COMP110: Principles of Computing

6: Object oriented programming

Learning outcomes

- **Explain** the key concepts of OOP, including objects, classes, fields, methods, inheritance and polymorphism
- **Use** objects to model systems
- **Write** simple object oriented programs

Classes and objects

A non-object-oriented program

Clone the `bsc-live-coding` repository to your local machine:

- Open an appropriate folder (e.g. on the `X:` drive) and right-click in empty space
- Select **Git Clone...**
- For the URL, enter `https://github.com/Falmouth-Games-Academy/bsc-live-coding.git`
- Click OK

Once it has finished downloading, open `bsc-live-coding\COMP110\06_OOP` in PyCharm

What's wrong with this program?

- Data for a single "thing" (a ball) is spread across multiple data structures
- It's messy — we have to type a lot of list indexing expressions
- It's inefficient — all that list indexing takes time
- It's error-prone — if we start inserting or removing elements, the lists can easily get out of step with each other

A better approach

- We can use a **class** to collect the data for a single ball
- A class has **fields**, each of which is essentially a variable
- Syntax:

```
class Ball:
    def __init__(self):
        self.pos_x = ...
        self.pos_y = ...
```

- We use a class by creating **instances** of it

The constructor

```
class Ball:
    def __init__(self):
        self.pos_x = ...
        self.pos_y = ...
```

- The **constructor** or **initialiser** is called when an instance of the class is created
- Must be named `__init__`
  - Note the double underscores: `_ _ i n i t _ _`
- First parameter must be `self`, and is the instance being created
- Other parameters are optional

Fields

```
class Ball:
    def __init__(self):
        self.pos_x = ...
        self.pos_y = ...
```

- In Python, **fields** are defined by **assigning** to them
  - Just like ordinary variables
- Usually define all fields in `__init__`
  - It's possible to define new fields after, but for maintainability it is better to collect them all in the same place

Instantiating

- To create an instance of a class, call the class as if it was a function:

```
ball = Ball()
```

- If `__init__` takes parameters other than `self`, specify them here
- To access fields, use **dot notation**:

```
ball.pos_x += 10
print ball.pos_x
```

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Methods

- As well as **fields**, classes can also contain **methods**
- A method is simply a **function** which operates on a particular instance of the class
- Syntax is similar to regular Python functions:

```
class Ball:
    def update(self):
        print "Do something"
```

- Methods take `self` as their first parameter, can optionally take other parameters
- `self` can be used inside the method to access fields
- Use dot notation to call methods

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Recap of terminology

- An **object** is a collection of **fields** which store data, and **methods** which act on that data
  - Fields can also be called **attributes** or **member variables**
  - Methods can also be called **member functions**
- The fields and methods available on an object are determined by its **class**, i.e. its **type**
- A class is a "blueprint" for an object; an **instance** is the object itself

Encapsulation

Good OOP design allows for:

- Related code and data definitions to be collected in a single place
- Development of modular reusable components
- Decoupling of object behaviour from implementation details

Inheritance and polymorphism

Different shapes

Handling of multiple shapes is currently not ideal

- `draw` method has a big **`if-elif`** block
- Imagine if we also had to do e.g. collision detection – we'd need another **`if-elif`** block
- If we add a new shape, we have to remember to update all of these blocks

A better way?

- We could define multiple classes, e.g. `SquareBall`, `CircleBall`, `TriangleBall`
- But they would have common code (e.g. `update` method) that we would need to copy and paste...

Inheritance

- Classes can **inherit** from other classes

```
class SquareBall(Ball):
    def __init__(self):
        ...
```

- Here `Ball` is the **base class**, `SquareBall` is the **derived class** or **subclass**
- The subclass automatically has all fields and methods from the base class
- The subclass can add new fields and methods
- The subclass can also **override** methods from the base class

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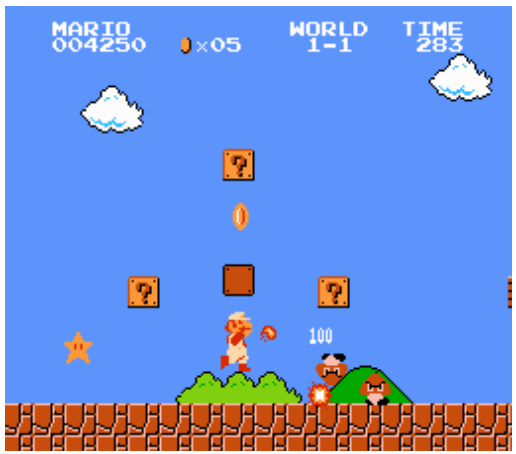
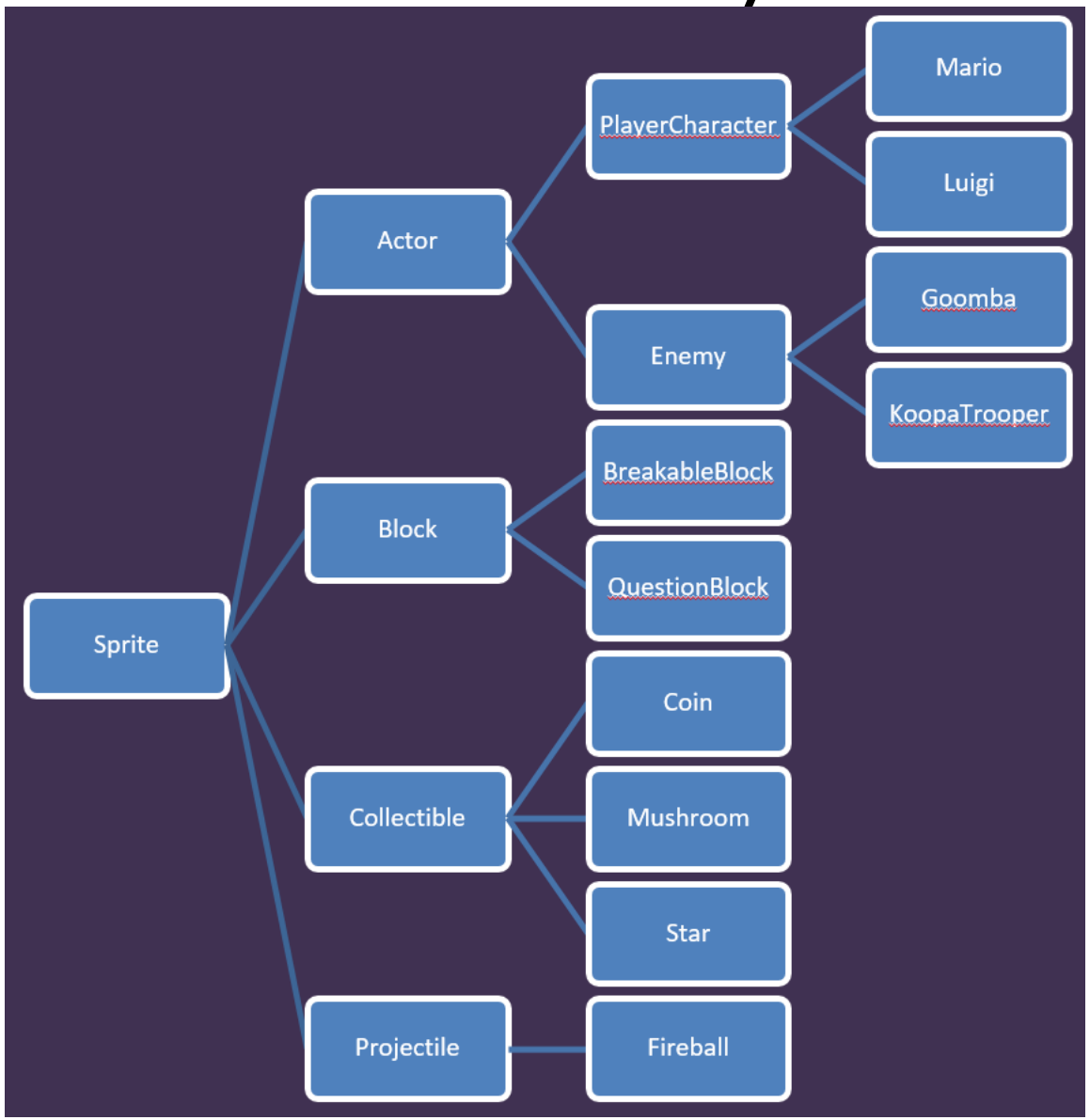
Inheritance hierarchy





Polymorphism

```
ball.draw(screen)
```

- Here `ball` might be an instance of `SquareBall`, `CircleBall` or `TriangleBall`
- Whichever it is, Python will execute the appropriate `draw` method
- The author of this code doesn't need to worry about squares, circles or triangles
- If we added a new shape class, everything works automatically
- This is **polymorphism** — the same code can use objects of many different classes
  - From Greek: "many-shape-ism"

Abstract classes and methods

- It no longer makes sense to instantiate `Ball` directly — it exists only as a base class for other classes
- `Ball` is an **abstract class**
- Similarly, `Ball.draw()` should never be called directly — all subclasses should override it
- `Ball.draw()` is an **abstract method**

Worksheet C