Unit 02:
Classes and Objects

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CSC 115: Fundamentals of Programming II

University of Victoria

Unit 01 Overview

- Related Reading:
  - Textbook pages 23-25
- Learning Objectives: (You should be able to…)
  - create and use your own objects and classes in Java
  - describe what it means to create an instance of a class
  - describe the purpose of the following:
    - data fields
    - constructors
    - setters and getters (or accessors and mutators)
    - toString
  - describe the difference between non-static and static methods

Classes and Objects

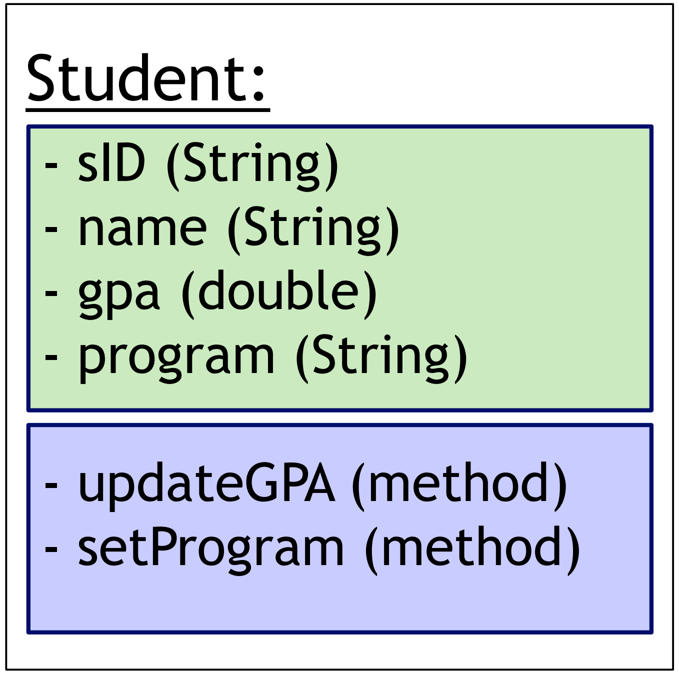
- So far the variables we have created have allowed us to represent numbers and text…
- … but sometimes the information we work with in our programs cannot be adequately represented by a single number or text

- Example:
  - We could represent a song with simply a title…
  - … but we may also want to know about the artist, duration, genre, etc.

  - Similarly, we could represent a student by a student number…
  - … but we may also want to know their name, program, gpa, etc.

Classes

- Classes allow us to define our own data types by defining:
  - their **attributes** (that help us differentiate one from another)
  - and **associated behaviours** (what operations we can do with it)
- Student example:



Student:

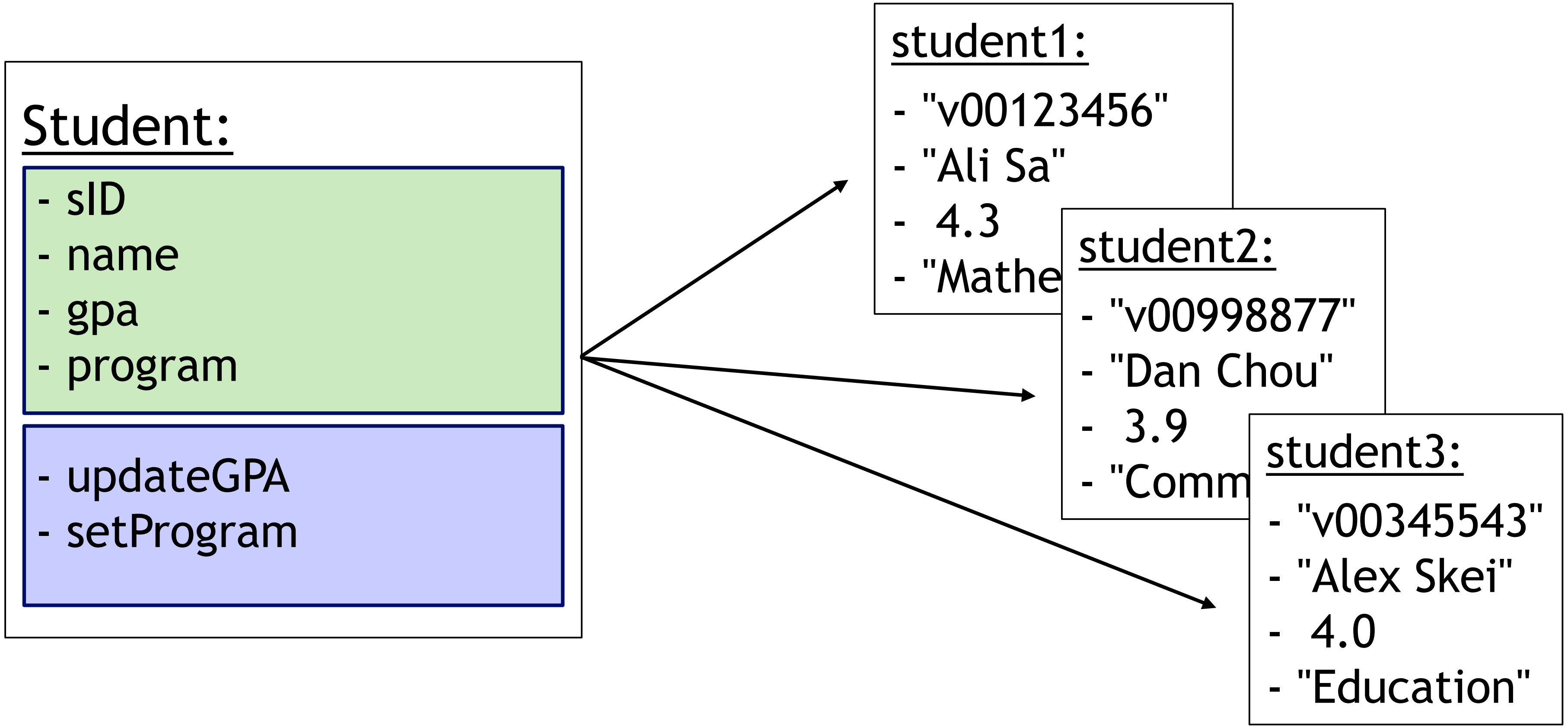
- sID (String)
- name (String)
- gpa (double)
- program (String)

- updateGPA (method)
- setProgram (method)

We can think of a class as the blueprint for an object

Classes and Objects

- We consider a class the blueprint for an object…
- … when we create an object we say that it is an *instance* of a class



Classes and Objects

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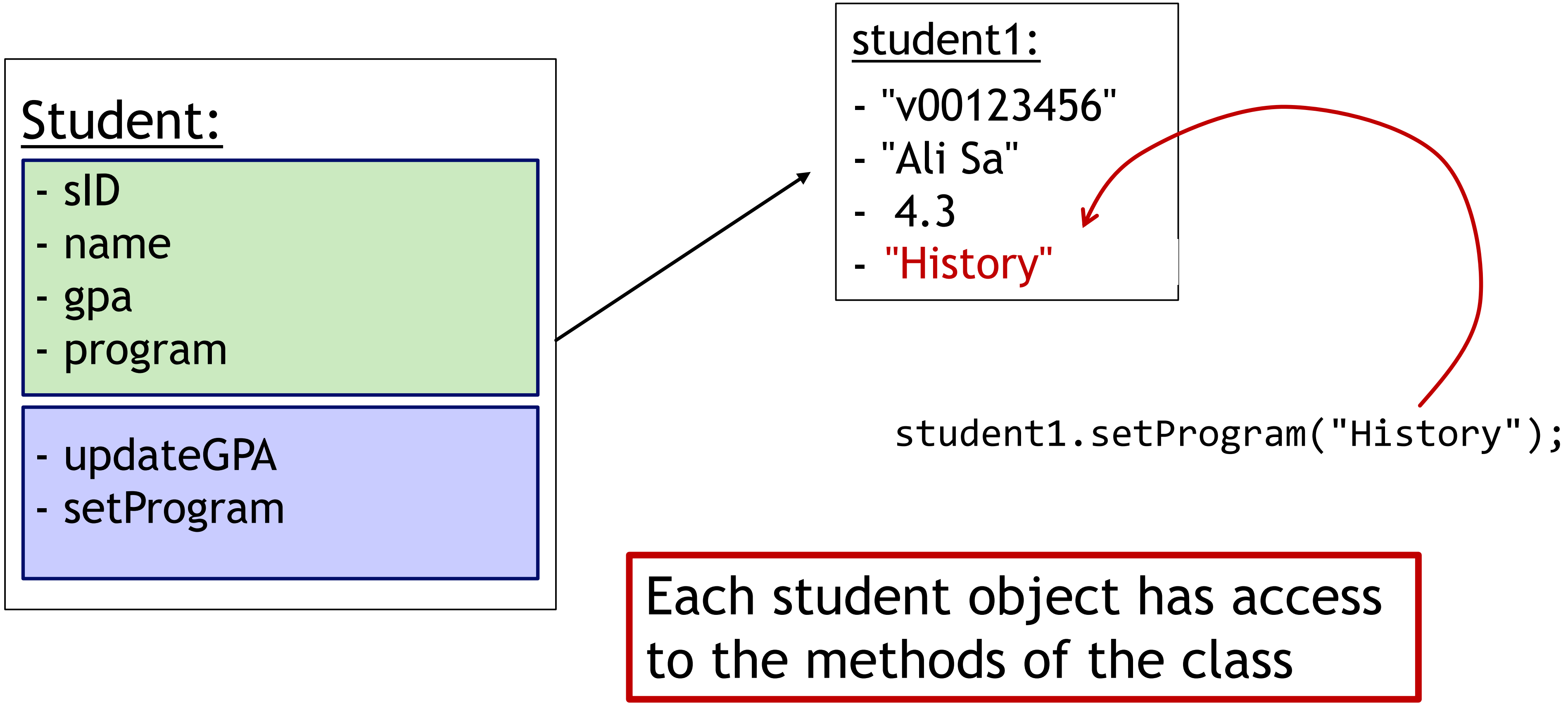
- ... when we create an object we say that it is an *instance* of a class



Student:

- sID
- name
- gpa
- program

- updateGPA
- setProgram

student1:

- "v00123456"
- "Ali Sa"
- 4.3
- "History"

```
student1.setProgram("History");
```

Each student object has access to the methods of the class

Fields

- Another name for a class attributes is a **field**

- **Fields** can be accessed and updated like variables:
  - output: `System.out.println(fieldname);`
  - modify: `fieldName = newValue;`

- For example:
  - The Student class has four fields
  - The student1 object is an instance of the Student class
    - The diagram on the right illustrates the values for each field

<u>student1:</u>

- sID: "v00123456"
- name: "Ali Sa"
- gpa: 4.3
- program: "Mathematics"

Initializing Objects

- **new**: the new keyword allocates memory for a new instance of a class:

```
Student s1 = new Student();
s1.sID =  "v00123456";
s1.name = "Ali Sa";
```

These lines of code both call the Student class’ **Constructor**

- There is a way to initialize the values of an object’s fields when it is first declared:

```
Student s1 = new Student("v00123456", "Ali Sa", …);
```

Constructor

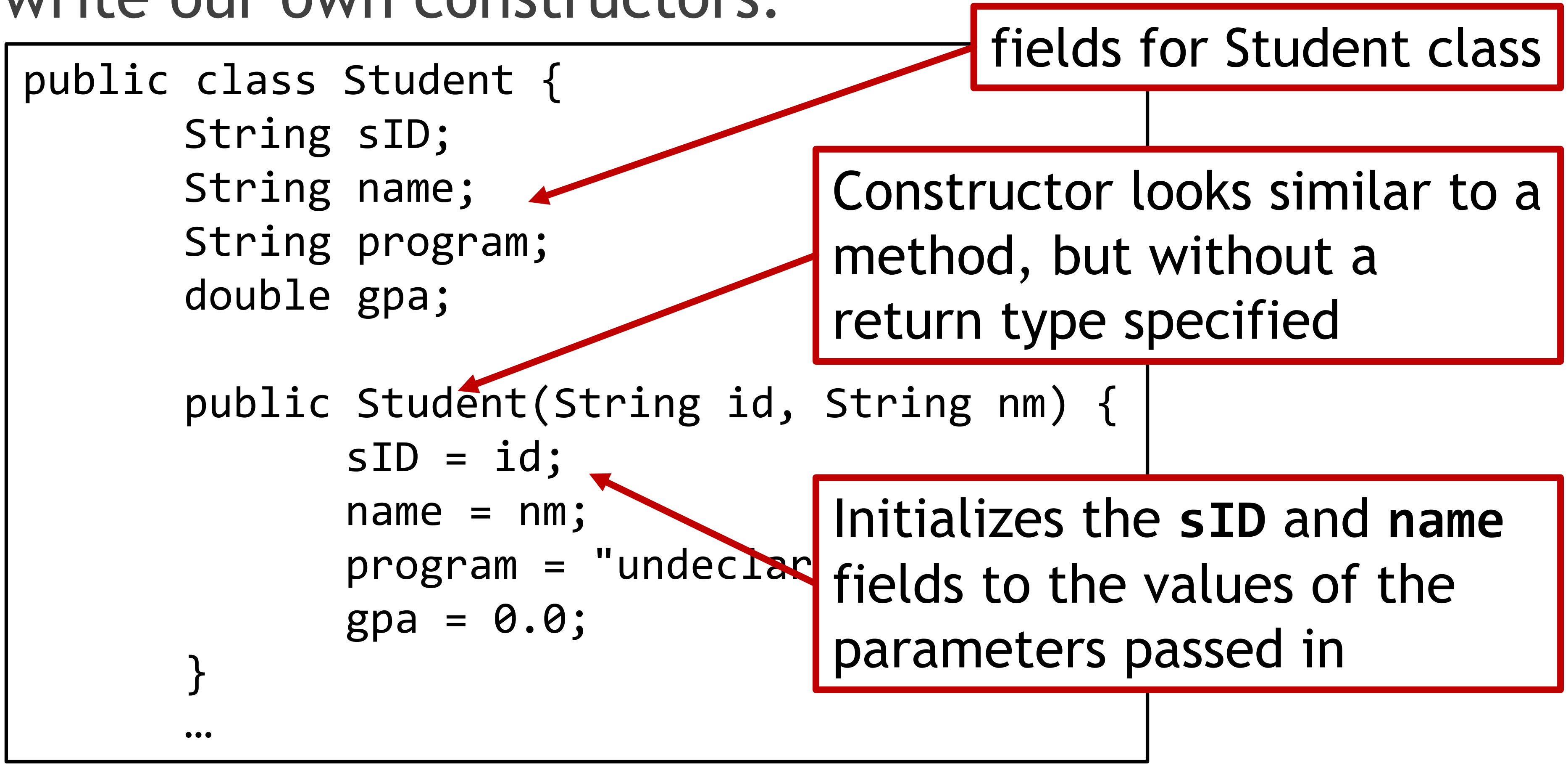
- The **constructor** initializes the **field** values when an object is created
- The **constructor** is automatically called when the `new` keyword is used
- General syntax:

```
public Name(parameters) {
    statements;
}
```

- A constructor looks similar to a method, with some key differences:
  - the name of the constructor *always* matches the class name
  - no `return` type is specified
    - constructors implicitly return the new object being created

Constructor

- If a class has no constructor, Java gives it a default constructor with no parameters that sets all fields to 0 or null
- We can also write our own constructors.
  - Example:



```
public class Student {
      String sID;
      String name;
      String program;
      double gpa;

      public Student(String id, String nm) {
            sID = id;
            name = nm;
            program = "undeclar
            gpa = 0.0;
      }
      …
```

fields for Student class

Constructor looks similar to a method, but without a return type specified

Initializes the **sID** and **name** fields to the values of the parameters passed in

Constructor – code trace

In Student.java:

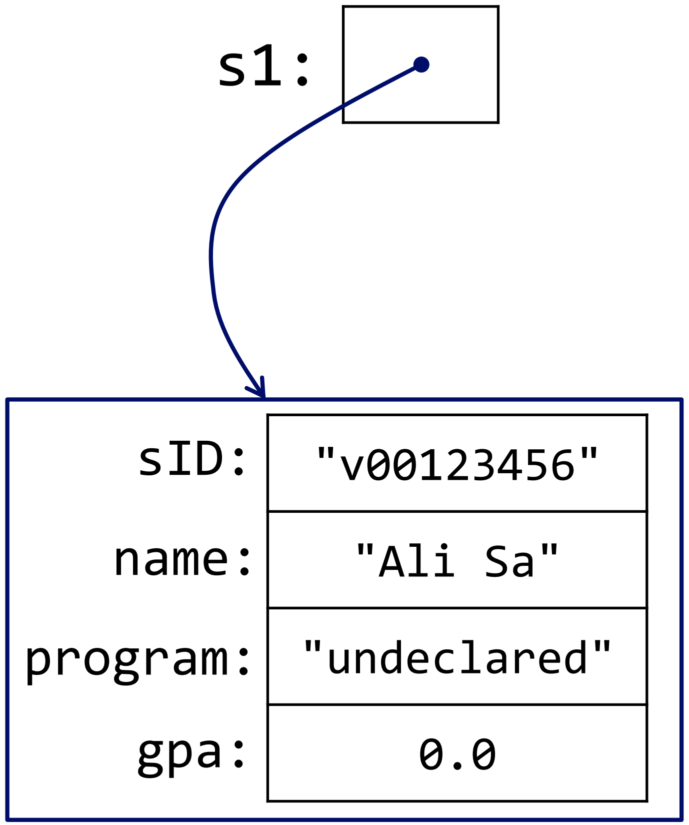
```
public Student(String id, String nm) {
        sID = id;
        name = nm;
        program = "undeclared";
        gpa = 0.0;
}
```

In a different program:

```
Student s1 = new Student("v00123456", "Ali Sa");
```

We are calling the constructor here:

Memory:



s1:

sID: "v00123456"

name: "Ali Sa"

program: "undeclared"

gpa: 0.0

Multiple Constructors

- A class can have multiple constructors
- Each constructor must have a unique set of parameters
    - This is similar to how methods can have the same name, but have a unique set (number and types) of parameters
- When we create a new instance of an object with the **new** keyword, and then call a constructor…
    - the constructor called will be based on the parameter list we call it with

Access Modifiers

- So far, our examples have all used the `public` keyword
- The `public` keyword is an **access modifier**

- Access modifiers:
  - **`public:`** allows accessibility by any other class
  - **`private:`** only accessible within the declared class
  - **`protected:`** only accessible by classes within the same package, or by subclasses (we will learn about these later)

Student example

- We can set the access modifiers for all of our fields to private:

```
public class Student {
      private String sID;
      private String name;
      private String program;
      private double gpa;

      …

}
```

- Now we will need another way to work with these fields!

Accessor / Mutator methods

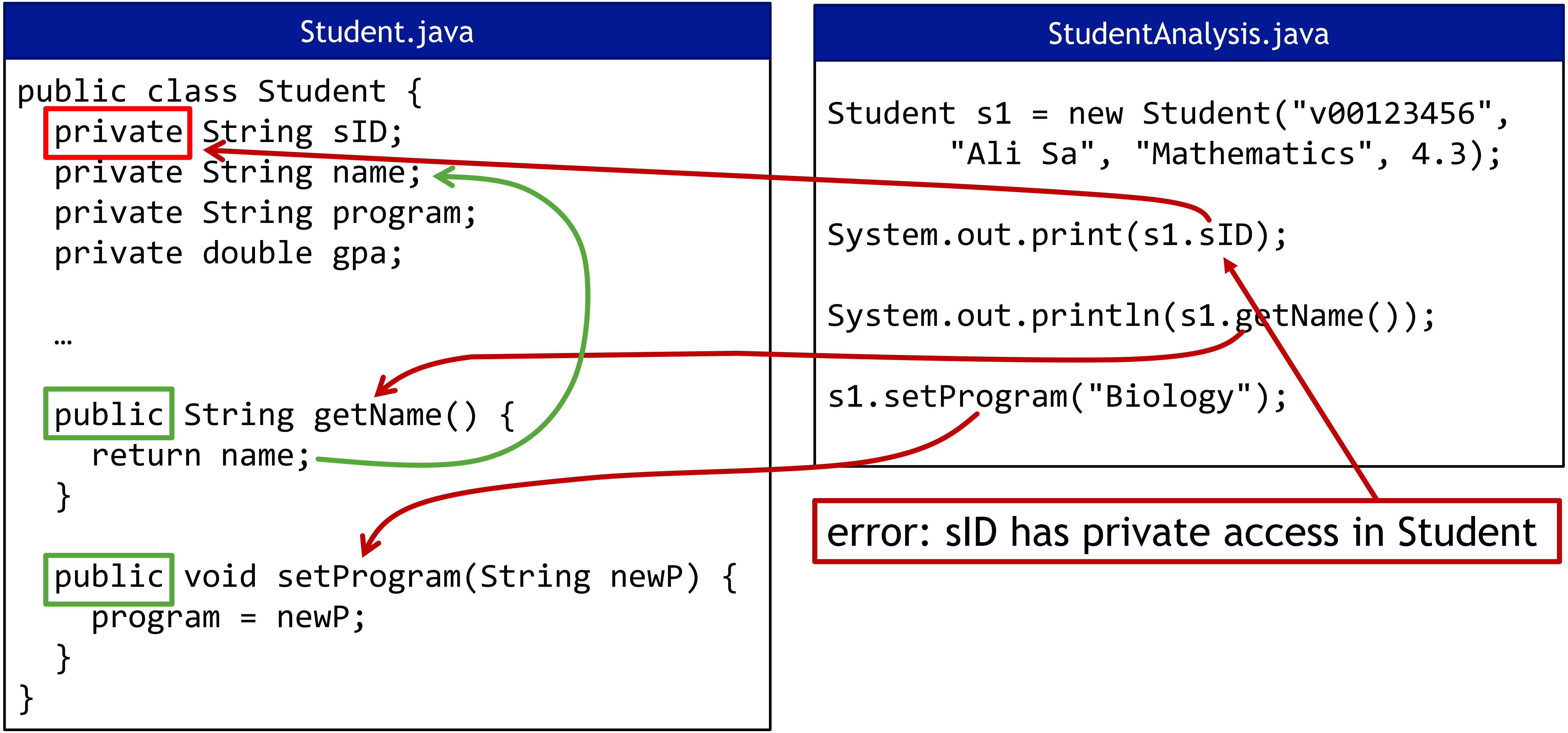
- Sometimes called “getters” and “setters”
- Typically, many fields within a class are not publicly accessible
- Instead, we will define methods that allow us to access (get) or mutate (set) the values of fields indirectly

```
public String getProgram() {
    return program;
}
public void setProgram(String newProgram) {
    program = newProgram;
}
```

These methods are public so can be accessed by other classes

These methods are defined within the Student class, so they can access private fields

Accessor and Mutator Example



Student.java

```
public class Student {
  private String sID;
  private String name;
  private String program;
  private double gpa;

  …

  public String getName() {
    return name;
  }

  public void setProgram(String newP) {
    program = newP;
  }
}
```

StudentAnalysis.java

```
Student s1 = new Student("v00123456",
      "Ali Sa", "Mathematics", 4.3);

System.out.print(s1.sID);

System.out.println(s1.getName());

s1.setProgram("Biology");
```

error: sID has private access in Student

The toString method

- The `toString` method returns a String representation of an object
- It is up to the programmer to decide what information is present in String representation of the object
- This method is automatically called when we print out an object

toString example

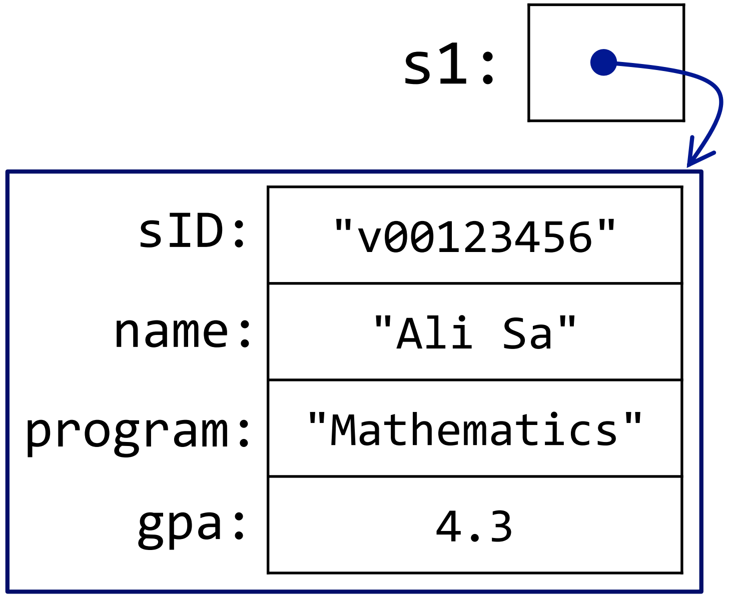
Student.java

```
public class Student {
  private String sID;
  private String name;
  private String program;
  private double gpa;

  …

}
```

StudentAnalysis.java

```
Student s1 = new Student("v00123456",
      "Ali Sa", "Mathematics", 4.3);

System.out.print(s1);
```

Memory:



sID:	"v00123456"
name:	"Ali Sa"
program:	"Mathematics"
gpa:	4.3

Output: **Student@5ca881b5**

toString example

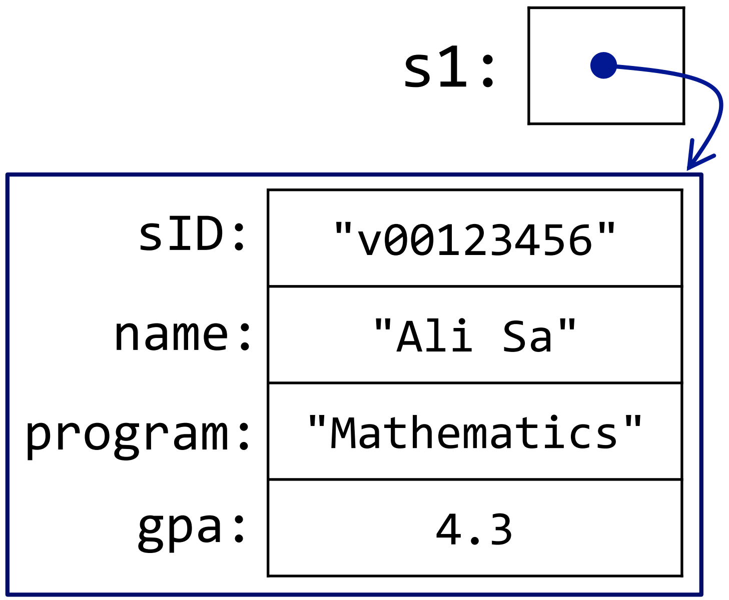
Student.java

```
public class Student {
  private String sID;
  private String name;
  private String program;
  private double gpa;


  …

  public String toString() {
    String s = name + " – " + sID;
    return s;
  }
}
```

StudentAnalysis.java

```
Student s1 = new Student("v00123456",
      "Ali Sa", "Mathematics", 4.3);

System.out.print(s1);
```

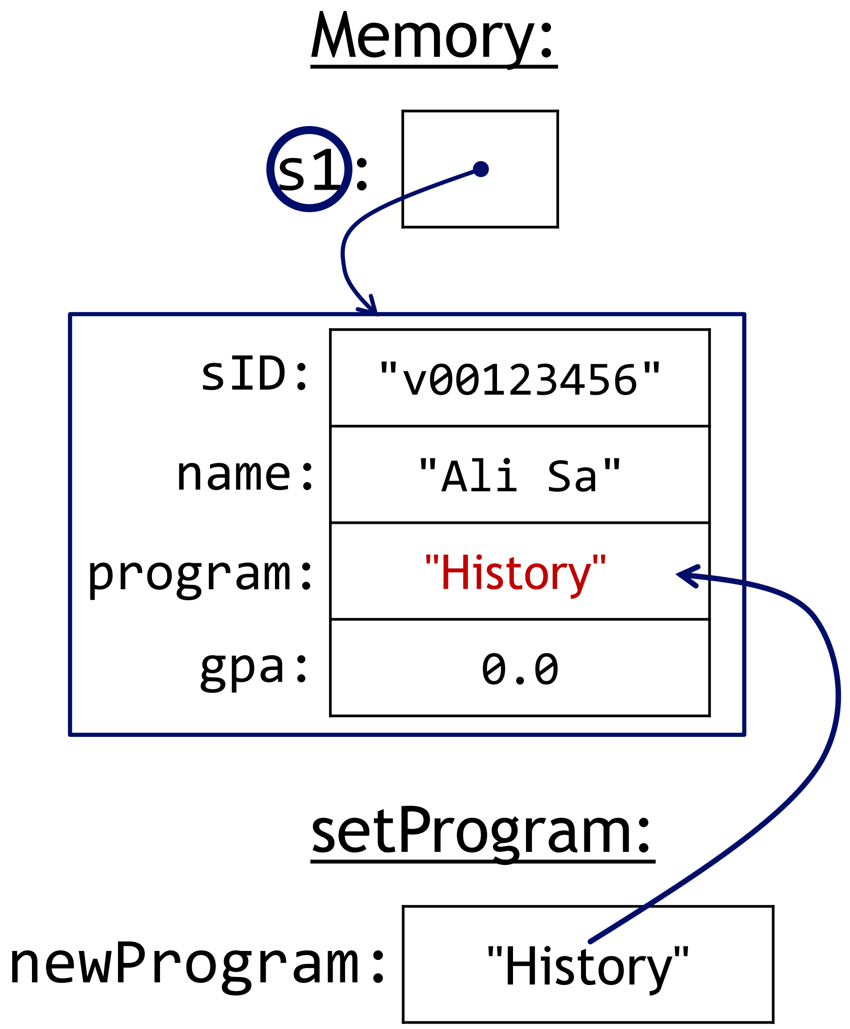
Memory:



Output: **Ali Sa - v00123456**

The this keyword

```
public class Student {
    private String sID;
    private String name;
    private double gpa;
    private String program;

    …                        s1.setProgram("History");

    public void setProgram(String newProgram) {
        program = newProgram;
    }
}
```



Memory:

s1:

sID: "v00123456"

name: "Ali Sa"

program: "History"

gpa: 0.0

setProgram:

newProgram: "History"

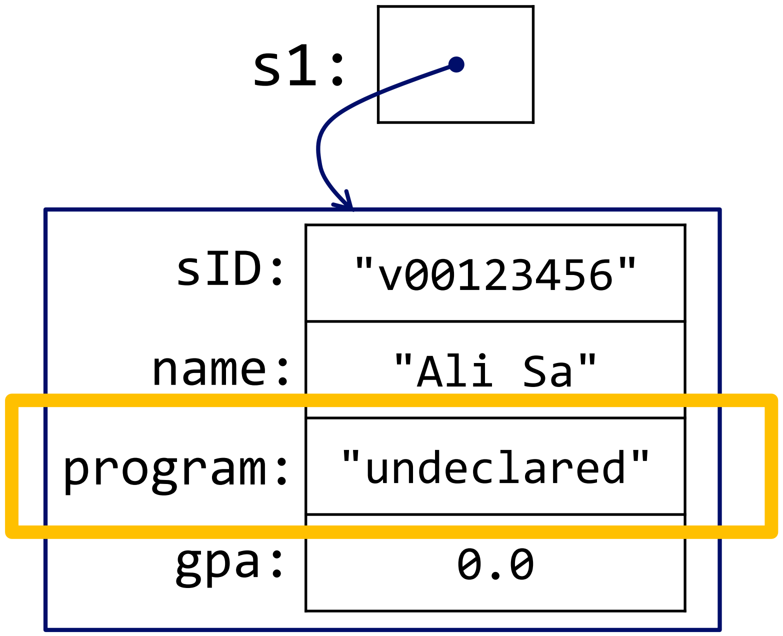
The **this** keyword

```
public class Student {
   private String sID;
   private String name;
   private double gpa;
   private String program;

   …

   public void setProgram(String program) {
      System.out.println(program);
   }
}
```

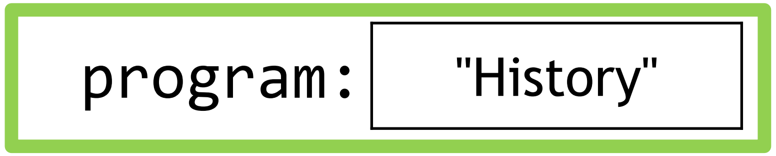
```
s1.setProgram("History");
```

What is output?

Memory:



setProgram:



The **this** keyword

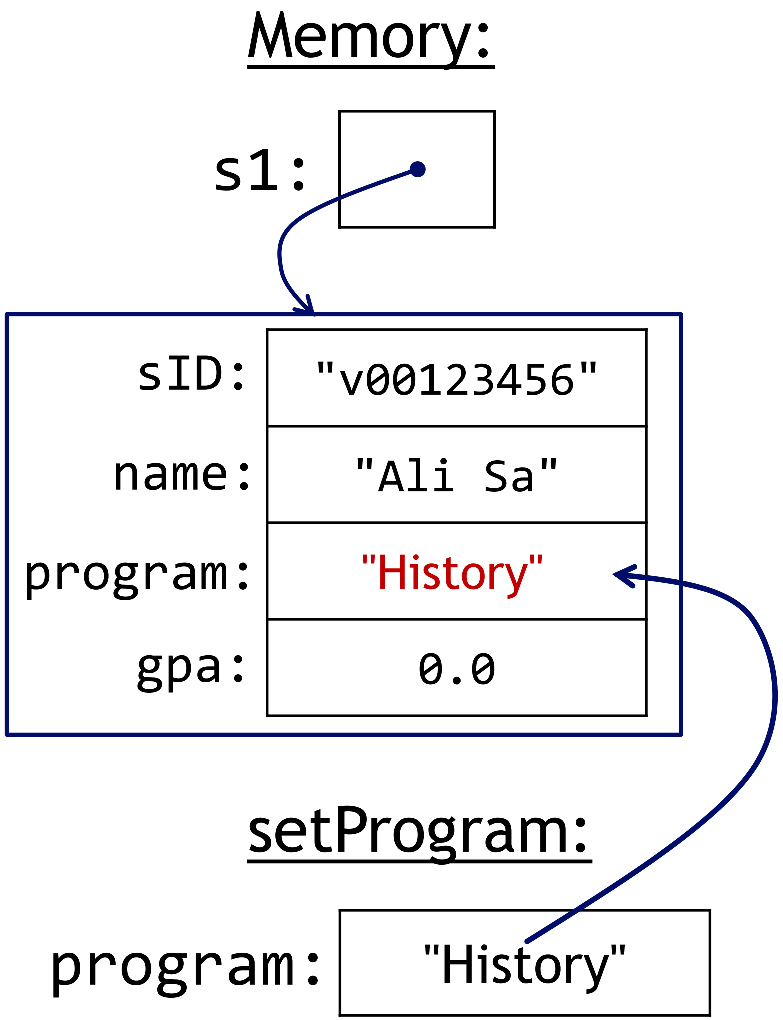
```
public class Student {
    private String sID;
    private String name;
    private double gpa;
    private String program;

    …

    public void setProgram(String program) {
        this.program = program;
    }
}
```

we use **this** to refer to something that is part of the class

```
s1.setProgram("History");
```

refers to the class instance variable (field)

refers to the parameter



The **this** keyword

- We often use the **this** keyword in our constructors:

We use **this** to refer to the instance variables (fields). In the constructor, we want to initialize these with values passed in as parameters.

```
public class Student {
    private String sID;
    private String name;
    private double gpa;
    private String program;

    public Student(String sID, String name, double gpa, String program) {
        this.sID     = sID;
        this.name    = name;
        this.gpa     = gpa;
        this.program = program;
    }
```

Static vs. Non-Static

- A **static** method means that it can be accessed without creating an object of the class
  - typical for generic methods that operate on data passed in as a parameter
  - example: the methods in our ArrayOperations.java file
  - **CANNOT** access instance variables within a class

- An **instance** method is defined within a class
  - instance methods are called on instance of a class
  - operate on the object's instance variables (fields)

Static vs. Non-Static

- A **static** method operates on the parameters it is passed
  - Utility methods:
    - Operations that work on the array passed in as a parameter
    - Operations you might find on a calculator
  - These aren’t associated with instances of an object (or that object’s fields)

- An **instance** method operates on an object and the object’s fields
  - Student class:
    - update information about the student
  - Song class:
    - update information about the song’s title or artist, add time to the duration, etc.

Static vs. Non-Static

- A **static** variable is not associated with each specific instance of a class
- Whereas each object has its own values for each of its **instance** variables (fields)

- Example:

```
public class BankAccount {
    String id;
    double savings;
    static double interestRate = 0.05;
```

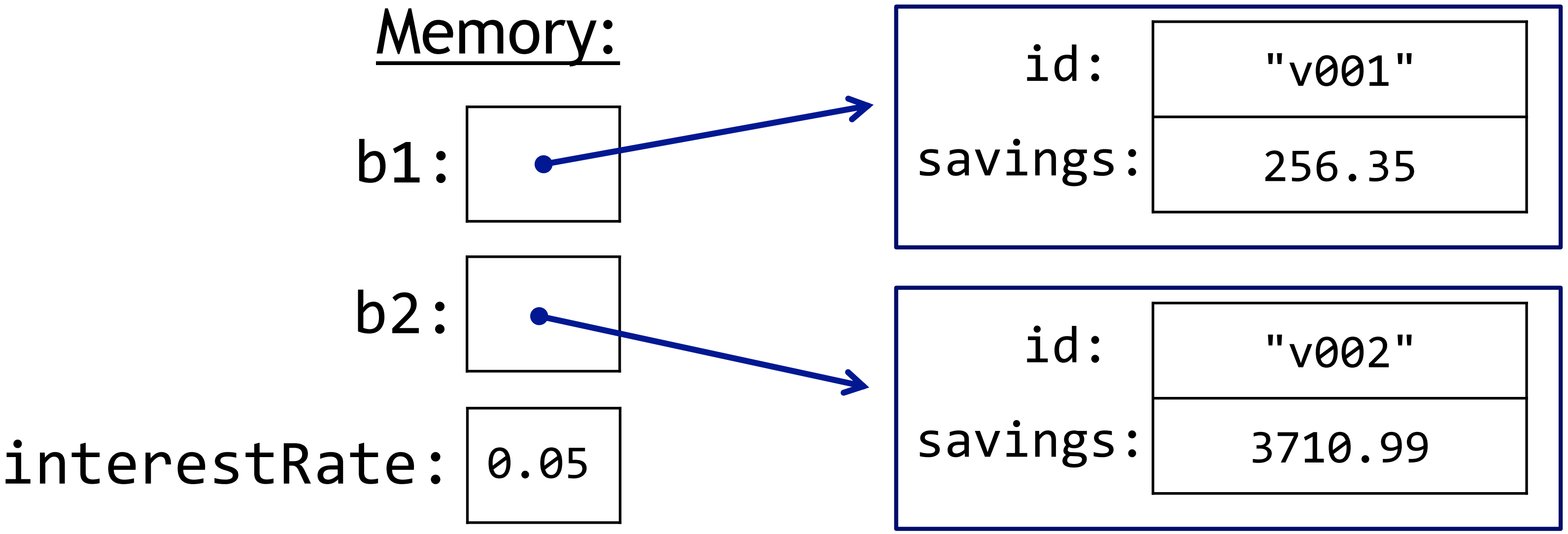
Each BankAccount object will have it’s own id and amount of money in their savings account

There is only one interestRate that is shared by all BankAccounts

Static vs. Non-Static

- Example:

```
BankAccount b1 = new BankAccount("v001", 256.35);
BankAccount b2 = new BankAccount("v002", 3710.99);
```



Each instance of an object has memory allocated for each of its instance variables (fields)

We only need to allocate memory for static variables once

Equality example

- Often we want to check for equality in our programs
- For example:
  - Searching through a database for a particular item
  - Searching through a list to count the number of occurrences of something

- We use the == to determine if two primitive type variables are equal to one another
  - This works for variables of type `int`, `double`, `boolean`, etc.
  - It's not quite as simple for Strings, arrays, or objects

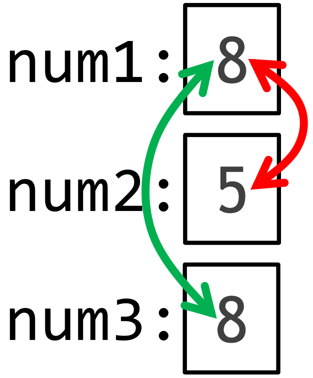
Equality example

- It all comes down to how the data is stored in memory

- For primitive types:

```
int num1 = 8;
int num2 = 5;
int num3 = 8;
```

Memory:



num1: 8

num2: 5

num3: 8

- `num1 == num2` evaluates to `false`
- `num1 == num3` evaluates to `true`

Equality example

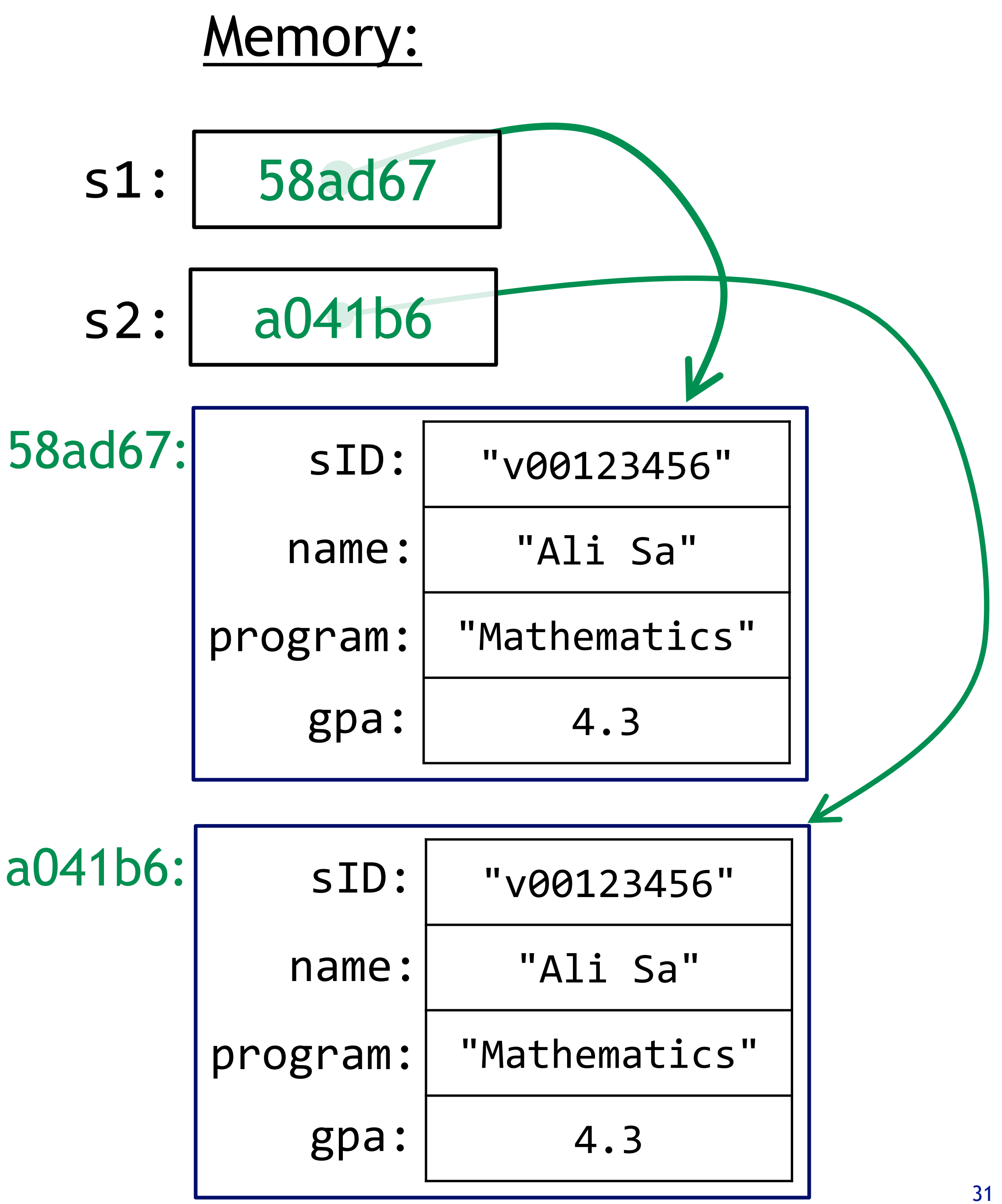
- It all comes down to how the data is stored in memory

- For objects, Strings, and arrays, the same thing happens
  - Using == still compares two values in memory…

- But we need to consider what the values of our variables are
  - Remember that for these types the variable is referencing a location in memory where the data we associate with the particular object is stored
  - So although it is possible to use == to compare two objects, the operation likely isn’t doing what we intended it to do
  - Let’s take a look

Equality example

- Assume we have two student objects
  - And associate both s1 and s2 with Ali
- We can see they are equal
  - but == determines if the two values stored in memory are equivalent
- What are the values of s1 and s2?
  - s1 and s2 store the memory address of where the object data is being stored
  - We typically visualize this as an arrow pointing to the location in memory



Memory:

s1: 58ad67

s2: a041b6

58ad67:

sID:	"v00123456"
name:	"Ali Sa"
program:	"Mathematics"
gpa:	4.3

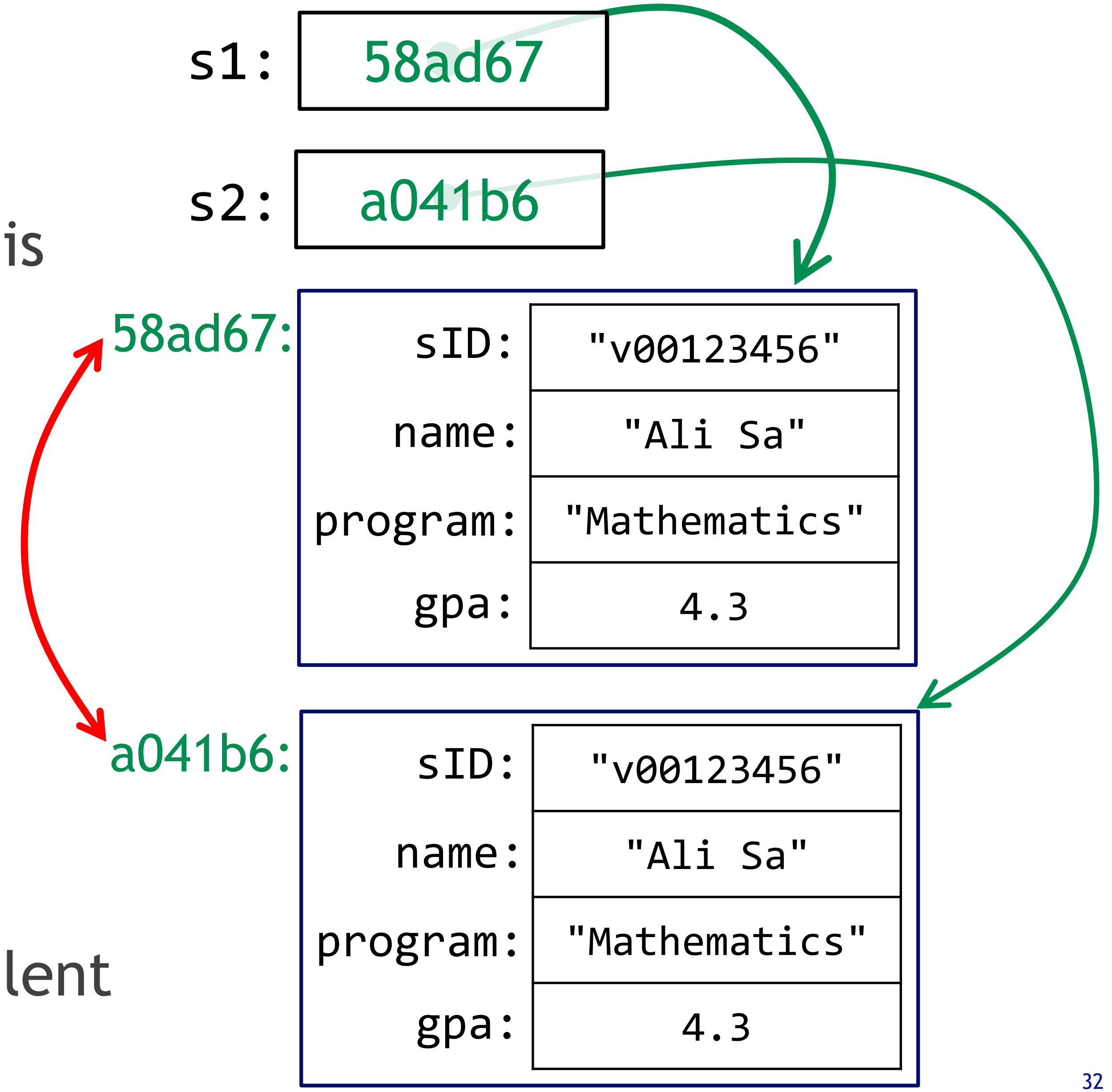
a041b6:

sID:	"v00123456"
name:	"Ali Sa"
program:	"Mathematics"
gpa:	4.3

Equality example

- So let’s consider what == does here:
- `s1 == s2` is checking if the value 58ad67, which is a memory address, is equal to the value a041b6
  - The two addresses are not the same!
  - So `s1 == s2` evaluates to false
  - Which likely is not what we wanted or expected
- Instead we will add a method to the Student class that allows us to determine if two students are equivalent

Memory:



s1: 58ad67

s2: a041b6

58ad67:

sID:	"v00123456"
name:	"Ali Sa"
program:	"Mathematics"
gpa:	4.3

a041b6:

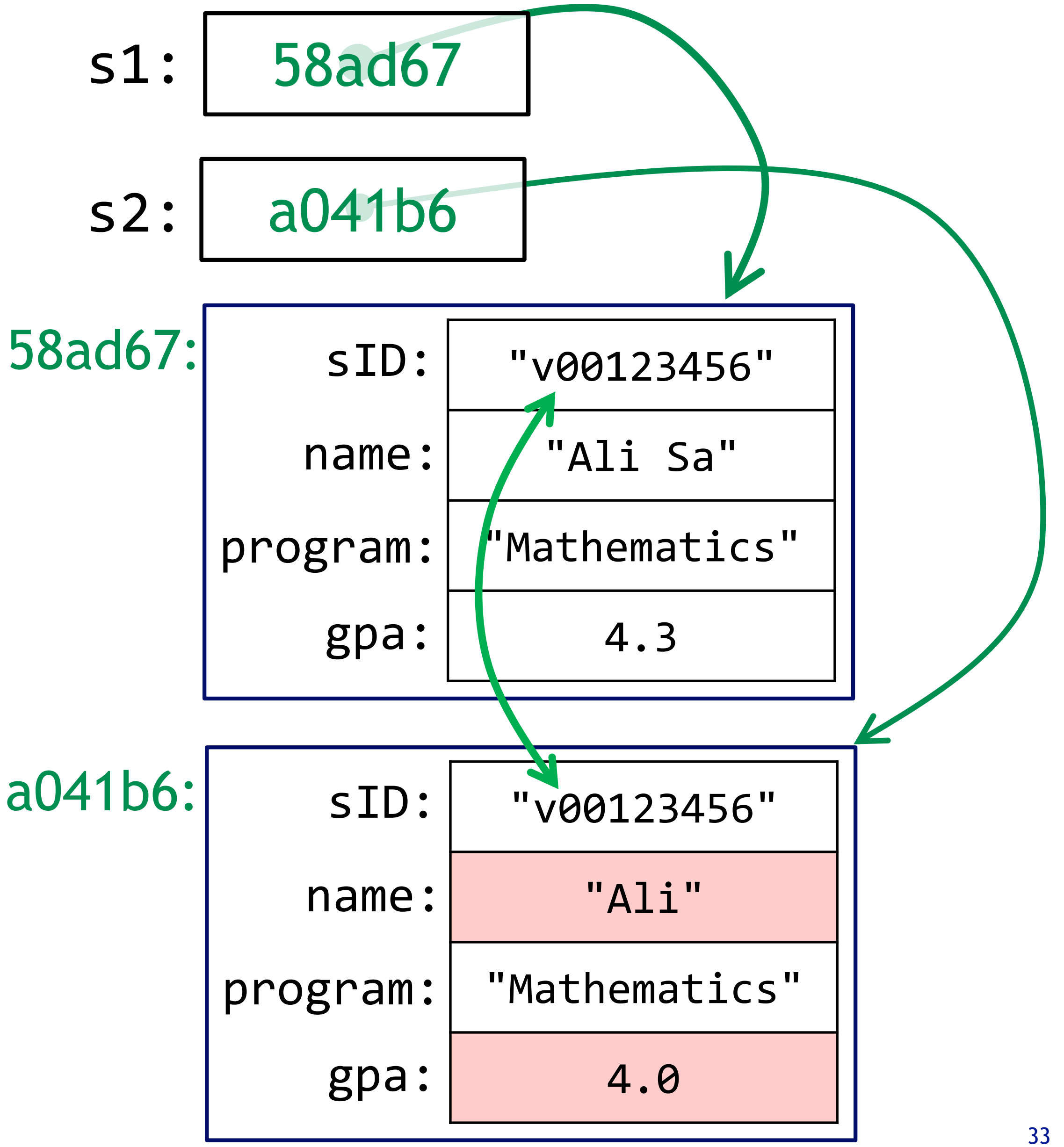
sID:	"v00123456"
name:	"Ali Sa"
program:	"Mathematics"
gpa:	4.3

Equality example

Student.java

```
public class Student {
  private String sID;
  private String name;
  private String program;
  private double gpa;

  …

  public String getSID() {
    return sid;
  }

  public boolean equals(Student other) {
    return sID.equals(other.getSID());
  }
}
```

Memory:



s1: 58ad67

s2: a041b6

58ad67:

sID:	"v00123456"
name:	"Ali Sa"
program:	"Mathematics"
gpa:	4.3

a041b6:

sID:	"v00123456"
name:	"Ali"
program:	"Mathematics"
gpa:	4.0

Equality summary

- The String class also has an `equals` method
- Key takeaways:
  - We want to call the **`equals`** method when comparing two objects, not `==`
  - For example:

```
Student s1 = new Student("v00123456", "Ali Sa", "Mathematics", 4.3);
Student s2 = new Student("v00123456", "Ali Sa", "Mathematics", 4.3);
```

`s1 == s2` evaluates to `false`

`==` compares if `s1` and `s2` are referencing the same location in memory, probably NOT what we want

`s1.equals(s2)` evaluates to `true`

`equals` calls the object's `equals` method, where the programmer specifies the equivalence relation between two objects