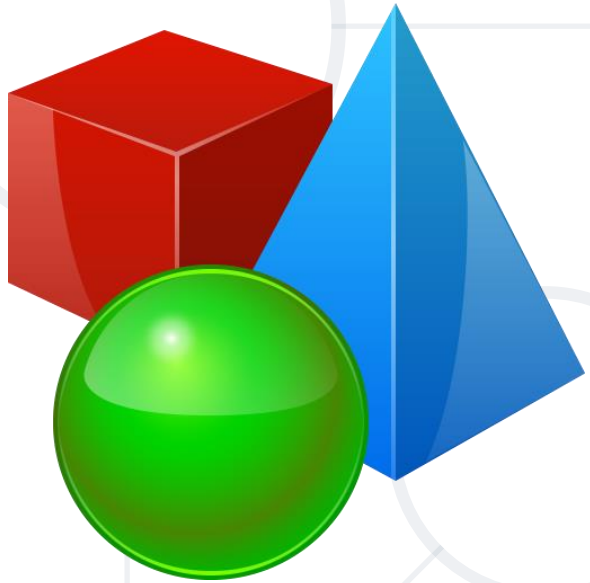
Objects and Classes

Enums, Objects, Class Definition & Members



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Special Types

Typedef and Enumerations

Typedef

- `Typedef`s allows creating aliases for existing types
  - Should be used within the problem's context
  - E.g.: `map<string, vector<int> >` to `StudentScores`
- Syntax: similar to declaring a variable, place `typedef` in declaration

```
typedef string tenStrings[10];
tenStrings words = { "the", "quick", "brown", "fox",
"jumps", "over", "the", "lazy", "dog", "!" };

typedef map<string, vector<int> > StudentScores;
StudentScores judgeAssignment2Scores;
```

Special Types

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Enumerations

Enumerations

- Enumerations contain a fixed list of special constant values
  - i.e. all possible values are known and can be written in code
  - Have some semantic meaning in the real world
- E.g. standard colors – red, green, blue, yellow, orange, etc.
- E.g. currencies – USD, BGN, GBP, etc.
- E.g. automobile fuel type – Petrol, Diesel, Electricity

Enumerations

- C++ has two enumeration types – `enum` and `enum class`

`enum` defines a list of named constant integers

```
enum color { red, blue, pink };
color eyeColor = blue;
// same as color eyeColor = 1;
```

`enum class` defines a new data type

```
enum class Color { red, blue, pink };
Color eyeColor = Color::blue;
/* Color eyeColor = 1 - invalid,
compile time error */
```

Enumerations

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Representing the Real World

Object-Oriented Programming

Representing the Real World in Code

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- So far our data types were essentially "just numbers"
  - `int`, `float`, and `double` are obviously numbers
  - `char` is also a number, although treated like a symbol
  - arrays of the above types are still just numerical data
- The physical world CAN be represented entirely by numbers
  - Computers work with `1`s and `0`s anyway
- What matters is not the data itself, but how you interpret it

Representing the Real World in Code

- In the real world, we usually talk about "**objects**"
  - e.g.: **Peter**, **United Kingdom**, **Zhivko's Car**
  - Objects have attributes/properties, e.g.: **age**, **population**, **fuel**
  - Objects can sometimes do things, e.g.: **talk**, **leave EU**, **break**
- There are usually multiple objects of the same **type/class**
  - **Peter**, **Churchill**, **Abd al Hakim**, and **Hanyu** are all people
  - **United Kingdom**, **India**, and **Egypt** are all countries
- Object-oriented programming focuses on such **classes & objects**

Object-Oriented Programming

OOP Concept and C++ OOP

Object-Oriented Programming

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- Introduces ways to group data into user-defined data types
  - E.g. a **`Person`** type, a **`Country`** type, a **`Car`** type, etc.
  - Variables defined in a user-defined type are called **"fields"**
- Such types are called **"classes"**
- Variables with such a type are called **"objects"**
- In addition to data, we can add functions to a **class**
  - Functions in a class are called **methods**

Objects and Classes

Classes

- In programming, **classes** provide the structure for **objects**
- User-defined data types
  - Act as a **template** for **objects** of the same type
- Definition contains the class "**members**":
  - Fields, Methods, Constructors, Destructors
- One class may have many instances (objects)

Objects

- Any variable of a `class`-defined data type
  - `Operator.` (dot) is used for accessing members of an object
- The **instance** is the object itself, which is created at runtime
- All instances have common **behavior**

Defining Classes

Defining Classes

- Specification of a given type of objects from the real world

```
class Dice {
access_modifier:
    members…
access_modifier:
  …
};
```

Class name

Key word

Class body

Don’t forget the ; after definition

- Members of a class are variables and functions
- Access modifiers - where members can be accessed from

Defining Classes – Example

- Person class
  - Age, Name, Height
- For now, ignore access modifiers – just place `public:` at the beginning
- Notice we can use data types that are themselves objects of classes
  - name here is an object of the STL class string

Access modifier

```
#include<string>
class Person {
public:
  std::string name;
  int age;
  double height;
};

int main(){
  Person p;
  return 0;
};
```

Defining C++ Classes

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Using Objects

Using Objects

- Creating a variable of a `class` data type
- Objects follow the same rules as normal variables
  - Can be passed as a copy to a function or by reference with `&`
  - Can be put into arrays, vectors, etc.
- Accessing members through an **`operator.`** (dot)
  - For access through an iterator, we use the **`operator->`**

Methods – Example

```
class Person {
  class Body {
  public:
    double height;
    double weight;
  };
public:
  string name;
  int age;
  Body body;
};
```

```
Person person;
person.name = "George Georgiev";
person.age = 25;
person.body.height = 1.82;
person.body.weight = 87;

Person otherPerson;
person.name = "Ana Ivanova";
person.age = 42;
person.body.height = 1.6;
person.body.weight = 54;
```

Using C++ Objects

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Constructors

Constructors

- **Constructors** initialize objects of a class
  - Follow same rules as functions, but without a `return` type
  - Can have overloads, default parameters, etc.

```
class Person {
  string name; int age = 0; double height = 0;
  Person(string pName, int pAge, double pHeight) {
    name = pName;
    age = pAge;
    height = pHeight;
  }
};
```

Class name

Parameters

Body

Calling Constructors

- Can be called on declaration directly

```
Person peter("Peter Brown", 31, 1.69);
```

  - Since C++11 can be called with { } brackets too:

```
Person peter{"Peter Brown", 31, 1.69};
```

- Can be used to create objects to pass to a variable/function:

```
Person peter{“Peter Brown”, 31, 1.69};
Person ivan = Person(“Ivan Ivanov”, 12, 1.52));
vector<Person> people;
people.push_back(Person(“Ana Ivanova”, 43, 1.60));
```

Default Constructor

- A constructor without parameters is a default constructor

```
Person() { name = "<unknown>"; }
```

  - Called when no other constructor is called

```
Person p; Person people[3];
```

  - Auto-generated if class has no other constructors
- If no default constructor for e.g. **`Person`**:
  - Default creation ~~`Person p;`~~ and ~~`Person p[3];`~~ won't compile
  - Some structures e.g.: ~~`vector<Person> people;`~~ won't compile

Constructors

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Quick Quiz

- What values will **p** have for its fields?

a) **name** empty, **age==0**, **height==0**

b) **name=="Ary O'usure"**, **age==42**, **height==1.3**

c) **name** empty, **age==42**, **height==1.3**

d) **name=="Ary O'usure"**, **age==0**, **height==0**

e) There will be a compilation error

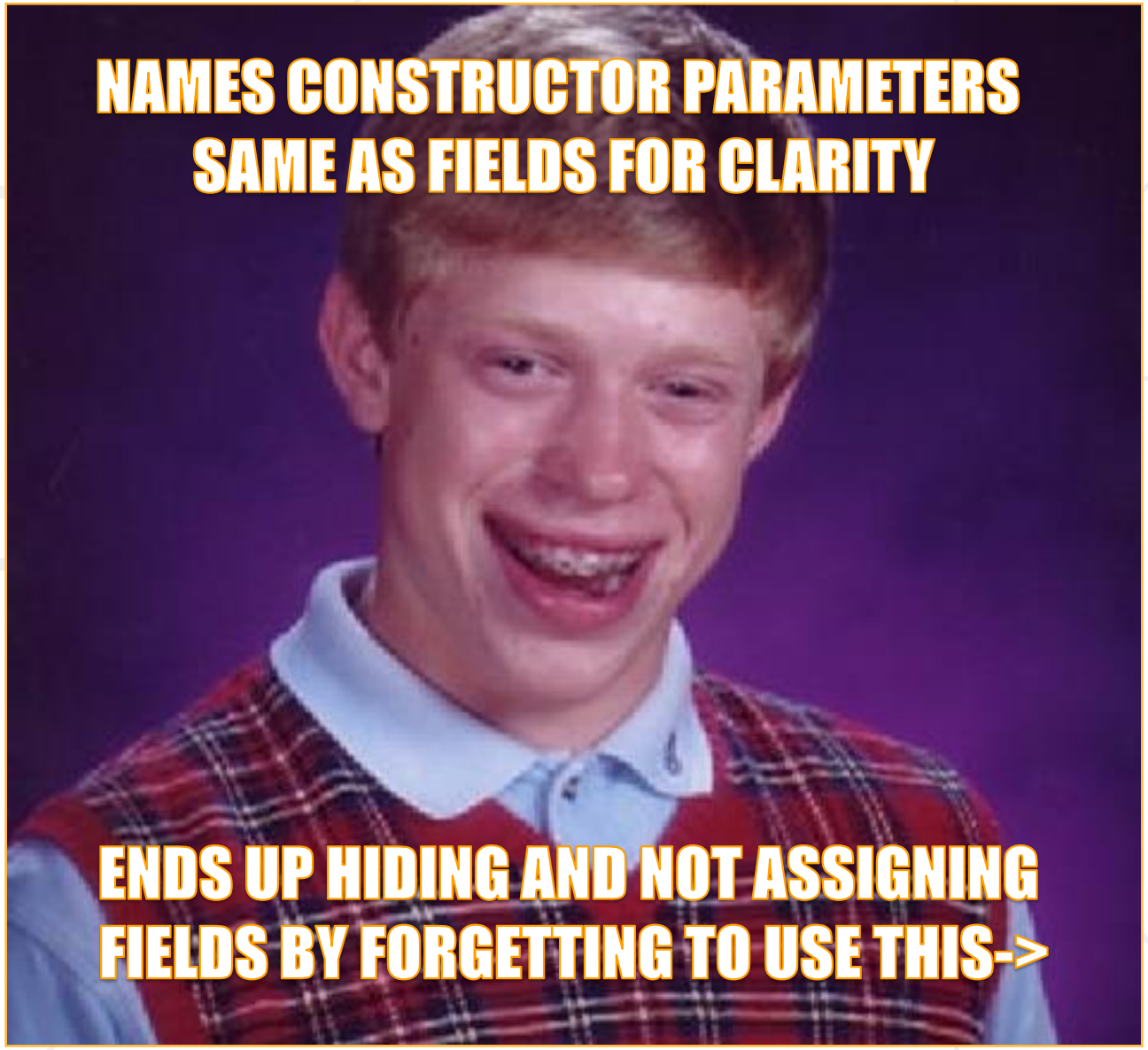
```
class Person {
    public:
    string name;
    int age = 0;
    double height = 0;
    Person(string name,
           int age,
           double height) {
        name = name;
        age = age;
        height = height;
    }
};
…
Person p("Ary O'usure",
         42, 1.3);
```

PITFALL: HIDING FIELDS WITH PARAMETERS

The parameter names match the field names here.

When there is such a conflict, the “more-local” variable hides the “less-local” variable.

So, the constructor in this case will assign the parameters with their own values and not see the fields at all.



The `this` Pointer

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The this Pointer

- C++ gives us **this** pointer to explicitly access class members
- **this** points to whatever the current object is
- Very useful in any method where parameters match the fields

```
Person(string name, int age, double height) {
  this->name = name;
  this->age = age;
  this->height = height;
};
```

- There is a convention to always use **this**, even if not needed

Pitfall: Hiding Fields

Solution: Using `this->`

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Constructor Initializer List

C++ Constructor Initializer List

- Constructor body is **always** executed **after** a member creation
- C++ constructors are typically written with initializer lists:

```
ClassName(parameters) :
    member1(member1Parameters),
    …
    memberN(memberNParameters) {
}
```

  - Executes before the body
  - If a member is omitted, it is default-constructed (if possible)
  - This syntax is also immune to the member-hiding problem

Constructor Initializer List

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Simple Methods

Methods

- Methods are functions declared inside a class
  - Follow the same rules as normal functions
  - Compiler knows which methods belong to which class
  - E.g.: size(), begin(), sort() are methods in the list class
- Methods can access class fields and other members directly
  - Can read and write fields, call other methods, etc.
  - Can use this-> to explicitly refer to members

Methods – Example

A method for printing information

```
void printPersonInfo() {
    cout << "name: " << this->name
    << ", age: " << this->age
    << ", height: " << this->body.height
    << ", weight: " << this->body.weight
    << endl;
}

A method for aging up

void makePersonOlder(int years) {
    this->age += years;
}
```

Simple Methods

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Code Quality Issues of the Last Example

- Should a **`Person`** know about and access the console?
  - Low cohesion – the class knows more than its name suggests
- Should a **`Person`** directly access a **`Body`**?
  - *No, that's not what I meant!... But.. if you're interested…*
  - Bad encapsulation & high coupling – class has access to implementation details of another class
- Do we need "Person" in method names on a **`Person`** class?
  - They all work on the **`Person`** class, no need to write it everywhere

Methods – Refactoring for better Quality

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- This is somewhat better

```
class Person {
  ...
  void makeOlder(int years) {
    this->age += years;
  }
  ...
  string getInfo() {
    ostringstream info;
    info << "name: " << this->name
      << ", age: " << this->age
      << ", " << this->body.getInfo();
    return info.str();
  }
};
```

Methods – Refactoring for better Quality

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```
class Person {
  class Body {
    ...
    string getInfo() {
      ostringstream info;
      info << "height: " << this->height
           << ", weight: " << this->weight;
      return info.str();
    }
  };
  ...
};
```

Refactoring Methods

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Access Modifiers

Encapsulation, Getters and Setters

Encapsulation (1)

- Do you see a problem in the following code?
  - We're updating the **radius**, but that doesn't update the **area**

```
const double PI = 3.14;

class Cirsle {
public:
  double radius;
  double area;

  circle(double radius) :
    radius(rasius),
    area(radius * radius * PI) {}
};
```

```
int main() {
  Circle c(10);
  c.radius = 20;
  cout << c.area << endl;
  return 0
}
```

Encapsulation (2)

- Encapsulation – hiding internal state & operations from outside
  - And providing a controlled interface for interactions
  - *You usually don't have direct access to a car's engine - but you have pedals, a gear lever, etc.*
- A class should keep its internal state correct
  - Hide its members so external code doesn't use them incorrectly
  - Have public methods that access members correctly
- Encapsulation makes code simpler
  - *You don't need to know how a specific class works to use it*

`public` and `private`

- Access modifiers
  - Control whether external code has member access
  - `public` – access both by code "outside" & "inside" the class
  - `private` – access ONLY to code "inside" the class
- Every member has that access after an access modifier
  - Until another modifier is encountered
  - Access modifiers can set the access for multiple members

Adding Encapsulation in C++

- Let's encapsulate our **`Circle`**'s member fields:
  - **`private`** access **`radius`** & **`area`**
  - **`public`** constructor
  - Now we can create **`Circle`**s, but external code can't access **`radius`** and **`area`**
- But how can we print the **`area`** now or change the **`radius`**?
  - We still need to add public methods for interaction

Adding Encapsulation in C++

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```
class Circle {
private:
 double radius;
 double area;
public:
  Circle(double radius) :
    radius(radius),
    area(radius * radius * PI) {}
};
```

Getters and Setters

- "Getter" & "Setter" – common names for some **specific methods**
- Getter – **public** method returning a value of **private** member

```
double getArea() { return this->area; }
```

  - Can sometimes calculate what to return (e.g. calculate **area**)
- Setter – **public** method assigning a value of **private** member
  - Keeps internal state correct while giving access to external code

```
void setRadius(double radius) {
  this->radius = radius;
  this->area = radius * raduis * PI;
}
```

Getters and Setters – Example (1)

```
class Circle {
private:
  double radius;
  double area;
public:
  circle(double radius) :
    radius(radius),
    area(radius * radius * PI) {}

  double getRadius() { return this->radius; }
  double getArea() { return this->area; }
  void setRadius(double radius) {
    this->radius = radius;
    this->area = radius * radius * PI;
  }
};
```

Getters and Setters – Example (2)

```
int main() {

  Circle c(10);
  cout << c.getArea() << endl;

  c.setRaduis(20)
  cout << c.getArea() << endl;

  return 0;
}
```

C++ struct vs class

C++ struct vs class

- In C++ **`struct`** and **`class`** mean exactly the same thing, except:
  - **`class`** by default uses **`private:`** at the start
  - **`struct`** by default uses **`public:`** at the start
  - i.e. **`class`** with the **`public`** at the the start is the same as a **`struct`**

```
class C {
public:
};
```

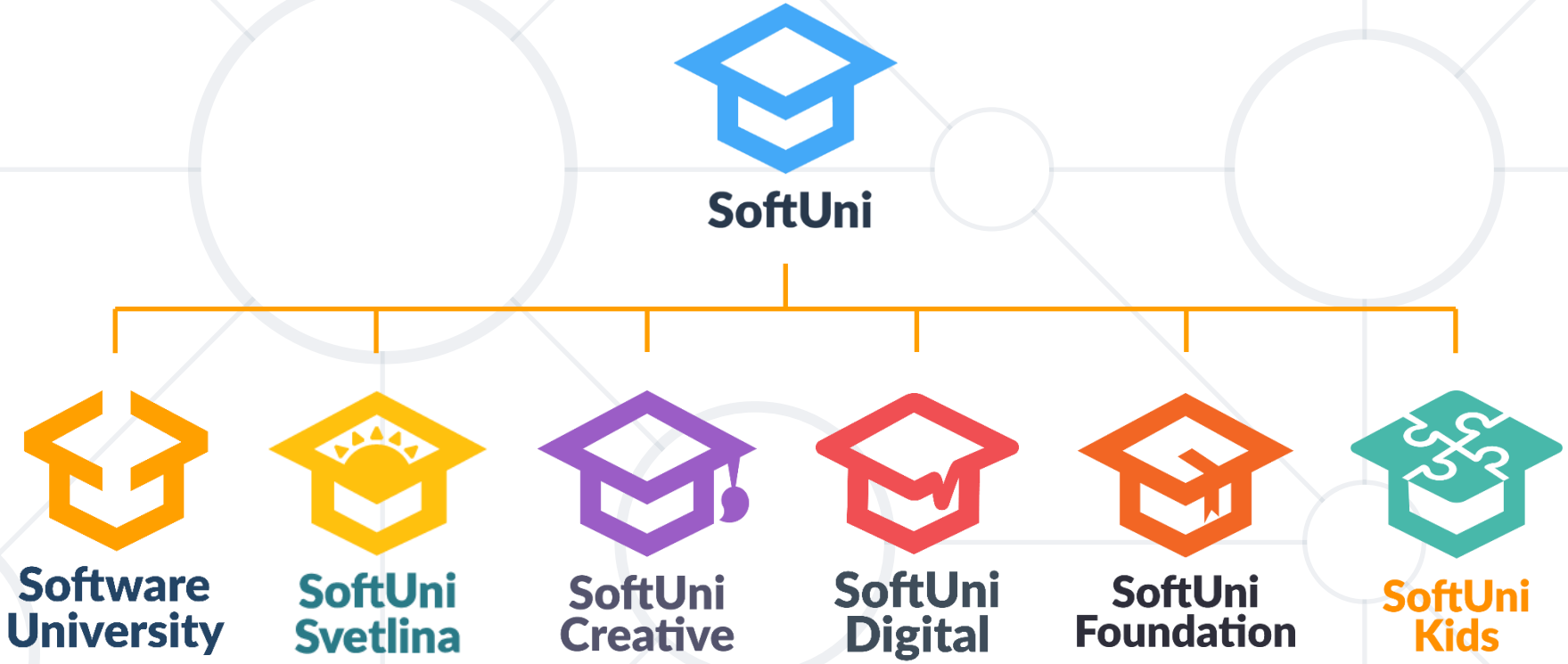
```
struct C {
};
```

- The C++ community usually prefers class to actual classes
  - **`struct`** is sometimes used for *Plain Old Data* (POD) objects – no constructors, no methods, etc., only public-access fields

Summary

- Typedefs allow shortening code by creating **type aliases**
- Enumerations are types with user-defined values
- Classes define templates for objects
  - **Fields**, **Methods**, **Constructors**, **Destructors**
- Objects is an **instance** of a class
- Classes should **encapsulate** their internal state
  - And provide **methods** for **interaction**

Questions?



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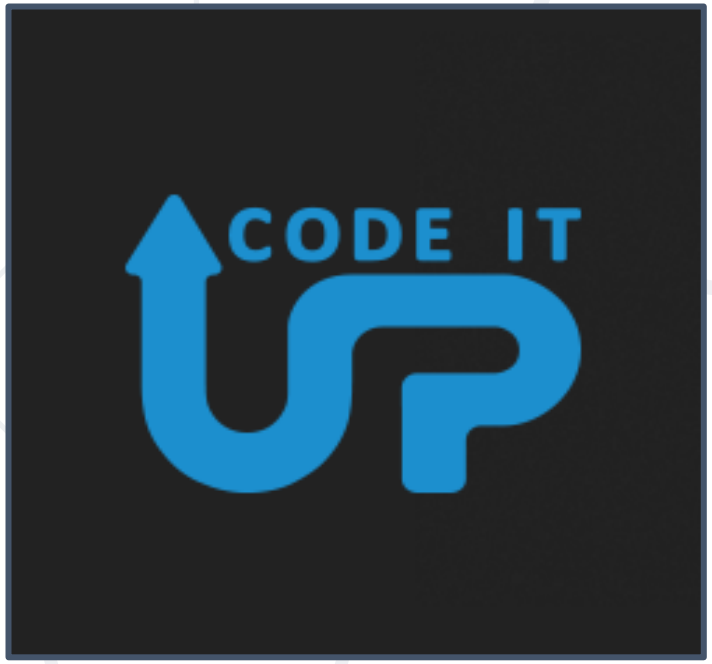

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