marks : ")
if sub in M:
    print("Social Studies paper has maximum marks allotted = ", M[sub])

```

OUTPUT

```

The Dictionary has name of subjects and maximum marks allotted to them
Enter the subject for which you want to know extra marks : Computers
Social Studies paper has maximum marks allotted = 50

```

11.6 OVERLOADING MISCELLANEOUS FUNCTIONS

Python allows you to overload functions like `long()`, `float()`, `abs()`, and `hex()`. Remember that we have used these functions on built-in type variables to convert them from one type to another. We can use these functions to convert a value of one user-defined type (object) to a value of another type.

Example 11.7 Program to overload `hex()`, `oct()`, and `float()` functions

```

class Number:
    def __init__(self, num):
        self.num = num
    def display(self):
        return self.num
    def __abs__(self):
        return abs(self.num)
    def __float__(self):
        return float(self.num)
    def __oct__(self):
        return oct(self.num)
    def __hex__(self):
        return hex(self.num)
    def __setitem__(self, num):
        self.num = num
N = Number(-14)
print("N IS : ", N.display())
print("ABS(N) IS : ", abs(N))
N = abs(N)
print("Converting to float....., N IS : ", float(N))
print("Hexadecimal equivalent of N IS : ", hex(N))
print("Octal equivalent of N IS : ", oct(N))

```

OUTPUT

```
N IS : -14
ABS(N) IS : 14
Converting to float....., N IS : 14.0
Hexadecimal equivalent of N IS : 0xe
Octal equivalent of N IS : 016
```

Let us take another example in which we have two classes for calculating the distance. One has distance specified in meters and the other has distance in kilometers. There are two functions—`km()` and `mts()`, which takes the argument of class `Distance` and then converts the distance into kilometers and meters respectively.

Example 11.8 Program to illustrate conversion of class objects

```
class Distance_m:
    def __init__(self, m):
        self.m = m
    def display(self):
        print("Distance in meters is : ", self.m)
def mts(D):
    return D.km*1000
class Distance_km:
    def __init__(self, km):
        self.km = km
    def display(self):
        print("Distance in kilometers is : ", self.km)
def km(D):
    return D.m/1000
Dm = Distance_m(12345)
Dm.display()
print("Distance in kilo metres = ", km(Dm))
Dkm = Distance_km(12.345)
Dkm.display()
print("Distance in metres = ", mts(Dkm))
```

OUTPUT

```
Distance in meters is : 12345
Distance in kilo metres = 12
Distance in kilometers is : 12.345
Distance in metres = 12345.0
```

11.7 OVERRIDING THE `__call__()` METHOD

The `__call__()` method is used to overload call expressions. The `__call__()` method is called automatically when an instance of the class is called. It can be passed to any positional or keyword arguments. Like other functions, the `__call__()` method also supports all of the argument-passing modes. The `__call__()` method can be declared as, `def __call__(self, [args...])`

Example 11.9 Program to overload the `__call__()` method

```
class Mult:
    def __init__(self, num):
        self.num = num
    def __call__(self, 0):
        return self.num * 0
x = Mult(10)
print(x(5))
```

OUTPUT

50

Summary

- The meaning of operators like `+`, `=`, `*`, `/`, `>`, `<`, etc. are pre-defined in any programming language. So, programmers can use them directly on built-in data types to write their programs.
- Operator overloading allows programmers to extend the meaning of existing operators so that in addition to the basic data types, they can also be applied to user-defined data types.
- With operator overloading, a programmer is allowed to provide his own definition for an operator to a class by overloading the built-in operator.
- Operator overloading is also known as operator *ad hoc polymorphism* since different operators have different implementations depending on their arguments.
- The `__add__()` method returns the new combined object to the caller.
- By default, Python does not allow you to apply indexes on class objects but if you have defined the `__getitem__()` and `__setitem__()` in the class, then you can simply work with indices as with any other built-in type.

Glossary

Ad hoc polymorphism A specific case of polymorphism where different operators have different implementations depending on their arguments.

Membership operator An operator that checks whether the specified item is present in the instance of an object or not.

Operator Overloading Redefining the meaning of operators when they operate on class objects.

Exercises

Fill In The Blanks

1. _____ allows programmers to redefine the meaning of existing operators.
2. Operator overloading is also known as _____ polymorphism.
3. _____ is a specific case of _____ polymorphism where different operators have different implementations depending on their arguments.
4. The name of the function to overload `**` operator is _____.
5. The `__add__()` method returns _____.
6. To overload the `*=` operator you will use _____ function.

7. The `__eq__` function gives _____ as result when left hand argument does not know how to test for equality with given right hand argument.
8. The _____ method is used to overload call expressions.
9. The `__call__()` method supports all of the _____ modes.
10. _____ method is written to perform `longObj - Number`, where `Number` is a user-defined class.

State True Or False

1. You can have overload only one operator per class.
2. Operator overloading allows you to create new operators.
3. With operator overloading, a programmer is allowed to provide his own definition for an operator to a class.
4. Operator overloading makes the program simple to understand.
5. To overload the `<=<` operator, you will write the code for `__lshift__` function.
6. All the operators can be overloaded.
7. Writing `intObj + classObj` is same as writing `classObj + intObj`.
8. Special methods are used for performing operator overloading.
9. The `__getitem__()` and `__setitem__()` methods are defined for lists, tuples, and strings but not for class objects.
10. The `__call__()` method can be passed any positional or keyword arguments.

Multiple Choice Questions

1. Which function will be written to overload the `in` operator?
 - (a) `__call__()`
 - (b) `__contains__()`
 - (c) `__member__()`
 - (d) `__add__()`
2. Which of the following function will help you to retrieve an item at a particular index?
 - (a) `slice`
 - (b) `__getitem__()`
 - (c) `__setitem__()`
 - (d) `in`
3. Which of the following function is used to set value for a particular item at the specified index?
 - (a) `slice`
 - (b) `__getitem__()`
 - (c) `__setitem__()`
 - (d) `in`
4. Membership operator when overloaded is invoked on _____.
 - (a) object
 - (b) class
 - (c) method
 - (d) attribute
5. Which conversion function cannot be overloaded in a class?
 - (a) `long()`
 - (b) `hex()`
 - (c) `str()`
 - (d) None of these
6. Which function is called when the following code is executed?


```
C = Complex()
format(C)
```

 - (a) `format()`
 - (b) `__format__()`
 - (c) `str()`
 - (d) None of these
7. If we write the following lines of code, then which function will be invoked and what will it return?


```
N1 = Number(10)
N2 = Number(20)
print(N1<N2)
```

 - (a) `__lt__`, False
 - (b) `__gt__`, False
 - (c) `__lt__`, True
 - (d) `__gt__`, True
8. When we add two objects of class `Complex`, which functions are called when we write `print(C1 + C2)`?
 - (a) `__add__()`, `__str__()`
 - (b) `__str__()`, `__add__()`
 - (c) `__sum__()`, `__str__()`
 - (d) `__str__()`, `__sum__()`

Review Questions

1. Define the term operator overloading.
2. Assume that you have overloaded the `+` operator in your program. Illustrate the cases in which the operator overloaded function will be called and the cases in which the default function will be called.
3. Define the term ad hoc polymorphism.
4. Give the advantages of operator overloading.
5. Differentiate between `__add__`, `__radd__`, and `__iadd__` functions.
6. Which functions will you use to index a class object? Explain with the help of an example.
7. Which operator is used to check whether a value is present in the object or not? Can you overload this object on user-defined types? If yes, how?

8. Is it possible to convert a class object into a floating type value? If yes, how?
9. With the help of an example explain how you can convert a value of one class type into a value of another class type.
10. When is the `__call__()` method invoked?

Programming Problems

1. Write a class `Money` with attributes `Rupees` and `Paise`. Overload operators `+=`, `-=`, and `>=` so that they may be used on two objects. Also write functions so that a desired amount of money can be either added or subtracted from `Money`.
2. Use the class defined in the previous functions to calculate the amount of money to be paid by multiplying it with a specified quantity.
3. Again, using class `Money`, find the price of one item given the total amount paid and number of units of item bought.
4. Write a class `INR` with attributes `Rupees` and `Paise`. Write another class `USD` with attributes `dollars` and `cents`. Write a function to convert `USD` into `INR` and vice versa.
5. Write a program that overloads the `+` operator to add two objects of class `Time`.
6. Write a menu driven program to overload `+=`, `-=`, and `*` operators on the `Matrix` class.
7. Write a menu driven program to overload `+=`, `-=`, `==`, `>=`, and `<=` operators on the `Distance` class.
8. Write a menu driven program to overload `+=`, `-=`, `==`, `>=`, and `<=` operators on the `Time` class.
9. Write a menu driven program to overload `+=`, `-=`, `==`, `>=`, and `<=` operators on the `Height` class.
10. Write a menu driven program to overload `+=`, `-=`, `==`, `>=`, and `<=` operators on the `Binary` class.
11. Write a menu driven program to overload `+=`, `-=`, `*`, `/`, `==`, `>=`, and `<=` operators on the `Complex` class.
12. Write a menu driven program to overload `+=`, `-=`, `*`, `/`, `==`, and `>=`, and `<=` operators on the `Polynomial` class.
13. Write a menu driven program to overload `+=`, `-=`, `*`, `/`, `==`, `>=`, and `<=` operators on the `Fraction` class.
14. Write a menu driven program to overload `+=`, `-=`, `==`, `>=`, and `<=` operators on the `String` class.
15. Write a program to convert minutes into class `Time` with data members—`hrs` and `mins`.
16. Write a program to convert class `Time` with data members—`hrs` and `mins` into minutes.
17. Write a menu driven program that performs conversion to and from `Array` class.
18. Write a menu driven program that performs conversion to and from `String` class.
19. Write a menu driven program that performs conversion from a `Square` to `Rectangle` class.
20. Write a program to convert data of class `Student` having members—`roll no` and `marks` in three subjects to another class `Student` that stores just the `roll number` and the `average`.
21. Write a program to convert `Polar co-ordinates` specified in one class into `Rectangular co-ordinates`.
22. Write a program to convert temperature specified in `Celsius` in one class into `Fahrenheit` in another class.
23. Write a program to implement a timer using increment operator overloading.

Find the Output

1.

```
class Point:
    def __init__(self, x, y):
        self.x = x
        self.y = y
    def __abs__(self):
        return (self.x**2 + self.y**2)**0.5
    def __add__(self, P):
        return Point(self.x + P.x, self.y + P.y)
    def display(self):
        print(self.x, self.y)
```

```
P1 = Point(12, 25)
P2 = Point(21, 45)
print(abs(P2))
P1 = P1+ P2
P1.display()
```
2.

```
class A(object):
    def __init__(self, num):
        self.num = num
    def __eq__(self, other):
        return self.num == other.num
```

```

class B(object):
    def __init__(self, num):
        self.num = num
print(A(5) == B(5))
3. class Circle:
    def __init__(self, radius):
        self.__radius = radius
    def getRadius(self):
        return self.__radius
    def area(self):
        return 3.14 * self.__radius ** 2
    def __add__(self, C):
        return Circle( self.__radius + C.__
radius )
C1 = Circle(5)
C2 = Circle(9)
C3 = C1 + C2
print("RADIUS : ", C3.getRadius())
print("AREA : ", C3.area())
4. class Circle:
    def __init__(self, radius):
        self.__radius = radius
    def __gt__(self, another_circle):
        return self.__radius >
another_circle.__radius
    def __lt__(self, C):
        return self.__radius < C.__radius
    def __str__(self):
        return "Circle has radius " +
str(self.__radius)
C1 = Circle(5)
C2 = Circle(9)
print(C1)
print(C2)
print("C1 < C2 : ", C1 < C2)
print("C2 > C1 : ", C1 > C2)
5. class One:
    def __init__(self):
        num = 10
    def __eq__(self, T):
        if isinstance(T, One):
            return True
        else:
            return NotImplemented
class Two:
    def __init__(self):
        num = 100
print(One() == Two())
6. class A:
    def __bool__(self):
        return True

```

```

X = A()
if X:
    print('yes')
7. class String(object):
    def __init__(self, val):
        self.val = val
    def __add__(self, other):
        return self.val + '...' + other.val
    def __sub__(self, other):
        return "Not Implemented"
S1 = String("Hello")
S2 = String("World")
print(S1 + S2)
print(S1 - S2)
8. class String(object):
    def __init__(self, val):
        self.val = val
    def __str__(self):
        return self.val
    def __repr__(self):
        return "This is String representation
of " + self.val
S = String("Hi")
print(str(S))
9. class A:
    def __len__(self):
        return 0
X = A()
if not X:
    print('no')
else:
    print('yes')
10. class A:
    def __init__(self):
        self.str = "abcdef"
    def __getitem__(self, i):
        return self.str[i]
x = A()
for i in x:
    print(i, end=" ")
11. class A:
    str = "Hi"
    def __gt__(self, str):
        return self.str > str
X = A()
print(X > 'hi')

```

Find the Error

1.

```
class Matrix:
    def __init__(self):
        Mat = []
    def setValue(self, number):
        self.number = number
    def display(self):
        print(self.number)
M1 = Matrix()
M1.setValue([1,2],[3,4])
M2 = Matrix()
M2.setValue([5,6],[2,3])
M3 = Matrix()
M3 = M1 + M2
M3.display()
```
2.

```
class A(object):
    def __init__(self, num):
        self.num = num
    def __eq__(self, other):
        return self.num == other.num
class B(object):
    def __init__(self, val):
        self.val = val
print(A(5) == B(5))
```
3.

```
class Point:
    def __init__(self, x, y):
        self.x = x
        self.y = y
    def __mul__(self, num):
        return self.x * num + self.y * num
P1 = Point(3, 4)
print(2*P1)
```
4.

```
class String(object):
    def __init__(self, val):
        self.val = val
S1 = String("Hello")
print(S1[5])
```
5.

```
class Number:
    def __init__(self, num):
        self.num = num
    def __sub__(self, N):
        return Number(self.num - N)
    def __sub__(N, self):
        return Number(N - self.num)
x = Number(4)
y = x-4
```
6.

```
class A:
    def __init__(self):
        self.str = "abcdef"
    def __setitem__(self, i, val):
        self.str[i] = val
x = A()
x[2] = 'X'
```

Answers**Fill in the Blanks**

- | | | | |
|---------------------------|-------------------------|--------------------------------|-----------------------------|
| 1. operator overloading | 4. <code>__pow__</code> | 6. <code>__imul__</code> | 9. argument-passing |
| 2. compile time or ad hoc | 5. the new combined | 7. <code>NotImplemented</code> | 10. <code>__rsub__()</code> |
| 3. ad hoc polymorphism | object to the caller | 8. <code>__call__()</code> | |

State True or False

1. False 2. False 3. True 4. True 5. False 6. False 7. False 8. True 9. True 10. True

Multiple Choice Questions

1. (b) 2. (b) 3. (c) 4. (a) 5. (d) 6. (c) 7. (c) 8. (a)