

Chapter 8: Classes and Decorators

Object-Oriented Programming and Function Enhancement in Python

CS 101 - Fall 2025

On For Today

 Let's dive into Python's powerful organizational features!

Topics covered in today's discussion:

- **What are Classes?** - Building custom data types
- **Objects and Instances** - Creating and using objects
- **Methods and Attributes** - Adding behavior and properties
- **Constructors and Inheritance** - Advanced class concepts
- **What are Decorators?** - Function enhancers explained
- **Built-in Decorators** - `@property`, `@staticmethod`, `@classmethod`
- **Custom Decorators** - Creating your own function wrappers
- **Real-World Applications** - Classes and decorators in action

Get Ready for Classes and Decorators!

Ready to build amazing Python objects and enhance functions!



Part 1: Python Classes

What We'll Learn

Classes are blueprints for creating objects - they help us organize code and model real-world concepts!

Think of classes as: Cookie cutters that create cookie objects - same shape, different decorations!

What Are Classes?

Definition

Classes are templates for creating objects. They bundle data (attributes) and functions (methods) together to model real-world concepts or abstract ideas.

Think of them as: Blueprints for houses - each house (object) follows the blueprint (class) but can have different colors, sizes, and features!

Classes: The Basics

Basic Class Syntax

```
# Basic class definition
class Dog:
    # Class attribute (shared by all instances)
    species = "Canis lupus"

    # Constructor method (__init__)
    def __init__(self, name, age):
        # Instance attributes (unique to each object)
        self.name = name
        self.age = age

    # Instance method
    def bark(self):
        return f"{self.name} says Woof!"

    # Another method with parameters
    def celebrate_birthday(self):
        self.age += 1
        return f"Happy birthday {self.name}! Now {self.age} years old!"

# Creating objects (instances)
my_dog = Dog("Buddy", 3)
your_dog = Dog("Luna", 5)

print(my_dog.bark())          # Buddy says Woof!
print(your_dog.celebrate_birthday()) # Happy birthday Luna! Now 6 years old!
```

Key Class Concepts Explained

Important Terms

Class: The blueprint or template

Object/Instance: A specific creation from the class

Attributes: Variables that store data

Methods: Functions that belong to the class

self: Reference to the current instance

__init__: Constructor method that runs when creating objects

Working with Objects

Creating Class Objects

```
class Car:  
    # Class attribute  
    wheels = 4  
  
    # Constructor  
    def __init__(self, make, model, year):  
        self.make = make      # Instance attribute  
        self.model = model    # Instance attribute  
        self.year = year      # Instance attribute  
        self.odometer = 0     # Default instance attribute  
  
    # Method  
    def drive(self, miles):  
        self.odometer += miles  
        return f"Drove {miles} miles. Total: {self.odometer}"
```

Key Point: A class is used to create an object. Each instance is own object. Neat-O!

Working with Objects

Creating and Using Objects

```
# Create instances
car1 = Car("Toyota", "Camry", 2022)
car2 = Car("Honda", "Civic", 2021)

# Access attributes
print(f"Car 1: {car1.make} {car1.model}") # Toyota Camry
print(f"Car 2: {car2.year}") # 2021

# Call methods
print(car1.drive(100)) # Drove 100 miles. Total: 100
print(car1.drive(50)) # Drove 50 miles. Total: 150

# Modify attributes
car2.make = "Acura" # Changing attribute value
print(car2.make) # Acura

# Access class attributes
print(Car.wheels) # 4 (from class)
print(car1.wheels) # 4 (inherited from class)
```

Key Point: Each object has its own copy of instance attributes but shares class attributes!

Quick Challenge #1 (3 minutes)

Your Turn: Basic Class Creation

Challenge: Create a `Student` class with the following features:

1. Attributes: `name`, `student_id`, `grade_level`, and `gpa` (default to 0.0)
2. Methods:
 - `introduce()` - returns “Hi, I’m [name], student ID [id]”
 - `update_gpa(new_gpa)` - updates the GPA
 - `is_honor_student()` - returns True if GPA >= 3.5

Starter Code:

```

class Student:
    # Your code here
    pass

# Test your class
student1 = Student("Alice", "S001", 10)
print(student1.introduce())
student1.update_gpa(3.8)
print(f"Honor student: {student1.is_honor_student()}")

```

Challenge #1 Solutions

Solutions

```

class Student:
    def __init__(self, name, student_id, grade_level, gpa=0.0):
        self.name = name
        self.student_id = student_id
        self.grade_level = grade_level
        self.gpa = gpa

    def introduce(self):
        return f"Hi, I'm {self.name}, student ID {self.student_id}"

    def update_gpa(self, new_gpa):
        self.gpa = new_gpa
        return f"GPA updated to {self.gpa}"

    def is_honor_student(self):
        return self.gpa >= 3.5

# Test results
student1 = Student("Alice", "S001", 10)
print(student1.introduce())          # Hi, I'm Alice, student ID S001
student1.update_gpa(3.8)
print(f"Honor student: {student1.is_honor_student()}") # True

student2 = Student("Bob", "S002", 11, 3.2)
print(f"Bob honor status: {student2.is_honor_student()}") # False

```

Class Inheritance

Inheritance Basics

Inheritance allows you to create a new class based on an existing class. The new class inherits attributes and methods from the parent class!

Think of it as: Family traits - children inherit characteristics from parents but can also have their own unique features!

Inheritance Example

Parent and Child Classes

```
# Parent class (Base class)
class Animal:
    def __init__(self, name, species):
        self.name = name
        self.species = species
        self.energy = 100

    def eat(self):
        self.energy += 10
        return f"{self.name} is eating. Energy: {self.energy}"

    def sleep(self):
        self.energy += 20
        return f"{self.name} is sleeping. Energy: {self.energy}"

# Child class inherits from Animal
class Dog(Animal):
    def __init__(self, name, breed):
        super().__init__(name, "Canine") # Call parent constructor
        self.breed = breed

    def bark(self): # New method specific to Dog
        return f"{self.name} barks! Woof woof!"

    def play_fetch(self): # Another dog-specific method
        self.energy -= 15
        return f"{self.name} plays fetch! Energy: {self.energy}"

# Using inheritance
my_dog = Dog("Max", "Golden Retriever")
print(my_dog.eat())      # Inherited from Animal
print(my_dog.bark())     # Dog-specific method
print(my_dog.play_fetch()) # Dog-specific method
```

Method Overriding

Customizing Inherited Methods

```
class Bird(Animal):
    def __init__(self, name, can_fly=True):
        super().__init__(name, "Avian")
        self.can_fly = can_fly

    # Override the sleep method from Animal
    def sleep(self):
        self.energy += 30 # Birds need more rest!
        return f"{self.name} sleeps in a nest. Energy: {self.energy}"

    # New method
    def fly(self):
        if self.can_fly:
            self.energy -= 20
            return f"{self.name} soars through the sky!"
        else:
            return f"{self.name} cannot fly."

# Comparison
dog = Dog("Buddy", "Labrador")
bird = Bird("Tweety")

print(dog.sleep()) # Uses Animal's sleep method (energy +20)
print(bird.sleep()) # Uses Bird's overridden sleep method (energy +30)
print(bird.fly()) # Bird-specific method
```

Key Point: Child classes can override parent methods to provide specialized behavior!

Quick Challenge #2 (3 minutes)

Your Turn: Inheritance Practice

Challenge: Create a `Vehicle` parent class and a `Motorcycle` child class:

Vehicle class: - Attributes: `make`, `model`, `year`, `fuel_level` (default 100) - Methods: `start_engine()`, `refuel()`

Motorcycle class: - Inherits from Vehicle - Additional attribute: `engine_size` - New

method: `wheelie()` (reduces fuel by 5) - Override `start_engine()` to include motorcycle-specific message

Starter Code:

```
class Vehicle:  
    # Your Vehicle class here  
    pass  
  
class Motorcycle(Vehicle):  
    # Your Motorcycle class here  
    pass  
  
# Test your classes  
bike = Motorcycle("Harley", "Sportster", 2023, 883)  
print(bike.start_engine())  
print(bike.wheelie())
```

Challenge #2 Solutions

Solutions

```
class Vehicle:
    def __init__(self, make, model, year, fuel_level=100):
        self.make = make
        self.model = model
        self.year = year
        self.fuel_level = fuel_level

    def start_engine(self):
        return f"{self.year} {self.make} {self.model} engine started!"

    def refuel(self):
        self.fuel_level = 100
        return f"Tank refueled to {self.fuel_level}%"

class Motorcycle(Vehicle):
    def __init__(self, make, model, year, engine_size, fuel_level=100):
        super().__init__(make, model, year, fuel_level)
        self.engine_size = engine_size

    def start_engine(self): # Override parent method
        return f"{self.year} {self.make} {self.model} motorcycle roars to life! "

    def wheelie(self):
        self.fuel_level -= 5
        return f"Awesome wheelie! Fuel: {self.fuel_level}%"

# Test results
bike = Motorcycle("Harley", "Sportster", 2023, 883)
print(bike.start_engine()) # Motorcycle roars to life!
print(bike.wheelie())     # Awesome wheelie! Fuel: 95%
print(bike.refuel())      # Tank refueled to 100%
```

Part 2: Python Decorators

What We'll Learn

Decorators are a way to modify or enhance functions without changing their code. They're like gift wrapping for functions!

Think of decorators as: Gift wrapping - the present (function) stays the same, but the wrapper adds something special!

What Are Decorators?

Definition

Decorators are functions that take another function as input and extend or modify its behavior without permanently changing it. They use the `@decorator_name` syntax!

Think of them as: Function enhancers - like adding superpowers to your existing functions!

Decorators: The Basics

Basic Decorator Syntax

```
# Simple decorator function
def my_decorator(func):
    def wrapper():
        print("Something before the function")
        result = func() # Call the original function
        print("Something after the function")
        return result
    return wrapper

# Using the decorator with @ syntax
@my_decorator
def say_hello():
    print("Hello, World!")

# When we call say_hello(), it's actually wrapped
say_hello()

# Output:
# Something before the function
# Hello, World!
# Something after the function
```

Key Point: The `@decorator_name` syntax is equivalent to `func = decorator_name(func)`!

Understanding How Decorators Work

Step-by-Step Breakdown

What happens when you use `@my_decorator`:

1. **Decorator function** receives the original function as input
2. **Wrapper function** is created inside the decorator
3. **Wrapper function** calls the original function and adds extra behavior
4. **Decorator returns** the wrapper function
5. **Original function name** now points to the wrapper function

Decorators with Arguments

Handling Function Parameters

```
# This decorator adds timing to functions
def timer_decorator(func):
    def wrapper():
        import time
        start_time = time.time()
        result = func()
        end_time = time.time()
        print(f"Function took {end_time - start_time:.4f} seconds")
        return result
    return wrapper

@timer_decorator
def slow_function():
    import time
    time.sleep(1)
    return "Done!"

slow_function() # Function took 1.0041 seconds
```

Setting Up Decorators with Arguments

Handling Function Parameters

```
# Decorator that works with functions that have arguments
def logging_decorator(func):
    def wrapper(*args, **kwargs): # Accept any arguments
        print(f"Calling function: {func.__name__}")
        print(f"Arguments: args={args}, kwargs={kwargs}")
        result = func(*args, **kwargs) # Pass arguments to original function
        print(f"Function returned: {result}")
        return result
    return wrapper

@logging_decorator
def add_numbers(a, b):
    return a + b

@logging_decorator
def greet(name, greeting="Hello"):
    return f"{greeting}, {name}!"

# Test the decorated functions
result1 = add_numbers(5, 3)
print(f"Result: {result1}")

result2 = greet("Alice", greeting="Hi")
print(f"Result: {result2}")
```

Built-in Decorators: `@property`, `@staticmethod` and `@classmethod`

! Important

- The `@staticmethod` decorator in Python marks a method inside a class that does not require access to the class or any instance of the class. It behaves like a regular function but is contained within the class's namespace for logical organization.
- The `@classmethod` decorator is a built-in decorator used to define a method that belongs to the class itself, rather than to an instance of the class.
- The `@property` decorator is a built-in decorator used to define managed attributes within a class. It allows you to transform regular methods into "properties," which can be accessed like attributes but have underlying getter, setter, and deleter methods to control their behavior.

Using Built-in Decorators: @property

The @property Decorator

`@property` turns a method into a readable attribute. It's used for computed properties and data validation!

```
class Circle:
    def __init__(self, radius):
        self._radius = radius # Private attribute

    @property
    def radius(self):
        """Getter for radius"""
        return self._radius

    @radius.setter
    def radius(self, value):
        """Setter with validation"""
        if value < 0:
            raise ValueError("Radius cannot be negative!")
        self._radius = value

    @property
    def area(self):
        """Computed property - calculated on demand"""
        import math
        return math.pi * self._radius ** 2

    @property
    def diameter(self):
        """Another computed property"""
        return 2 * self._radius

# Using the Circle class
circle = Circle(5)
print(f"Radius: {circle.radius}")      # Uses @property getter
print(f"Area: {circle.area:.2f}")      # Computed property
print(f"Diameter: {circle.diameter}")  # Another computed property

circle.radius = 10 # Uses @radius.setter
print(f"New area: {circle.area:.2f}")
```

Using Built-in Decorators: `@staticmethod` and `@classmethod`

Class-related Decorators

```
class MathUtils:
    pi = 3.14159

    @staticmethod
    def add(x, y):
        """Static method - doesn't need self or cls"""
        return x + y

    @classmethod
    def circle_area(cls, radius):
        """Class method - receives cls (the class) as first argument"""
        return cls.pi * radius ** 2

    def instance_method(self):
        """Regular instance method - needs self"""
        return "This is an instance method"

# Using different types of methods
# Static method - can call without creating instance
result = MathUtils.add(5, 3)
print(f"Static method result: {result}")

# Class method - can call without creating instance
area = MathUtils.circle_area(10)
print(f"Circle area: {area:.2f}")

# Instance method - needs an instance
utils = MathUtils()
print(utils.instance_method())

# You can also call static and class methods on instances
print(f"Instance calling static: {utils.add(2, 7)}")
print(f"Instance calling class method: {utils.circle_area(3):.2f}")
```

Quick Challenge #3 (3 minutes)

Your Turn: Creating Custom Decorators

Challenge: Create a decorator called `repeat_decorator` that runs a function multiple times:

1. The decorator should take a parameter for how many times to repeat
2. It should print the result each time
3. Return the result from the last execution

Bonus: Create a `BankAccount` class with `@property` for balance validation

Starter Code:

```
# Create your decorator here
def repeat_decorator(times):
    # Your decorator code here
    pass

@repeat_decorator(3)
def roll_dice():
    import random
    return random.randint(1, 6)

# Test your decorator
result = roll_dice()

# Bonus: BankAccount class
class BankAccount:
    # Your class with @property here
    pass
```

Challenge #3 Solutions (I)

Solutions

```
# Solution 1: Custom repeat decorator
def repeat_decorator(times):
    def decorator(func):
        def wrapper(*args, **kwargs):
            result = None
            for i in range(times):
                result = func(*args, **kwargs)
                print(f"Execution {i+1}: {result}")
            return result
        return wrapper
    return decorator

@repeat_decorator(3)
def roll_dice():
    import random
    return random.randint(1, 6)

print("Rolling dice 3 times:")
final_result = roll_dice()
print(f"Final result: {final_result}")
```

Challenge #3 Solutions (II)

Solutions

```
# Solution 2: BankAccount with @property
class BankAccount:
    def __init__(self, initial_balance=0):
        self._balance = initial_balance

    @property
    def balance(self):
        return self._balance

    # The below setter provides a controlled way to modify
    # the balance with validation, but the current code
    # does not demonstrate this functionality. It is a
    # useful feature for ensuring data integrity when
    # someone directly assigns to the balance property.

    @balance.setter
    def balance(self, amount):
        if amount < 0:
            raise ValueError("Balance cannot be negative!")
        self._balance = amount

    def deposit(self, amount):
        if amount > 0:
            self._balance += amount
        return f"Deposited ${amount}. New balance: ${self._balance}"

    def withdraw(self, amount):
        if amount > self._balance:
            return "Insufficient funds!"
        self._balance -= amount
        return f"Withdrew ${amount}. New balance: ${self._balance}"

# Test BankAccount
account = BankAccount(100)
print(f"Initial balance: ${account.balance}")
print(account.deposit(50))
print(account.withdraw(30))

# This would trigger the setter
account.balance = 200 # This calls the setter method

# This would trigger the validation
try:
    account.balance = -50 # This would raise ValueError22
except ValueError as e:
    print(f"Error: {e}")
```

Real-World Applications

Practical Uses

Classes and decorators are everywhere in real Python applications! Let's see some practical examples you'll encounter.

Common scenarios: Web development, game development, data processing, API design, and scientific computing

Real-World Example: E-commerce System

Note

Classes for Shopping Cart

```
class Product:
    def __init__(self, name, price, category):
        self.name = name
        self.price = price
        self.category = category

    def __str__(self):
        return f"{self.name} (${self.price:.2f})"

class ShoppingCart:
    def __init__(self):
        self.items = []
        self._discount_rate = 0.0

    def add_item(self, product, quantity=1):
        self.items.append({"product": product, "quantity": quantity})
        return f"Added {quantity}x {product.name} to cart"

    @property
    def total(self):
        subtotal = sum(item["product"].price * item["quantity"]
                      for item in self.items)
        return subtotal * (1 - self._discount_rate)

    @property
    def item_count(self):
        return sum(item["quantity"] for item in self.items)

    def apply_discount(self, rate):
        if 0 <= rate <= 1:
            self._discount_rate = rate
            return f"Applied {rate*100}% discount"
        return "Invalid discount rate"

# Using the e-commerce system
laptop = Product("Gaming Laptop", 1299.99, "Electronics")
mouse = Product("Wireless Mouse", 29.99, "Electronics")

cart = ShoppingCart()
print(cart.add_item(laptop))
print(cart.add_item(mouse, 2))

print(f"Items in cart: {cart.item_count}")
print(f"Total: ${cart.total:.2f}")

print(cart.apply_discount(0.1)) # 10% discount
print(f"Total after discount: ${cart.total:.2f}")
```

Output:

```

class Product:
    def __init__(self, name, price, category):
        self.name = name
        self.price = price
        self.category = category

    def __str__(self):
        return f"{self.name} (${self.price:.2f})"

class ShoppingCart:
    def __init__(self):
        self.items = []
        self._discount_rate = 0.0

    def add_item(self, product, quantity=1):
        self.items.append({"product": product, "quantity": quantity})
        return f"Added {quantity}x {product.name} to cart"

    @property
    def total(self):
        subtotal = sum(item["product"].price * item["quantity"]
                      for item in self.items)
        return subtotal * (1 - self._discount_rate)

    @property
    def item_count(self):
        return sum(item["quantity"] for item in self.items)

    def apply_discount(self, rate):
        if 0 <= rate <= 1:
            self._discount_rate = rate
            return f"Applied {rate*100}% discount"
        return "Invalid discount rate"

# Using the e-commerce system
laptop = Product("Gaming Laptop", 1299.99, "Electronics")
mouse = Product("Wireless Mouse", 29.99, "Electronics")

cart = ShoppingCart()
print(cart.add_item(laptop))
print(cart.add_item(mouse, 2))

print(f"Items in cart: {cart.item_count}")
print(f"Total: ${cart.total:.2f}")

print(cart.apply_discount(0.1)) # 10% discount
print(f"Total after discount: ${cart.total:.2f}")

```

```
Added 1x Gaming Laptop to cart
Added 2x Wireless Mouse to cart
Items in cart: 3
Total: $1359.97
Applied 10.0% discount
Total after discount: $1223.97
```

Real-World Example: Game Development

Note

Classes with Inheritance for Game Characters

```
class GameCharacter:
    def __init__(self, name, health=100, attack_power=10):
        self.name = name
        self.max_health = health
        self._health = health
        self.attack_power = attack_power
        self.level = 1

    @property
    def health(self):
        return self._health

    @health.setter
    def health(self, value):
        self._health = max(0, min(value, self.max_health)) # Keep between 0 and max

    @property
    def is_alive(self):
        return self._health > 0

    def attack(self, target):
        if not self.is_alive:
            return f"{self.name} cannot attack - defeated!"

        damage = self.attack_power
        target.health -= damage
        return f"{self.name} attacks {target.name} for {damage} damage!"

class Warrior(GameCharacter):
    def __init__(self, name):
        super().__init__(name, health=150, attack_power=15)
        self.armor = 5

    def shield_bash(self, target):
        damage = self.attack_power + self.armor
        target.health -= damage
        return f"{self.name} shield bashes {target.name} for {damage} damage!"

class Mage(GameCharacter):
    def __init__(self, name):
        super().__init__(name, health=80, attack_power=20)
        self.mana = 100

    def cast_fireball(self, target):
        if self.mana < 20:
            return f"{self.name} is out of mana!"

        self.mana -= 20
        damage = self.attack_power * 2
        target.health -= damage
        return f"{self.name} casts fireball on {target.name} for {damage} damage!"

# Game battle simulation
```

Output:

```
class GameCharacter:
    def __init__(self, name, health=100, attack_power=10):
        self.name = name
        self.max_health = health
        self._health = health
        self.attack_power = attack_power
        self.level = 1

    @property
    def health(self):
        return self._health

    @health.setter
    def health(self, value):
        self._health = max(0, min(value, self.max_health)) # Keep between 0 and max

    @property
    def is_alive(self):
        return self._health > 0

    def attack(self, target):
        if not self.is_alive:
            return f"{self.name} cannot attack - defeated!"

        damage = self.attack_power
        target.health -= damage
        return f"{self.name} attacks {target.name} for {damage} damage!"

class Warrior(GameCharacter):
    def __init__(self, name):
        super().__init__(name, health=150, attack_power=15)
        self.armor = 5

    def shield_bash(self, target):
        damage = self.attack_power + self.armor
        target.health -= damage
        return f"{self.name} shield bashes {target.name} for {damage} damage!"

class Mage(GameCharacter):
    def __init__(self, name):
        super().__init__(name, health=80, attack_power=20)
        self.mana = 100

    def cast_fireball(self, target):
        if self.mana < 20:
            return f"{self.name} is out of mana!"

        self.mana -= 20
        damage = self.attack_power * 2
        target.health -= damage
        return f"{self.name} casts fireball on {target.name} for {damage} damage!"

# Game battle simulation
```

```
Warrior: Sir Lancelot (Health: 150)
Mage: Gandalf (Health: 80)

Battle begins!
Sir Lancelot attacks Gandalf for 15 damage!
Mage health: 65
Gandalf casts fireball on Sir Lancelot for 40 damage!
Warrior health: 110
Sir Lancelot shield bashes Gandalf for 20 damage!
Mage health: 45
Mage alive: True
```

Real-World Example: Web API with Decorators



Note

Decorators for Web Development

```

import time
from functools import wraps

# Authentication decorator
def require_auth(func):
    @wraps(func)
    def wrapper(*args, **kwargs):
        # Simulate checking authentication
        user_authenticated = True # In real app, check session/token
        if not user_authenticated:
            return {"error": "Authentication required", "status": 401}
        return func(*args, **kwargs)
    return wrapper

# Rate limiting decorator
def rate_limit(max_calls=5, time_window=60):
    call_times = []

    def decorator(func):
        @wraps(func)
        def wrapper(*args, **kwargs):
            now = time.time()
            # Remove old calls outside time window
            call_times[:] = [t for t in call_times if now - t < time_window]

            if len(call_times) >= max_calls:
                return {"error": "Rate limit exceeded", "status": 429}

            call_times.append(now)
            return func(*args, **kwargs)
        return wrapper
    return decorator

# Logging decorator
def log_api_call(func):
    @wraps(func)
    def wrapper(*args, **kwargs):
        print(f"API call: {func.__name__} at {time.strftime('%Y-%m-%d %H:%M:%S')}")
        result = func(*args, **kwargs)
        print(f"API response: {result}")
        return result
    return wrapper

# API endpoint class
class UserAPI:
    def __init__(self):          32
        self.users = {
            1: {"name": "Alice", "email": "alice@email.com"}, 
            2: {"name": "Bob", "email": "bob@email.com"}
        }

        @log_api_call
        @require_auth

```

Output:

```

import time
from functools import wraps

# Authentication decorator
def require_auth(func):
    @wraps(func)
    def wrapper(*args, **kwargs):
        # Simulate checking authentication
        user_authenticated = True # In real app, check session/token
        if not user_authenticated:
            return {"error": "Authentication required", "status": 401}
        return func(*args, **kwargs)
    return wrapper

# Rate limiting decorator
def rate_limit(max_calls=5, time_window=60):
    call_times = []

    def decorator(func):
        @wraps(func)
        def wrapper(*args, **kwargs):
            now = time.time()
            # Remove old calls outside time window
            call_times[:] = [t for t in call_times if now - t < time_window]

            if len(call_times) >= max_calls:
                return {"error": "Rate limit exceeded", "status": 429}

            call_times.append(now)
            return func(*args, **kwargs)
        return wrapper
    return decorator

# Logging decorator
def log_api_call(func):
    @wraps(func)
    def wrapper(*args, **kwargs):
        print(f"API call: {func.__name__} at {time.strftime('%Y-%m-%d %H:%M:%S')}")
        result = func(*args, **kwargs)
        print(f"API response: {result}")
        return result
    return wrapper

# API endpoint class
class UserAPI:
    def __init__(self):          34
        self.users = {
            1: {"name": "Alice", "email": "alice@email.com"}, 34
            2: {"name": "Bob", "email": "bob@email.com"} 34
        }

        @log_api_call
        @require_auth

```

```
==== API Testing ====
API call: get_user at 2025-11-13 21:14:00
API response: {'user': {'name': 'Alice', 'email': 'alice@email.com'}, 'status': 200}
{'user': {'name': 'Alice', 'email': 'alice@email.com'}, 'status': 200}
API call: get_user at 2025-11-13 21:14:00
API response: {'user': {'name': 'Bob', 'email': 'bob@email.com'}, 'status': 200}
{'user': {'name': 'Bob', 'email': 'bob@email.com'}, 'status': 200}
API call: create_user at 2025-11-13 21:14:00
API response: {'user': {'name': 'Charlie', 'email': 'charlie@email.com'}, 'id': 3, 'status': 201}
{'user': {'name': 'Charlie', 'email': 'charlie@email.com'}, 'id': 3, 'status': 201}
```

Final Challenge: Putting It All Together (5 minutes)

Your Turn: Library Management System

Challenge: Create a complete library system using classes, inheritance, and decorators:

Requirements: 1. Book class with title, author, ISBN, and available status 2. Library class that manages books with methods to add/checkout/return books 3. Member class that inherits from a Person base class 4. Use `Property` for computed attributes 5. Create a decorator that logs all library operations

Bonus: Add different types of books (TextBook, Novel) with specific behaviors

Starter Code:

```
# Create your classes and decorators here

# Test your system
library = Library("City Library")
book1 = Book("Python Programming", "John Doe", "123456789", True)
member1 = Member("Alice", "M001", "alice@email.com")

# Test the system
library.add_book(book1)
library.checkout_book("123456789", member1)
```

Final Challenge: Complete Solution

Library Management System Solution

```
from datetime import datetime
from functools import wraps

# Logging decorator for library operations
def log_operation(func):
    @wraps(func)
    def wrapper(*args, **kwargs):
        timestamp = datetime.now().strftime("%Y-%m-%d %H:%M:%S")
        print(f"[{timestamp}] Operation: {func.__name__}")
        result = func(*args, **kwargs)
        print(f"[{timestamp}] Result: {result}")
        return result
    return wrapper

# Base classes
class Person:
    def __init__(self, name, email):
        self.name = name
        self.email = email

    def __str__(self):
        return f"{self.name} ({self.email})"

class Member(Person):
    def __init__(self, name, member_id, email):
        super().__init__(name, email)
        self.member_id = member_id
        self.borrowed_books = []

    @property
    def books_count(self):
        return len(self.borrowed_books)

    @property
    def can_borrow(self):
        return self.books_count < 3 # Max 3 books per member

class Book:
    def __init__(self, title, author, isbn, available=True):
        self.title = title
        self.author = author
        self.isbn = isbn
        self._available = available
        self.borrowed_by = None

    @property
    def available(self):
        return self._available

    @available.setter
    def available(self, value):
```

Best Practices (I)

Classes and Decorators

💡 Writing Clean Object-Oriented Code

Classes Best Practices: * Use clear, descriptive class names (PascalCase) * Keep classes focused on a single responsibility * Use `@property` for computed attributes and validation * Document your classes and methods * Use inheritance when there's a clear “is-a” relationship

Decorators Best Practices: * Use `@wraps` from `functools` to preserve function metadata * Keep decorators simple and focused * Document what your decorators do * Consider performance impact of decorators * Use built-in decorators when appropriate

Best Practices (II)

Classes and Decorators

💡 Writing Clean Object-Oriented Code

General Guidelines: * Favor composition over inheritance when relationships are complex * Use descriptive variable and method names * Keep methods short and focused * Test your classes and decorators thoroughly

Summary (I)

Classes and Decorators Mastery

💡 What You've Learned Today

Classes Mastery: * Creating classes with attributes and methods * Understanding constructors (`__init__`) and `self` * Implementing inheritance and method overriding * Using `@property` for computed attributes and validation

Decorators Mastery: * Understanding how decorators modify function behavior * Creating custom decorators with and without parameters * Using built-in decorators: `@property`, `@staticmethod`, `@classmethod` * Applying decorators in real-world scenarios

Summary (II)

Classes and Decorators Mastery

💡 What You've Learned Today

- Real-World Applications:** * E-commerce systems with product and cart classes
- * Game development with character inheritance * Web APIs with authentication and logging decorators * Library management systems combining classes and decorators

Congrats!

Congratulations! You've mastered Python's Classes and Decorators!

Next Steps: Continue Your Journey

Where to Go From Here

Immediate Practice: * Create classes for your own projects * Experiment with multiple inheritance * Build custom decorators for common patterns * Practice with `@dataclass` decorator

Advanced Topics to Explore: * Abstract Base Classes (ABC) * Context managers (`__enter__`, `__exit__`) * Metaclasses and advanced decorators * Design patterns (Singleton, Factory, Observer)

Resources: * “Effective Python” by Brett Slatkin * Python’s `abc` and `dataclasses` modules * Practice building larger object-oriented projects * Explore web frameworks like Flask/Django that use decorators extensively

Keep coding, keep building amazing objects!