Advanced Python Programming (4321602) - Winter 2023 Solution

Milav Dabgar

January 24, 2024

Question 1

Question 1(a) [3 marks]

What is Dictionary? Explain with example.

Solution

Dictionary is a collection of key-value pairs in Python which is mutable and ordered.
Dictionary Properties:

Property	Description
Mutable	Values can be changed
Ordered	Insertion order is maintained (Python 3.7+)
Indexed	Accessed via keys
No Duplicates	Duplicate keys are not allowed

```
# Dictionary Example
student = {
    "name": "Raj",
    "age": 20,
    "course": "IT"
}
print(student["name"])  # Output: Raj

```

- **Key-Value Structure**: Each element has a key and a value
- **Fast Access**: Data access in O(1) time complexity
- **Dynamic Size**: Size can be increased or decreased at runtime

Mnemonic

Dictionary = Key Value Treasure

Question 1(b) [4 marks]

Explain Tuple Built-in functions and methods.

Solution

Tuple has limited built-in methods because it is immutable.
Tuple Methods:

Method	Description	Example
count()	Returns frequency of element	`t.count(5)`
index()	Returns first index of element	`t.index('a')`
len()	Returns length of tuple	`len(t)`
max()	Returns maximum value	`max(t)`
min()	Returns minimum value	`min(t)`

```python
# Tuple Methods Example
numbers = (1, 2, 3, 2, 4, 2)
print(numbers.count(2))     # Output: 3
print(numbers.index(3))     # Output: 2
print(len(numbers))         # Output: 6

```

- **Immutable Nature**: Methods do not modify the tuple
- **Return Values**: All methods return new values
- **Type Conversion**: `tuple()` function can convert list to tuple

Mnemonic

Count Index Length Max Min

Question 1(c) [7 marks]

Write a python program to demonstrate set operations.

Solution

Set operations are based on mathematical set theory.
Set Operations:

Operation	Symbol	Method	Description
Union	`|`	`union()`	Elements of both sets
Intersection	`&`	`intersection()`	Common elements
Difference	`-`	`difference()`	Minus second from first
Symmetric Difference	`^`	`symmetric_difference()`	Unique elements only

```python
# Set Operations Program
set1 = {1, 2, 3, 4, 5}
set2 = {4, 5, 6, 7, 8}

print("Set 1:", set1)
print("Set 2:", set2)

# Union Operation
union_result = set1 | set2
print("Union:", union_result)

# Intersection Operation
intersection_result = set1 & set2
print("Intersection:", intersection_result)

# Difference Operation
```

```python
difference_result = set1 - set2
print("Difference:", difference_result)

# Symmetric Difference
sym_diff_result = set1 ^ set2
print("Symmetric Difference:", sym_diff_result)

# Subset and Superset
set3 = {1, 2}
print("Is set3 subset of set1?", set3.issubset(set1))
print("Is set1 superset of set3?", set1.issuperset(set3))

```

- **Mathematical Operations**: Implements operations of set theory
- **Efficient Processing**: Duplicate elements are automatically removed
- **Boolean Results**: Subset/superset operations return boolean

Mnemonic

Union Intersection Difference Symmetric

Question 1(c) OR [7 marks]

Write a python program to demonstrate the dictionaries functions and operations.

Solution

Dictionary operations provide powerful tools for data manipulation.
Dictionary Methods:

Method	Description	Example
keys()	Returns all keys	`dict.keys()`
values()	Returns all values	`dict.values()`
items()	Returns key-value pairs	`dict.items()`
get()	Safe value retrieval	`dict.get('key')`
update()	Merges dictionary	`dict.update()`

```python
# Dictionary Operations Program
student_data = {
    "name": "Amit",
    "age": 21,
    "course": "IT",
    "semester": 2
}

print("Original Dictionary:", student_data)

# Accessing values
print("Student Name:", student_data.get("name"))
print("Student Age:", student_data["age"])

# Adding new key-value pair
student_data["city"] = "Ahmedabad"
print("After adding city:", student_data)

# Updating existing value
```

```python
student_data.update({"age": 22, "semester": 3})
print("After update:", student_data)

# Dictionary methods
print("Keys:", list(student_data.keys()))
print("Values:", list(student_data.values()))
print("Items:", list(student_data.items()))

# Removing elements
removed_value = student_data.pop("semester")
print("Removed value:", removed_value)
print("Final Dictionary:", student_data)

```

- **Dynamic Operations**: Keys and values can be added/removed at runtime
- **Safe Access**: `get()` method prevents KeyError
- **Iteration Support**: `keys()`, `values()`, `items()` methods are useful for loops

Mnemonic

Get Keys Values Items Update Pop

Question 2

Question 2(a) [3 marks]

Distinguish between Tuple and List in Python.

Solution

Tuple vs List Comparison:

Feature	Tuple	List
Mutability	Immutable (cannot change)	Mutable (can change)
Syntax	Parentheses `()`	Square brackets `[]`
Performance	Faster	Slower
Memory	Less memory	More memory
Methods	Limited (count, index)	Many methods available
Use Case	Fixed data	Dynamic data

- **Immutable Nature**: Tuple cannot be changed once created
- **Performance**: Tuple operations are faster than list
- **Memory Efficient**: Tuple uses less memory

Mnemonic

Tuple Tight, List Light

Question 2(b) [4 marks]

What is the dir() function in python? Explain with example.

Solution

`dir()` function is a built-in function that returns a list of attributes and methods of an object.
dir() Function Features:

Feature	Description
Object Inspection	Shows attributes of object
Method Discovery	Lists available methods
Namespace Exploration	Shows variables of current namespace
Module Analysis	Explores contents of module

```
# dir() Function Example
# For string object
text = "Hello"
string_methods = dir(text)
print("String methods:", string_methods[:5])

# For list object
my_list = [1, 2, 3]
list_methods = dir(my_list)
print("List methods:", [m for m in list_methods if not m.startswith('_')][:5])

# For current namespace
print("Current namespace:", dir()[:3])

# For built-in functions
import math
print("Math module:", dir(math)[:5])

```

- **Interactive Development**: Useful for knowing capabilities of objects
- **Debugging Tool**: To quickly identify available methods
- **Learning Aid**: Helpful for exploring new libraries

Mnemonic

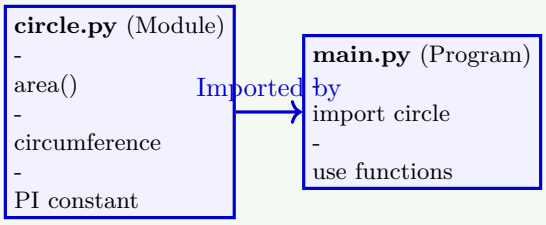
Dir = Directory of Methods

Question 2(c) [7 marks]

Write a program to define a module to find the area and circumference of a circle. Import module to another program.

Solution

Module approach improves code reusability and organization.



File 1: circle.py (Module)

```python
# circle.py - Circle calculation module
import math

# Constants
PI = math.pi

def area(radius):
    """Calculate area of circle"""
    if radius < 0:
        return "Radius cannot be negative"
    return PI * radius * radius

def circumference(radius):
    """Calculate circumference of circle"""
    if radius < 0:
        return "Radius cannot be negative"
    return 2 * PI * radius

def display_info():
    """Display module information"""
    print("Circle Module - Version 1.0")
    print("Functions: area(), circumference()")

```

File 2: main.py (Main Program)

```python
# main.py - Main program using circle module
import circle

# Get radius from user
radius = float(input("Enter radius: "))

# Calculate using module functions
circle_area = circle.area(radius)
circle_circumference = circle.circumference(radius)

# Display results
print(f"Circle with radius {radius}:")
print(f"Area: {circle_area:.2f}")
print(f"Circumference: {circle_circumference:.2f}")

# Display module info
circle.display_info()

```

- **Modular Design**: Organizes functions in a separate file
- **Reusability**: Module can be used in multiple programs
- **Namespace Management**: Functions are accessed via module prefix

Mnemonic

Import Calculate Display

Question 2(a) OR [3 marks]

Explain Nested Tuple with example.

Solution

Nested Tuple contains other tuples inside it, creating a hierarchical data structure.
Nested Tuple Features:

Feature	Description
Multi-dimensional	2D or 3D data structure
Immutable	Immutable at all levels
Indexing	Access using multiple square brackets
Heterogeneous	Can store different data types

```
# Nested Tuple Example
student_records = (
    ("Raj", 20, ("IT", 2)),
    ("Priya", 19, ("CS", 1)),
    ("Amit", 21, ("IT", 3))
)

# Accessing nested elements
print("First student:", student_records[0])
print("First student name:", student_records[0][0])
print("First student course:", student_records[0][2][0])

# Iterating through nested tuple
for student in student_records:
    name, age, (course, semester) = student
    print(f"{name} - Age: {age}, Course: {course}, Sem: {semester}")

```

- **Data Organization**: Useful for grouping related data
- **Immutable Structure**: Structure cannot be changed once created
- **Efficient Access**: Fast index-based access

Mnemonic

Nested = Tuple Inside Tuple

Question 2(b) OR [4 marks]

What is PIP? Write the syntax to install and uninstall python packages.

Solution

PIP (Pip Installs Packages) is a Python package installer that downloads and installs packages from PyPI.
PIP Commands:

Command	Syntax	Description
Install	`pip install package`	Installs package
Uninstall	`pip uninstall package`	Removes package
List	`pip list`	Shows installed packages
Show	`pip show package`	Displays package info
Upgrade	`pip install --upgrade pkg`	Updates package

```
# PIP Command Examples (Run in Terminal/Command Prompt)
```

```

# Install a package
# pip install requests

# Install specific version
# pip install Django==3.2.0

# Uninstall a package
# pip uninstall numpy

# List all installed packages
# pip list

# Show package information
# pip show matplotlib

# Upgrade a package
# pip install --upgrade pandas

# Install from requirements file
# pip install -r requirements.txt

```

- **Package Management**: Can easily manage third-party libraries
- **Version Control**: Specific versions can be installed
- **Dependency Resolution**: Required dependencies are installed automatically

Mnemonic

PIP = Package Install Python

Question 2(c) OR [7 marks]

Explain different ways of importing package. How are modules and packages connected to each other?

Solution

Different ways of imports in Python are important for code organization and namespace management.
Import Methods:

Method	Syntax	Usage
Basic Import	`import module`	Full module name required
From Import	`from module import function`	Direct function access
Alias Import	`import module as alias`	Short name for module
Star Import	`from module import *`	Import all functions
Package Import	`from package import module`	Import from package

```
# Different Import Ways

# 1. Basic Import
import math
result = math.sqrt(16)

# 2. From Import
from math import sqrt, pi
```

```
result = sqrt(16)
area = pi * 5 * 5

# 3. Alias Import
import numpy as np
array = np.array([1, 2, 3])

# 4. Star Import (not recommended)
from math import *
result = cos(0)

# 5. Package Import
from mypackage import module1
from mypackage.subpackage import module3

```

Module-Package Connection:

- **Modules**: Single .py files containing Python code
- **Packages**: Directories containing multiple modules with `__init__.py`
- **Namespace**: Packages create hierarchical namespace structure
- **___init___.py**: Makes directory a package and controls imports

Mnemonic

Import From As Star Package

Question 3

Question 3(a) [3 marks]

Describe Runtime Error and Syntax Error. Explain with example.

Solution

Error Types Comparison:

Error Type	When Occurs	Detection	Example
Syntax Error	Code parsing time	Before execution	Missing colon
Runtime Error	During execution	While running	Zero division
Logic Error	Always	After execution	Wrong logic

```
# Syntax Error Example
# print("Hello World"  # Missing closing parenthesis
# SyntaxError: unexpected EOF while parsing

# Runtime Error Examples
try:
    # ZeroDivisionError
    result = 10 / 0
except ZeroDivisionError:
    print("Cannot divide by zero")

try:
    # FileNotFoundError
    file = open("nonexistent.txt", "r")
except FileNotFoundError:
```

```
    print("File not found")

```

- **Syntax Errors**: Detected before code runs
- **Runtime Errors**: occur during program execution
- **Prevention**: Exception handling handles runtime errors

Mnemonic

Syntax Before, Runtime During

Question 3(b) [4 marks]

What is Exception handling in Python? Explain with example.

Solution

Exception handling is a mechanism that gracefully handles runtime errors and prevents program crashes.
Exception Handling Keywords:

Keyword	Purpose	Description
try	Code prone to exception	Risk code block
except	To handle exception	Error handling block
finally	Always executed	Cleanup code
else	If no exception	Success code block
raise	To raise manual exception	Custom error throwing

```
# Exception Handling Example
def safe_division(a, b):
    try:
        # Code that might raise exception
        result = a / b
        print(f"Division successful: {result}")

    except ZeroDivisionError:
        # Handle specific exception
        print("Error: Cannot divide by zero")
        result = None

    except TypeError:
        # Handle type errors
        print("Error: Invalid data types")
        result = None

    else:
        # Executes if no exception
        print("Division completed successfully")

    finally:
        # Always executes
        print("Division operation finished")

    return result

# Test the function
safe_division(10, 2)   # Normal case
```

```
safe_division(10, 0)   # Zero division
safe_division(10, "a") # Type error

```

- **Error Prevention**: Prevents program from crashing
- **Graceful Handling**: Provides user-friendly error messages
- **Resource Management**: Cleanup operations in finally block

Mnemonic

Try Except Finally Else Raise

Question 3(c) [7 marks]

Create a function for division of two numbers, if the value of any argument is non-integer then raise the error or if second argument is 0 then raise the error.

Solution

Creating custom exception handling function is important for validation and error control.

```
def safe_integer_division(num1, num2):
    """
    Divide two numbers with validation
    Raises TypeError if arguments are not integers
    Raises ZeroDivisionError if second argument is 0
    """

    # Check if both arguments are integers
    if not isinstance(num1, int):
        raise TypeError(f"First argument must be integer, got {type(num1).__name__}")

    if not isinstance(num2, int):
        raise TypeError(f"Second argument must be integer, got {type(num2).__name__}")

    # Check for zero division
    if num2 == 0:
        raise ZeroDivisionError("Cannot divide by zero")

    # Perform division
    result = num1 / num2
    return result

# Test the function with different cases
def test_division():
    test_cases = [
        (10, 2),      # Valid case
        (15, 3),      # Valid case
        (10, 0),      # Zero division error
        (10.5, 2),    # Non-integer first argument
        (10, 2.5),    # Non-integer second argument
        ("10", 2),    # String argument
    ]

    for num1, num2 in test_cases:
        try:
            result = safe_integer_division(num1, num2)
            print(f"{num1} / {num2} = {result}")

```

```
        except TypeError as e:
            print(f"Type Error: {e}")

        except ZeroDivisionError as e:
            print(f"Zero Division Error: {e}")

        except Exception as e:
            print(f"Unexpected Error: {e}")

        print("-" * 40)

# Run tests
test_division()

```

- **Input Validation**: Checks type and value of arguments
- **Custom Errors**: Raises specific exceptions
- **Error Messages**: Clear and descriptive error messages

Mnemonic

Validate Type, Check Zero, Divide Safe

Question 3(a) OR [3 marks]

Describe any five built-in exceptions in Python.

Solution

Built-in Exceptions:

Exception	Cause	Example
ValueError	Invalid value for operation	`int("abc")`
TypeError	Wrong data type	`"5" + 5`
IndexError	Index out of range	`list[10]`
KeyError	Dictionary key not found	`dict["missing"]`
FileNotFoundError	File does not exist	`open("missing.txt")`

- **Automatic Detection**: Python automatically raises these exceptions
- **Specific Handling**: Each exception has a specific purpose
- **Inheritance**: All exceptions inherit from BaseException class

Mnemonic

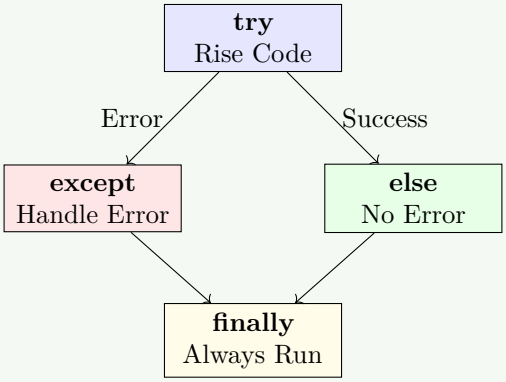
Value Type Index Key File

Question 3(b) OR [4 marks]

Explain try...except...else...finally block with example.

Solution

Exception Block Structure:




```python
# Complete Exception Block Example
def file_operation(filename):
    try:
        # Try to open file
        f = open(filename, "r")
        print("File opened successfully")

    except FileNotFoundError:
        # Handle if file missing
        print("Error: File not found")

    else:
        # Run if no error occurred
        print("Reading file content...")
        print(f.read())
        f.close()

    finally:
        # Always runs
        print("File operation attempt finished")

# Test with existing and missing files
file_operation("existing.txt")
file_operation("missing.txt")

```

- **Else Block**: Executes only if try block raises no exception
- **Finally Block**: Executes regardless of error (cleanup code)
- **Complete Flow**: Covers all possibilities of execution

Mnemonic

Try Exception Else Finally

Question 3(c) OR [7 marks]

Write a user defined exception that could be raised when the text entered by a user consists of less than 10 characters.

Solution

User-defined exceptions allow custom validation logic.

```python
class ShortTextError(Exception):
    """Custom exception for text validation"""
    def __init__(self, length):
        self.length = length
        self.message = f"Text too short ({length} chars). Minimum 10 required."
        super().__init__(self.message)

def validate_text():
    while True:
        try:
            # Get user input
            text = input("Enter text (min 10 chars): ")

            # Check length
            if len(text) < 10:
                raise ShortTextError(len(text))

            print(f"Valid text accepted: {text}")
            break

        except ShortTextError as e:
            print(f"Error: {e}")
            print("Please try again.\n")

        except Exception as e:
            print(f"Unexpected error: {e}")

# Run the validation
print("--- Text Validation Program ---")
# validate_text() # Uncomment to run

```

- **Inheritance**: Custom exception class inherits from `Exception`
- **Raising**: `raise` keyword used to trigger exception
- **Usage**: Helps in implementing domain-specific constraints

Mnemonic

Class Inherit Raise Catch

Question 4

Question 4(a) [3 marks]

Write five points on difference between Text File and Binary File.

Solution

Text vs Binary File:

Feature	Text File	Binary File
Content	Human readable characters	Machine readable (0s and 1s)
Encoding	Uses encoding (ASCII/UTF-8)	No encoding used
Extensions	.txt, .py, .csv	.bin, .jpg, .exe
EOL	Handles Newline translation	No translation
Processing	Slower processing	Faster processing

- **Readability**: Text files can be opened in simple editors
- **Portability**: Binary files are continuous stream of bytes
- **Usage**: Text for documents, Binary for images/videos/data

Mnemonic

Text Human, Binary Machine

Question 4(b) [4 marks]

Write a program to read the data from a file and separate the uppercase character and lowercase character into two separate files.

Solution

File processing involves reading, analyzing, and writing to multiple files.

```python
def separate_case_chars(source_file):
    try:
        # Strings to store separated characters
        upper_chars = ""
        lower_chars = ""

        # Read source file
        with open(source_file, "r") as f:
            content = f.read()

            # Process each character
            for char in content:
                if char.isupper():
                    upper_chars += char
                elif char.islower():
                    lower_chars += char

        # Write uppercase characters
        with open("uppercase.txt", "w") as f:
            f.write(upper_chars)

        # Write lowercase characters
        with open("lowercase.txt", "w") as f:
            f.write(lower_chars)

        print("Characters separated successfully!")

    except FileNotFoundError:
        print("Source file not found")

# Create a sample file first
with open("input.txt", "w") as f:
```

```
    f.write("Hello World! Python Programming.")

# Run separation
separate_case_chars("input.txt")

```

- **String Methods**: `isupper()` and `islower()` check case
- **File Handling**: Uses `with` statement for safe file operations
- **Data Separation**: Content is filtered into different streams

Mnemonic

Read Loop Check Write

Question 4(c) [7 marks]

Describe dump() and load() method. Explain with example.

Solution

`dump()` and `load()` are part of **pickle** module used for object serialization.
Pickle Methods:

Method	Purpose	Mode
dump(obj, file)	Serializes object to file	Write Binary ('wb')
load(file)	Deserializes object from file	Read Binary ('rb')

```
import pickle

# Data to serialize
student = {
    "name": "Rahul",
    "roll": 101,
    "marks": [85, 90, 88]
}

# DUMP Example
try:
    with open("data.pkl", "wb") as f:
        pickle.dump(student, f)
    print("Data dumped successfully")
except Exception as e:
    print(f"Error: {e}")

# LOAD Example
try:
    with open("data.pkl", "rb") as f:
        loaded_data = pickle.load(f)
    print("Data loaded successfully:")
    print(loaded_data)
except Exception as e:
    print(f"Error: {e}")

```

- **Serialization**: Converting object to byte stream (Pickling)
- **Deserialization**: Converting byte stream back to object (Unpickling)
- **Persistence**: Allows saving state of objects to disk

Mnemonic

Dump Store, Load Restore

Question 4(a) OR [3 marks]

List different types of file modes provided by python for file operations and explain their uses.

Solution

Python File Modes:

Mode	Name	Description
'r'	Read	Default mode. Opens for reading.
'w'	Write	Opens for writing. Overwrites file.
'a'	Append	Opens for writing. Appends to end.
'x'	Create	Creates new file. Fails if exists.
'b'	Binary	Binary mode (e.g., 'rb', 'wb').
'+'	Update	Read and Write (e.g., 'r+', 'w+').

- **Safety**: 'x' prevents accidental overwriting
- **Binary**: 'b' must be used for non-text files
- **Combination**: '+ can be combined with other modes

Mnemonic

Read Write Append Create

Question 4(b) OR [4 marks]

Describe readline() and writeline() functions of the file.

Solution

Note: Python has `writelines()` but no `writeline()`.
Line Operations:

Function	Purpose	Example
readline()	Reads single line	`line = f.readline()`
readlines()	Reads all lines into list	`lines = f.readlines()`
writelines()	Writes list of strings	`f.writelines(list)`

```
# Write lines
lines = ["First Line\n", "Second Line\n"]
with open("demo.txt", "w") as f:
    f.writelines(lines)

# Read lines
with open("demo.txt", "r") as f:
    line1 = f.readline()
```

```
    print(f"Read 1: {line1.strip()}")

    line2 = f.readline()
    print(f"Read 2: {line2.strip()}")

```

- **Sequential**: readline moves pointer line by line
- **List Support**: writelines accepts iterable (list/tuple)
- **Memory**: readline is efficient for large files

Mnemonic

Read One, Write Many

Question 4(c) OR [7 marks]

Write a python program to demonstrate seek() and tell() methods.

Solution

`seek()` moves file pointer, `tell()` returns current position.

```
# Seek and Tell Demonstration
filename = "seek_demo.txt"

# Create file
with open(filename, "w") as f:
    f.write("Hello Python World")

# Read operations
with open(filename, "r") as f:
    # Initial position
    print(f"Start Position: {f.tell()}")  # 0

    # Read first 5 chars
    print(f"Read: {f.read(5)}")          # Hello
    print(f"Current Position: {f.tell()}") # 5

    # Seek to start
    f.seek(0)
    print(f"After seek(0): {f.tell()}")   # 0

    # Seek to specific position
    f.seek(6)
    print(f"After seek(6): {f.read(6)}")  # Python

    # Seek from end (requires binary mode usually, or specific syntax)
    # f.seek(0, 2) moves to end

```

Method	Syntax
tell()	`pos = f.tell()`
seek()	`f.seek(offset, whence)`

- **Navigation**: Allows random access in files
- **Whence**: 0=Start, 1=Current, 2=End

- **Binary**: Relative seeking works best in binary mode

Mnemonic

Tell Position, Seek Location

Question 5

Question 5(a) [3 marks]

Draw the shape of circle and rectangle using turtle and fill with red color.

Solution

```
import turtle

t = turtle.Turtle()

# Fill color set to red
t.fillcolor("red")

# Draw Circle
t.begin_fill()
t.circle(50)      # Draw circle with radius 50
t.end_fill()

# Move to new position
t.penup()
t.goto(100, 0)
t.pendown()

# Draw Rectangle
t.begin_fill()
for _ in range(2):
    t.forward(100) # Length
    t.right(90)
    t.forward(50)  # Width
    t.right(90)
t.end_fill()

turtle.done()

```

- **begin_fill()**: Starts filling shape
- **end_fill()**: Completes filling shape
- **Geometry**: Circle and loop-based rectangle drawing

Mnemonic

Begin Fill End

Question 5(b) [4 marks]

Explain various inbuilt methods for changing the direction of turtle.

Solution

Turtle Direction Methods:

Method	Description	Example
right(angle)	Turn right by angle	`t.right(90)`
left(angle)	Turn left by angle	`t.left(45)`
setheading(angle)	Set absolute angle	`t.setheading(0)`
towards(x,y)	Point towards coords	`t.towards(0,0)`

```
# Direction Examples
import turtle
t = turtle.Turtle()

t.forward(100)
t.right(90)       # Turn 90 degrees right
t.forward(50)
t.left(45)        # Turn 45 degrees left
t.setheading(180) # Face West (180 degrees)

```

- **Relative**: right/left are relative to current direction
- **Absolute**: setheading uses 0-360 degree system
- **Navigation**: Essential for drawing complex shapes

Mnemonic

Right Left Heading Towards

Question 5(c) [7 marks]

Write a python program to draw rainbow using turtle.

Solution

Rainbow drawing utilizes concentric semi-circles with VIBGYOR colors.

```
import turtle

def draw_rainbow():
    # Setup screen
    wn = turtle.Screen()
    wn.bgcolor("skyblue")

    # Setup turtle
    t = turtle.Turtle()
    t.speed(5)
    t.pensize(10)

    # Rainbow colors (VIBGYOR reversed)
    colors = ['violet', 'indigo', 'blue', 'green',
              'yellow', 'orange', 'red']

    # Initial position parameters
    radius = 180

    # Draw arcs
```

```
    for color in colors:
        t.penup()
        t.goto(0, -50)     # Center bottom
        t.setheading(90)   # Face up
        t.right(90)        # Face right (0 deg)
        t.forward(radius)  # Move to start of arc
        t.left(90)         # Face up again
        t.pendown()

        t.pencolor(color)
        t.circle(radius, 180) # Draw semi-circle

        radius -= 20      # Decrease radius for next color

    t.hideturtle()
    turtle.done()

draw_rainbow()

```

- **Looping**: Iterates through list of colors
- **Concentric**: Radius decreases for each inner arc
- **Arc**: `circle(radius, 180)` draws half circle

Mnemonic

Colors Loop Radius Circle