Python Cook Book

Everyone can cook delicious recipes with Python

- 100% Practical
- 300+ Code Recipes
- Easy To Follow

Hernando Abella

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Everyone can cook delicious recipes

300 + Recipes

By Hernando Abella

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Thanks (again!)

Table of contents

Introduction

Learn to cook delicious and fun recipes in Python. codes that will help you grow in the programming environment using this wonderful language.

Some of the recipes you will create will be related to: Algorithms, classes, flow control, functions, design patterns, regular expressions, working with databases, and many more things.

Learning these recipes will give you a lot of confidence when you are creating great programs, and you will have more understanding when reading live code.

Abstract Classes

Abstract classes serve as templates for creating concrete classes. They define methods that must be implemented by subclasses, ensuring a consistent interface across different implementations. By defining common behavior and enforcing specific methods, abstract classes promote code reuse and maintainability. They cannot be instantiated directly, highlighting their role as conceptual models rather than concrete entities. Abstract classes are essential in scenarios where multiple classes share common traits but also require specific implementations.

Collection of similar objects

```
class ANamed:
    name = ""

class Flower(ANamed):
    pass

class City(ANamed):
    pass

class Star(ANamed):
    pass

rose = Flower()
rose.name = "Rose"

rome = City()
rome.name = "Rome"

sirius = Star()
sirius.name = "Sirius"

rows = [rose, rome, sirius]
names = ", ".join([r.name for r in rows])

# names is "Rose, Rome, Sirius"
```

Conformance checking (is, as)

```
from abc import ABC

class PUID(ABC):
    id = 0

class Named(ABC):
    name = ""

class Flower(Named):
    def __init__(self, name):
        self.name = name

rose = Flower("Rose")
isPUID = isinstance(rose, PUID)

isNamed = isinstance(rose, Named)

print(isPUID) # isPId is False
print(isNamed) # isNamed is True
```

Constructor requirements

```
from abc import *

class List(ABC):
    @abstractmethod
    def __init__(self, item_count):
        self.itemCount = item_count

class SortedList(List):
    def __init__(self, item_count):
        super().__init__(item_count)
        # implementation
        print(item_count)

lst = SortedList(10)
print(lst.itemCount)

# 10
# 10
```

Declaration and initialization

```
from abc import ABC, abstractmethod

class Printable(ABC):
    @abstractmethod
    def print(self, color):
        pass
shape = Printable() # <-error
```

Inheritance of abstract classes

```python
from abc import *

class AVehicle(ABC):
    @property
    @abstractmethod
    def max_speed(self):
        pass

class ATruck(AVehicle):
    @property
    @abstractmethod
    def capacity(self):
        pass

class Kamaz5320(ATruck):
    @property
    def max_speed(self):
        return 85

    @property
    def capacity(self):
        return 8000

kamaz = Kamaz5320()
maxSpeed = kamaz.max_speed
# maxSpeed is 85

print(maxSpeed) # 85
```

Methods requirements

```
from abc import *

class Car(ABC):
    @abstractmethod
    def start_engine(self):
        pass

    @abstractmethod
    def stop_engine(self):
        pass

class SportCar(Car):
    def __init__(self):
        self.started = False

    def start_engine(self):
        if self.started:
            return False
        print("start engine")
        self.started = True
        return True

    def stop_engine(self):
        print("stop engine")
        self.started = False

car = SportCar()
car.start_engine()
# start engine
```

Multiple inheritance

```
from abc import *

class PId(ABC):
    @property
    @abstractmethod
    def id(self):
        pass

class Priced(ABC):
    @property
    @abstractmethod
    def price(self):
        pass

class Goods(PId, Priced):
    def __init__(self, p_id, p_price):
        self._id = p_id
        self._price = p_price

    @property
    def id(self):
        return self._id

    @property
    def price(self):
        return self._price

def show_id_and_price(info):
    print(f"id = {info.id}, price = {info.price}")

bread = Goods(1, 5)
show_id_and_price(bread)
# printed: id = 1, price = 5
```

Properties requirements

```
from abc import *

class ACar(ABC):
    @property
    @abstractmethod
    def engine_volume(self):
        pass

    @engine_volume.setter
    @abstractmethod
    def engine_volume(self, val):
        pass

class Airwave(ACar):
    def __init__(self):
        self._engineVolume = 1500

    @property
    def engine_volume(self):
        return self._engineVolume

airwave = Airwave()
print(airwave.engine_volume) # 1500
```

Subscript requirements

```
from abc import *

class AIterable(ABC):
    @abstractmethod
    def __getitem__(self, i):
        pass

class PowerOfTwo(AIterable):
    pass

    def __getitem__(self, i):
        return pow(2, i)

power = PowerOfTwo()
p8 = power[8]
# p8 is 256

p16 = power[16]
#p16 is 65536

print(p8)
print(p16)
```

Algorithms

Algorithms are step-by-step procedures or formulas for solving problems and performing tasks. They are the backbone of computer science, enabling efficient data processing and decision-making. An algorithm takes input, processes it through a series of well-defined steps, and produces an output. They can range from simple arithmetic operations to complex data structures and sorting techniques. Effective algorithms are characterized by their efficiency, scalability, and clarity. Understanding and designing algorithms are crucial for optimizing performance and resource utilization in software development.

Sorting algorithms:

Bubble Sort

```python
def bubble_sort(arr):
    items = arr[:]
    for i in range(len(items)):
        for j in range(i + 1, len(items)):
            if items[j] < items[i]:
                items[j], items[i] = items[i], items[j]
    return items

items = [4, 1, 5, 3, 2]
sort_items = bubble_sort(items)
print("Sorted items:", sort_items)
# Sorted items: [1, 2, 3, 4, 5]
```

Counting Sort

```
def counting_sort(arr):
    maximum = max(arr)
    counts = [0] * (maximum + 1)
    items = [0] * len(arr)

    for x in arr:
        counts[x] += 1

    total = 0
    for i in range(len(counts)):
        old_count = counts[i]
        counts[i] = total
        total += old_count

    for x in arr:
        items[counts[x]] = x
        counts[x] += 1

    return items

items = [4, 1, 5, 3, 2]
sort_items = counting_sort(items)
print("Sorted items:", sort_items)
# Sorted items: [1, 2, 3, 4, 5]
```

Merge Sort

```
def merge_sort(items):
    if len(items) <= 1:
        return items

    middle = len(items) // 2
    left = items[:middle]
    right = items[middle:]

    def merge(left, right):
        result = []
        left_index = 0
        right_index = 0

        while left_index < len(left) and right_index < len(right):
            if left[left_index] < right[right_index]:
                result.append(left[left_index])
                left_index += 1
            else:
                result.append(right[right_index])
                right_index += 1

        result.extend(left[left_index:])
        result.extend(right[right_index:])
        return result

    return merge(merge_sort(left), merge_sort(right))

items = [4, 1, 5, 3, 2]
sort_items = merge_sort(items)
print("Sorted items:", sort_items)
# Sorted items: [1, 2, 3, 4, 5]
```

Quick Sort

```
def quick_sort(items):
    def do_sort(items, fst, lst):
        if fst >= lst:
            return
        i = fst
        j = lst
        x = items[(fst + lst) // 2]

        while i <= j:
            while items[i] < x:
                i += 1
            while items[j] > x:
                j -= 1
            if i <= j:
                items[i], items[j] = items[j], items[i]
                i += 1
                j -= 1
        do_sort(items, fst, j)
        do_sort(items, i, lst)

    sorted_items = items[:]
    do_sort(sorted_items, 0, len(sorted_items) - 1)
    return sorted_items

items = [4, 1, 5, 3, 2]
sort_items = quick_sort(items)
print("Sorted items:", sort_items)
# Sorted items: [1, 2, 3, 4, 5]
```

Radix Sort

```
def list_to_buckets(items, c_base, i):
    buckets = [[] for _ in range(c_base)]

    p_base = c_base ** i
    for x in items:
        digit = (x // p_base) % c_base
        buckets[digit].append(x)
    return buckets

def buckets_to_list(buckets):
    result = []
    for bucket in buckets:
        result.extend(bucket)
    return result

def radix_sort(arr, c_base=10):
    max_val = max(arr)
    i = 0
    while c_base ** i <= max_val:
        arr = buckets_to_list(list_to_buckets(arr, c_base, i))
        i += 1
    return arr

items = [4, 1, 5, 3, 2]
sort_items = radix_sort(items)
print("Sorted items:", sort_items)
# Sorted items: [1, 2, 3, 4, 5]
```

Searching algorithms:

Binary Search

```
def binary_search(arr, x):
    i = -1
    j = len(arr)
    while i + 1 != j:
        m = (i + j) // 2
        if x == arr[m]:
            return m
        if x < arr[m]:
            j = m
        else:
            i = m
    return None

items = [2, 3, 5, 7, 11, 13, 17]

print(binary_search(items, 1))
# Will print None
print(binary_search(items, 7))
# Will print 3
print(binary_search(items, 19))
# Will print None
```

Fast Linear Search

```
def fast_linear_search(arr, x):
    i = 0
    count = len(arr)
    arr.append(x)
    while True:
        if arr[i] == x:
            arr.pop()  # Remove the last element
            return i if i < count else None
        i += 1

items = [2, 3, 5, 7, 11, 13, 17]

print(fast_linear_search(items, 1))
# Will print None
print(fast_linear_search(items, 7))
# Will print 3
print(fast_linear_search(items, 19))
# Will print None
```

Interpolation Search

```
def interpolation_search(arr, x):
    low = 0
    high = len(arr) - 1

    while low <= high and x >= arr[low] and x <= arr[high]:
        mid = low + ((x - arr[low]) * (high - low)) // (arr[high] -
arr[low])

        if arr[mid] < x:
            low = mid + 1
        elif arr[mid] > x:
            high = mid - 1
        else:
            return mid

    if arr[low] == x:
        return low
    if arr[high] == x:
        return high
    return None

items = [2, 3, 5, 7, 11, 13, 17]

print(interpolation_search(items, 1))
# Will print None
print(interpolation_search(items, 7))
# Will print 3
print(interpolation_search(items, 19))
# Will print None
```

Linear Search

```
def linear_search(arr, x):
    i = 0
    count = len(arr)
    while i < count:
        if arr[i] == x:
            return i
        i += 1
    return None

items = [2, 3, 5, 7, 11, 13, 17]

print(linear_search(items, 1))  # Will print None
print(linear_search(items, 7))  # Will print 3
print(linear_search(items, 19))  # Will print None
```

Changes in new versions

In software development, new versions of a program or system often bring various changes that can include bug fixes, performance improvements, and new features. These updates are crucial for maintaining security, improving user experience, and staying competitive.

Alias type syntax

```python
# *** in version 3.10: ***
from typing import TypeAlias

Index: TypeAlias = int

# *** before: ***
Width = int
```

Comparison operators

```
# *** before: ***
b1 = 1 < "A"
# b1 is True

b2 = 1 == "A"
# b2 is False

# *** in version 3: ***
b1 = 1 < "A" # <- TypeError

b2 = 1 == "A"
# b2 is False
```

Context Variables

```
# *** in version 3.7 ***
import contextvars
number = contextvars.ContextVar("number", default="-1")
contexts = list()

def print_number():
    print(f"number: {number.get()}")

print_number()
# number: -1

# Creating contexts and setting the number
for n in [1, 2, 3]:
    ctx = contextvars.copy_context()
    ctx.run(number.set, n)
    contexts.append(ctx)

# Running print_number () function in each context
for ctx in reversed(contexts):
    ctx.run(print_number)
```

Context variable objects in Python is an interesting type of variable which returns the value of variable according to the context. It may have multiple values according to context in single thread or execution. The ContextVar class present in contextvars module, which is used to declare and work with context variables in python.

Note: This is supported in python version > = 3.7.

Data classes

```python
from dataclasses import dataclass

@dataclass
class Employee:
    name: str
    age: int
    job_title: str
    salary: float

    def give_raise(self, amount: float):
        self.salary += amount
        return self.salary

# Create an instance of the Employee class
employee1 = Employee(name="John Doe", age=30, job_title="Software Engineer", salary=70000.0)

# Print employee details
print(employee1)

# Give the employee a raise
employee1.give_raise(5000.0)
print(f"New salary after raise: {employee1.salary}")
# New salary after raise: 75000.0
```

Dictionary Merge

```
# Define dictionaries
d1 = {1: "one", 2: "two"}
d2 = {3: "three", 4: "four"}
d3 = {5: "five"}

# Merge d1 and d2 using dictionary unpacking
dAll = {**d1, **d2}
print(dAll)
# {1: 'one', 2: 'two', 3: 'three', 4: 'four'}

# Update dAll with d3
dAll.update(d3)
print(dAll)
# {1: 'one', 2: 'two', 3: 'three', 4: 'four', 5: 'five'}
```

Exceptions handling

```python
# before version 3

try:
    # Code that may raise an exception
    result = 10 / 0
except ZeroDivisionError:
    # Handling the specific exception
    print("Error: Division by zero!")

# after version 3

try:
    # Code that may raise an exception
    result = 10 / 0
except ZeroDivisionError as e:
    # Handling the specific exception and accessing exception object
    print(f"Error: {e}")
```

Extended Iterable Unpacking

```
# Example of extended iterable unpacking

# Unpacking a tuple
tuple_values = (1, 2, 3, 4, 5)
a, *b, c = tuple_values

print("a:", a)  # Output: 1
print("b:", b)  # Output: [2, 3, 4]
print("c:", c)  # Output: 5

# Unpacking a list with excess items
list_values = [1, 2, 3, 4, 5, 6, 7]
first, *middle, last = list_values

print("first:", first)    # Output: 1
print("middle:", middle)  # Output: [2, 3, 4, 5, 6]
print("last:", last)      # Output: 7

# Using extended iterable unpacking with default values
values = [1, 2]
x, y, *z = values

print("x:", x)  # Output: 1
print("y:", y)  # Output: 2
print("z:", z)  # Output: []

# Using extended iterable unpacking with an empty iterable
empty_values = []
a, *b = empty_values

print("a:", a)  # Output: None
print("b:", b)  # Output: []
```

Features of f-strings

```
# Example before version 3

name = "Alice"
age = 30

# Using format()
formatted_string = "Name: {}, Age: {}".format(name, age)
print(formatted_string)
# Output: Name: Alice, Age: 30

# Example after version 3.12

name = "Alice"
age = 30

# Using f-strings
formatted_string = f"Name: {name}, Age: {age}"
print(formatted_string)
# Output: Name: Alice, Age: 30
```

Guaranteed dictionary order

```
# Example before version 3.5

# Define a dictionary
unordered_dict = {'b': 2, 'a': 1, 'c': 3}

# Iterate over the dictionary
for key, value in unordered_dict.items():
    print(key, value)

# Output order may vary:
# a 1
# b 2
# c 3

# Example after version 3.7

# Define a dictionary
ordered_dict = {'b': 2, 'a': 1, 'c': 3}

# Iterate over the dictionary
for key, value in ordered_dict.items():
    print(key, value)

# Output order is guaranteed to be insertion order:
# b 2
# a 1
# c 3
```

IANA time zone support

```
from datetime import datetime
import zoneinfo

# Create a timezone-aware datetime object for New York
ny_timezone = zoneinfo.ZoneInfo("America/New_York")
ny_time = datetime.now(ny_timezone)

# Create a timezone-aware datetime object for London
london_timezone = zoneinfo.ZoneInfo("Europe/London")
london_time = datetime.now(london_timezone)

# Display the timezone-aware datetimes
print("Current time in New York:", ny_time.strftime('%Y-%m-%d %H:%M:%S %Z%z'))
print("Current time in London:", london_time.strftime('%Y-%m-%d %H:%M:%S %Z%z'))
```

The **zoneinfo** module provides a concrete time zone implementation to support the IANA time zone database as originally specified in PEP 615. By default, zoneinfo uses the system's time zone data if available; if no system time zone data is available, the library will fall back to using the first-party tzdata package available on PyPI.

Integer division

```
# *** before ***
i1 = 1 / 2
# i is 0 (type 'int')

i2 = 1 // 2
# i2 is 0 (type 'int')

# *** in version 3: ***
i1 = 1 / 2
# i1 is 0.5 (type 'float')

i2 = 1 // 2
# i2 is 0 (type 'int')

print("i1 is", i1)
print("i1 type is", type(i1))
print("i2 is", i2)
print("i2 type is", type(i2))
```

Methods of dictionaries

```
# *** before: ***
dic = {2: "two", 1: "one"}
keys = dic.keys()
keys.sort()
# keys is list
values = dic.values()
values.sort()
# values is list

# *** in version 3: ***
dic = {1: "one", 2: "two"}
keys = dic.keys()
# keys.sort() # <-Error
# keys is dict_keys
values = list(dic.values())
values.sort()
# values is list

print("keys is", keys)
print("keys type is", type(keys))
print("values is", values)
print("values type is", type(values))
```

New Type Union Operator

```
# *** in version 3.10 ***
def sqrt(number: int | float) -> float:
    return number ** 0.5

sqrt9 = sqrt(9)
print(f"{sqrt9 = }")
sqrt16 = sqrt(16.0)
print(f"{sqrt16 = }")
```

New string methods

```
# *** in version 3.9 ***
dataString = "Substring removing"

print(dataString
      .removesuffix(' removing'))
# prints "Substring"

print(dataString
      .removeprefix('Sub'))
# prints "string removing"
```

Octal literals

```
# *** before: ***
octal = 042
# octal is 34

# *** in version 3: ***
octal = 0o42
# octal is 34

print(octal)
```

Parenthesized context managers

```
# *** in version 3.10: ***
with (open("file.out", "rb") as rf,
     open("file_copy.out", "wb") as wf):
    pass

# *** before: ***
with open("file.out", "rb") as rf:
    with open("file_copy.out", "wb") as wf:
        pass
```

Simplified asynchronous call

```python
# *** in version 3.10: ***
import asyncio


async def greeting():
    print("Hello!")

asyncio.run(greeting())
```

Throw an exception

```
# *** before: ***
raise IOError, "file error"

# *** in version 3: ***
raise IOError("file error")
```

Type Hinting Generics

```python
# *** before: ***
def greet_all(names: list[str]):
    for name in names:
        print("Hello", name)

data = ["Alex", "Anna", 2]
greet_all(data)
```

Unicode strings

```
# Example before version 3 (Python 2)

# Defining a Unicode string
unicode_str = u"Hello, \u2603"  # The Unicode character \u2603 is a snowman

# Printing the Unicode string
print(unicode_str)  # Output: Hello, ☃

# Encoding the Unicode string to bytes
encoded_str = unicode_str.encode('utf-8')
print(encoded_str)  # Output: b'Hello, \xe2\x98\x83'

# Example after version 3 (Python 3)

# Defining a Unicode string
unicode_str = "Hello, \u2603"  # The Unicode character \u2603 is a snowman

# Printing the Unicode string
print(unicode_str)  # Output: Hello, ☃

# Encoding the Unicode string to bytes
encoded_str = unicode_str.encode('utf-8')
print(encoded_str)  # Output: b'Hello, \xe2\x98\x83'

# Decoding bytes back to a Unicode string
decoded_str = encoded_str.decode('utf-8')
print(decoded_str)  # Output: Hello, ☃
```

Variables for the ‘for’ loop

```
# *** before: ***
i = 1
[i for i in range(5)]
print i
# i is 4

# *** in version 3: ***

i = 1
[i for i in range(5)]
print(i)
# i is 1
```

Walrus Operator :=

```
import re
data = "Pi is equal to 3.14"
pNumber = r'\d+\.\d+'
pWord = r'\w{3,15}'

# *** in version 3.8 ***
if m := re.search(pNumber, data):
    number = float(m.group())
    print(number)
elif m := re.search(pWord, data):
    word = m.group()
print(word)

# *** before: ***
m = re.search(pNumber, data)
if m:
    number = float(m.group())
    print(number)
else:
    m = re.search(pWord, data)
if m:
    word = m.group()
print(word)

numbers = [1, 3, 5, 7]

# *** in version 3.8: ***
if (n := len(numbers)) > 3:
    print(f"len is {n} elements, expected <= 3")

# *** before: ***
n = len(numbers)
if n > 3:
    print(f"len is {n} elements, expected <= 3")
```

Walrus-operator is another name for assignment expressions. According to the official documentation, it is a way to assign to variables within an expression using the notation NAME $:=$ expr.

f-strings support

```
from datetime import datetime

number = 42
pi = 3.1415
text = "answer"
now = datetime.now()

# *** in version 3.8 ***
print('in version 3.8:')
print(f'{number=}')
print(f'{pi=}')
print(f'{text=}')
print(f'{now=}')

print()
# *** before: ***
print('before:')
print(f'number={number}')
print(f'pi={pi}')
print(f'text={text}')
print(f'now={now}')
```

map and filter functions

```
# *** before: ***
n1 = [1, 2, 3]
n2 = map(lambda x: x * x, n1)
# n2 is lsit

n3 = filter(lambda x: x * x, n1)
# n3 is list

# *** in version 3 ***
n1 = [1, 2, 3]
n2 = map(lambda x: x * x, n1)
#n2 is map

n3 = filter(lambda x: x % 2 == 1, n1)
# n3 is filter

n4 = list(n2)
# n4 is list

print("n2 is", n2)
print("n2 type is", type(n2))
print("n3 is", n3)
print("n3 type is", type(n3))
print("n4 is", n4)
```

match statements

```python
def http_status_code_message(status_code):
    if status_code == 200:
        return "OK"
    elif status_code == 404:
        return "Not Found"
    elif status_code == 500:
        return "Internal Server Error"
    else:
        return "Unknown Status Code"

print(http_status_code_message(200))  # OK
print(http_status_code_message(404))  # Not Found
print(http_status_code_message(123))  # Unknown Status Code


def http_status_code_message(status_code):
    match status_code:
        case 200:
            return "OK"
        case 404:
            return "Not Found"
        case 500:
            return "Internal Server Error"
        case _:
            return "Unknown Status Code"

print(http_status_code_message(200))  # OK
print(http_status_code_message(404))  # Not Found
print(http_status_code_message(123))  # Unknown Status Code
```

print function

```
# Python 2 example
print "Hello, World!"  # Hello, World!
print "The answer is", 42  # The answer is 42

# Using a trailing comma to avoid a newline at the end
print "Hello,",
print "World!"  # Hello, World!

# Python 3 example
print("Hello, World!")  # Hello, World!
print("The answer is", 42)  # The answer is 42

# To avoid a newline at the end, use the end parameter
print("Hello,", end=" ")
print("World!")  # Hello, World!
```

range function

```
# Python 2 example using range
numbers = range(1, 10)
print numbers  # [1, 2, 3, 4, 5, 6, 7, 8, 9]

# Python 2 example using xrange
numbers = xrange(1, 10)
print numbers  # xrange(1, 10)
print list(numbers)  # [1, 2, 3, 4, 5, 6, 7, 8, 9]

# Python 3 example using range
numbers = range(1, 10)
print(numbers)  # range(1, 10)
print(list(numbers))  # [1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Classes

In object-oriented programming, classes are fundamental building blocks that define the blueprint for objects. A class encapsulates data for the object and methods to manipulate that data, promoting modularity and code reuse.

Check for reference equality

```
class MyClass:
    def _init_(self, value):
        self.value = value

# Create two instances of MyClass
obj1 = MyClass(10)
obj2 = MyClass(10)
obj3 = obj1

# Check for reference equality using id()
print(id(obj1) == id(obj2))
# False, different objects in memory
print(id(obj1) == id(obj3))
# True, same object in memory
```

Constructors:

Call of the own constructor

```
class Person:
    def __init__(self, first_name, last_name, age):
        self.first_name = first_name
        self.last_name = last_name
        self.age = age

    @classmethod
    def from_full_name(cls, full_name, age):
        first_name, last_name = full_name.split()
        # Call the main constructor with first name and last name extracted from full name
        return cls(first_name, last_name, age)

    def display_person(self):
        print(f'Name: {self.first_name} {self.last_name}, Age: {self.age}')

# Create an instance using the main constructor
person1 = Person("John", "Doe", 30)
person1.display_person()
# Output: Name: John Doe, Age: 30

# Create an instance using the alternative constructor
person2 = Person.from_full_name("Jane Smith", 25)
person2.display_person()
# Output: Name: Jane Smith, Age: 25
```

Call of the parent constructor

```
class Person:
    def _init_(self, first_name, last_name, age):
        self.first_name = first_name
        self.last_name = last_name
        self.age = age

    def display_person_info(self):
        print(f'Name: {self.first_name} {self.last_name}, Age: {self.age}')

class Employee(Person):
    def _init_(self, first_name, last_name, age, employee_id, position):
        # Call the parent constructor to initialize first_name, last_name, and age
        super()._init_(first_name, last_name, age)
        self.employee_id = employee_id
        self.position = position

    def display_employee_info(self):
        # Call the parent class method to display basic info
        super().display_person_info()
        print(f'Employee ID: {self.employee_id}, Position: {self.position}')

# Create an instance of Person
person = Person("John", "Doe", 45)
person.display_person_info()  # Output: Name: John Doe, Age: 45

# Create an instance of Employee
employee = Employee("Jane", "Smith", 30, "E123", "Software Engineer")
employee.display_employee_info()
# Output:
# Name: Jane Smith, Age: 30
# Employee ID: E123, Position: Software Engineer
```

Default constructor

```
class Book:
    def _init_(self, title="Unknown Title", author="Unknown Author", year=0):
        self.title = title
        self.author = author
        self.year = year

    def display_info(self):
        print(f'Title: {self.title}, Author: {self.author}, Year: {self.year}')

# Create an instance using the default constructor
default_book = Book()
default_book.display_info()
# Output: Title: Unknown Title, Author: Unknown Author, Year: 0

# Create an instance with custom values
custom_book = Book("1984", "George Orwell", 1949)
custom_book.display_info()
# Output: Title: 1984, Author: George Orwell, Year: 1949
```

Optional parameter values

```python
class Car:
    def __init__(self, make="Unknown Make", model="Unknown Model", year=0, color="Unknown Color"):
        self.make = make
        self.model = model
        self.year = year
        self.color = color

    def display_info(self):
        print(f'Make: {self.make}, Model: {self.model}, Year: {self.year}, Color: {self.color}')

# Create an instance using the default constructor (all default values)
default_car = Car()
default_car.display_info()  # Output: Make: Unknown Make, Model: Unknown Model, Year: 0, Color: Unknown Color

# Create an instance with some custom values
custom_car1 = Car(make="Toyota", model="Corolla")
custom_car1.display_info()
# Output: Make: Toyota, Model: Corolla, Year: 0, Color: Unknown Color

# Create an instance with all custom values
custom_car2 = Car(make="Honda", model="Civic", year=2022, color="Red")
custom_car2.display_info()
# Output: Make: Honda, Model: Civic, Year: 2022, Color: Red
```

Replacement of the parent constructor

```
class Person:
    def __init__(self, first_name, last_name, age):
        self.first_name = first_name
        self.last_name = last_name
        self.age = age

    def display_person_info(self):
        print(f'Name: {self.first_name} {self.last_name}, Age: {self.age}')

class Employee(Person):
    def __init__(self, first_name, last_name, age, employee_id, position):
        # Call the parent constructor to initialize first_name, last_name, and age
        super().__init__(first_name, last_name, age)
        # Initialize the additional attributes
        self.employee_id = employee_id
        self.position = position

    def display_employee_info(self):
        # Call the parent class method to display basic info
        super().display_person_info()
        print(f'Employee ID: {self.employee_id}, Position: {self.position}')

# Create an instance of Person
person = Person("John", "Doe", 45)
person.display_person_info()
# Output: Name: John Doe, Age: 45

# Create an instance of Employee
employee = Employee("Jane", "Smith", 30, "E123", "Software Engineer")
employee.display_employee_info()
# Output:
# Name: Jane Smith, Age: 30
```

```
# Employee ID: E123, Position: Software Engineer
```

With paramenters

```python
class Rectangle:
    def _init_(self, length, width):
        self.length = length
        self.width = width

    def area(self):
        return self.length * self.width

# Creating an instance of Rectangle with specific dimensions
rectangle1 = Rectangle(5, 3)
print("Area of rectangle1:", rectangle1.area())
# Output: Area of rectangle1: 15

# Creating another instance of Rectangle with different dimensions
rectangle2 = Rectangle(7, 4)
print("Area of rectangle2:", rectangle2.area())
# Output: Area of rectangle2: 28
```

Without any paramenters

```python
class MyClass:
    def _init_(self):
        print("This is the default constructor.")

    def display(self):
        print("Inside MyClass.")

# Creating an instance of MyClass
obj = MyClass()
obj.display()
```

Create a copy of the object

```
import copy

class Person:
    def __init__(self, name, age):
        self.name = name
        self.age = age

    def display_info(self):
        print(f'Name: {self.name}, Age: {self.age}')

# Create an instance of Person
person1 = Person("Alice", 30)
person1.display_info()
# Output: Name: Alice, Age: 30

# Create a shallow copy of person1
person2 = copy.copy(person1)
person2.display_info()
# Output: Name: Alice, Age: 30

# Modify the copy
person2.name = "Bob"
person2.display_info()
# Output: Name: Bob, Age: 30
person1.display_info()
# Output: Name: Alice, Age: 30

# Create a deep copy of person1
person3 = copy.deepcopy(person1)
person3.display_info()
# Output: Name: Alice, Age: 30
```

Definition and initialization

```python
# Definition
class SomeClass:
    pass

# Initialization
someClass = SomeClass()
```

Descriptors

```
class AgeDescriptor:
    def _init_(self):
        self._age = None

    def _get_(self, instance, owner):
        print("Getting age")
        return self._age

    def _set_(self, instance, value):
        if not isinstance(value, int):
            raise ValueError("Age must be an integer")
        if value < 0:
            raise ValueError("Age cannot be negative")
        print("Setting age")
        self._age = value

    def _delete_(self, instance):
        print("Deleting age")
        self._age = None

class Person:
    age = AgeDescriptor()

    def _init_(self, name, age):
        self.name = name
        self.age = age

    def display_info(self):
        print(f'Name: {self.name}, Age: {self.age}')

# Create an instance of Person
person = Person("Alice", 30)
person.display_info()
# Output: Name: Alice, Age: 30

# Get the age
print(person.age)
# Output: Getting age, 30

# Set a new age
```

```
person.age = 35
# Output: Setting age

# Get the updated age
print(person.age)
# Output: Getting age, 35

# Delete the age
del person.age  # Output: Deleting age

# Try to get the deleted age
print(person.age)
# Output: Getting age, None
```

Descriptors is an object attribute with “binding behavior”, one whose attribute access has been overridden by methods in the descriptor protocol. Those methods are defined for an object; it is said to be a descriptor.

Destructor

```python
class FileManager:
    def __init__(self, file_name, mode):
        self.file_name = file_name
        self.mode = mode
        self.file = open(file_name, mode)
        print(f'File {self.file_name} opened in {self.mode} mode.')

    def write_data(self, data):
        if self.file and not self.file.closed:
            self.file.write(data)
            print(f'Written data: {data}')

    def __del__(self):
        if self.file and not self.file.closed:
            self.file.close()
            print(f'File {self.file_name} closed.')

# Using the FileManager class
file_manager = FileManager('example.txt', 'w')
file_manager.write_data('Hello, world!')

# Deleting the file_manager object explicitly
del file_manager

# Output:
# File example.txt opened in w mode.
# Written data: Hello, world!
# File example.txt closed.
```

Events

```
class Event:
    def _init_(self):
        self.handlers = []

    def add_handler(self, handler):
        self.handlers.append(handler)

    def remove_handler(self, handler):
        self.handlers.remove(handler)

    def fire(self, *args, **kwargs):
        for handler in self.handlers:
            handler(*args, **kwargs)

class TemperatureSensor:
    def _init_(self):
        self.temperature_changed = Event()
        self._temperature = 0

    @property
    def temperature(self):
        return self._temperature

    @temperature.setter
    def temperature(self, value):
        if value != self._temperature:
            self._temperature = value
            self.temperature_changed.fire(value)

class Display:
    def show_temperature(self, temperature):
        print(f'Temperature changed to {temperature} degrees.')

# Create a TemperatureSensor instance
sensor = TemperatureSensor()

# Create a Display instance
display = Display()

# Add the display's show_temperature method as a handler for the temperature_changed event
```

```python
sensor.temperature_changed.add_handler(display.show_temperature)

# Change the temperature, which triggers the event
sensor.temperature = 25

# Output:
# Temperature changed to 25 degrees.
```

Fields

```
class Car:
    def _init_(self, make, model, year):
        self.make = make  # instance field
        self.model = model  # instance field
        self.year = year  # instance field

    def display_info(self):
        print(f'Car: {self.year} {self.make} {self.model}')

# Create an instance of Car
my_car = Car('Toyota', 'Corolla', 2021)
my_car.display_info()
# Output: Car: 2021 Toyota Corolla
```

Inheritance:

Abstract classes

```
from abc import ABC, abstractmethod
import math

class Shape(ABC):
    @abstractmethod
    def area(self):
        pass

    def description(self):
        return "This is a shape."

class Rectangle(Shape):
    def _init_(self, length, width):
        self.length = length
        self.width = width

    def area(self):
        return self.length * self.width

    def description(self):
        return f"This is a rectangle with length {self.length} and width {self.width}."

class Circle(Shape):
    def _init_(self, radius):
        self.radius = radius

    def area(self):
        return math.pi * (self.radius ** 2)

    def description(self):
        return f"This is a circle with radius {self.radius}."

# Instances of Rectangle and Circle
rectangle = Rectangle(5, 3)
circle = Circle(4)

# Displaying information and calculating area
print(rectangle.description())
# Output: This is a rectangle with length 5 and width 3.
```

```python
print("Area:", rectangle.area())
# Output: Area: 15

print(circle.description())
# Output: This is a circle with radius 4.
print("Area:", circle.area())
# Output: Area: 50.26548245743669
```

Base class

```
class Animal:
    def _init_(self, name, species):
        self.name = name
        self.species = species

    def make_sound(self):
        raise NotImplementedError("Subclasses must implement this method")

    def describe(self):
        return f"{self.name} is a {self.species}"

# Define a derived class
class Dog(Animal):
    def _init_(self, name, breed):
        super()._init_(name, "Dog")
        self.breed = breed

    def make_sound(self):
        return "Bark"

    def describe(self):
        return f"{self.name} is a {self.breed} dog"

# Define another derived class
class Cat(Animal):
    def _init_(self, name, breed):
        super()._init_(name, "Cat")
        self.breed = breed

    def make_sound(self):
        return "Meow"

    def describe(self):
        return f"{self.name} is a {self.breed} cat"

# Create instances of Dog and Cat
dog = Dog("Buddy", "Golden Retriever")
cat = Cat("Whiskers", "Siamese")

# Use methods from the base class and overridden methods
```

```
print(dog.describe())  # Output: Buddy is a Golden Retriever dog
print(dog.make_sound())  # Output: Bark

print(cat.describe())  # Output: Whiskers is a Siamese cat
print(cat.make_sound())  # Output: Meow
```

Compability check (is)

```
# Define the base class
class Animal:
    def _init_(self, name):
        self.name = name

    def make_sound(self):
        raise NotImplementedError("Subclasses must implement this method")

# Define a derived class
class Dog(Animal):
    def make_sound(self):
        return "Bark"

# Define another derived class
class Cat(Animal):
    def make_sound(self):
        return "Meow"

# Define a function to check compatibility using isinstance
def check_instance(obj, cls):
    if isinstance(obj, cls):
        print(f"{obj.name} is an instance of {cls._name_}.")
    else:
        print(f"{obj.name} is NOT an instance of {cls._name_}.")

# Define a function to check subclass compatibility using issubclass
def check_subclass(sub, parent):
    if issubclass(sub, parent):
        print(f"{sub._name_} is a subclass of {parent._name_}.")
    else:
        print(f"{sub._name_} is NOT a subclass of {parent._name_}.")

# Create instances of Dog and Cat
dog = Dog("Buddy")
cat = Cat("Whiskers")

# Check instance compatibility
check_instance(dog, Animal)
```

```
# Output: Buddy is an instance of Animal.
check_instance(cat, Animal)
# Output: Whiskers is an instance of Animal.
check_instance(dog, Dog)
# Output: Buddy is an instance of Dog.
check_instance(cat, Dog)
# Output: Whiskers is NOT an instance of Dog.

# Check subclass compatibility
check_subclass(Dog, Animal)
# Output: Dog is a subclass of Animal.
check_subclass(Cat, Animal)
# Output: Cat is a subclass of Animal.
check_subclass(Dog, Cat)
# Output: Dog is NOT a subclass of Cat.
```

Interface inheritance

```python
from abc import ABC, abstractmethod

# Define the abstract base class
class Vehicle(ABC):
    @abstractmethod
    def start_engine(self):
        pass

    @abstractmethod
    def stop_engine(self):
        pass

    @abstractmethod
    def drive(self):
        pass

# Define a concrete class that inherits from Vehicle
class Car(Vehicle):
    def start_engine(self):
        return "Car engine started."

    def stop_engine(self):
        return "Car engine stopped."

    def drive(self):
        return "Car is driving."

# Define another concrete class that inherits from Vehicle
class Bike(Vehicle):
    def start_engine(self):
        return "Bike engine started."

    def stop_engine(self):
        return "Bike engine stopped."

    def drive(self):
        return "Bike is driving."

# Create instances of Car and Bike
car = Car()
bike = Bike()
```

```
# Use the methods defined in the interface
print(car.start_engine())
# Output: Car engine started.
print(car.drive())
# Output: Car is driving.
print(car.stop_engine())
# Output: Car engine stopped.

print(bike.start_engine())
# Output: Bike engine started.
print(bike.drive())
# Output: Bike is driving.
print(bike.stop_engine())
# Output: Bike engine stopped.
```

Method override

```python
# Define the base class
class Animal:
    def __init__(self, name):
        self.name = name

    def make_sound(self):
        return "Some generic sound"

    def describe(self):
        return f"This is {self.name}."

# Define a subclass that overrides the make_sound method
class Dog(Animal):
    def make_sound(self):
        return "Bark"

# Define another subclass that overrides the make_sound method
class Cat(Animal):
    def make_sound(self):
        return "Meow"

# Create instances of Dog and Cat
dog = Dog("Buddy")
cat = Cat("Whiskers")

# Use the overridden methods
print(dog.describe())
# Output: This is Buddy.
print(dog.make_sound())
# Output: Bark

print(cat.describe())
# Output: This is Whiskers.
print(cat.make_sound())
# Output: Meow
```

Private class members

```python
class Person:
    def __init__(self, name, age):
        self._name = name
        self._age = age

    def _display_info(self):
        return f"Name: {self._name}, Age: {self._age}"

    def get_info(self):
        return self._display_info()

# Creating an instance of Person
person = Person("Alice", 30)

# Accessing private attributes (not enforced)
print(person._name)
# Output: Alice
print(person._age)
# Output: 30

# Accessing private method (not enforced)
print(person._display_info())
# Output: Name: Alice, Age: 30

# Accessing method to retrieve information (recommended way)
print(person.get_info())
# Output: Name: Alice, Age: 30
```

Property override

```
import math

# Define the base class
class Shape:
    @property
    def area(self):
        return 0  # Default implementation for base class

# Define a subclass that overrides the area property
class Rectangle(Shape):
    def __init__(self, width, height):
        self.width = width
        self.height = height

    @property
    def area(self):
        return self.width * self.height

# Define another subclass that overrides the area property
class Circle(Shape):
    def __init__(self, radius):
        self.radius = radius

    @property
    def area(self):
        return math.pi * (self.radius ** 2)

# Create instances of Rectangle and Circle
rectangle = Rectangle(5, 3)
circle = Circle(4)

# Access the overridden properties
print("Area of rectangle:", rectangle.area)
# Output: Area of rectangle: 15
print("Area of circle:", circle.area)
# Output: Area of circle: 50.26548245743669
```

Protected class members

```python
class Person:
    def __init__(self, name, age):
        self._name = name
        self._age = age

    def display_info(self):
        return f"Name: {self._name}, Age: {self._age}"

# Creating an instance of Person
person = Person("Alice", 30)

# Accessing protected attributes (not enforced)
print(person._name)  # Output: Alice
print(person._age)   # Output: 30

# Accessing method to display information (recommended way)
print(person.display_info())
# Output: Name: Alice, Age: 30
```

Reduction to the base type

```
# Define the base class
class Animal:
    def _init_(self, name):
        self.name = name

    def make_sound(self):
        return "Some generic sound"

# Define a subclass
class Dog(Animal):
    def make_sound(self):
        return "Bark"

# Create an instance of Dog
dog = Dog("Buddy")

# Treat the Dog object as an Animal
animal = Animal("Max")
animal = dog  # Reducing Dog to Animal

# Use methods of the base type
print(animal.name)
# Output: Buddy
print(animal.make_sound())
# Output: Bark
```

Methods:

Array of parameters

```
def sum_numbers(*args):
    total = 0
    for num in args:
        total += num
    return total

# Using the sum_numbers method with different numbers of arguments
print(sum_numbers(1, 2, 3))
# Output: 6
print(sum_numbers(1, 2, 3, 4, 5))
# Output: 15
print(sum_numbers(10, 20, 30, 40, 50))
# Output: 150
```

Class methods

```python
class Person:
    def _init_(self, name, age):
        self.name = name
        self.age = age

    def display_info(self):
        return f"Name: {self.name}, Age: {self.age}"

    @classmethod
    def from_string(cls, string):
        name, age = string.split(',')
        return cls(name.strip(), int(age.strip()))

# Using the class method to create Person objects
person1 = Person.from_string("Alice, 30")
person2 = Person.from_string("Bob, 25")

# Displaying information of created Person objects
print(person1.display_info())
# Output: Name: Alice, Age: 30
print(person2.display_info())
# Output: Name: Bob, Age: 25
```

In/Out parameters

```
def double_numbers(numbers):
    for i in range(len(numbers)):
        numbers[i] *= 2
    return numbers

# Original list of numbers
original_numbers = [1, 2, 3, 4, 5]

# Calling the method with the original list
modified_numbers = double_numbers(original_numbers)

# Displaying the modified list
print("Modified Numbers:", modified_numbers)
# Output: Modified Numbers: [2, 4, 6, 8, 10]

# Original list remains unchanged
print("Original Numbers:", original_numbers)
# Output: Original Numbers: [1, 2, 3, 4, 5]
```

Multiple return values

```
import math

def get_circle_info(radius):
    area = math.pi * radius**2
    circumference = 2 * math.pi * radius
    return area, circumference

# Calling the method and unpacking the returned tuple
circle_area, circle_circumference = get_circle_info(5)

# Displaying the results
print("Circle Area:", circle_area)
# Output: Circle Area: 78.53981633974483
print("Circle Circumference:", circle_circumference)
# Output: Circle Circumference: 31.41592653589793
```

Optional parameter values

```python
def greet(name, message="Hello"):
    return f"{message}, {name}!"

# Calling the method with and without providing a custom message
print(greet("Alice"))
# Output: Hello, Alice!
print(greet("Bob", "Hi there"))
# Output: Hi there, Bob!
```

Variable parameters

```
def sum_numbers(*args):
    total = 0
    for num in args:
        total += num
    return total

def print_info(**kwargs):
    for key, value in kwargs.items():
        print(f"{key}: {value}")

# Using the sum_numbers method with different numbers of positional arguments
print("Sum:", sum_numbers(1, 2, 3))
# Output: Sum: 6
print("Sum:", sum_numbers(1, 2, 3, 4, 5))
# Output: Sum: 15
print("Sum:", sum_numbers(10, 20, 30, 40, 50))
# Output: Sum: 150

# Using the print_info method with different numbers of keyword arguments
print_info(name="Alice", age=30)
# Output: name: Alice, age: 30
print_info(name="Bob", age=25, city="New York")
# Output: name: Bob, age: 25, city: New York
```

With return value

```python
def add_numbers(a, b):
    return a + b

# Calling the method and storing the returned value
result = add_numbers(3, 5)

# Displaying the returned value
print("Result:", result)  # Output: Result: 8
```

Without any parameters

```python
from datetime import datetime

def get_current_year():
    return datetime.now().year

# Calling the method
current_year = get_current_year()

# Displaying the current year
print("Current Year:", current_year)
```

Without any return value

```python
def print_message(message):
    print("Message:", message)

# Calling the method
print_message("Hello, World!")
```

Nested class

```
class Outer:
    def _init_(self, name):
        self.name = name
        self.inner = self.Inner()

    def display_outer(self):
        print("Outer Name:", self.name)

    class Inner:
        def display_inner(self):
            print("Inner Class")

# Creating an instance of the outer class
outer_obj = Outer("Outer Object")

# Accessing methods of the outer class
outer_obj.display_outer()
# Output: Outer Name: Outer Object

# Accessing methods of the inner class
inner_obj = outer_obj.inner
inner_obj.display_inner()
# Output: Inner Class
```

Properties:

Computed properties

```
import math

class Circle:
    def _init_(self, radius):
        self.radius = radius

    @property
    def area(self):
        return math.pi * self.radius ** 2

# Creating an instance of Circle
circle = Circle(5)

# Accessing the computed property
print("Radius:", circle.radius)
# Output: Radius: 5
print("Area:", circle.area)
# Output: Area: 78.53981633974483
```

Lazy properties

```
import math

class LazyProperty:
    def _init_(self, func):
        self.func = func

    def _get_(self, instance, owner):
        if instance is None:
            return self
        value = self.func(instance)
        setattr(instance, self.func._name_, value)
        return value

class Circle:
    def _init_(self, radius):
        self.radius = radius

    @LazyProperty
    def area(self):
        print("Calculating area...")
        return math.pi * self.radius ** 2

# Creating an instance of Circle
circle = Circle(5)

# Accessing the lazy property
print("Radius:", circle.radius)
# Output: Radius: 5
print("Area:", circle.area)
# Output: Calculating area... \n Area: 78.53981633974483
print("Area:", circle.area)
# Output: Area: 78.53981633974483 (no re-calculation)
```

Read-Only properties: Computed properties

```
import math


class Circle:
    def _init_(self):
        self.radius = 0

    @property
    def area(self):
        return math.pi * pow(self.radius, 2)


circle = Circle()
circle.radius = 2
# circle.area is 12.566370614359172

print(circle.area)
```

Read-Only properties: Stored properties

```
class FilmList:
    def _init_(self):
        self._count = 10

    @property
    def count(self):
        return self._count


filmList = FilmList()
count = filmList.count

print(count) # count is  10
```

Stored properties

```
class Person:
    def _init_(self, name, age):
        self.name = name
        self.age = age

# Creating an instance of Person
person = Person("Alice", 30)

# Accessing stored properties
print("Name:", person.name)  # Output: Name: Alice
print("Age:", person.age)    # Output: Age: 30

# Modifying stored properties
person.name = "Bob"
person.age = 25

# Displaying modified properties
print("Modified Name:", person.name)
# Output: Modified Name: Bob
print("Modified Age:", person.age)
# Output: Modified Age: 25
```

Type properties

```
class Circle:
    pi = 3.14159

    def __init__(self, radius):
        self.radius = radius

    def calculate_area(self):
        return Circle.pi * self.radius ** 2

# Creating instances of Circle
circle1 = Circle(5)
circle2 = Circle(10)

# Accessing the type property
print("Value of pi:", Circle.pi)  # Output: Value of pi: 3.14159

# Calculating areas using type property
print("Area of circle 1:", circle1.calculate_area())
# Output: Area of circle 1: 78.53975
print("Area of circle 2:", circle2.calculate_area())
# Output: Area of circle 2: 314.159
```

Subscripts (indexer methods):

With generic parameter

```
class MyList:
    def _init_(self):
        self.data = {}

    def _getitem_(self, index):
        return self.data[index]

    def _setitem_(self, index, value):
        self.data[index] = value

# Creating an instance of MyList
my_list = MyList()

# Using integer indices
my_list[0] = 'a'
my_list[1] = 'b'
print("Element at index 0:", my_list[0])
# Output: Element at index 0: a
print("Element at index 1:", my_list[1])
# Output: Element at index 1: b

# Using string keys
my_list['first'] = 10
my_list['second'] = 20
print("Element with key 'first':", my_list['first'])
# Output: Element with key 'first': 10
print("Element with key 'second':", my_list['second'])
# Output: Element with key 'second': 20
```

With multiple parameter

```
class Matrix:
    def __init__(self, rows, columns):
        self.rows = rows
        self.columns = columns
        self.data = [[0] * columns for _ in range(rows)]

    def __getitem__(self, indices):
        row, column = indices
        return self.data[row][column]

    def __setitem__(self, indices, value):
        row, column = indices
        self.data[row][column] = value

# Creating an instance of Matrix
matrix = Matrix(3, 3)

# Setting values using multiple indices
matrix[0, 0] = 1
matrix[1, 1] = 2
matrix[2, 2] = 3

# Getting values using multiple indices
print("Value at position (0, 0):", matrix[0, 0])
# Output: Value at position (0, 0): 1
print("Value at position (1, 1):", matrix[1, 1])
# Output: Value at position (1, 1): 2
print("Value at position (2, 2):", matrix[2, 2])
# Output: Value at position (2, 2): 3
```

With one parameter

```
class MyList:
    def _init_(self, data):
        self.data = data

    def _getitem_(self, index):
        return self.data[index]

    def _setitem_(self, index, value):
        self.data[index] = value

# Creating an instance of MyList
my_list = MyList([1, 2, 3, 4, 5])

# Accessing elements using single index
print("Element at index 0:", my_list[0])
# Output: Element at index 0: 1
print("Element at index 2:", my_list[2])
# Output: Element at index 2: 3

# Modifying elements using single index
my_list[1] = 10
my_list[3] = 20
print("Modified list:", my_list.data)
# Output: Modified list: [1, 10, 3, 20, 5]
```

Type member

```
class Employee:
    # Class variable
    company_name = "TechCorp"
    employee_count = 0

    def _init_(self, name, position):
        self.name = name
        self.position = position
        Employee.employee_count + = 1

    # Class method
    @classmethod
    def set_company_name(cls, name):
        cls.company_name = name

    # Class method to get employee count
    @classmethod
    def get_employee_count(cls):
        return cls.employee_count

# Accessing and modifying class variables
print("Company Name:", Employee.company_name)
# Output: Company Name: TechCorp
print("Initial Employee Count:", Employee.employee_count)
# Output: Initial Employee Count: 0

# Creating instances of Employee
emp1 = Employee("Alice", "Developer")
emp2 = Employee("Bob", "Designer")

# Accessing class variable via instance
print("Company Name (via emp1):", emp1.company_name)
# Output: Company Name (via emp1): TechCorp
print("Employee Count (via emp1):", emp1.employee_count)
# Output: Employee Count (via emp1): 2

# Using class method to set company name
Employee.set_company_name("InnoTech")
print("Updated Company Name:", Employee.company_name)
```

```python
# Output: Updated Company Name: InnoTech

# Using class method to get employee count
print("Total Employees:", Employee.get_employee_count())
# Output: Total Employees: 2
```

Control Flow

Control flow in programming determines the order in which instructions are executed. It encompasses decision-making, looping, and branching mechanisms that allow a program to execute different code paths based on conditions. Key constructs include conditional statements (if, else if, else) for decision-making, switch statements for handling multiple conditions, and loops (for, while, do...while) for repeating code. Control flow also involves breaking out of loops with "break" and skipping iterations with "continue". These constructs are fundamental for creating dynamic and responsive software that can adapt to various inputs and situations.

if/else statements:

Complex conditions

```
X = 10
Y = 20
Z = 30

if Z > X and Z > Y:
    if X < Y:
        print("Z is the largest and X is smaller than Y.")
    else:
        print("Z is the largest but X is not smaller than Y.")
else:
    print("Z is not the largest.")
# Output: Z is the largest and X is smaller than Y.
```

Is not valid example

```
# Invalid example
if latitud == 0  # SyntaxError: invalid syntax
location = "Equator"
```

Ternary operator

```
n = -42
classify = "positive" if n > 0 else "negative"

print(classify)  # Output: negative
```

Valid example

```
import random

def get_latitude():
    return random.randint(-90, 90)

latitude = get_latitude()
location = ""

if latitude == 0:
    location = "Equator"
elif latitude == 90:
    location = "North Pole"
elif latitude == -90:
    location = "South Pole"
else:
    location = "Not at the Equator or Pole"

print(f"latitude is {latitude}")
# Example output: latitude is -57
print(f"location is \"{location}\"")
# Example output: location is "Not at the Equator or Pole"
```

Match statements:

Different types of values

```
monitor_inch_size = 24

match monitor_inch_size:
    case 15:
        str = "too small"
    case 16 | 17 | 18:
        str = "good for the past decade"
    case 19 | 20 | 21 | 22 | 23:
        str = "for office work"
    case 24 | 25 | 26 | 27:
        str = "great choice"
    case _:
        str = ""

print(f'str is "{str}"')
# Output: str is "great choice"
```

Example with a tuple

```python
message = ("error", 404, "Not Found")

match message:
    case ("error", code, description):
        result = f"Error {code}: {description}"
    case ("warning", description):
        result = f"Warning: {description}"
    case ("info", description):
        result = f"Info: {description}"
    case ("success", code, description):
        result = f"Success {code}: {description}"
    case _:
        result = "Unknown message type"

print(result)  # Output: Error 404: Not Found
```

Match if conditions

```
numbers = [5, -2, 0, 10, -8]

for number in numbers:
    match number:
        case n if n > 0:
            print(f"{n} is positive")
        case n if n < 0:
            print(f"{n} is negative")
        case 0:
            print("Zero")
        case _:
            print("Unknown number")
```

Simple conditions

```
# Define a function to calculate the tax based on income
def calculate_tax(income):
    match income:
        case x if x <= 10000:
            tax = x * 0.1
        case x if 10000 < x <= 50000:
            tax = 10000 * 0.1 + (x - 10000) * 0.2
        case x if x > 50000:
            tax = 10000 * 0.1 + 40000 * 0.2 + (x - 50000) * 0.3
    return tax

# Test the function
print("Tax for $5000:", calculate_tax(5000))
# Tax for $5000: 500.0
print("Tax for $25000:", calculate_tax(25000))
# Tax for $25000: 4000.0
print("Tax for $75000:", calculate_tax(75000))
# Tax for $75000: 17000.0
```

Interruption of a control flow:

“break statement”

```
# Example using a while loop
number = 0
while number < 5:
    print(number)
    if number == 3:
        break  # Exit the loop when number reaches 3
    number += 1
print("Loop ended")
```

“continue statement”

```
# Example using a for loop
for i in range(5):
    if i == 2:
        continue  # Skip the rest of the loop when i is 2
    print(i)
```

With return value

```python
# Define a function to calculate the square of a number
def square(x):
    return x ** 2  # Return the square of the input value

# Call the function and store the result in a variable
result = square(5)

# Print the result
print("Square of 5 is:", result)
```

With return value

```
# Define a function to print a message and return
def print_and_return():
    print("Function execution is complete.")
    return  # No value is returned

# Call the function
print_and_return()
print("After function call")
```

Loops:

“do-while” loop

```
i = 7
f7 = 1

while i > 1:
    f7 *= i
    i -= 1

print(f'f7 is {f7}')
# Output: f7 is 5040
```

“for in range” loop

```
f7 = 1

for i in range(7, 1, -1):
    f7 *= i

print(f'f7 is {f7}')  # Output: f7 is 5040
```

“for-in” loop

```python
# Example with a list
fruits = ["apple", "banana", "cherry"]
for fruit in fruits:
    print(fruit)

# apple
# banana
# cherry
```

“while” loop

```python
# Initialize a counter
i = 0

# Define a while loop
while i < 5:
    print(i)
    i += 1  # Increment the counter

# 0
# 1
# 2
# 3
# 4
```

Endless loop

```
while True:
    # statements
```

Enumerations

Enumerations, or enums, are a data type that consists of a set of named values called elements or members. Enums are used to represent a collection of related constants in a readable and maintainable way. They enhance code clarity and safety by providing meaningful names for sets of values, reducing errors from using arbitrary numbers or strings. Enums are commonly used in scenarios like defining states, categories, or types where a variable can only take one out of a small set of possible values. This makes the code more intuitive and less prone to mistakes.

Base member value

```python
from enum import Enum

# Define an enumeration class
class Color(Enum):
    RED = 1
    GREEN = 2
    BLUE = 3

# Access the value of an enumeration member
red_value = Color.RED.value
print("Value of RED:", red_value)
# Output: Value of RED: 1
```

Base type

```
from enum import Enum

# Define an enumeration class
class DataType(Enum):
    INTEGER = 42
    FLOAT = 3.14
    STRING = "hello"
    CUSTOM_OBJECT = {"name": "John", "age": 30}

# Accessing enumeration members and their data types
print("Integer value:", DataType.INTEGER.value, "Type:", type(DataType.INTEGER.value))
# Integer value: 42 Type: <class 'int'>
print("Float value:", DataType.FLOAT.value, "Type:", type(DataType.FLOAT.value))
# Float value: 3.14 Type: <class 'float'>
print("String value:", DataType.STRING.value, "Type:", type(DataType.STRING.value))
# String value: hello Type: <class 'str'>
print("Custom object value:", DataType.CUSTOM_OBJECT.value, "Type:", type(DataType.CUSTOM_OBJECT.value))
# Custom object value: {'name': 'John', 'age': 30} Type: <class 'dict'>
```

Conversion from a string

```python
from enum import Enum

# Define an enumeration class
class Color(Enum):
    RED = 1
    GREEN = 2
    BLUE = 3

# Convert a string to an enumeration member
def string_to_enum(string_value):
    try:
        enum_member = Color[string_value]
        return enum_member
    except KeyError:
        print(f"No enum member found for {string_value}")
        return None

# Test the conversion
color_string = "GREEN"
color_enum_member = string_to_enum(color_string)
if color_enum_member:
    print(f"Enum member for {color_string}: {color_enum_member}")
    # Enum member for GREEN: Color.GREEN
```

Converting to a String

```python
from enum import Enum

# Define an enumeration class
class Color(Enum):
    RED = 1
    GREEN = 2
    BLUE = 3

# Convert an enumeration member to a string
def enum_to_string(enum_member):
    return str(enum_member)  # Using str() function

# Test the conversion
color_enum_member = Color.GREEN
color_string = enum_to_string(color_enum_member)
print(f"String representation: {color_string}")
# String representation: Color.GREEN

# Alternatively, directly access the name attribute
color_string = color_enum_member.name
print(f"String representation (using name attribute): {color_string}")
# String representation (using name attribute): GREEN
```

Definition and initialization

```
from enum import Enum

class Season(Enum):
    Summer, Fall, Winter, Spring = range(4)

summer = Season.Summer
winter = Season.Winter

print(summer) # Season.Summer
print(winter) # Season.Winter
```

Enums comparison

```
from enum import Enum

class Size(Enum):
    xs, s, m, l, xl = range(5)

small = Size.s
large = Size.l

print("is l > s:", large.value > small.value)
# is l > s: True
```

Explicitly set base value

```python
from enum import Enum

class Season(Enum):
    Summer = 1
    Fall = 2
    Winter = 3
    Spring = 4

winter = Season.Winter
baseWinter = winter.value

print(baseWinter) # 3
```

Get the list of values

```
from enum import Enum

class Season(Enum):
    Summer, Fall, Winter, Spring = range(4)

values = list(Season)

print(values)
print(values[0])
# [<Season.Summer: 0>, <Season.Fall: 1>, <Season.Winter:
2>, <Season.Spring: 3>]
# Season.Summer
```

Initializing from a base value

```
from enum import Enum

class Season(Enum):
    Summer = 0
    Fall = 1
    Winter = 2
    Spring = 3

winter = Season(2)
# winter is Season.Winter

print(winter) # Season.Winter
```

Exceptions Handling

Exceptions handling is a programming technique used to manage unexpected or erroneous situations that may occur during runtime. When a program encounters an exceptional condition (e.g., division by zero, file not found), it throws an exception, which disrupts the normal flow of execution.

Catch all exceptions

```
class IsNoneException(Exception):
    pass

class IsEmptyException(Exception):
    pass

def throw_when_null_or_empty(data):
    if data is None:
        raise IsNoneException()

    if len(data) == 0:
        raise IsEmptyException()

try:
    throw_when_null_or_empty(None)
except Exception as e:
    print("Error happened " + e._class_._name_)

# Error happened IsNoneException
```

Catch the specific exception

```python
class IsNoneException(Exception):
    pass

class IsEmptyException(Exception):
    pass

def throw_when_null_or_empty(data):
    if data is None:
        raise IsNoneException()

    if len(data) == 0:
        raise IsEmptyException()

try:
    throw_when_null_or_empty([])
except IsNoneException:
    print("list is not specified")
except IsEmptyException:
    print("list is empty")

# list is empty
```

Define an exception type

```
class SimpleException(Exception):
    pass

raise SimpleException("Oops!")
```

Guaranteed code execution

```python
def throw_if_true(param):
    try:
        if param:
            raise OSError("test exception")
    except OSError:
        print("except")
    finally:
        print("finally")

throw_if_true(True)
# printed: "except" and "finally"
throw_if_true(False)
# printed only "finally"
```

If no exception occurred

```python
def throw_if_true(param):
    try:
        if param:
            raise OSError("test exception")
    except OSError:
        print("except")
    else:
        print("else")

throw_if_true(True)
# printed: "except"
throw_if_true(False)
# printed only "else"
```

Method throwing an exception

```python
# any method can throw an error
def method_with_exception():
    raise Exception("test exception")

method_with_exception()

# Exception: test exception
```

Re-throw exceptions

```
def method_with_exception():
    try:
        raise Exception("test exception")
    except Exception as ex:
        # implementation of any partial procesing
        # and send error to the calling code
        raise ex

try:
    method_with_exception()
except Exception as e:
    print(e.args[0])

# test exception
```

Throw an exception

```
class Seller:
    def __init__(self):
        self.cars = []

    def sell(self):
        if len(self.cars) == 0:
            raise Exception("No cars for sale")

seller = Seller()
try:
    seller.sell()
except Exception as e:
    print(e.args[0])
    # e.args[0] is "No cars for sale"
```

Extensions

Extensions in programming languages allow developers to enhance existing types or classes without modifying their source code. They provide a way to add new functionality, methods, or properties to types that are already defined.

Adding object methods

```
from math import *

excluded_methods = frozenset(["__module__", "__qualname__"])

def class_extend(cls):
    class Meta(type):
        def __new__(mcs, name, bases, attrs):
            for name, value in attrs.items():
                if name not in excluded_methods:
                    setattr(cls, name, value)
            return cls
    return Meta

class Point:
    def __init__(self, x, y):
        self.x = x
        self.y = y

class Point(metaclass=class_extend(Point)):
    def distance_to(self, p2):
        d1 = pow(self.x - p2.x, 2)
        d2 = pow(self.y - p2.y, 2)
        return sqrt(d1 + d2)

point1 = Point(1, 2)
point2 = Point(2, 3)
distance = point1.distance_to(point2)

print(f"{distance = }")
# distance = 1.4142135623730951
```

Functions

Functions in programming are blocks of reusable code that perform a specific task. They allow developers to encapsulate logic, promote code reusability, and enhance readability by breaking down complex operations into smaller, manageable parts.

Array of parameters

```
def get_avg(*values):
    if len(values) == 0:
        return 0

    sum_v = 0
    for value in values:
        sum_v += value
    return sum_v / len(values)

avg = get_avg(1, 2, 3, 4)

print(f"{avg = }") # avg is 2.5
```

In/Out parameters

```
def swap_strings(s1, s2):
    tmp = s1[0]
    s1[0] = s2[0]
    s2[0] = tmp

s1 = ["A"]
s2 = ["B"]
swap_strings(s1, s2)

print(f"s1[0] is {s1[0]}, s2[0] is {s2[0]}")
# s1[0] is "B", s2[0] is "A"
```

Multiple return values

```
def get_first_last(ar):
    if len(ar) == 0:
        return -1, -1
    return ar[0], ar[-1]

ar = [2, 3, 5]
first, last = get_first_last(ar)

print(f"first is {first}")  # first is 2
print(f"last is {last}")    # last is 5
```

Optional parameter values

```python
# Using Default Parameter Values in Python
def say_goodbye(message="Goodbye!"):
    print(message)

say_goodbye()
# prints "Goodbye!"

say_goodbye("See you")
# prints "See you"

# Before Using Default Parameters
def old_say_goodbye(message=None):
    if message is None:
        message = "Goodbye!"
    print(message)

old_say_goodbye()
# prints "Goodbye!"

old_say_goodbye("See you")
# prints "See you"
```

Out parameters

```
# in Python, you can't change param reference
def get_sum(summ, n1, n2):
    summ.append(n1 + n2):

ar_sum = []
get_sum(ar_sum, 5, 3)
# ar_sum is [13]
```

Recursion

```python
def fibonacci(x):
    return x if x <= 1 else fibonacci(x - 1) + fibonacci(x - 2)

f10 = fibonacci(10)

print(f"f10 is {f10}")  # f10 is 55
```

Variable parameters

```
def print5(data):
    if len(data) > 5:
        data = data[0: 5]

    print(data)

print5("1234567") # prints: 12345
```

With return value

```
def get_sum(n1, n2):
    return n1 + n2

result = get_sum(5, 3)

print(f"{result = }") # result is 8
```

Without any parameters

```
def say_goodbye():
    print("Goodbye!")

say_goodbye()
```

Without any return value

```
def add_3_and_print(value):
    print(value + 3)

add_3_and_print(5) # 8
```

Generic Types

Generic types in programming languages allow developers to define classes, functions, or interfaces that can work with various data types without specifying them beforehand. This flexibility enhances code reusability and type safety by enabling components to be more generic and adaptable to different scenarios.

Class conformity

```
from typing import TypeVar, Generic

class Vehicle:
    def test(self):
        print(f"test: {self}")

class Car(Vehicle):
    pass

class Truck:
    pass

T = TypeVar('T', bound=Vehicle)

class Service(Generic[T]):
    def _init_(self):
        selt.v_list = list[T]()

    def add(self, item: T):
        self.v_list.append(item)

    def test(self):
        for item in self.v_list:
            item.test()

service = Service[Vehicle]()
service.add(Vehicle())
service.add(Car())
# Warning: Expected type 'Vehicle'
service.add(Truck())
service.test()
```

Default value

```
from typing import TypeVar, Generic, Type T = TypeVar('T')

class Size(Generic[T]):
    def _init_(self, width: T, height: T):
        self.width = width
        self.height = height

    def reset(self):
        self.width = type(self.width)()
        self.height = type(self.height)()

    def print(self):
        print(f{[{self.width}; {self.height}]})

size_int = Size[int](5, 9)
size_int.print()
# prints: [5; 9]
size_int.reset()
size_int.print()
# prints: [0; 0]
```

Generic classes

```
from typing import TypeVar, Generic
T = TypeVar('T')

class Size(Generic[T]):
    def __init__(self, width: T, height: T):
        self.width = width
        self.height = height

    def as_text(self):
        return f"[{self.width}; {self.height}]"

size_int = Size[int](5, 8)
text_int = size_int.as_text()
# text_int is "[5; 8]"

size_float = Size[float](3.7, 1.58)
text_float = size_float.as_text()
# textFloat is "[3.7; 1.58]"

print(f"{text_int=}")
print(f"{text_float=}")
```

Generic collections

```
# List of integer
int_list = list[int]()
int_list.append(5)
print(f"{int_list = }")

# Dictionary
dic = dict[int, str]()
dic[1] = "one"
print(f"{dic = }")

# Set
set_float = set[float]()
set_float.add(3.14)
print(f"{set_float = }")

# nt_list = [5]
# dic = {1: 'one'}
# set_float = {3.14}
```

Generic methods

```
from typing import TypeVar
T = TypeVar('T')

def swap(v1: list[T], v2: list[T]):
    v1[0], v2[0] = v2[0], v1[0]

n1 = [5]
n2 = [7]
swap(n1, n2)
# n1[0] is 7, n2[0] is 5

s1 = ["cat"]
s2 = ["dog"]
swap(s1, s2)
# s1[0] is "B", s2[0] is "A"

print(f'{n1 = }, {n2 = }')
print(f'{s1 = }, {s2 = }')
```

Interface conformity

```
from abc import ABC, abstractmethod
from typing import TypeVar, Generic

class Vehicle(ABC):
    @abstractmethod
    def test(self):
        pass

class Car(Vehicle):
    def test(self):
        print(f"test {self}")

T = TypeVar('T', bound=Vehicle)

class Service(Generic[T]):
    def __init__(self):
        self.v_list = list[T]()

    def add(self, item: T):
        self.v_list.append(item)

    def test(self):
        for item in self.v_list:
            item.test()

service = Service[Car]()
service.add(Car())
service.test()
```

Substitution principle

```
class Vehicle:
    def test(self):
        print(f"test {self}")

class Car(Vehicle):
    pass

class Truck(Vehicle):
    pass

lst = list[Vehicle]()
lst.append(Vehicle())
lst.append(Car())
lst.append(Truck())

for vehicle in lst:
    vehicle.test()
```

Initializing of Types

Initializing types refers to the process of setting initial values or states for variables, objects, or data structures in a program. This process ensures that entities in the program start with predefined values, which are often crucial for correct functioning and behavior.

Classes:

With a constructor

```
class Phone:
    def __init__(self, model):
        self.model = model


class Employee:
    def __init__(self, first_name, last_name, phone):
        self.first_name = first_name
        self.last_name = last_name
        self.phone = phone


# Create instances
nokia_phone = Phone("Nokia 6610")
kim = Employee("Victorya", "Kim", Phone("IPhone 11 Pro"))

# Access and print phone model
print(kim.phone.model) # Iphone 11 Pro
```

Without any constructor

```
class Phone:
    pass  # No explicit constructor needed

class Employee:
    pass  # No explicit constructor needed

# Create instances and assign attributes
nokia_phone = Phone()
nokia_phone.model = "Nokia 6610"

kim = Employee()
kim.firstName = "Victorya"
kim.lastName = "Kim"
kim.phone = Phone()
kim.phone.model = "IPhone 5"

# Access and print phone model
print(kim.phone.model) # Iphone 5
```

Collections:

Dictionaries

```
# Dictionary<String, String>
languages = {"ru": "russian", "en": "english"}

# Dictionary<Int, String>
numbers = {1: "one", 2: "two", 3: "three"}

# Dictionary<Int, Employee>
class Employee:
    def __init__(self, first_name, last_name):
        self.firstName = first_name
        self.lastName = last_name

employees = {
    1: Employee("Anton", "Pavlov"),
    2: Employee("Elena", "Kirienko")
}

print(f"{languages = }")
# languages = {'ru': 'russian', 'en': 'english'}
print(f"{numbers = }")
# numbers = {1: 'one', 2: 'two', 3: 'three'}
print(f"{employees = }")
# employees = {1: <__main__.Employee object at 0x000001B63A33C950>, 2: <__main__.Employee object at 0x000001B63A33C980>}
```

Lists

```
# list of integer
primeNumbers = [2, 3, 5, 7, 11, 13, 17, 19]

# list of string
gameList = ["soccer", "hockey", "basketball"]


# list of Employee
class Employee:
    def _init_(self, first_name, last_name):
        self.firstName = first_name
        self.lastName = last_name


employess = [Employee("Pavlov", "Anton"), Employee("Kirienko", "Elena")]

print(f"{primeNumbers = }")
# primeNumbers = [2, 3, 5, 7, 11, 13, 17, 19]
print(f"{gameList = }")
# gameList = ['soccer', 'hockey', 'basketball']
print(f"{employess = }")
# employess = [<_main_.Employee object at 0x0000015D2F5FC830>, <_main_.Employee object at 0x0000015D2F5FC860>]
```

Set

```
intHashSet = {2, 3, 5, 7, 11, 13, 17, 19}

print(intHashSet)
# {2, 3, 5, 7, 11, 13, 17, 19}
```

Enumerations

```
from enum import Enum

class PreciousMetal(Enum):
    Platinum = 1
    Gold = 2
    Silver = 3

class Season(Enum):
    Summer, Fall, Winter, Spring = range(4)

Planet = Enum('Planet', 'Mercury Venus Earth')

gold = PreciousMetal.Gold
fall = Season.Fall
earth = Planet.Earth

print(f"{gold = }")
# gold = <PreciousMetal.Gold: 2>
print(f"{fall = }")
# fall = <Season.Fall: 1>
print(f"{earth = }")
# earth = <Planet.Earth: 3>
```

Simple types

```
import sys
from typing import Final

# "Final" for constants

# Int
number: int = 42
otherNumber = 37
maxInt = sys.maxsize
MB: Final = 103876

# Float
exp: float = 2.71828
billion = 1E+9

# String
greeting: Final[str] = "Hello"

# MultiLine String
text1 = "this is some\n + \
    multiLine text"

text2: str = """this is some
multiLine text"""

text3 = ("this is some\n"
        "multiLine text")

# Bool
sunIsStar = True
earthIsStar = False

# Character "A"
charA = 'A' # '\u0041', chr(65);

# Tuple (Int, String)
one = (1, "one")

print(f"{number = }")
# number = 42
print(f"{otherNumber = }")
```

```
# otherNumber = 37
print(f"{maxInt = }")
# maxInt = 9223372036854775807
print(f"{MB = }")
# MB = 103876
print(f"{exp = }")
# exp = 2.71828
print(f"{billion = }")
# billion = 1000000000.0
print(f"{greeting = }")
# greeting = 'Hello'
print(f"{text1 = }")
# text1 = 'this is some\n +      multiLine text'
print(f"{text2 = }")
# text2 = 'this is some\nmultiLine text'
print(f"{text3 = }")
# text3 = 'this is some\nmultiLine text'
print(f"{sunIsStar = }")
# sunIsStar = True
print(f"{earthIsStar = }")
# earthIsStar = False
print(f"{charA = }")
# charA = 'A'
print(f"{one = }")
# one = (1, 'one')
```

Structures:

With a constructor

```python
# The Python language has no structure
class Size:
    def __init__(self, width, height):
        self.width = width
        self.height = height

class Point:
    def __init__(self, top, left):
        self.top = top
        self.left = left

class Rectangle:
    def __init__(self, p_size, p_point):
        self.size = p_size
        self.point = p_point

size = Size(10, 10)
point = Point(5, 5)
rect = Rectangle(size, point)

print(rect.point.left) # 5
```

Without any constructor

```
# The Python language has no structures
class Size:
    width = 0
    height = 0

class Point:
    top = 0
    left = 0

class Rectangle:
    size = Size()
    point = Point()

rect = Rectangle()
rect.size.width = 10
rect.size.height = 10
rect.point.top = 5
rect.point.left = 5

print(rect.point.left)
```

Lambda Expressions

Lambda expressions, also known as anonymous functions, provide a concise way to define small, inline functions in programming languages that support functional programming paradigms. They are used primarily for short and simple functions without the overhead of traditional function declaration syntax. Lambda expressions are especially useful in functional-style programming where functions are treated as first-class citizens and can be passed as arguments to other functions. They typically use arrow notation (=>) for defining the function body and are widely used in languages like Python, JavaScript, Java, C#, and more.

Capture of variables

```
def make_increment(n):
    return lambda x: x + n

inc3 = make_increment(3)
value = 5
inc5 = make_increment(value)

x1 = inc3(10)
# x1 is 13

x2 = inc5(50)
# x2 is 55

print(f"{x1 = }")
print(f"{x2 = }")
```

Currying

```python
def carry(f):
    return lambda a: lambda b: f(a, b)

def avg(a, b): return (a + b) / 2

n1 = avg(1, 3)
# n1 is 2.0

# first universal method
avg1 = carry(avg)(1)
# avg1 is avg func with first param = 1
n2 = avg1(5)
# n2 is 3.0 = (1 + 5) / 2

print("n1 is", n1)
print("n2 is", n2)
```

Function as a parameter

```
numbers = [2, 3, 1, 7, 9]
numbers1 = list(map(lambda x: x * 2 + 1 , numbers))
# numbers1 is [5, 7, 3, 15, 19]

numbers2 = list(filter(lambda x: x % 3 == 0, numbers1))
# numbers2 is [3, 9]

print(numbers1) # [5, 7, 3, 15, 19]
print(numbers2) # [3, 15]
```

Function as a return value

```
def make_sum_func():
    return lambda a, b: a + b

sumFunc = make_sum_func()
sumValue = sumFunc(5, 8)

print(f"{sumValue = }") # sumValue is 13
```

Memoization

```
from datetime import datetime

def memoize(f):
    memo = dict()

    def memo_fun(x):
        if x in memo:
            return memo[x]
        r = f(x)
        memo[x] = r
        return r
    return memo_fun

def fibonacci(x):
    return x if (x <= 1) else fibonacci(x - 1) + fibonacci(x - 2)

mem_fibonacci = memoize(fibonacci)
for i in range(1, 3):
    start = datetime.now()
    f37 = mem_fibonacci(37)
    delta = datetime.now() - start
    seconds = delta.total_seconds()
    print(f"{i}: f37 is {f37}" )
    print(f"{i}: seconds is {seconds}")

# prints:
# 1: f37 is 24157817
# 1: seconds is 7.296308
# 2: f37 is 24157817
# 2: seconds is 0.0

start = datetime.now()
f38 = mem_fibonacci(38)
delta = datetime.now() - start
seconds = delta.total_seconds()
print(f"f38 is {f38}")
print(f"seconds is {seconds}")
# f38 is 39088169
# seconds is 12.796998
```

Memoization (Recursive)

```
from datetime import datetime

def memoize(f):
    memo = dict()

    def memo_fun(x):
        if x in memo:
            return memo[x]
        r = f(memo_fun, x)
        memo[x] = r
        return r

    return memo_fun

def fib(f, x):
    return x if (x <= 1) else f(x - 1) + f(x - 2)

mem_fibonacci = memoize(fib)
for i in range(1, 3):
    start = datetime.now()
    f37 = mem_fibonacci(37)
    delta = datetime.now() - start
    microseconds = delta.seconds * 1000000 + delta.microseconds
    print(f"{i}: f37 is {f37}")
    print(f"{i}: microseconds is {microseconds}")

# prints:
# 1: f37 is 24157817
# 1: microseconds is 10003
# 2: f37 is 24157817
# 2: microseconds is 0

start = datetime.now()
f38 = mem_fibonacci(38)
delta = datetime.now() - start
microseconds = delta.seconds * 1000000 + delta.microseconds
print(f"f38 is {f38}")
print(f"microseconds is {microseconds}")
# f38 is 39088169
# microseconds is 23187
```

Modify captured variables

```
x = 5

addYtoX = lambda y: x += y # <- Error
```

Recursion

```python
def fibonacci(x):
    return x if x <= 1 else fibonacci(x - 1) + fibonacci(x - 2)

f10 = fibonacci(10)
print(f"f10 is {f10}")  # Output: f10 is 55
```

Void function as a parameter

```
def check_and_process(number, process):
    if number < 10:
        process(number)

check_and_process(5, lambda number: print(number * 10))
# printed: 50
```

With multiple operators

```
from math import *

class Point:
    def __init__(self, x, y):
        self.x = x
        self.y = y

# you can't put multiple statements in a lambda
def get_distance(p1, p2):
    d1 = pow(p1.x - p2.x, 2)
    d2 = pow(p1.y - p2.y, 2)
    return sqrt(d1 + d2)

point1 = Point(0, 0)
point2 = Point(5, 5)
distance = get_distance(point1, point2)
# distance is 7.071
print(f"{distance = }")
```

With multiple parameters

```python
# not recommended in PEP 8
avg_lambda = lambda a, b: (a + b) / 2
avg1 = avg_lambda(3, 5)
# avg1 is 4.0

# recommended
def avg_func(a, b):
    return (a + b) / 2

avg2 = avg_func(2, 7)
# avg2 is 4.5

print(f"avg1 = {avg1}")
print(f"avg2 = {avg2}")
```

With one parameter

```python
# not recommended in PEP 8
powOfTwo = lambda power: pow(2.0, power)
pow8 = powOfTwo(8)
# pow8 is 256.0

# recommended
def pow_of_three(power):
    return pow(3.0, power)

pow3 = powOfTwo(3)
# pow3 is 27.0

print(f"{pow8 =}")
print(f"{pow3 =}")
```

Without return value

```python
# not recommended in PEP 8
add2AndPrint = lambda a: print(a + 2)
add2AndPrint(5)
# printed 7

# recommended
def add3_and_print(a):
    print(a + 3)

add3_and_print(7)
# printed 10
```

Lists and Collections

Lists and collections refer to data structures that allow grouping and managing multiple elements in programming. These structures are essential for storing, accessing, and manipulating data efficiently. Lists, often synonymous with arrays in some languages, are ordered collections where each element is indexed starting from zero. They can hold elements of the same type or even mixed types depending on the language's flexibility.

Dictionaries:

Adding and removing of elements

```
dic = {1: "one", 2: "two"}
print(f"{dic = }")

dic[3] = "three"
# dic is {1: 'one', 2: 'two', 3: 'three'}
print(f"{dic = }")

dic[3] = "three"
# dic is {1: 'one', 2: 'two', 3: 'three'}
print(f'{dic = }')

dic.pop(3)
# dic is {1: 'one', 2: 'two'}
print(f'{dic = }')

del dic[2]
# dic is {1: 'one'}
print(f'{dic = }')

dic.clear()
# dic is empty
print(f'{dic = }')
```

Amount of elements

```
dic = {1: "one", 2: "two"}
count = len(dic)
# count is 2

print(f'{count = }')
```

Checking of presence of a key

```
dic = {1: "one", 2: None}
exists1 = 1 in dic
# exists1 is True

exists2 = 2 in dic
# exists2 is True

exists3 = 3 in dic
# exists3 is False

print(f'{exists1 = }')
print(f'{exists2 = }')
print(f'{exists3 = }')
```

Converting a dictionary

```
dic = {1: "one", 2: "two"}
upperDic = {k: v.upper() for k, v in dic.items()}

print(f'{upperDic = }')
```

Default value

```
dic = {1: "A", 2: "B"}
# value1 = dic[3] # <- Error
# value1 is nil
value2 = dic.get(3, "-")
# value2 is "-"

print(f'{value2 = }')
```

Dictionaries initialization

```
# Empty dictionary
d1 = {}
d2 = dict()

# init with some data
d3 = {1: "one", 2: "two"}
d4 = dict(one=1, two=2)
# d4 is {'one': 1, 'two': 2}

d5 = dict(d4, three=3)
#d4 is {'one': 1, 'two': 2, 'three' : 3}

print(f'{d1 = }')
print(f'{d2 = }')
print(f'{d3 = }')
print(f'{d4 = }')
print(f'{d5 = }')
```

Dictionary Merge

```
d1 = {1: "one"}
d2 = {2: "two"}
d3 = {3: "three"}

dAll = d1 | d2
print(f'{dAll = }')
# dAll is {1: 'one', 2: 'two'}

dAll |= d3
print(f'{dAll =}')
# dAll is {1: 'one', 2: 'two', 3: 'three'}
```

Filtering of elements

```
dic = {1: "one", 2: "two", 3: "three"}
oddDic = {k: v for k, v in dic.items() if k % 2 == 1}

# oddDic is {1: 'one', 3: 'three'}

print(f'{oddDic = }')
```

Get value by key

```
d = {1: "one", 2: "two"}

one = d[1]
# one is "one"

two = d[2]
# two is "two"

# three = d[3] # <-Error

print(f'{one = }')
print(f'{two = }')
```

Getting keys by value

```
dic = {1: "A", 2: "B", 3: "A"}
valueTwo = "A"
keys = []

for key, value in dic.items():
    if value == valueTwo:
        keys.append(key)

# keys is [1, 3]
print(f'{keys = }')
```

Getting of a list of keys

```
dic = {1: "one", 2: "two"}
keys = list(dic.keys())
# keys is [1, 2]

print(f'{keys = }')
```

Getting of a list of values

```
dic = {1: "one", 2: "two"}
values = list(dic.values())
# values is ["one", "two"]

print(f'{values = }')
```

Grouping collection

```
numbers = [1, 2, 3, 4, 5]
arr = [[y for y in numbers if y % 2 == x] for x in [0, 1]]
dic = {"even": arr[0], "odd": arr[1]}
# dic is {'even': [2, 4], 'odd': [1, 3, 5]}

print(f"{dic = }")
```

Iterating over a dictionary

```
dic = {1: "one", 2: "two"}

str1 = ""
for key, value in dic.items():
    str1 + = ("{" if str1 = = "" else ", ") + f"{key} : \"{value}\""

str1 + = "}"
# str1 is "{1: "one", 2: "two"}"

str2 = ""
for value in dic.values():
    str2 + = ("" if str2 = = "" else ", ") + value

# str2 is "one, two"

print(f'{str1 = }')
print(f'{str2 = }')
```

Sort dictionary by keys

```
import operator

dic = {3: 'three', 1: 'one', 2: 'two'}

sorted_dic = sorted(dic.items(), key=operator.itemgetter(0))
# sorted_dic is {1: 'one', 2: 'two', 3: 'three'}

print(f'{sorted_dic = }')
```

Sort dictionary by values

```
import operator

dic = {3: 'B', 1: 'C', 2: 'A'}

sorted_dic = sorted(dic.items(), key=operator.itemgetter(1))
# sorted_dic is {2: 'A', 3: 'B', 1: 'C'}

print(f'{sorted_dic = }')
```

Iterators and generators:

Reverse generator

```
def reverse(data):
    current = len(data)
    while current >= 1:
        current -= 1
        yield data[current]

for c in reverse("string"):
    print(c)
# printed: g, n, i, r, t, s

for i in reverse([1, 2, 3]):
    print(i)
# printed: 3, 2, 1
```

Reverse iterator

```
class Reverse:
    def _init_(self, data):
        self.data = data
        self.index = len(data)

    def _iter_(self):
        return self

    def _next_(self):
        if self.index == 0:
            raise StopIteration
        self.index -= 1
        return self.data[self.index]

# Testing the Reverse iterator with a string
for c in Reverse("string"):
    print(c)
# Output: g, n, i, r, t, s

# Testing the Reverse iterator with a list
for i in Reverse([1, 2, 3]):
    print(i)
# Output: 3, 2, 1
```

Simple generator

```
def counter(low, high, step):
    current = low
    while current <= high:
        yield current
        current += step

for c in counter(3, 9, 2):
    print(c)
# printed 3, 5, 7, 9
```

Simple iterator

```
class Counter:
    def __init__(self, low, high, step):
        self.current = low
        self.high = high
        self.step = step

    def __iter__(self):
        return self

    def __next__(self):
        if self.current > self.high
            raise StopIteration
        else:
            result = self.current
            self.current += self.step
            return result

for c in Counter(3, 9, 2):
    print(c)
# printed 3, 4, 7, 9
```

Lists:

Adding and removing of elements

```
primeNumbers = [2, 5, 7]
print(primeNumbers)

primeNumbers.append(11)
# primeNumbers is [2, 5, 7, 11]
print(primeNumbers)

primeNumbers.insert(1, 3)
# primeNumbers is [2, 3, 5, 7, 11]
print(primeNumbers)

primeNumbers.remove(2)
# primeNumbers is [3, 5, 7, 11]
print(primeNumbers)

del primeNumbers[1]
# primeNumbers is [3, 7, 11]

primeNumbers.extend([13, 17])
# primeNumbers is [3, 7, 11, 13, 17]
print(primeNumbers)

primeNumbers.clear()
# primeNumbers is []
print(primeNumbers)
```

Arrays comparing

```python
ar1 = [1, 2, 4, 3]
ar2 = [1, 2, 3, 4, 5]

diff = set(ar2) - set(ar1)
# diff is {5}
print(f'{diff = }')
```

Checking equality of lists

```
n1 = [1, 2, 3]
n2 = [1, 2, 3]
n3 = [3, 2, 1]

equal1 = n1 == n2
# equal1 is True

equal2 = n1 == n3
# equal2 is False

equal3 = set(n1) == set(n3)
# equal3 is True

print(f"{equal1 = }")
print(f"{equal2 = }")
print(f"{equal3 = }")
```

Converting of a list

```
numbers = [1, 2, 3, 4, 5]
numbers = [x * 3 for x in numbers]
# numbers is [3, 6, 9, 12, 15]
print(f'{numbers =}')

numbers = list(map(lambda x: x*2, numbers))
# numbers is [6, 12, 18, 24, 30]
print(f'{numbers = }')
```

Dynamic lists

```
count = 5
lst_int = [0] * count
lst_int[0] = 1
# lst_int = [1, 0, 0, 0, 0]

print(f'{lst_int = }')
```

Filtering of elements

```
numbers = [1, 2, 3, 4, 5]
odd_items = [item for item in numbers if item % 2]
# odd_items is [1, 3, 5]

print(f'{odd_items = }')
```

Finding a list item

```
numbers = [2, 3, 5, 7, 11, 13, 17]
contain5 = 5 in numbers
# contain5 is True

index5 = 10 in numbers
# contain10 is False

number2 = [1, 9, 8, 3, 1, 6, 7]
containNum = number2.count(1)
# containNum is 2

print(f'{contain5 = }')
print(f'{index5 = }')
print(f'{contain10 = }')
print(f'{containNum = }')
```

Getting Min and Max values

```
numbers = [11, 2, 5, 7, 3]

minValue = min(numbers)
# minValue is 2
maxValue = max(numbers)
# max is 11

print(f"{minValue = }")
print(f"{maxValue = }")
```

Getting part of a list

```
numbers = [2, 3, 5, 7, 11]

first2 = numbers[:2]
# first2 is [2, 3]
last3 = numbers[2:]
# last3 is [5, 7, 11]

print(f"{first2 = }")
print(f"{last3 = }")
```

Getting unique values

```
numbers = [1, 3, 2, 1, 3]
unique = list(set(numbers))
# unique is [2, 3, 1]

print(f'{unique = }')
```

Iterating over an array (recursive)

```
numbers = [2, 3, 5, 7, 11, 13, 17]
string = ""
for i in reversed(numbers):
    string = string + str(i) + "; "

# string is "17; 13; 11; 7; 5; 3; 2 "

print(f"{string = }")
```

Iterating over a list

```
numbers = [2, 3, 5, 7, 11, 13, 17]
string = ""
for i in numbers:
    string = string + str(i) + "; "

# string is "2; 3; 5; 7; 11; 13; 17; "

print(f"{string = }")
```

Iterating over a list with index

```
numbers = [2, 3, 5, 7, 11, 13, 17]
string = ""
for i in range(0, len(numbers)):
    string += str(numbers[i])
    if i < (len(numbers) - 1):
        string += "; "

# string is "2; 3; 5; 7; 11; 13; 17"
print(f"{string = }")
```

List copying

```
import copy
numbers1 = [1, 2, 3, 4, 5]

# the first method
numbers2 = list(numbers1)

# the second method
numbers3 = numbers1[:]

# the third method with deep copy
numbers4 = copy.deepcopy(numbers1)

print(f"{id(numbers1) = }")
print(f"{id(numbers2) = }")
print(f"{numbers2 = }")
print(f"{id(numbers3) = }")
print(f"{numbers3 = }")
print(f"{id(numbers4) = }")
print(f"{numbers4 = }")
```

List length

```python
numbers = [1, 2, 3]
length = len(numbers)
# length is 3

print(f"{length = }")
```

List with a default value

```
value = 5
count = 3
lst = [value] * count
# array is [5, 5, 5]

print(f"{lst = }")
```

List initialization

```
# Empty array
n1 = []
n2 = list()

# Single-dimensional array
n3 = [1, 2, 3]
n4 = ["1", "2", "3"]

# Multidimensional array
n5 = [[1, 2], [3, 4, 5]]
```

List merging

```python
firstNumbers = [2, 3, 5]
secondNumbers = [7, 11, 13]

allNumbers = firstNumbers + secondNumbers
# allNumbers is [2, 3, 5, 7, 11, 13]

print(f'{allNumbers = }')
```

Sorting of elements

```
numbers = [11, 2, 5, 7, 3]

numbers.sort()
# numbers is [2, 3, 5, 7, 11]
print(f'{numbers = }')

# descending
numbers.sort(reverse=True)
# numbers is [11, 7, 5, 3, 2]
print(f'{numbers = }')

lst = [['B', 3], ['A', 2], ['C', 1]]
lst.sort(key=lambda i: i[1], reverse=True)
# arr is [['B', 3], ['A', 2], ['C', 1]]
print(f'{lst = }')
```

Sum of elements

```
numbers = [2, 3, 5, 7, 11]
numbers_sum = sum(numbers)
# numbers_sum is 28

strings = ["A", "B", "C"]
strings_sum = ''.join(strings)
# strings_sum is 'ABC'

print(f"{numbers_sum = }")
print(f"{strings_sum = }")
```

every() and some() methods

```python
from collections import deque

intQueue = deque()
intQueue.append(1)
intQueue.append(3)
intQueue.append(5)

first = intQueue.popleft()
# first is 1
second = intQueue.popleft()
# second is 3
third = intQueue.popleft()

print(f"{first = }")
print(f"{second = }")
print(f"{third = }")
```

Sets:

Adding and removing of elements

```
set1 = {"A", "B", "C"}
set1.add("D")
# set1 is {'C', 'D', 'A', 'B'}
print(f"{set1 = }")

set1.remove("A")
# set1 is {'C', 'B', 'D'}
print(f"{set1 = }")

set1.pop()
# set1 is {'B', 'D'}
print(f"{set1 = }")

set1.clear()
# set1 is {}
print(f"{set1 = }")
```

Converting of a set

```
set1 = {1, 2, 3}
set3 = [x * 3 for x in set1]
# set3 is [3, 6, 9]
print(f"{set3 = }")
```

Filtering of elements

```python
set1 = {1, 2, 3}
oddArr = [i for i in set1 if i % 2]
# oddArr is [1, 3]

print(f'{oddArr = }')
```

Iterating over a set

```
chars = {"A", "B", "C", "D"}
s = ""
for c in chars:
    s += ("" if s == "" else "; ") + c

# s is "B; A; C; D"
print(f"{s = }")
```

Search for an element

```
chars = {"A", "B", "C", "D"}
containA = "A" in chars
# containA is True

containE = "E" in chars
# containE is False

chars2 = {"A", "B"}
containAll = chars > chars2
# containAll is True

print(f"{containA = }")
print(f"{containE = }")
print(f"{containAll = }")
```

Sets comparison

```
first = {1, 2}
second = {2, 1}
third = {1, 2, 3}

isEqual = first == second
print(f'{isEqual = }')
# isEqual is True

isIntersects = not first.isdisjoint(third)
# intersects is True
print(f'{isIntersects = }')

isSubset = third.issubset(first)
# isSubset is False
print(f'{isSubset = }')

isSubset = first.issubset(third)
# isSubset is True
print(f'{isSubset = }')
```

Sets initialization

```
int_set = {1, 2, 3}
str_set = {"one", "two", "three"}

print(f'{int_set = }')
print(f'{str_set = }')
```

Sets operations

```python
first = {1, 2, 3}
second =  {3, 4, 5}

# union
third1 = first | second
# third1 is {1, 2, 3, 4, 5}

# difference
third2 = first - second
# third2 is {1, 2}

# intersection
third3 = first & second
# third3 is {3}

# symmetric difference
third4 = first ^ second
# third4 is {1, 2, 4, 5}

print(f"{third1 = }")
print(f"{third2 = }")
print(f"{third3 = }")
print(f"{third4 = }")
```

Sorting of elements

```
chars = {"A", "B", "C", "D"}
s = "; ".join(chars)
# s is "C; B; D; A"
print(f'{s = }')

sortedChars = sorted(chars)
s = "; ".join(sortedChars)
# s is "A; B; C; D"
print(f'{s = }')
```

Stack<T> (LIFO)

```
from collections import deque

intStack = deque()
intStack.append(1)
intStack.append(3)
intStack.append(5)

first = intStack.pop()
# first is 5
second = intStack.pop()
# second is 3
third = intStack.pop()
# third is 1

print(f"{first = }")
print(f"{second = }")
print(f"{third = }")
```

Multi-threaded Operations

Multi-threaded operations refer to the ability of a program or application to execute multiple threads concurrently. Threads are independent sequences of instructions within a program that can run simultaneously, allowing for parallel execution and efficient utilization of multi-core processors.

Keywords "async" and "await"

```
import asyncio

async def async_task(name, delay):
    print(f"Task {name} started, will take {delay} seconds.")
    await asyncio.sleep(delay)
    print(f"Task {name} completed.")

async def main():
    tasks = [async_task("A", 2), async_task("B", 3), async_task("C",
1)]
    await asyncio.gather(*tasks)

# Run the main function to execute the tasks
asyncio.run(main())

# Task A started, will take 2 seconds.
# Task B started, will take 3 seconds.
# Task C started, will take 1 seconds.
# Task C completed.
# Task A completed.
# Task B completed.
```

Start of a new thread

```
import threading
import time

# Define a function for the thread
def print_numbers(name, count):
    for i in range(1, count + 1):
        print(f"Thread {name}: {i}")
        time.sleep(1)  # Simulate a time-consuming task

# Create threads
thread1 = threading.Thread(target=print_numbers, args=("A", 5))
thread2 = threading.Thread(target=print_numbers, args=("B", 3))

# Start threads
thread1.start()
thread2.start()

# Wait for both threads to complete
thread1.join()
thread2.join()

print("Both threads have finished execution.")
# Thread A: 1
# Thread B: 1
# Thread A: 2
# Thread B: 2
# Thread A: 3
# Thread B: 3
# Thread A: 4
# Thread A: 5
# Both threads have finished execution.
```

Start of a new thread and waiting

```
import threading
import time

# Define a function for the thread
def perform_task(name, duration):
    print(f"Thread {name} starting.")
    time.sleep(duration)  # Simulate a time-consuming task
    print(f"Thread {name} finished after {duration} seconds.")

# Create a thread
thread = threading.Thread(target=perform_task, args=("Worker",
5))

# Start the thread
thread.start()

# Wait for the thread to complete
print("Main thread is waiting for the Worker thread to finish.")
thread.join()

print("Worker thread has finished. Main thread continues.")
# Thread Worker starting.Main thread is waiting for the Worker
thread to finish.

# Thread Worker finished after 5 seconds.
# Worker thread has finished. Main thread continues.
```

Synchronization with blocking

```
import threading
import time

# Define a shared resource
shared_counter = 0
counter_lock = threading.Lock()

# Define a function for the thread that increments the shared resource
def increment_counter(name, increments):
    global shared_counter
    for _ in range(increments):
        # Acquire the lock before accessing the shared resource
        counter_lock.acquire()
        try:
            local_counter = shared_counter
            local_counter += 1
            time.sleep(0.1)  # Simulate a time-consuming task
            shared_counter = local_counter
            print(f"Thread {name}: shared_counter = {shared_counter}")
        finally:
            # Release the lock
            counter_lock.release()

# Create threads
thread1 = threading.Thread(target=increment_counter, args=("A", 5))
thread2 = threading.Thread(target=increment_counter, args=("B", 5))

# Start threads
thread1.start()
thread2.start()

# Wait for both threads to complete
thread1.join()
thread2.join()
```

```python
print(f"Final value of shared_counter: {shared_counter}")
# Thread A: shared_counter = 1
# Thread A: shared_counter = 2
# Thread A: shared_counter = 3
# Thread A: shared_counter = 4
# Thread A: shared_counter = 5
# Thread B: shared_counter = 6
# Thread B: shared_counter = 7
# Thread B: shared_counter = 8
# Thread B: shared_counter = 9
# Thread B: shared_counter = 10
# Final value of shared_counter: 10
```

Thread task object

```
import threading
import time

# Define a class for the thread task
class IncrementCounterTask:
    def _init_(self, name, increments, lock):
        self.name = name
        self.increments = increments
        self.lock = lock
        self.shared_counter = 0

    def _call_(self):
        for _ in range(self.increments):
            self.lock.acquire()
            try:
                local_counter = self.shared_counter
                local_counter += 1
                time.sleep(0.1)  # Simulate a time-consuming task
                self.shared_counter = local_counter
                print(f"Thread {self.name}: shared_counter = {self.shared_counter}")
            finally:
                self.lock.release()

# Create a lock
counter_lock = threading.Lock()

# Create thread task objects
task1 = IncrementCounterTask("A", 5, counter_lock)
task2 = IncrementCounterTask("B", 5, counter_lock)

# Create threads
thread1 = threading.Thread(target=task1)
thread2 = threading.Thread(target=task2)

# Start threads
thread1.start()
thread2.start()
```

```
# Wait for both threads to complete
thread1.join()
thread2.join()

print(f"Final value of task1 shared_counter: {task1.shared_counter}")
print(f"Final value of task2 shared_counter: {task2.shared_counter}")
# Thread A: shared_counter = 1
# Thread A: shared_counter = 2
# Thread A: shared_counter = 3
# Thread A: shared_counter = 4
# Thread A: shared_counter = 5
# Thread B: shared_counter = 1
# Thread B: shared_counter = 2
# Thread B: shared_counter = 3
# Thread B: shared_counter = 4
# Thread B: shared_counter = 5
# Final value of task1 shared_counter: 5
# Final value of task2 shared_counter: 5
```

Operators Overloading

Operator overloading is a programming technique that allows operators to be redefined or customized for user-defined types (classes or structs). This means that operators such as +, -, *, /, ==, !=, <, >, <=, >=, and others can be given specific meanings for objects of a particular class or struct.

Binary operators

```
class Vector:
    def __init__(self, x, y):
        self.x = x
        self.y = y

    def __add__(self, other):
        if isinstance(other, Vector):
            return Vector(self.x + other.x, self.y + other.y)
        raise TypeError("Operand must be of type 'Vector'")

    def __sub__(self, other):
        if isinstance(other, Vector):
            return Vector(self.x - other.x, self.y - other.y)
        raise TypeError("Operand must be of type 'Vector'")

    def __mul__(self, other):
        if isinstance(other, (int, float)):
            return Vector(self.x * other, self.y * other)
        raise TypeError("Operand must be a number")

    def __truediv__(self, other):
        if isinstance(other, (int, float)):
            if other == 0:
                raise ValueError("Cannot divide by zero")
            return Vector(self.x / other, self.y / other)
        raise TypeError("Operand must be a number")

    def __str__(self):
        return f"Vector({self.x}, {self.y})"

# Create instances of Vector
v1 = Vector(2, 3)
v2 = Vector(4, 5)

# Test operator overloading
print(f"v1 + v2 = {v1 + v2}")  # Vector(6, 8)
print(f"v1 - v2 = {v1 - v2}")  # Vector(-2, -2)
print(f"v1 * 3 = {v1 * 3}")    # Vector(6, 9)
print(f"v2 / 2 = {v2 / 2}")    # Vector(2.0, 2.5)
```

Comparison operators

```python
class Point:
    def __init__(self, x, y):
        self.x = x
        self.y = y

    def __eq__(self, other):
        return self.x == other.x and self.y == other.y

    def __lt__(self, other):
        return (self.x, self.y) < (other.x, other.y)

    def __le__(self, other):
        return (self.x, self.y) <= (other.x, other.y)

    def __gt__(self, other):
        return (self.x, self.y) > (other.x, other.y)

    def __ge__(self, other):
        return (self.x, self.y) >= (other.x, other.y)

    def __ne__(self, other):
        return not self == other


# Example usage:
point1 = Point(1, 2)
point2 = Point(2, 3)
point3 = Point(1, 2)

print(f"point1 == point2: {point1 == point2}")  # False
print(f"point1 == point3: {point1 == point3}")  # True
print(f"point1 < point2: {point1 < point2}")  # True
print(f"point1 <= point2: {point1 <= point2}")  # True
print(f"point1 > point2: {point1 > point2}")  # False
print(f"point1 >= point2: {point1 >= point2}")  # False
print(f"point1 != point2: {point1 != point2}")  # True
```

Custom operators

```
class Vector:
    def _init_(self, x, y):
        self.x = x
        self.y = y

    def _add_(self, other):
        return Vector(self.x + other.x, self.y + other.y)

    def _sub_(self, other):
        return Vector(self.x - other.x, self.y - other.y)

    def _mul_(self, scalar):
        return Vector(self.x * scalar, self.y * scalar)

    def _truediv_(self, scalar):
        return Vector(self.x / scalar, self.y / scalar)

    def _eq_(self, other):
        return self.x = = other.x and self.y = = other.y

    def _lt_(self, other):
        return (self.x ** 2 + self.y ** 2) < (other.x ** 2 + other.y
** 2)

    def _le_(self, other):
        return (self.x ** 2 + self.y ** 2) < = (other.x ** 2 + other.y
** 2)

    def _repr_(self):
        return f"Vector({self.x}, {self.y})"

# Example usage:
v1 = Vector(1, 2)
v2 = Vector(3, 4)
v3 = v1 + v2
v4 = v2 - v1
v5 = v1 * 3
v6 = v2 / 2

print(f"v1: {v1}") # v1: Vector(1, 2)
print(f"v2: {v2}") # v2: Vector(3, 4)
```

```
print(f"v1 + v2: {v3}") # v1 + v2: Vector(4, 6)
print(f"v2 - v1: {v4}") # v2 - v1: Vector(2, 2)
print(f"v1 * 3: {v5}") # v1 * 3: Vector(3, 6)
print(f"v2 / 2: {v6}") # v2 / 2: Vector(1.5, 2.0)

print(f"v1 == v2: {v1 == v2}") # v1 == v2: False
print(f"v1 < v2: {v1 < v2}") # v1 < v2: True
print(f"v1 <= v2: {v1 <= v2}") # v1 <= v2: True
```

Equivalence operators

```
class Point:
    def _init_(self, x, y):
        self.x = x
        self.y = y

    def _eq_(self, other):
        if not isinstance(other, Point):
            return NotImplemented
        return self.x == other.x and self.y == other.y

    def _ne_(self, other):
        if not isinstance(other, Point):
            return NotImplemented
        return not self == other

    def _repr_(self):
        return f"Point({self.x}, {self.y})"

# Example usage:
point1 = Point(1, 2)
point2 = Point(1, 2)
point3 = Point(2, 3)

print(f"point1 == point2: {point1 == point2}")  # True
print(f"point1 == point3: {point1 == point3}")  # False
print(f"point1 != point2: {point1 != point2}")  # False
print(f"point1 != point3: {point1 != point3}")  # True
```

Unary operators

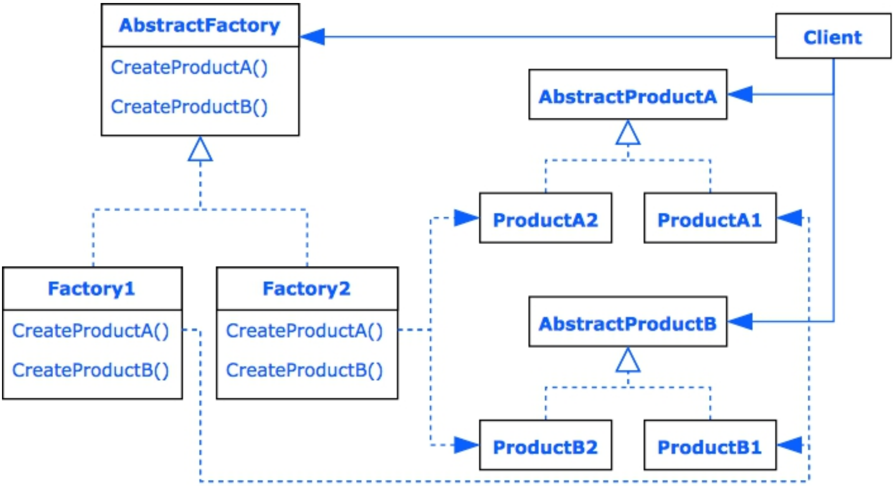
```python
class Vector:
    def __init__(self, x, y):
        self.x = x
        self.y = y

    def __neg__(self):
        return Vector(-self.x, -self.y)

    def __pos__(self):
        return Vector(+self.x, +self.y)

    def __repr__(self):
        return f"Vector({self.x}, {self.y})"

# Example usage:
v1 = Vector(3, 4)
v_neg = -v1
v_pos = +v1

print(f"v1: {v1}")          # v1: Vector(3, 4)
print(f"-v1: {v_neg}")      # -v1: Vector(-3, -4)
print(f"+v1: {v_pos}")      # +v1: Vector(3, 4)
```

Design Patterns

Design patterns are proven solutions to common problems that arise during software design and development. They represent best practices and reusable templates that help developers solve recurring design challenges effectively.

Creational patterns:

Abstract factory

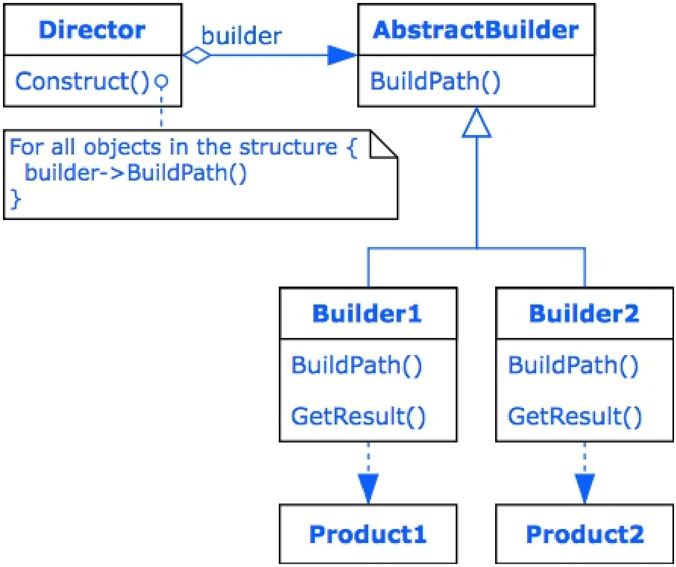



```
from abc import ABC, abstractmethod

# abstract factory
class IFactory(ABC):
    @abstractmethod
    def create_a(self):
        pass

    @abstractmethod
    def create_b(self):
        pass

# concrete factory 1
class Factory1(IFactory):
    def create_a(self):
        return ProductA1()

    def create_b(self):
        return ProductB1()

# concrete factory 2
class Factory2(IFactory):
    def create_a(self):
        return ProductA2()
```

```python
    def create_b(self):
        return ProductB2()

# abstract product A
class ProductA(ABC):
    @abstractmethod
    def test_a(self):
        pass

# abstract product B
class ProductB(ABC):
    @abstractmethod
    def test_b(self):
        pass

# concrete product A1
class ProductA1(ProductA):
    def test_a(self):
        print('test A1')

# concrete product A2
class ProductA2(ProductA):
    def test_a(self):
        print('test A2')

# concrete product B1
class ProductB1(ProductB):
    def test_b(self):
        print('test B1')

# concrete product B2
class ProductB2(ProductB):
    def test_b(self):
        print('test B2')

# client code
def check_factory(factory):
    product_a = factory.create_a()
    product_b = factory.create_b()
    product_a.test_a()
    product_b.test_b()

check_factory(Factory1())
```

```
# test A1
# test B1
check_factory(Factory2())
# test A2
# test B2
```

Builder

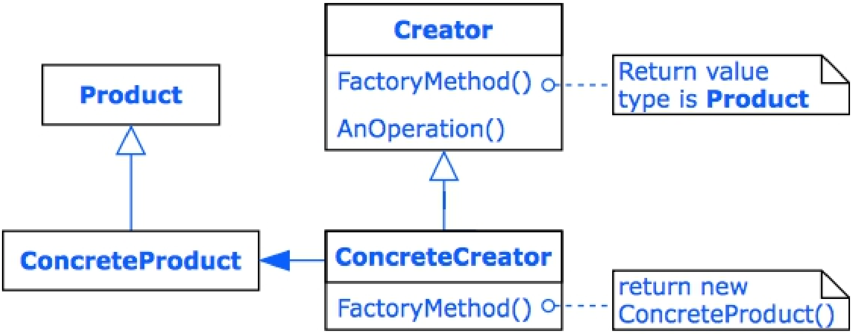



```python
from abc import ABC, abstractmethod

# Abstract Builder
class TextBuilder(ABC):
    @abstractmethod
    def add_text(self, value):
        pass

    @abstractmethod
    def add_new_line(self, value):
        pass

    @abstractmethod
    def get_result(self):
        pass

# Concrete Builder 1
class PlainTextBuilder(TextBuilder):
    def __init__(self):
        self.text = ""

    def add_text(self, value):
```

```python
        self.text += value

    def add_new_line(self, value):
        self.text += "\n" + value

    def get_result(self):
        return self.text

# Concrete Builder 2
class HtmlBuilder(TextBuilder):
    def __init__(self):
        self.html = ""

    def add_text(self, value):
        self.html += f"<span>{value}</span>"

    def add_new_line(self, value):
        self.html += f"<br/>\n<span>{value}</span>"

    def get_result(self):
        return self.html

# Director
class TextMaker:
    def make_text(self, text_builder):
        text_builder.add_text("line 1")
        text_builder.add_new_line("line 2")

# Client
if __name__ == "__main__":
    text_maker = TextMaker()

    text_builder = PlainTextBuilder()
    text_maker.make_text(text_builder)
    text = text_builder.get_result()
    # line 1
    # line 2

    html_builder = HtmlBuilder()
    text_maker.make_text(html_builder)
    html = html_builder.get_result()
    # html: <span>line 1</span><br/>
    #       <span>line 2</span>
```

```
print(f"text:\n{text}")
print(f"html:\n{html}")
```

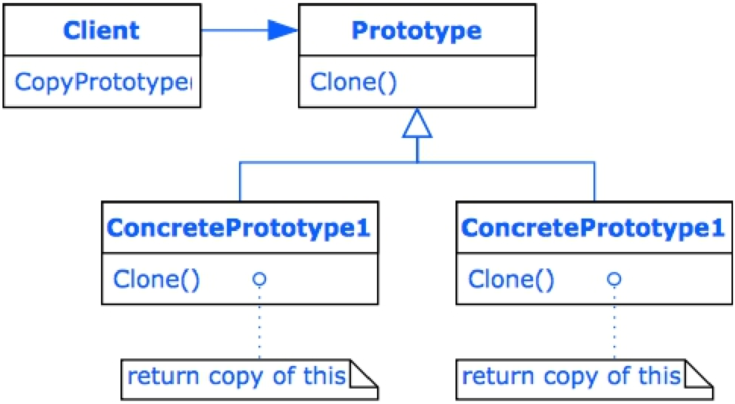
Factory method




```
from abc import ABC, abstractmethod

# Product
class Employee(ABC):
    @abstractmethod
    def test(self):
        pass

# Concrete Product
class Manager(Employee):
    def test(self):
        print("Manager")

# Creator
class Creator(ABC):
    # Factory Method
    @abstractmethod
    def create_employee(self):
        pass

    # Some operation
    def test(self):
        self.create_employee().test()

# Concrete Creator
class ManagerCreator(Creator):
    # Factory Method
    def create_employee(self):
```

```
        return Manager()

# Client
if __name__ == "__main__":
    creator = ManagerCreator()
    creator.test()
    # printed: Manager
```

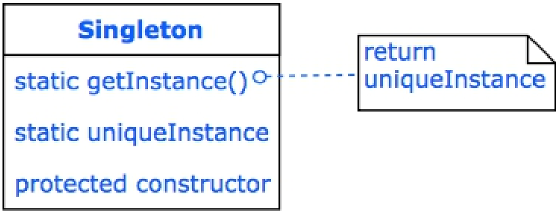
Prototype




```python
import copy

# Prototype
class Shape:
    def __init__(self, line_count):
        self.line_count = line_count

    def clone(self):
        return copy.deepcopy(self)

# ConcretePrototype
class Square(Shape):
    def __init__(self):
        super().__init__(4)

# Client
class ShapeMaker:
    def __init__(self, shape):
        self._shape = shape

    def make_shape(self):
        return self._shape.clone()

if __name__ == "__main__":
    square = Square()
    maker = ShapeMaker(square)
```

```
square1 = maker.make_shape()
square2 = maker.make_shape()

print("square1.line_count is", square1.line_count)
# square1.line_count is 4
print("square2.line_count is", square2.line_count)
# square2.line_count is 4
```

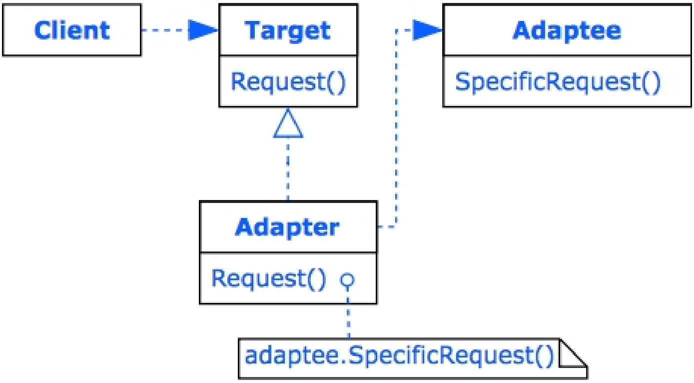
Singleton




```
class Settings:
    _singleton_instance = None

    def __new__(cls):
        if cls._singleton_instance is None:
            cls._singleton_instance = super().__new__(cls)
            cls._singleton_instance.port = 0
            cls._singleton_instance.host = ""
        return cls._singleton_instance

if __name__ == "__main__":
    settings = Settings()
    settings.host = "192.168.100.1"
    settings.port = 33

    settings1 = Settings()
    # settings1.port is 33
    print("settings1.port is", settings1.port)
    # settings1.port is 33
```

Structural patterns:

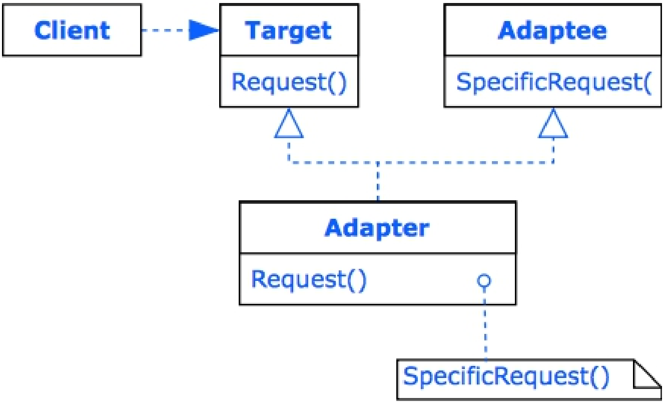
Adapter (Composition)




```python
class StringList:
    def __init__(self):
        self.rows = []

    # SpecificRequest
    def get_string(self):
        return "\n".join(self.rows)

    def add(self, value):
        self.rows.append(value)

# Adapter
class TextAdapter:
    def __init__(self, row_list):
        self.row_list = row_list

    # Request
    def get_text(self):
        return self.row_list.get_string()

def get_text_adapter():
    row_list = StringList()
    adapter = TextAdapter(row_list)

    row_list.add("line 1")
    row_list.add("line 2")
    return adapter
```

```python
# Client
if __name__ == "__main__":
    adapter = get_text_adapter()
    text = adapter.get_text()
    # text: line 1
    # line 2
    print(text)
    # line 1
    # line 2
```

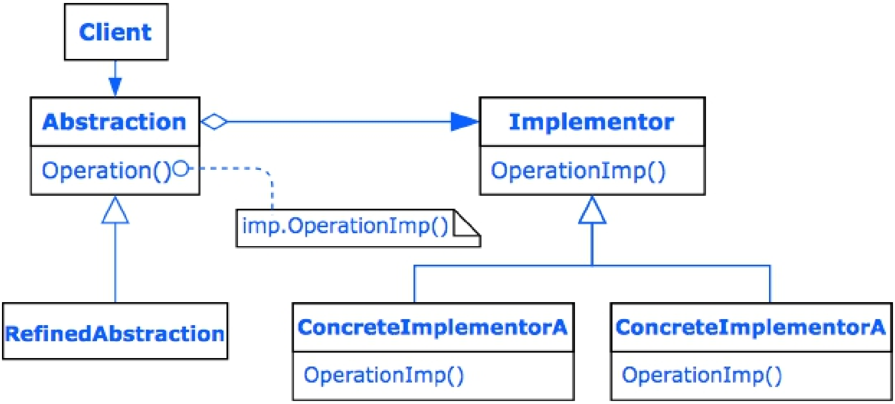
Adapter (Inheritance)




```
# Adaptee
class StringList:
    def __init__(self):
        self.rows = []

    # SpecificRequest
    def get_string(self):
        return "\n".join(self.rows)

    def add(self, value):
        self.rows.append(value)

# Adapter
class TextAdapter(StringList):
    def __init__(self):
        super().__init__()

    # Request
    def get_text(self):
        return self.get_string()

def get_text_adapter():
    adapter = TextAdapter()
    adapter.add("line 1")
    adapter.add("line 2")
    return adapter
```

```python
# Client
if __name__ == "__main__":
    adapter = get_text_adapter()
    text = adapter.get_text()
    # text: line 1
    # line 2
    print(text)
```

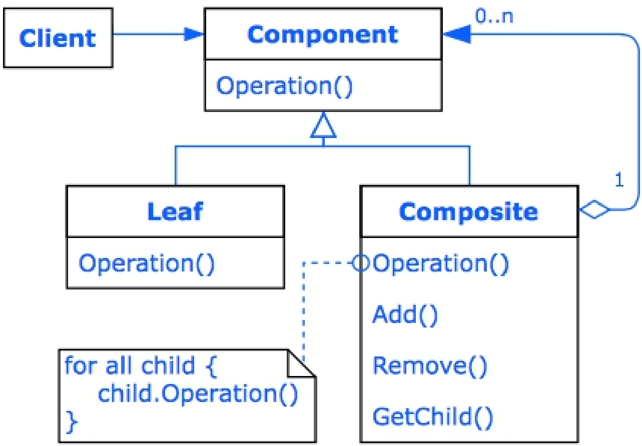
Bridge




```
# Implementor
class TextImp:
    def __init__(self):
        self._rows = []

    def get_string(self):
        return "\n".join(self._rows)


# RefinedAbstraction
class TextMaker:
    def __init__(self, imp):
        self.text_imp = imp

    def get_text(self):
        return self.text_imp.get_string()

    def add_line(self, value):
        self.text_imp.append_line(value)


# ConcreteImplementor
class HtmlBuilder(TextImp):
    def __init__(self):
        super().__init__()

    def append_line(self, value):
```

```python
        self._rows.append("<span>" + value + "</span><br/>")


# Client
if __name__ == "__main__":
    text_maker = TextMaker(TextImp())
    text_maker.add_line("line 1")
    text_maker.add_line("line 2")
    text = text_maker.get_text()

    html_maker = TextMaker(HtmlBuilder())
    html_maker.add_line("line 1")
    html_maker.add_line("line 2")
    html = html_maker.get_text()

    print(text)
    print(html)
    # line 1
    # line 2
    # <span>line 1</span><br/>
    # <span>line 2</span><br/>
```

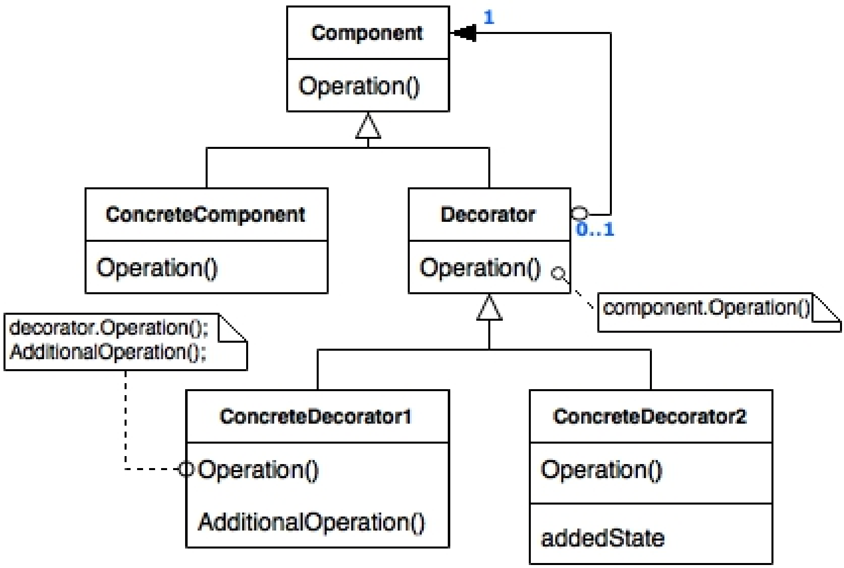
Composite




```
# Component
class Graphic:
    def draw(self):
        pass

# Leaf
class Circle(Graphic):
    def draw(self):
        print("Draw circle")

# Leaf
class Square(Graphic):
    def draw(self):
        print("Draw square")

# Composite
class CImage(Graphic):
    def _init_(self):
        self.graphics = []

    def add(self, graphic):
        self.graphics.append(graphic)
```

```
    def remove(self, graphic):
        self.graphics.remove(graphic)

    def draw(self):
        print("Draw image")
        for graphic in self.graphics:
            graphic.draw()


# Client
if __name__ == "__main__":
    image = CImage()
    image.add(Circle())
    image.add(Square())
    picture = CImage()
    picture.add(image)
    picture.add(CImage())
    picture.draw()

# Output:
# Draw image
# Draw circle
# Draw square
```

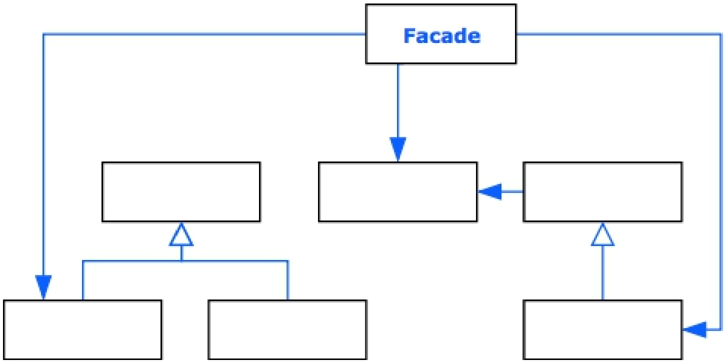
Decorator




```python
# Component
class Shape:
    # Operation()
    def get_info(self):
        return "shape"

    def show_info(self):
        print(self.get_info())


# ConcreteComponent
class Square(Shape):
    def _init_(self):
        super()._init_()

    # Operation()
    def get_info(self):
        return "square"


# Decorator
```

```python
class ShapeDecorator(Shape):
    def __init__(self, shape):
        super().__init__()
        self.shape = shape

    # Operation()
    def get_info(self):
        return self.shape.get_info()


# ConcreteDecorator
class ColorShape(ShapeDecorator):
    def __init__(self, shape, color):
        super().__init__(shape)
        self.color = color

    def get_info(self):
        return f"{self.color} {self.shape.get_info()}"


# Create a basic square
square = Square()

# Decorate the square with color
colored_square = ColorShape(square, "red")

# Show information about the colored square
colored_square.show_info()  # red square
```

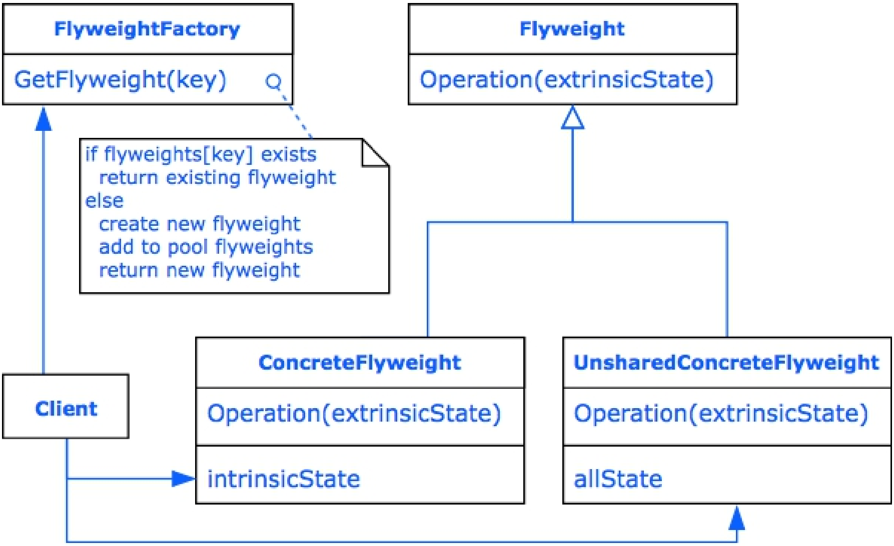
Facade




```
# Complex parts
class Kettle:
    def turn_off(self):
        print("Kettle turn off")

class Toaster:
    def turn_off(self):
        print("Toaster turn off")

class Refrigerator:
    def turn_off(self):
        print("Refrigerator turn off")

# Facade
class Kitchen:
    def _init_(self, kettle, toaster, refrigerator):
        self.kettle = kettle
        self.toaster = toaster
        self.refrigerator = refrigerator

    def off(self):
```

```
        self.kettle.turn_off()
        self.toaster.turn_off()
        self.refrigerator.turn_off()

kettle = Kettle()
toaster = Toaster()
refrigerator = Refrigerator()
kitchen = Kitchen(kettle, toaster, refrigerator)
kitchen.off()

# Kettle turn off
# Toaster turn off
# Refrigerator turn off
```

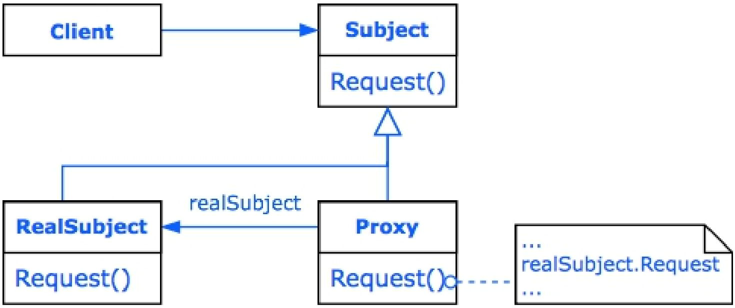
Flyweight




```python
# Flyweight
class Char:
    def __init__(self, c):
        self._c = c

    # Operation(extrinsicState)
    def print_span(self, style):
        span = f'<span style="{style}">{self._c}</span>'
        print(span)


# FlyweightFactory
class CharFactory:
    def __init__(self):
        self.chars = {}

    # GetFlyweight(key)
    def get_char(self, c):
        if c not in self.chars:
            self.chars[c] = Char(c)
        return self.chars[c]
```

```
# Client
factory = CharFactory()
charA = factory.get_char("A")
charA.print_span("font-size: 40pt")

charB = factory.get_char("B")
charB.print_span("font-size: 12")

charA1 = factory.get_char("A")
charA1.print_span("font-size: 12")

equal = charA is charA1
# equal is True

print(equal)

# <span style="font-size: 40pt">A</span>
# <span style="font-size: 12">B</span>
# <span style="font-size: 12">A</span>
```

Proxy

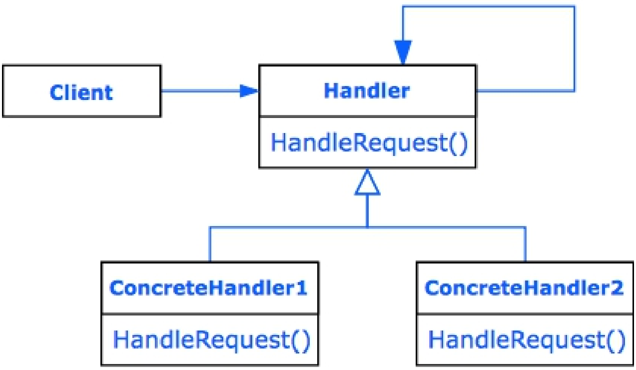



```python
# Subject
class Graphic:
    def __init__(self, file_name):
        self._file_name = file_name

    def get_file_name(self):
        return self._file_name


# RealSubject
class CImage(Graphic):
    def __init__(self, file_name):
        super().__init__(file_name)

    # Request()
    def draw(self):
        print("draw", self._file_name)


# Proxy
class ImageProxy(Graphic):
    def __init__(self, file_name):
        super().__init__(file_name)
        self._image = None

    def get_image(self):
        if self._image is None:
            self._image = CImage(self._file_name)
        return self._image
```

```python
    def draw(self):
        self.get_image().draw()


# Client
proxy = ImageProxy("1.png")
# operation without creating a RealSubject
file_name = proxy.get_file_name()
# forwarded to the RealSubject
proxy.draw()
# draw 1.png
print("file_name is", file_name)
# file_name is 1.png
```

Behavioral patterns:

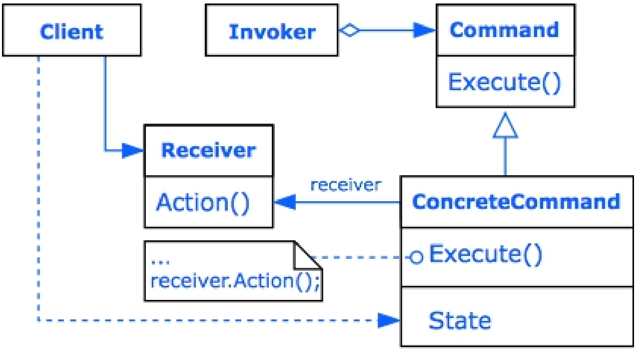
Chain of responsibility




```python
# Handler
class Rescuer:
    def __init__(self, code, next_rescuer=None):
        self._code = code
        self._next_rescuer = next_rescuer

    # HandleRequest()
    def help(self, code):
        if self._code == code:
            self.to_help()
        elif self._next_rescuer is not None:
            self._next_rescuer.help(code)

    def to_help(self):
        pass


# ConcreteHandler
class Firefighter(Rescuer):
    def __init__(self, next_rescuer=None):
        super().__init__(1, next_rescuer)

    def to_help(self):
        print("call firefighters")


# ConcreteHandler
```

```
class Police(Rescuer):
    def _init_(self, next_rescuer=None):
        super()._init_(2, next_rescuer)

    def to_help(self):
        print("call the police")


# ConcreteHandler
class Ambulance(Rescuer):
    def _init_(self, next_rescuer=None):
        super()._init_(3, next_rescuer)

    def to_help(self):
        print("call on ambulance")


ambulance = Ambulance()
police = Police(ambulance)
firefighter = Firefighter(police)
firefighter.help(1)
# printed: call firefighters
firefighter.help(2)
# printed: call the police
firefighter.help(3)
# printed: call the ambulance
```

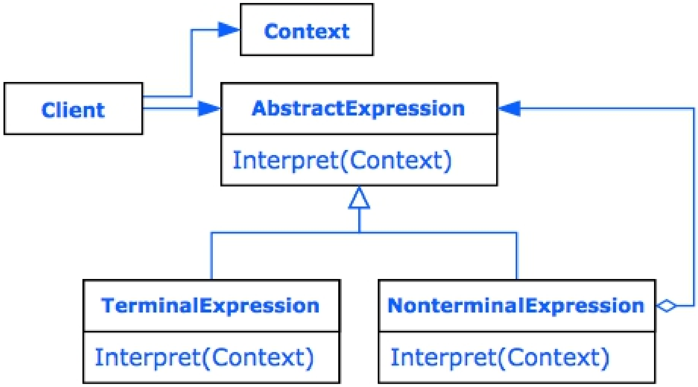
Command




```
# Invoker
class BankClient:
    def _init_(self, put_command, get_command):
        self._put_command = put_command
        self._get_command = get_command

    def put_money(self):
        self._put_command.execute()

    def get_money(self):
        self._get_command.execute()


# Receiver
class Bank:
    def give_money(self):
        print("money to the client")

    def receive_money(self):
        print("money from the client")


# Command interface
class Command:
    def execute(self):
        pass


# ConcreteCommand
```

```
class PutCommand(Command):
    def _init_(self, bank):
        self._bank = bank

    def execute(self):
        self._bank.receive_money()


# ConcreteCommand
class GetCommand(Command):
    def _init_(self, bank):
        self._bank = bank

    def execute(self):
        self._bank.give_money()


# Client
bank = Bank()
put_command = PutCommand(bank)
get_command = GetCommand(bank)
client = BankClient(put_command, get_command)
client.get_money()
# printed: money to the client
client.put_money()
# printed: money from the client
```

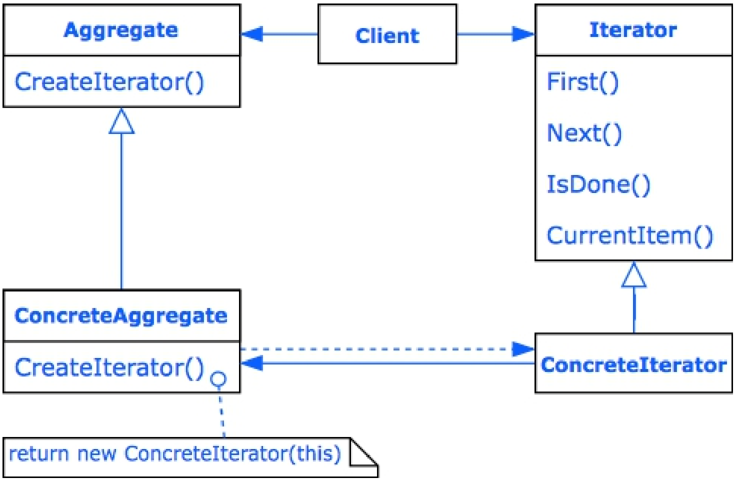
Interpreter




```python
# TerminalExpression
class DivExpression:
    def __init__(self, divider):
        self._divider = divider

    def interpret(self, i):
        return i % self._divider == 0


# NonterminalExpression
class OrExpression:
    def __init__(self, exp1, exp2):
        self.exp1 = exp1
        self.exp2 = exp2

    def interpret(self, i):
        return self.exp1.interpret(i) or self.exp2.interpret(i)


# NonterminalExpression
class AndExpression:
    def __init__(self, exp1, exp2):
        self.exp1 = exp1
        self.exp2 = exp2

    def interpret(self, i):
        return self.exp1.interpret(i) and self.exp2.interpret(i)
```

```python
# Client
div_exp5 = DivExpression(5)
div_exp7 = DivExpression(7)
or_exp = OrExpression(div_exp5, div_exp7)
and_exp = AndExpression(div_exp5, div_exp7)

# 21 is divided by 7 or 5?
result1 = or_exp.interpret(21)
# 21 is not divided by 7 and 5
result2 = and_exp.interpret(21)
# 35 is divided by 7 and 5
result3 = and_exp.interpret(35)

print("21 is divided by 7 or 5?", result1)
# 21 is divided by 7 or 5? True
print("21 is divided by 7 and 5?", result2)
# 21 is divided by 7 and 5? False
print("35 is divided by 7 and 5?", result3)
# 35 is divided by 7 and 5? True
```

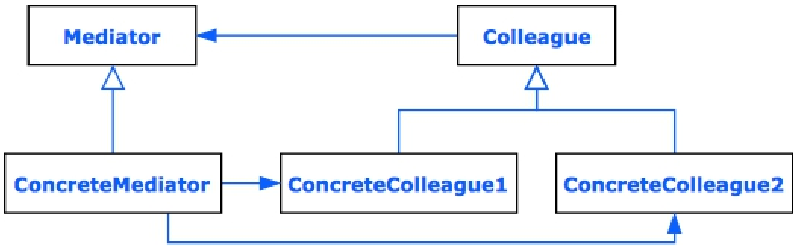
Iterator




```
# ConcreteAggregate
class PrimeNumbers:
    def _init_(self):
        self.numbers = [2, 3, 5, 7, 11]

    def get_iterator(self):
        return Iterator(self)


# ConcreteIterator
class Iterator:
    def _init_(self, prime_numbers):
        self.index = 0
        self.numbers = prime_numbers.numbers

    def first(self):
        self.index = 0

    def next(self):
        self.index + = 1

    def is_done(self):
        return self.index > = len(self.numbers)

    def current_item(self):
```

```python
        return self.numbers[self.index]


# Client
numbers = PrimeNumbers()
iterator = numbers.get_iterator()
sum_result = 0

iterator.first()
while not iterator.is_done():
    sum_result += iterator.current_item()
    iterator.next()

print(f"sum is {sum_result}")  # sum is 28
```

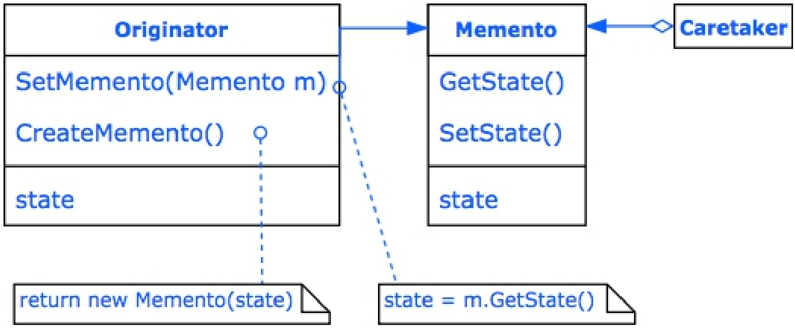
Mediator




```
# Mediator
class Mediator:
    def __init__(self):
        self._switchers = []

    def add(self, switcher):
        self._switchers.append(switcher)

    def sync(self, switcher):
        state = switcher.get_state()
        for s in self._switchers:
            s.set_state(state)


# Colleague
class Switcher:
    def __init__(self, mediator):
        self._state = False
        self._mediator = mediator
        self._mediator.add(self)

    def sync(self):
        self._mediator.sync(self)

    def get_state(self):
        return self._state

    def set_state(self, value):
        self._state = value
```

```
# ConcreteMediator
class SyncMediator(Mediator):
    def _init_(self):
        super()._init_()


# Client
mediator = SyncMediator()
switcher1 = Switcher(mediator)
switcher2 = Switcher(mediator)
switcher3 = Switcher(mediator)

switcher1.set_state(True)
state2 = switcher2.get_state()
# state2 is False
state3 = switcher3.get_state()
# state3 is False
print("state2 is", state2)
print("state3 is", state3)

switcher1.sync()
state2 = switcher2.get_state()
# state2 is True
state3 = switcher3.get_state()
# state3 is True
print("state2 is", state2)
print("state3 is", state3)
# state2 is False
# state3 is False
# state2 is True
# state3 is True
```

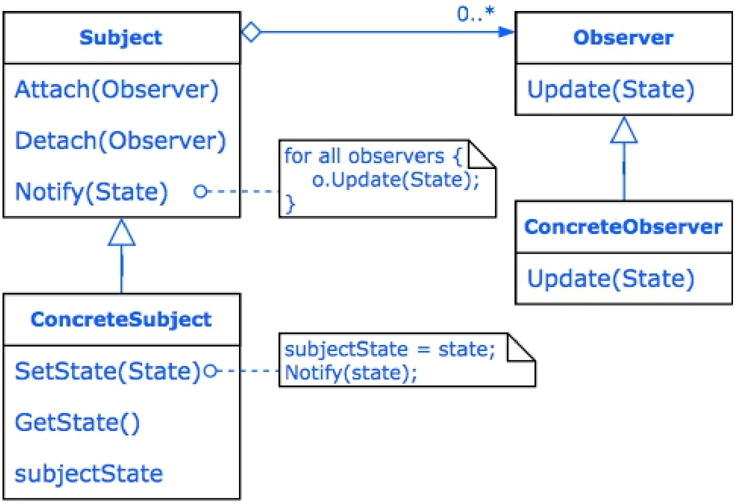
Memento




```
# State
class Point:
    def _init_(self, x, y):
        self.x = x
        self.y = y


class Memento:
    def _init_(self, m_state):
        self._state = m_state

    def get_state(self):
        return self._state


# Originator
class Shape:
    def _init_(self):
        self.position = Point(0, 0)

    def move(self, left, top):
        self.position.x + = left
        self.position.y + = top

    def get_memento(self):
        state = Point(self.position.x, self.position.y)
        return Memento(state)

    def set_memento(self, memento):
```

```python
        self.position = memento.get_state()

    def show_position(self):
        print(f"{self.position.x}, {self.position.y}")


# Caretaker
class ShapeHelper:
    def _init_(self, h_shape):
        self.stack = []
        self.shape = h_shape

    def move(self, left, top):
        self.stack.append(self.shape.get_memento())
        self.shape.move(left, top)

    def undo(self):
        if self.stack:
            self.shape.set_memento(self.stack.pop())


shape = Shape()
helper = ShapeHelper(shape)
helper.move(2, 3)
# shape.position is (2, 3)
shape.show_position()
helper.move(-5, 4)
# shape.position is (-3, 7)
shape.show_position()

helper.undo()
# shape.position is (2, 3)
shape.show_position()
helper.undo()
# shape.position is (0, 0)
shape.show_position()
```

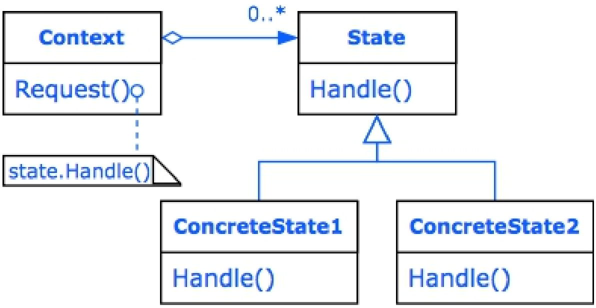
Observer




```
# concreteObserver
class TextObserver:
    def _init_(self, o_name):
        self.name = o_name

    def update(self, state):
        print(f"{self.name}: {state}")


# Subject
class TestSubject:
    def _init_(self):
        self._observers = []

    def attach(self, observer):
        self._observers.append(observer)

    def detach(self, observer):
        if observer in self._observers:
            self._observers.remove(observer)

    def notify(self, state):
        for observer in self._observers:
```

```python
            observer.update(state)

# ConcreteSubject
class TextEdit(TestSubject):
    def _init_(self):
        super()._init_()
        self.text = ""

    # SetState(State)
    def set_text(self, s_text):
        self.text = s_text
        self.notify(self.text)

    def get_text(self):
        return self.text


# client
observer1 = TextObserver("Observer #1")
observer2 = TextObserver("Observer #2")

text_edit = TextEdit()
text_edit.attach(observer1)
text_edit.attach(observer2)

text_edit.set_text("test text")
# printed:
# Observer #1: test text
# Observer #2: test text
```

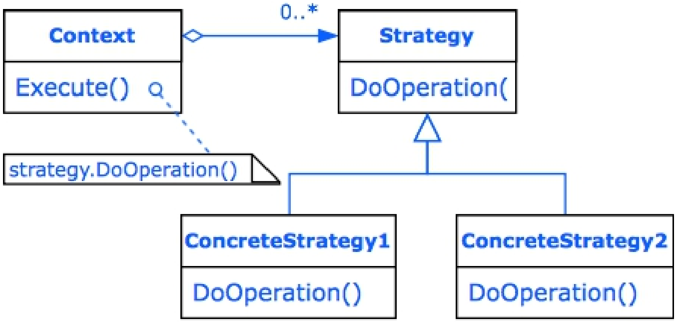
State




```python
# ConcreteState
class CloseState:
    def open(self, c):
        print("open the connection")
        c.set_state(OpenState())

    def close(self, c):
        print("connection is already closed")


# ConcreteState
class OpenState:
    def open(self, c):
        print("connection is already open")

    def close(self, c):
        print("close the connection")
        c.set_state(CloseState())


# Context
class Connection:
    def _init_(self):
        self.state = CloseState()

    def open(self):
        self.state.open(self)

    def close(self):
```

```python
        self.state.close(self)

    def set_state(self, s_state):
        self.state = s_state


# Client
con = Connection()
# printed: open the connection
con.open()
# printed: connection is already open
con.close()
# printed: close the connection
con.close()
# printed: connection is already closed
```

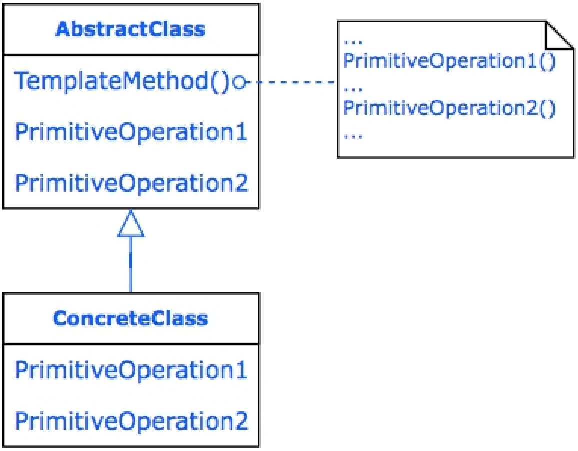
Strategy




```python
# ConcreteStrategy
class AddStrategy:
    def do_operation(self, a, b):
        return a + b

# ConcreteStrategy
class SubtractStrategy:
    def do_operation(self, a, b):
        return a - b

# Context
class Calc:
    def _init_(self):
        self.strategy = None

    def execute(self, a, b):
        if self.strategy is None:
            return 0
        return self.strategy.do_operation(a, b)

    def set_strategy(self, s_strategy):
        self.strategy = s_strategy

calc = Calc()
result1 = calc.execute(5, 3)
# result1 is 0

calc.set_strategy(AddStrategy())
result2 = calc.execute(5, 3)
```

```python
# result2 is 8

calc.set_strategy(SubtractStrategy())
result3 = calc.execute(5, 3)
# result3 is 2

print(f"result1 is {result1}")  # result1 is 0
print(f"result2 is {result2}")  # result2 is 8
print(f"result3 is {result3}")  # result3 is 2
```

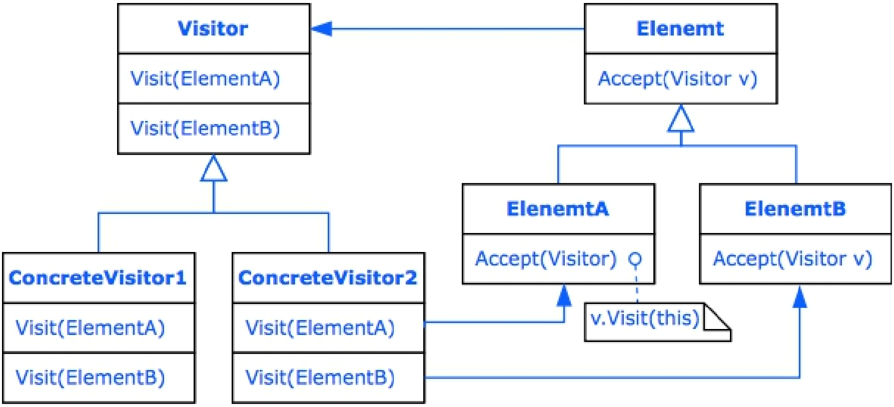
Template method




```
from abc import ABC, abstractmethod

class Shape(ABC):
    def draw(self):
        if not self.can_draw():
            return
        self.do_draw()
        self.notify_listeners()

    def can_draw(self):
        return True

    @abstractmethod
    def do_draw(self):
        pass

    def notify_listeners(self):
        print("shape is drawn")

class Circle(Shape):
    def __init__(self):
        super().__init__()

    def do_draw(self):
        print("draw a circle")
```

```
# Client
circle = Circle()
circle.draw()
# draw a circle
# shape is drawn
```

Visitor




```
from abc import ABC, abstractmethod

# ConcreteElement
class Engine:
    def accept(self, v):
        v.visit_engine(self)

# ConcreteElement
class Wheel:
    def _init_(self, w_number):
        self.number = w_number

    def get_number(self):
        return self.number

    def accept(self, v):
        v.visit_wheel(self)

# ConcreteElement
class Car:
    def _init_(self):
        self.items = [
            Engine(),
            Wheel(1), Wheel(2),
            Wheel(3), Wheel(4)
        ]
```

```python
    def accept(self, v):
        for item in self.items:
            item.accept(v)
        v.visit_car(self)

# ConcreteVisitor
class TestCarVisitor:
    def visit_engine(self, engine):
        print("repair engine")

    def visit_wheel(self, wheel):
        print("repair wheel #" + str(wheel.get_number()))

    def visit_car(self, car):
        print("repair car")

# ConcreteVisitor
class RepairCarVisitor:
    def visit_engine(self, engine):
        print("engine repaired")

    def visit_wheel(self, wheel):
        print("wheel #" + str(wheel.get_number()) + " repaired")

    def visit_car(self, car):
        print("car repaired")

# Client
car = Car()
v1 = TestCarVisitor()
v2 = RepairCarVisitor()

car.accept(v1)  # Use the TestCarVisitor
car.accept(v2)  # Use the RepairCarVisitor
```

Regular Expressions

Regular expressions are indispensable tools for tasks involving text processing, offering a versatile and efficient way to handle complex pattern matching requirements in software development and data manipulation tasks.

Check match string

```
import re

data1 = "aaab"
data2 = "aaaba"
data3 = "bbba"
pattern = re.compile(r'a+b')

b1 = bool(pattern.search(data1))
# b1 is True

b2 = bool(pattern.search(data2))
# b2 is True

b3 = bool(pattern.search(data3))
# b3 is False

print("b1 is", b1)  # b1 is True
print("b2 is", b2)  # b2 is True
print("b3 is", b3)  # b3 is False
```

Check match whole string

```python
import re

data1 = "aaab"
data2 = "aaaba"
pattern = re.compile(r'^a+b$')

match1 = pattern.fullmatch(data1)
b1 = match1 is not None
# b1 is True

match2 = pattern.fullmatch(data2)
b2 = match2 is not None
# b2 is False

print(f"b1 is {b1}")  # b1 is True
print(f"b2 is {b2}")  # b2 is False
```

Named groups

```python
import re

data1 = "aaab"
data2 = "aaaba"
pattern = re.compile(r'^(?P<group1>a+)b$')

match1 = pattern.fullmatch(data1)
b1 = match1 is not None
# b1 is True

match2 = pattern.fullmatch(data2)
b2 = match2 is not None
# b2 is False

if match1:
    print(f"Matched group1 in data1: {match1.group('group1')}")
# Matched group1 in data1: aaa

if match2:
    print(f"Matched group1 in data2: {match2.group('group1')}")

print(f"b1 is {b1}")  # b1 is True
print(f"b2 is {b2}")  # b2 is False
```

Regular expression options

```
import re

data = "AaaA\n\raaaA"
pattern = re.compile(r'^a+$', re.IGNORECASE | re.MULTILINE)

matches = pattern.findall(data)
value = matches[0] if matches else None

print(f"value is '{value}'")  # value is 'AaaA'

# Check dotAll flag equivalent
print(f"{bool(re.search(r'a.b', 'a\nb'))}")  # False
print(f"{bool(re.search(r'a.b', 'a\nb', re.DOTALL))}")  # True
```

Flag	Name	Modification
i	Ignore casing	Makes the expression search case-insensitively
g	Global	Makes the expression search for all occurences
s	Dot All	Makes the wild character. match newlines as well.
m	Multiline	Makes the boundary characters ^ and $ match the beginn ending of every single line instead of the beginning and en the whole string.
y	Sticky	Makes the expression start its searching from the indicated in its lastIndex property.
u	Unicode	Makes the expresion assume individual characters as code not code units and thus match 32-bit characters as well.

Replacement of the match

```
import re

data = "Pi = 3.14, exponent = 2.718"
pattern = r"(\d+\.\d+)"
# Capture group for floating-point numbers
data = re.sub(pattern, r"<f>\1</f>", data)
# Replace with <f> tags

print(f"data is {data}")  # Output the modified string
# Output: data is Pi = <f>3.14</f>, exponent = <f>2.718</
f>
```

Search all matches

```
import re

data = "Pi = 3.14, exponent = 2.718"
pattern = r'(\d+\.\d+)'
matches = re.findall(pattern, data)
# matches is ['3.14', '2.718']

print(f"{matches = }")
```

Search for a match

```
import re

data = "Pi is equal to 3.14"
pattern = r"\d+\.\d+"
# Pattern to match a floating-point number

# Search for the pattern in the data
match = re.search(pattern, data)
if match:
    # Convert the matched string to a float
    pi = float(match.group(0))
    # pi is 3.14

    print(f"pi is {pi}")
    # Output the value of pi
    # pi is 3.14
```

Simple Types

Simple types refer to basic data types that represent single values in programming languages.

Boolean:

Conversion from a string

```
# Conversion from a string to boolean in Python

str1 = "true"
# Convert the string to lowercase and compare with "true"
value1 = str1.lower() == "true"
# value1 is True

str2 = "false"
# Convert the string to lowercase and compare with "true"
value2 = str2.lower() == "true"
# value2 is False

print(f"value1 is {value1}")
# value1 is True
print(f"value2 is {value2}")
# value2 is False
```

Converting to a string

```
# Converting boolean to string in Python

sun_is_star = True
str1 = str(sun_is_star)
# str1 is "True"

earth_is_star = False
str2 = str(earth_is_star)
# str2 is "False"

print(f'str1 is "{str1}"')  # str1 is "True"
print(f'str2 is "{str2}"')  # str2 is "False"
```

Getting values

```
# Getting boolean values in Python

s_name = "Alex"
name_exists = len(s_name) > 0
# name exists is True

number = 7
is_ten = number == 10
# is_ten is False

print(f'name_exists is {name_exists}')
# name_exists is True
print(f'is_ten is {is_ten}')
# is_ten is False
```

Logical operations

```
# Logical operations in Python

value1 = True
value2 = False

value_not1 = not value1
# value_not1 is False

value_not2 = not value2
# value_not2 is True

value_and = value1 and value2
# value_and is False

value_or = value1 or value2
# value_or is True

value_xor = value1 ^ value2
# value_xor is True (Python doesn't represent boolean XOR as 1, it uses True)

print(f'value_not1 is {value_not1}')
# value_not1 is False
print(f'value_not2 is {value_not2}')
# value_not2 is True
print(f'value_and is {value_and}')
# value_and is False
print(f'value_or is {value_or}')
# value_or is True
print(f'value_xor is {value_xor}')
# value_xor is True
```

Character type:

Converting to a number and back

```
# Converting characters to numbers and back in Python

char_a = 'A'
int_value = ord(char_a)
# int_value is 65

print(f'char_a is "{char_a}"')  # char_a is "A"
print(f'int_value is {int_value}')  # int_value is 65

int_value += 1
char_b = chr(int_value)
# char_b is 'B'

print(f'char_b is "{char_b}"')  # char_b is "B"
print(f'int_value is {int_value}')  # int_value is 66
```

Converting to a string

```python
# Converting characters to strings in Python

char_a = 'A'
print(f'char_a is "{char_a}"')
# char_a is "A"

str_var = "character " + char_a
# str_var is "character A"
print(f'str_var is "{str_var}"')
# str_var is "character A"
```

Escape characters

```
# Escape characters in Python

# \' for a single quote.
c1 = "'"

# \" for a double quote.
c2 = ""

# \\ for a backslash.
c3 = "\\"

# \0 for a null character.
c4 = "\0"

# \b for a backspace.
c5 = "\b"

# \n for a new line.
c6 = "\n"

# \r for a carriage return.
c7 = "\r"

# \t for a horizontal tab.
c8 = "\t"

# \v for a vertical tab.
c9 = "\v"

# \x for a unicode character hex value. (Example: \x41 represents 'A')
c10 = "\x41"

# Printing the escape characters
print(f"c1 is '{c1}'") # c1 is '''
print(f"c2 is \"{c2}\"") # c2 is """"
print(f"c3 is '{c3}'") # c3 is '\'
print(f"c4 is '{c4}'") # c4 is ''
print(f"c5 is '{c5}'") # c5 is '
print(f"c6 is '{c6}'") # c6 is '
print(f"c7 is '{c7}'") # '
```

```
# '7 is '
print(f"c8 is '{c8}'") # c8 is ' '
print(f"c9 is '{c9}'") # c9 is '
# '
print(f"c10 is '{c10}'") # c10 is 'A'
```

Getting from a string

```
# Getting characters from a string in Python

# Define a string
str = "ABC"

# Get individual characters using indexing
charA = str[0]  # charA is 'A'
charB = str[1]  # charB is 'B'
charC = str[2]  # charC is 'C'

# Iterate through the string and build a list of characters
charList = ";".join(str) + ";"
# charList is "A;B;C;"

# Printing the characters and the character list
print(f"charA is \"{charA}\"")  # charA is "A"
print(f"charB is \"{charB}\"")  # charB is "B"
print(f"charC is \"{charC}\"")  # charC is "C"
print(f"charList is \"{charList}\"")  # charList is "A;B;C;"
```

Special Characters

```
c_ruble = '\u20BD' # ₽
c_lambda = '\u03BB' # λ

print(f"{c_ruble = }") # c_ruble = '₽'
print(f"{c_lambda = }") # c_lambda = 'λ
```

Date and time:

Comparison of dates

```python
from datetime import datetime, timedelta

# Get the current date and time
now = datetime.now()

# Get yesterday's date and time
yesterday = now - timedelta(days=1)

# Compare the dates
are_equal = now == yesterday
# are_equal is False

are_later = now > yesterday
# are_later is True

are_earlier = now < yesterday
# are_earlier is False

# Print the results
print(f"are_equal is {are_equal}")
# are_equal is False
print(f"are_later is {are_later}")
# are_later is True
print(f"are_earlier is {are_earlier}")
# are_earlier is False
```

Conversion from a string

```
from datetime import datetime

# Convert the string to datetime using strptime
string_dt = "1945-05-09 01:00".replace(" ", "T")
victory_dt = datetime.fromisoformat(string_dt)

# First method
string_date = "1945-05-09"
victory_date1 = datetime.strptime(string_date, "%Y-%m-%d")

# Second method
parts = string_date.split("-")
victory_date2 = datetime(int(parts[0]), int(parts[1]), int(parts[2]))

# Print the results
print(victory_dt.strftime("%d.%m.%Y"))
# 09.05.1945
print(victory_date1.strftime("%m/%d/%Y"))
# 05/09/1945
print(victory_date2.strftime("%m/%d/%Y"))
# 05/09/1945
```

Converting to a string

```
from datetime import datetime

# Get the current datetime
now = datetime.now()

# Define formatting options
options_en = "%m/%d/%y %I:%M %p"
# For English (US) locale
options_ru = "%d.%m.%y %H:%M"
# For Russian (RU) locale
custom_format = "%Y-%m-%d"
# Custom format for date only

# Format the datetime objects
short_style_en = now.strftime(options_en)
short_style_ru = now.strftime(options_ru)
custom_style = now.strftime(custom_format)

# Print the formatted strings
print(f"shortStyleEn is \"{short_style_en}\"")
# shortStyleEn is "05/24/21 04:02 PM"
print(f"shortStyleRu is \"{short_style_ru}\"")
# shortStyleRu is "24.05.21 16:02"
print(f"customStyle is \"{custom_style}\"")
# customStyle is "2021-05-24"
```

Date changing

```
from datetime import datetime, timedelta

# Get the current datetime
now = datetime.now()

# Calculate yesterday
yesterday = now - timedelta(days=1)

# Calculate tomorrow
tomorrow = now + timedelta(days=1)

# Calculate next month
next_month = now.replace(day=1) + timedelta(days=32)  # Add
32 days to ensure we move to the next month

# Calculate next year
next_year = now.replace(year=now.year + 1)

# Print the results
print(f"now is \"{now.strftime('%x')}\"")
print(f"yesterday is \"{yesterday.strftime('%x')}\"")
print(f"tomorrow is \"{tomorrow.strftime('%x')}\"")
print(f"nextMonth is \"{next_month.strftime('%x')}\"")
print(f"nextYear is \"{next_year.strftime('%x')}\"")
```

Date initialization

```
from datetime import datetime

year = 1945
month = 5
day = 9

victory_date = datetime(year, month, day)

print(victory_date.strftime("%x, %X"))
# Output: 05/09/45, 00:00:00
```

Getting of the current date

```
from datetime import datetime

now = datetime.now()
print(f"now is \"{now}\"")
# now is "2024-06-10 22:26:11.530947"
```

Getting of year, month, day

```
from datetime import datetime

now = datetime.now()
year = now.year
month = now.month
day = now.day
hour = now.hour
minute = now.minute
second = now.second
day_of_week = now.weekday()  # Monday is 0, Sunday is 6

print(f"year is {year}")  # year is 2023
print(f"month is {month}")  # month is 5
print(f"day is {day}")  # day is 30
print(f"hour is {hour}")  # hour is 11
print(f"minute is {minute}")  # minute is 45
print(f"second is {second}")  # second is 52
print(f"day_of_week is {day_of_week}")  # day_of_week is 0
```

The interval between the dates

```python
from datetime import datetime

victory_date = datetime(1945, 5, 9)
now = datetime.now()

time_diff = now - victory_date

days = time_diff.days
minutes = time_diff.total_seconds() // 60

print(f"days is {days}")  # days is 28691
print(f"minutes is {minutes}")  # minutes is 41316446
```

Double and Float:

Arithmetic operations

```
d1 = 8.5 + 2.4
d2 = 8.5 - 2.4
d3 = 8.5 * 2
d4 = 8.5 / 2
# mod
d5 = 7.5 % 2
d6 = -7.5 % 2
# div
d7 = int(7.5 / 2)
d8 = -d7
d9 = 3.5
d9 += 1
d9 -= 1
d10 = d9
d9 += 1
d11 = d9
d9 -= 1
d12 = abs(-5.5)

print("d1 =", d1)  # d1 = 10.9
print("d2 =", d2)  # d2 = 6.1
print("d3 =", d3)  # d3 = 17.0
print("d4 =", d4)  # d4 = 4.25
print("d5 =", d5)  # d5 = 1.5
print("d6 =", d6)  # d6 = 0.5
print("d7 =", d7)  # d7 = 3
print("d8 =", d8)  # d8 = -3
print("d9 =", d9)  # d9 = 5.5
print("d10 =", d10)  # d10 = 4.5
print("d11 =", d11)  # d11 = 6.5
print("d12 =", d12)  # d12 = 5.5
```

Conversion from a string

```
# The first method
str_pi = "3.14"
pi_float = float(str_pi)

# The second method
str_exp = "2.71828"
exp = float(str_exp)

# The third method
str_half = "0,5"
half = float(str_half.replace(",", "."))

print("pi_float =", pi_float)  # pi_float = 3.14
print("exp =", exp)  # exp = 2.71828
print("half =", half)  # half = 0.5
```

Converting to a string

```
# Given double
exp = 2.718281828

# Converting to string using str()
s1 = str(exp)
# s1 is '2.718281828'

# Converting to string with fixed decimal places using format()
s2 = format(exp, '.3f')
# s2 is '2.718'

# Converting to string with specified decimal places using format()
and locale
import locale
from babel.numbers import format_decimal

locale.setlocale(locale.LC_ALL, 'en_US.UTF-8')
s3 = format_decimal(exp * 1000000, locale='en_US',
format='#,##0.00')
# s3 is '2,718,281.83'

print("s1 =", s1)  # s1 = 2.718281828
print("s2 =", s2)  # s2 = 2.718
print("s3 =", s3)  # s3 = 2,718,281.83
```

Converting to integer

```
# Given float
pi = 3.1415926535

# Converting to integer using int()
int_value = int(pi)
# int_value is 3

print(f"int_value is {int_value}")  # int_value is 3
```

Getting random values

```python
import random

# Getting random value between 0.0 and 1.0
random_value = random.random()

print(f"random is {random_value}")
# random is 0.19281624415432086
```

Number comparison

```
# Define the numbers
a = 1.0
b = 0.3 * 3 + 0.1

# Wrong way to compare
isEqual1 = a == b
# isEqual1 is False

isEqual2 = a is b
# isEqual2 is False

# Correct way to compare
delta = 0.0000000001
isEqual3 = abs(a - b) < delta
# isEqual3 is True

print("isEqual1 is", isEqual1)
print("isEqual2 is", isEqual2)
print("isEqual3 is", isEqual3)
```

Rounding and truncating

```
import math

# Define the value of pi
pi = 3.1415

# Rounding
pi_round1 = round(pi, 3)
# pi_round1 is 3.142
pi_round2 = "{:.3f}".format(pi)
# pi_round2 is 3.142

# Truncating
pi_trunc = math.trunc(pi * 1000) / 1000
# pi_trunc is 3.141

# Ceiling
pi_ceil = math.ceil(pi * 100) / 100
# pi_ceil is 3.15

print("pi_round1 =", pi_round1)  # pi_round1 = 3.142
print("pi_round2 =", pi_round2)  # pi_round2 = 3.142
print("pi_trunc =", pi_trunc)  # pi_trunc = 3.141
print("pi_ceil =", pi_ceil)  # pi_ceil = 3.15
```

Integer:

Arithmetic operations

```
d1 = 8 + 2
d2 = 8 - 2
d3 = 8 * 2
d4 = 8 / 2
d5 = 5 % 2
d6 = -5 % 2
d7 = 1
d7 += 1
d7 -= 1
d8 = d7
d7 += 1
d9 = d7

print("d1 =", d1)  # d1 = 10
print("d2 =", d2)  # d2 = 6
print("d3 =", d3)  # d3 = 16
print("d4 =", d4)  # d4 = 4.0
print("d5 =", d5)  # d5 = 1
print("d6 =", d6)  # d6 = 1
print("d7 =", d7)  # d7 = 2
print("d8 =", d8)  # d8 = 1
print("d9 =", d9)  # d9 = 2
```

BigInteger

```
# Maximum safe int value is 2^53
a = 9223372036854775807

b = 255
c = 1000

a1 = a * c

a2 = (a1 + c) // b

big_int = 9007199254740991
print("big_int =", big_int)

A = 9007199254740991

B = A + 10

print("a1 =", a1)  # a1 = 9223372036854775807000
print("a2 =", a2)  # a2 = 36170086419038335
print("B =", B)  # B = 9007199254741001
```

Bitwise operations

```
a = 5  # 0101
b = 6  # 0110

# And
c1 = a & b
# c1 is 4 (0100)

# Or
c2 = a | b
# c2 is 7 (0111)

# Xor
c3 = a ^ b
# c3 is 3 (0011)

# Shift right
c4 = a >> 1
# c4 is 2 (0010)

# Shift left
c5 = b << 1
# c5 is 12 (1100)

# Bits inversion
c6 = ~b
# c6 is -7 (-111)

print("c1 =", c1)  # c1 = 4
print("c2 =", c2)  # c2 = 7
print("c3 =", c3)  # c3 = 3
print("c4 =", c4)  # c4 = 2
print("c5 =", c5)  # c5 = 12
print("c6 =", c6)  # c6 = -7
```

Conversion from a string

```
str_number = "42"

# Using int() function
number1 = int(str_number)
# number1 is 42

# Using int() function with base
number2 = int(str_number, 10)
# number2 is 42

# Using the + operator
number3 = int(str_number)
# number3 is 42

print("number1 is", number1)
print("number2 is", number2)
print("number3 is", number3)
```

Converting to a string

```
number = 42

# Using str() function
s1 = str(number)
# s1 is "42"

# Using concatenation with an empty string
s2 = "" + str(number)
# s2 is "42"

# Using string formatting with zero padding
s3 = "{:03d}".format(number)
# s3 is "042"

print("s1 =", s1)  # s1 = 42
print("s2 =", s2)  # s2 = 42
print("s3 =", s3)  # s3 = 042
```

Getting random values

```
import random

def get_random_int(min_val, max_val):
    return random.randint(min_val, max_val)

random_val = get_random_int(0, 2)
print(f"random is {random_val}")
# random is 0, 1, or 2
```

Numeral system

```
# decimal number system
decimal = 42

# octal number system
octal = 0o42
# octal is 34

# hexadecimal number system
hexadecimal = 0x42
# hexadecimal is 66

# binary number system
binary = 0b1010
# binary is 10

# 42 to decimal string
s_decimal = str(decimal)
# s_decimal is "42"

# 42 to hexadecimal string
s_hexadecimal = hex(decimal)
# s_hexadecimal is "0x2a"

# 42 to binary string
s_binary = bin(decimal)
# s_binary is "0b101010"

print("octal =", octal)  # octal = 34
print("hexadecimal =", hexadecimal)  # hexadecimal = 66
print("binary =", binary)  # binary = 10
print("s_decimal =", s_decimal)  # s_decimal = 42
print("s_hexadecimal =", s_hexadecimal)  # s_hexadecimal = 0x2a
print("s_binary =", s_binary)  # s_binary = 0b101010
```

Mathematical operations:

Decimal logarithm

```python
import math

number = 1000
result = math.log10(number)
# result is 3.0

print(f"result is {result}")  # result is 3.0
```

Exponentiation

```
number = 8
power = 3
result1 = number ** power
# result1 is 512

import math
result2 = math.pow(number, power)
# result2 is 512.0

print(f"result1 is {result1}")  # result1 is 512
print(f"result2 is {result2}")  # result2 is 512.0
```

Logarithm

```
number = 8
power = 3
result1 = number ** power
# result1 is 512

import math
result2 = math.pow(number, power)
# result2 is 512.0

print(f"result1 is {result1}")  # result1 is 512
print(f"result2 is {result2}")  # result2 is 512.0
```

Sine, cosine and tangent

```
import math

sin90 = math.sin(math.pi / 2)
# sin90 is 1.0

cos180 = math.cos(math.pi)
# cos180 is -1.0

tan45 = math.tan(math.pi / 4)
# tan45 is 0.9999999999999999

print(f"sin90 is {sin90}")  # sin90 is 1.0
print(f"cos180 is {cos180}")  # cos180 is -1.0
print(f"tan45 is {tan45}")  # tan45 is 0.9999999999999999
```

Square root

```python
import math

number = 100
result = math.sqrt(number)
# result is 10.0

print(f"result is {result}")  # result is 10.0
```

min and max values

```python
numbers = [2, 1, 3]

min_value = min(numbers)
# min_value is 1

max_value = max(numbers)
# max_value is 3

print(f"min_value is {min_value}")  # min_value is 1
print(f"max_value is {max_value}")  # max_value is 3
```

Strings:

Change the case of characters

```python
def get_capitalize(word):
    if not word:
        return word
    return word[0].upper() + word[1:].lower()

str = "Lower and Upper"

lower = str.lower()
# lower is "lower and upper"

upper = str.upper()
# upper is "LOWER AND UPPER"

capitalize = get_capitalize(str)
# capitalize is "Lower and upper"

print(f"lower is \"{lower}\"")
print(f"upper is \"{upper}\"")
print(f"capitalize is \"{capitalize}\"")

# Output:
# lower is "lower and upper"
# upper is "LOWER AND UPPER"
# capitalize is "Lower and upper"
```

Character replacement

```
str_value = "1-3-2"
str_value = str_value[:2] + "2" + str_value[3:4] + "3"
# str_value is "1-2-3"

print(f"str_value is \"{str_value}\"")
```

Characters count

```
def reverse(word):
    # Characters count
    char_count = len(word)
    result = ""
    for i in range(char_count - 1, -1, -1):
        result += word[i]
    return result

string_reverse = reverse("string")
# string_reverse = "gnirts"

print("string_reverse is", string_reverse)
# string_reverse is gnirts
```

Converting to a number

```
# Convert string to integer
str_number = "42"

# The first method
number1 = int(str_number)

# The second method (same as first in Python)
number2 = int(str_number)

print("number1 =", number1) # number1 = 42
print("number2 =", number2) # number2 = 42

# Convert string to double/float
# The first method
str_pi = "3.14"
pi = float(str_pi)

# The second method
str_exp = "2.71828"
exp = float(str_exp)

# The third method
str_half = "0,5"
half = float(str_half.replace(",", "."))

print("pi =", pi) # pi = 3.14
print("exp =", exp) # exp = 2.71828
print("half =", half) # half = 0.5
```

Empty strings

```
# Empty strings
some_empty_string = ""
another_empty_string = ""

if not some_empty_string:
    print("string is empty")

if len(another_empty_string) == 0:
    print("another string is empty")

# Output:
# string is empty
# another string is empty
```

Escaping characters

```
# \t Insert a tab.
# \b Insert a backspace.
# \n Insert a newline.
# \r Insert a carriage return.
# \' or ' Insert a single quote.
# \" Insert a double quote.
# \\ Insert a backslash character.

str = 'She said "Hello!" to me.'
# str is "She said "Hello!" to me."

print(f'str is "{str}"')
# str is "She said "Hello!" to me."
```

Getting substring

```
str = "one way ticket"
way1 = str[4:7]
# way1 is "way"

way2 = str[-10:-7]
# way2 is "way"

print(f'way1 is "{way1}"') # way1 is "way"
print(f'way2 is "{way2}"') # way2 is "way"
```

Iterating over a string

```python
str = "level"

# Iterating without index
for c in str:
    print(c)

# Iterating with index
for i in range(len(str)):
    print(f'str[{i}] = {str[i]}')

# Output:
# l
# e
# v
# e
# l
# str[0] = l
# str[1] = e
# str[2] = v
# str[3] = e
# str[4] = l
```

Removing spaces

```
str = " Spaces "

trim_str = str.strip()
# trim_str is "Spaces"

print(f"{trim_str}") # "Spaces"
```

Replace multiple characters

```
import re

str = "1-/[=2/]=3"
separators = re.compile(r'[=/\\[\]]')
ar_str = separators.split(str)
str = "".join(ar_str)
# str is "1-23"

print(f'str is "{str}"')
# str is "1-23"
```

Split into an array

```
str_data = "1981|Kim Victorya|engineer"
arr_data = str_data.split("|")
year = int(arr_data[0])
# year is 1981
full_name = arr_data[1]
# full_name is "Kim Victorya"
position = arr_data[2]
# position is "engineer"

print("year is", year)  # year is 1981
print(f"name is '{full_name}'")  # name is 'Kim Victorya'
print(f"position is '{position}'")  # position is 'engineer'
```

String multiplication

```
str_val = "7" * 3
# str_val is "777"
print(f'str is "{str_val}"')  # str is "777"
```

String padding

```
str_val = "123"
len_val = 10

# Pad Start
pad_start1 = str_val.rjust(len_val)
# padStart1 is '       123'

pad_start2 = str_val.zfill(len_val)
# padStart2 is '0000000123'

# Pad End
pad_end1 = str_val.ljust(len_val)
# padEnd1 is '123       '

pad_end2 = str_val.ljust(len_val, "=*")
# padEnd2 is '123=*=*=*='

print(f"padStart1 is '{pad_start1}'")
# padStart1 is '       123'
print(f"padStart2 is '{pad_start2}'")
# padStart2 is '0000000123'
print(f"padEnd1 is '{pad_end1}'")
# padEnd1 is '123       '
print(f"padEnd2 is '{pad_end2}'")
# padEnd2 is '123=*=*=*='
```

String comparison

```
first = "A"
second = "B"
third = "A"

# String comparison
are_equal1 = first == second
# areEqual1 is False

are_not_equal = first != second
# areNotEqual is True

are_equal2 = first == third
# areEqual2 is True

more_than = first > second
# moreThan is False

print("areEqual1 is", are_equal1)
# areEqual1 is False
print("areEqual2 is", are_equal2)
# areEqual2 is True
print("areNotEqual is", are_not_equal)
# areNotEqual is True
print("moreThan is", more_than)
# moreThan is False
```

String concatenating

```python
s1 = "three"
s2 = "two"
s3 = s1 + ", " + s2
s3 += ", one"
s_go = s3 + ", " + "go!"
# s_go is "three, two, one, go!"

print(f's_go is "{s_go}"')
# s_go is "three, two, one, go!"
```

String interpolation

```
# Since Python 3.6
font_size = 14
font_family = "Arial"
style = f"font-size: {font_size}; font-family: {font_family}"
# style is "font-size: 14; font-family: Arial"
print(f"style is '{style}'")

# Since Python 3.6
ar = [1, 2, 3]
print(f"length is {len(ar)}")  # length is 3
print(f"ar[1] is {ar[1]}")  # ar[1] is 2
print(f"all > 0: {all(i > 0 for i in ar)}")
# all > 0: True
```

Strings list concatenating

```
numbers = ["one", "two", "three"]
number_list = "; ".join(numbers)
# number_list is "one; two; three"

print(number_list)  # one; two; three
```

Substring index

```
data_string = "Substring index"
index1 = data_string.find("string")
# index1 is 3

import re
index2 = re.search("string", data_string).start()
# index2 is 3

print(f"index1 is {index1}")  # index1 is 3
print(f"index2 is {index2}")  # index2 is 3
```

Substring inserting

```
class CustomString(str):
    def insert(self, index, string):
        return self[:index] + string + self[index:]

data_string = CustomString("string")

data_string = data_string.insert(0, "Sub")
print(data_string)
# Output: "Substring"

data_string = data_string.insert(9, "!")
print(data_string)
# Output: "Substring!"

data_string = data_string.insert(10, " inserting")
print(data_string)
# Output: "Substring! inserting"
```

Substring removing

```
class CustomString(str):
    def remove(self, start, end=None):
        if end is None:
            end = start + 1
        return self[:start] + self[end:]

data_string = CustomString("Substring removing!")

# Remove substring from index 9 to index 18
data_string = data_string.remove(9, 18)
print(data_string)  # Output: "Substring!"

# Remove characters from index 0 to index 2 (keeping characters from index 3 onwards)
data_string = data_string.remove(0, 3)
print(data_string)  # Output: "string!"
```

Substring replacement

```
import re

# Simple replacements
start_string = "3, 2, 1, go!"
start_string = (start_string
                .replace("1", "one")
                .replace("2", "two")
                .replace("3", "three"))
print(start_string)
# Output: "three, two, one, go!"

# Replace all occurrences
one_string = "1 1 1"
one_string = re.sub("1", "one", one_string)
print(one_string)
# Output: "one one one"
```

Substring searching

```python
data_string = "Substring search"

# Check if data_string contains "string"
if "string" in data_string:
    print('data_string contains "string"')

# Check if data_string starts with "Sub"
if data_string.startswith("Sub"):
    print('data_string starts with "Sub"')

# Check if data_string ends with "search"
if data_string.endswith("search"):
    print('data_string ends with "search"')
```

Tuple

```python
# Using a tuple
one = (1, "one")
number_one = one[0]  # number_one is 1
name_one = one[1]    # name_one is "one"

# Using a dictionary
two = {"number": 2, "name": "two"}
number_two = two["number"]  # number_two is 2
name_two = two["name"]      # name_two is "two"

print(f'nameOne is "{name_one}"')  # nameOne is "one"
print(f'numberOne is {number_one}')  # numberOne is 1
print(f'nameTwo is "{name_two}"')  # nameTwo is "two"
print(f'numberTwo is {number_two}')  # numberTwo is 2
```

Work with Color

Working with colors in programming often involves representing, manipulating, and displaying colors using various formats and operations.

Color to HTML color

```
orange = 0xffc80080

# Extracting the RGB part (ignoring alpha)
x = (orange >> 8) & 0xffffff
html_color = f"#{x:06x}"
print(f'style="color: {html_color}"')
# style="color: #ffc800"

# Including transparency
html_color_with_alpha = f"#{orange:08x}"
print(f'htmlColor is {html_color_with_alpha}')
# htmlColor is #ffc80080
```

Color to RGB

```
orange = 0xffc80080

red = (orange >> 24) & 0xff
green = (orange >> 16) & 0xff
blue = (orange >> 8) & 0xff
alpha = orange & 0xff

print("red is", red)     # red is 255
print("green is", green) # green is 200
print("blue is", blue)   # blue is 0
print("alpha is", alpha) # alpha is 128
```

HTML color to RGB

```
orange = "#FFC80080"

# Convert the hex string to an integer
x = int(orange[1:], 16)

# Extract the RGBA components
red = (x > > 24) & 0xff
green = (x > > 16) & 0xff
blue = (x > > 8) & 0xff
alpha = x & 0xff

print("red is", red)     # red is 255
print("green is", green) # green is 200
print("blue is", blue)   # blue is 0
print("alpha is", alpha) # alpha is 128
```

RGB to Color

```
def int_to_hex(i):
    return f"{i:02x}"

red = 51
green = 255
blue = 51
alpha = 128

# Combine RGB values into a hex string
c_green = f"#{int_to_hex(red)}{int_to_hex(green)}
{int_to_hex(blue)}"
print(c_green)  # Output: #33ff33

# Add the alpha value to the hex string
c_green_with_alpha = f"{c_green}{int_to_hex(alpha)}"
print(c_green_with_alpha)
# Output: #33ff3380
```

RGB to HTML color

```
red = 51
green = 255
blue = 51
alpha = 128

# Convert RGB values to an integer
value = (red << 16) + (green << 8) + blue

# Convert the integer to a hex string (without alpha)
html_color = f"{value:06x}"
print(f'style="color: #{html_color}"')
# Output: style="color: #33ff33"

# Include alpha and convert to hex string
value = (value << 8) + alpha
html_color_with_alpha = f"{value:08x}"
print(f'htmlColor is #{html_color_with_alpha}')
# Output: htmlColor is #33ff3380
```

Work with Database (DB)

Working with databases in software development involves managing data storage, retrieval, and manipulation using structured query languages (SQL) or NoSQL approaches.

Connect to the DB:

Connect to Access

```
# pip install pyodbc

import pyodbc

# Connection string for Access database
access_driver = '{Microsoft Access Driver (*.mdb, *.accdb)}'
access_db_file = 'path/to/your/database.accdb'
# Replace with the path to your Access database file

# Establishing a connection
try:
    conn = pyodbc.connect(driver=access_driver, dbq=access_db_file)
    print("Connected to the database")
except pyodbc.Error as e:
    print(f"Failed to connect to the database: {e}")
    exit()

# Creating a cursor to execute SQL queries
cursor = conn.cursor()

try:
    # Execute a SELECT query
    cursor.execute("SELECT * FROM YourTableName")
    result = cursor.fetchall()
    print(result)
except pyodbc.Error as e:
    print(f"Error executing query: {e}")
finally:
    # Close cursor and connection
    cursor.close()
    conn.close()
```

Connect to FireBird

```python
# pip install fdb

import fdb

options = {
    'host': 'HostName',
    'port': 3050,
    'database': 'DbName.fdb',
    'user': 'UserName',
    'password': 'Password'
}

# Connect to the Firebird database
try:
    conn = fdb.connect(**options)
    print("Connected to the database")
except fdb.Error as e:
    print(f"Failed to connect to the database: {e}")
    exit()

# Create a cursor to execute SQL queries
cursor = conn.cursor()

try:
    # Execute a SELECT query
    cursor.execute("SELECT * FROM country")
    result = cursor.fetchall()
    print(result)
except fdb.Error as e:
    print(f"Error executing query: {e}")
finally:
    # Close cursor and connection
    cursor.close()
    conn.close()
```

Connect to MySql

```
# pip install mysql-connector-python

import mysql.connector

# Establishing a connection
try:
    conn = mysql.connector.connect(
        host="localhost",
        user="root",
        password="password",
        database="world"
    )
    print("Connected to the database")
except mysql.connector.Error as e:
    print(f"Failed to connect to the database: {e}")
    exit()

# Creating a cursor to execute SQL queries
cursor = conn.cursor()

try:
    # Execute a SELECT query
    sql = "SELECT Language, Percentage FROM countrylanguage WHERE CountryCode = 'RUS' ORDER BY Percentage DESC"
    cursor.execute(sql)
    result = cursor.fetchall()
    print(result)
except mysql.connector.Error as e:
    print(f"Error executing query: {e}")
finally:
    # Close cursor and connection
    cursor.close()
    conn.close()
```

Connect to Oracle

```python
# pip install cx_Oracle

import cx_Oracle

# Establishing a connection
try:
    conn = cx_Oracle.connect(
        user="UserName",
        password="Password",
        dsn="localhost/DataBaseName"
    )
    print("Connected to the database")
except cx_Oracle.DatabaseError as e:
    print(f"Failed to connect to the database: {e}")
    exit()

# Creating a cursor to execute SQL queries
cursor = conn.cursor()

try:
    # Execute a SELECT query
    sql = "SELECT * FROM tablename"
    cursor.execute(sql)
    result = cursor.fetchall()
    print(result)
except cx_Oracle.DatabaseError as e:
    print(f"Error executing query: {e}")
finally:
    # Close cursor and connection
    cursor.close()
    conn.close()
```

Connect to PostgreSQL

```
# pip install psycopg2

import psycopg2

# Establishing a connection
try:
    conn = psycopg2.connect(
        user="UserName",
        password="Password",
        host="localhost",
        port="5432",
        database="DatabaseName"
    )
    print("Connected to the database")
except psycopg2.Error as e:
    print(f"Failed to connect to the database: {e}")
    exit()

# Creating a cursor to execute SQL queries
cursor = conn.cursor()

try:
    # Execute a SELECT query
    sql = "SELECT * FROM country"
    cursor.execute(sql)
    result = cursor.fetchall()
    print(result)
except psycopg2.Error as e:
    print(f"Error executing query: {e}")
finally:
    # Close cursor and connection
    cursor.close()
    conn.close()
```

Connect to SQL Server

```
# pip install pyodbc

import pyodbc

# Establishing a connection
try:
    conn = pyodbc.connect(
        'DRIVER={SQL Server};'
        'SERVER=serverName\\instanceName;'
        'DATABASE=DatabaseName;'
        'UID=UserName;'
        'PWD=Password;'
        'Trusted_Connection=no;'
    )
    print("Connected to the database")
except pyodbc.Error as e:
    print(f"Failed to connect to the database: {e}")
    exit()

# Creating a cursor to execute SQL queries
cursor = conn.cursor()

try:
    # Execute a SELECT query
    sql = "SELECT * FROM country"
    cursor.execute(sql)
    result = cursor.fetchall()
    print(result)
except pyodbc.Error as e:
    print(f"Error executing query: {e}")
finally:
    # Close cursor and connection
    cursor.close()
    conn.close()
```

Connect to SQLite

```python
import sqlite3

# Establishing a connection
try:
    conn = sqlite3.connect('DatabaseName.db')
    print("Connected to the database")
except sqlite3.Error as e:
    print(f"Failed to connect to the database: {e}")
    exit()

# Creating a cursor to execute SQL queries
cursor = conn.cursor()

try:
    # Execute a SELECT query
    sql = "SELECT * FROM countrylanguage"
    cursor.execute(sql)
    result = cursor.fetchall()
    for row in result:
        print(row)
except sqlite3.Error as e:
    print(f"Error executing query: {e}")
finally:
    # Close cursor and connection
    cursor.close()
    conn.close()
```

Execute SQL command

```python
import sqlite3

# Establishing a connection
try:
    conn = sqlite3.connect('DatabaseName.db')
    print("Connected to the database")
except sqlite3.Error as e:
    print(f"Failed to connect to the database: {e}")
    exit()

# Creating a cursor to execute SQL commands
cursor = conn.cursor()

try:
    # Execute the DELETE command with a parameter
    sql = "DELETE FROM color WHERE green = ?"
    cursor.execute(sql, (150,))

    # Commit the transaction
    conn.commit()

    print("Rows deleted successfully!")
except sqlite3.Error as e:
    print(f"Error executing command: {e}")
finally:
    # Close cursor and connection
    cursor.close()
    conn.close()
```

Execute SQL query

```
import sqlite3

# Establishing a connection
try:
    conn = sqlite3.connect('DatabaseName.db')
    print("Connected to the database")
except sqlite3.Error as e:
    print(f"Failed to connect to the database: {e}")
    exit()

# Creating a cursor to execute SQL queries
cursor = conn.cursor()

try:
    # Execute the SQL query
    sql = "SELECT Language, Percentage FROM countrylanguage WHERE CountryCode = 'USA' ORDER BY Percentage DESC"
    cursor.execute(sql)

    # Fetch all rows
    rows = cursor.fetchall()

    # Print results
    for row in rows:
        print(row[0], ": ", row[1])
except sqlite3.Error as e:
    print(f"Error executing query: {e}")
finally:
    # Close cursor and connection
    cursor.close()
    conn.close()
```

SQL query with parameters

```python
import sqlite3

# Establishing a connection
try:
    conn = sqlite3.connect('DatabaseName.db')
    print("Connected to the database")
except sqlite3.Error as e:
    print(f"Failed to connect to the database: {e}")
    exit()

# Creating a cursor to execute SQL queries
cursor = conn.cursor()

try:
    # Define the SQL query with parameters
    sql = "SELECT Language, Percentage FROM countrylanguage WHERE CountryCode = ? AND Percentage > ?"

    # Execute the SQL query with parameters
    cursor.execute(sql, ("USA", 0.5))

    # Fetch all rows
    rows = cursor.fetchall()

    # Print results
    for row in rows:
        print(row[0], ": ", row[1])
except sqlite3.Error as e:
    print(f"Error executing query: {e}")
finally:
    # Close cursor and connection
    cursor.close()
    conn.close()
```

Work with Files

Working with files in software development involves various operations related to reading, writing, and manipulating files stored on disk.

Archives:

Packing a zip file

```
import zipfile
import os

def zip_directory(directory, zip_file):
    with zipfile.ZipFile(zip_file, 'w', zipfile.ZIP_DEFLATED) as zipf:
        for root, _, files in os.walk(directory):
            for file in files:
                zipf.write(os.path.join(root, file),
os.path.relpath(os.path.join(root, file), directory))

source_path = "data"
zip_file = "data.zip"

zip_directory(source_path, zip_file)
```

Packing a zip file with a password

```
import os
import pyzipper

def zip_directory_with_password(directory, zip_file, password):
    with pyzipper.AESZipFile(zip_file, 'w', compression=pyzipper.ZIP_DEFLATED, encryption=pyzipper.WZ_AES) as zipf:
        zipf.setpassword(password.encode())
        for root, _, files in os.walk(directory):
            for file in files:
                zipf.write(os.path.join(root, file), os.path.relpath(os.path.join(root, file), directory))

source_path = "data"
zip_file = "data.zip"
password = "123"

zip_directory_with_password(source_path, zip_file, password)
```

Unpacking a zip file

```python
import zipfile

def unzip(zip_file, destination):
    with zipfile.ZipFile(zip_file, 'r') as zip_ref:
        zip_ref.extractall(destination)

zip_file = "data.zip"
destination = "tmp"

unzip(zip_file, destination)
```

Basic operations:

Check if the file exists

```python
import os

file_path = "file.txt"

# Asynchronously
if os.path.exists(file_path):
    print("File exists!")
else:
    print("File does not exist!")
```

Combining two parts of a path

```
import os

work_dir = os.path.dirname(os.path.abspath(__file__))
data_dir = os.path.join(work_dir, 'Data')

print("dataDir is", data_dir)
```

Copy a directory

```
import shutil
import os

source_path = "./data"
destination_path = "./data_copy"

try:
    # Use shutil.copytree to copy the entire directory
    shutil.copytree(source_path, destination_path, dirs_exist_ok=True)
    print("Directory copied successfully!")
except shutil.Error as e:
    print("Error:", e)
except OSError as e:
    print("OS error:", e)
```

Create a directory

```javascript
// using Node.js
// npm i @types/node

const fs = require("fs");

let path = "./data";
// Asyncronously:
fs.mkdir(path, (err) => {
  if (err) console.log("Error:", err);
  else console.log("Sucessfully created!");
});

// Synchronously:
if (!fs.existsSync(path)) {
  fs.mkdirSync(path);
}
```

Delete a directory

```python
import shutil
import os

path = "./data"

# Synchronously:
if os.path.exists(path):
    shutil.rmtree(path)
    print("Successfully deleted!")
else:
    print("Directory does not exist.")
```

Delete a directory with data

```python
import shutil
import os

path = "./data"

# Synchronously:
if os.path.exists(path):
    shutil.rmtree(path)
    print("Successfully deleted!")
else:
    print("Directory does not exist.")
```

Delete a file

```
import os

file_path = "file.txt"

try:
    os.remove(file_path)
    print("Deleted!")
except OSError as e:
    print(f"Error: {e.strerror}")
```

File copying

```python
import shutil

file_path = "file.txt"
file_path_to = "file_copy.txt"

try:
    shutil.copyfile(file_path, file_path_to)
    print("File copied!")
except OSError as e:
    print(f"Error: {e.strerror}")
```

File moving

```
import shutil

file_path = "file.txt"
new_file_path = "file_new.txt"

try:
    shutil.move(file_path, new_file_path)
    print("File moved successfully!")
except OSError as e:
    print(f"Error: {e.strerror}")
```

Get the working directory

```python
import os

# Get the current working directory
current_working_directory = os.getcwd()
print(f"Current working directory: {current_working_directory}")
```

Getting file properties

```
import os
import stat
import time

file_path = "file.txt"

# Get file properties
file_stats = os.stat(file_path)

# File size
file_size = file_stats.st_size

# File modification date
date_changes = time.ctime(file_stats.st_mtime)

# File creation date (Note: on some Unix systems, st_ctime is the change time)
creation_date = time.ctime(file_stats.st_ctime)

# Can read, write, and execute
can_rwe = (file_stats.st_mode & stat.S_IRWXU) == stat.S_IRWXU

# File extension
extension = os.path.splitext(file_path)[1]

# File name
file_name = os.path.basename(file_path)

# File name without extension
file_name_only = os.path.splitext(file_name)[0]

# File directory
file_dir = os.path.dirname(file_path)

print("fileSize is", file_size, "bytes")
print("dateChanges is", date_changes)
print("creationDate is", creation_date)
print("canRWE is", can_rwe)
print("extension is", extension)
print("fileName is", file_name)
print("fileNameOnly is", file_name_only)
```

```python
print("fileDir is", file_dir)
```

List of files in the directory

```python
import os

# Directory path
dir_path = os.getcwd()

# Synchronously
files = os.listdir(dir_path)
for file in files:
    print(file)

# Asynchronously (using asyncio and aiofiles)
import asyncio
import aiofiles.os

async def list_files_async(dir_path):
    files = await aiofiles.os.listdir(dir_path)
    for file in files:
        print(file)

# Running the async function
asyncio.run(list_files_async(dir_path))
```

Binary files:

Read array from a file

```
import struct

file_path = "file.out"

# Synchronously
try:
    with open(file_path, "rb") as file:
        data = file.read()
        numbers = struct.unpack(f'{len(data) // 4}i', data)
        print("numbers is", numbers)
except Exception as e:
    print("Error:", e)
```

Read dictionary from a file

```python
import json

file_path = "file.out"

# Synchronously
try:
    with open(file_path, "r", encoding="utf-8") as file:
        data = file.read()
        map = json.loads(data)
        print("map is", map)
except Exception as e:
    print("Error:", e)
```

Reading a binary file

```
file_path = "file.out"

# Asynchronously (using asyncio and aiofiles)
import asyncio
import aiofiles

async def read_binary_file(file_path):
    try:
        async with aiofiles.open(file_path, 'rb') as file:
            data = await file.read()
            print("Data is", data)
            bytes_array = bytearray(data)
            print("bytes is", bytes_array)
    except Exception as e:
        print("Error:", e)

# Run the asynchronous function
asyncio.run(read_binary_file(file_path))

# Synchronously
try:
    with open(file_path, 'rb') as file:
        data = file.read()
        print("Data is", data)
        bytes_array = bytearray(data)
        print("bytes is", bytes_array)
except Exception as e:
    print("Error:", e)
```

Write array to a file

```
import array

numbers = [1, 2, -3]
data = array.array('i', numbers)
# 'i' indicates signed integer

file_path = "file.out"

# Asynchronously (using asyncio and aiofiles)
import asyncio
import aiofiles

async def write_binary_file(numbers, file_path):
    try:
        async with aiofiles.open(file_path, 'wb') as file:
            file.write(numbers.tobytes())
            print("Data written to file!")
    except Exception as e:
        print("Error:", e)

# Run the asynchronous function
asyncio.run(write_binary_file(data, file_path))

# Synchronously
with open(file_path, 'wb') as file:
    file.write(data.tobytes())
    print("Data written to file!")
```

Write a directory to a file

```python
import json

# Define your map (equivalent to JavaScript Map)
map_data = {
    1: "one",
    2: "two"
}

file_path = "file.out"

# Convert map to JSON string
json_data = json.dumps(map_data)

# Write JSON string to file
with open(file_path, 'w', encoding='utf-8') as file:
    file.write(json_data)

print("Data written to file:", file_path)
```

Writing a binary file

```python
import array

# Data to write (equivalent to Uint8Array in JavaScript)
data = array.array('B', [120, 64, 97])

file_path = "file.out"

# Asynchronously equivalent in Python (write binary mode)
with open(file_path, 'wb') as file:
    file.write(data)

print("Data written to file:", file_path)
```

Text files:

Append text to a file

```python
file_path = "file.txt"

# Asynchronously equivalent in Python (append mode)
with open(file_path, 'a') as file:
    file.write("\nLine 4")

print("Appended:", file_path)

# Synchronously equivalent in Python (append mode)
try:
    with open(file_path, 'a') as file:
        file.write("\nLine 3")
    print("Text added successfully:", file_path)
except Exception as e:
    print("Error:", e)
```

Read file line by line

```
file_path = "file.txt"

# Asynchronously equivalent in Node.js (read line by line)
with open(file_path, 'r') as file:
    for line in file:
        print("Line from file:", line.rstrip())
        # rstrip() to remove newline characters
```

Read from a file

```
import asyncio

async def read_file_async(file_path):
    try:
        with open(file_path, 'r') as file:
            text = file.read()
            return text
    except FileNotFoundError:
        print(f"File '{file_path}' not found.")
    except Exception as e:
        print(f"Error reading file '{file_path}': {e}")

async def main():
    file_path = "file.txt"
    text = await read_file_async(file_path)
    if text:
        print(text)

# Run the main coroutine
asyncio.run(main())
```

Write to a file

```python
import asyncio

async def write_file_async(file_path, content):
    try:
        with open(file_path, 'w') as file:
            file.write(content)
        print(f"Text written to '{file_path}' asynchronously!")
    except Exception as e:
        print(f"Error writing to '{file_path}': {e}")

async def main():
    file_path = "file.txt"
    content = "Line 1\nLine 2"
    await write_file_async(file_path, content)

# Run the main coroutine
asyncio.run(main())
```

XML files:

Reading XML file

```
import xml.etree.ElementTree as ET

# XML example:
# <Lines>
#    <Line Id="1">one</Line>
#    <Line Id="2">two</Line>
# </Lines>


def read_xml_file(file_path):
    try:
        # Parse the XML file
        tree = ET.parse(file_path)
        root = tree.getroot()

        # Access elements and attributes
        for line in root.findall('Line'):
            line_id = line.get('Id')
            line_value = line.text
            print(f"Line {line_id} value: {line_value}")

    except Exception as e:
        print(f"Error reading XML file '{file_path}': {e}")

# File path
file_path = "data/data.xml"

# Read the XML file
read_xml_file(file_path)
```

Writing XML file

```
from lxml import etree

# XML example:
# <Line>
#   <Line Id="1">one</Line>
#   <Line Id="2">two</Line>
# </Line>

lines = etree.Element("Lines")
line = etree.SubElement(lines, "Line")
line.set("Id", "1")
line.text = "one"
line = etree.SubElement(lines, "Line")
line.set("Id", "2")
line.text = "two"

xml_text = etree.tostring(
    lines,            pretty_print=True,            xml_declaration=True,
encoding="utf-8"
).decode("utf-8")
file_name = "data.xml"

with open(file_name, "w") as text_file:
    print(xml_text, file=text_file)
```

Thanks for reading this great book!

In every line of code, they have woven a story of innovation and creativity. This book has been your compass in the vast world of Python.

Close this chapter knowing that every challenge overcome is an achievement, and every solution is a step toward mastery.

Your code is the melody that gives life to projects. May they continue creating and programming with passion!

Thank you for allowing me to be part of your journey.

With gratitude,

Hernando Abella

Author of Python Cook Book

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Thanks (again!)