Objectives

- Introduction to Object-Oriented Programming
- Introduction to APIs

- Get handouts from last time

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Review

- How should you "read" each of these expressions? What do they mean?
  - rem = num1 % num2
  - x += 1
- How do we convert from one data type to another?
- How do we get input from a user?
  - Give an example of getting input from a user, one where we want a string and one where we want a number

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Review: Modulo Operator: %

- Modular Arithmetic: Remainder from division
  - `x % y` means the remainder of x//y
  - Read as "x mod y"
- Example: `6 % 4`
  - Read as "six mod four"
  - 6//4 is 1 with a remainder of 2, so 6%4 evaluates to 2
- Works only with integers
  - Typically just positive numbers
- Precedence rules: P E - DM**%** AS

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Review: Trick: Arithmetic Shorthands

- Called **extended assignment operators**
- Increment Operator
  - `x = x + 1` can be written as `x += 1`
- Decrement Operator
  - `x = x - 1` can be written as `x -= 1`
- Shorthands are similar for `*, /, //` :
  - `amount *= 1.055`
  - `x //= 2`

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Review: Type Conversion

- You can convert a variable's type
  - Use the type's ***constructor***

Conversion Function/Constructor	Example	Value Returned
`int(<number or string>)`	`int(3.77)` `int("33")`	3 33
`float(<number or string>)`	`float(22)`	22.0
`str(<any value>)`	`str(99)`	"99"

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Review: Getting Input From User

- `input` is a ***function***
  - **Function**: A command to do something
    - A "subroutine"
- Syntax:
  - `input(<string_prompt>)`
- Semantics:
  - Display the prompt `<string_prompt>` in the terminal
  - Read in the user's input and *return* it as a string/text

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Getting Input From a User

- Save the result of calling input in a variable
  - Ex:

```
color = input("What is your favorite color? " )
```

- If you want the assigned variable to be of type int or float, we need to convert the result of calling input
  - Ex:

```
height = eval(input("Enter the height: " ))
width = float(input("Enter the width: "))
```


Tradeoffs in which approach to use. For another time…

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Review: Improving average2.py

- With what we just learned, how could we improve average2.py?
- Example of suggested approach to development
  1. Solve the problem, using hard-coded values
  2. Then add input
- Why?
  - Input is going to become fairly routine.
  - Faster to run program when you are testing and running a bunch of times
    - (no typing)

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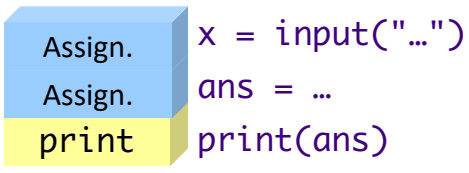
Design Patterns

- General, repeatable solution to a commonly occurring problem in software design
  - Template for solution

Design Patterns

- General, repeatable solution to a commonly occurring problem in software design
  - Template for solution
- Example (Standard Algorithm)
  - Get input from user
  - Do some computation
  - Display output



Programming Paradigm: Imperative

- Most modern programming languages are imperative
- Have data (numbers and strings in variables)
- Perform operations on data using operations, such as + (addition and concatenation)
- Data and operations are separate

- Add to imperative:
  object-oriented programming

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OBJECT-ORIENTED PROGRAMMING

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Object-Oriented Programming

- Program is a collection of **objects**
- Objects **combine** data and methods together
- Objects interact by invoking **methods** on other objects
  - Methods perform some operation on object

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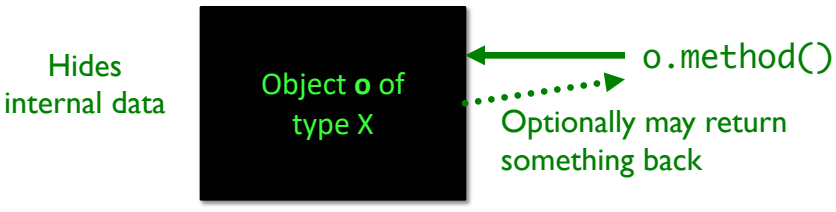
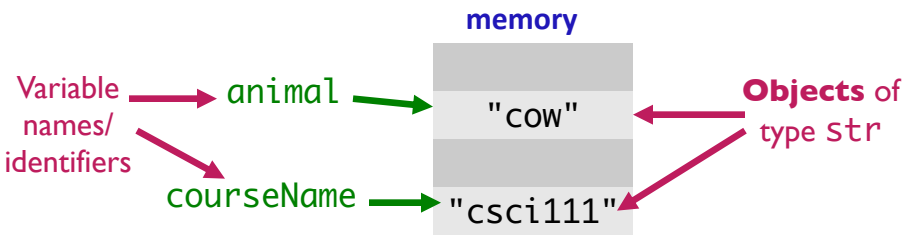


Object-Oriented Programming

- We've been using objects
  - Just didn't call them objects
- For example: **`str`** is a data type (or **class**)
  - We created objects of type (*class*) `string`
    - `animal = "cow"`
    - `coursename = "csci111"`



Example of OO Programming Abstraction

- Think of a smart phone– It's an ***object***
- What can you do to a phone?

Example of OO Programming Abstraction

- Think of a phone– it's an ***object***
- What can you do to a phone? Those are ***methods***
  - Turn it on/off
  - Open applications
  - Make a phone call
  - Mute it
  - Update settings
  - …

  methods
- You don't know ***how*** that operation is being done (i.e., implemented)
  - Just know ***what it does*** and that it ***works***

Example of OO Programming Abstraction

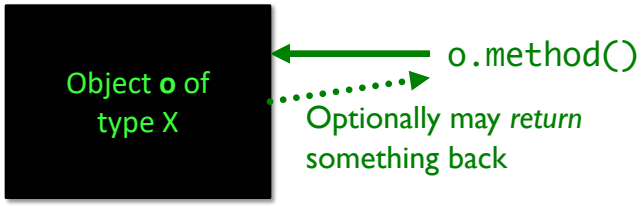
- A smart phone is an ***object***
- ***Methods*** you can call on your smart phone:
  - Turn it on/off
  - Open applications
  - Make a phone call
  - Mute it
  - Update settings
  - …
- `SmartPhone` is a ***class***, a.k.a., a data ***type***
  - My smart phone (identified by `myPhone`) is an object of type `SmartPhone`
  - You can call the above methods on any object of type `SmartPhone`

Object-Oriented Programming

- Objects combine data *and* methods together

Provides **interface** (*methods*) that users interact with

Hides internal data structures, implementation



Use an Application Programming Interface (**API**) to interact with a set of classes.

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Class Libraries

- Python provides libraries of classes
  - Defines methods that you can call on objects from those classes
  - `str` class provides a bunch of useful methods
    - More on that later
- Third-party libraries
  - Written by non-Python people
  - Can write programs using these libraries too

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Using a Graphics Module/Library

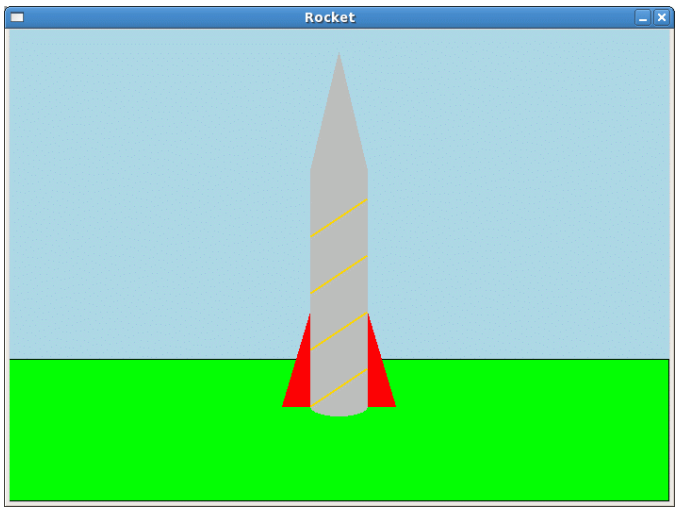
- Allows us to handle graphical input and output
  - Example output: Pictures
  - Example input: Mouse clicks
- Defines a collection of related graphics **classes**
- Not part of a standard Python distribution
  - Need to ***import*** from `graphics.py`
- Use the library to help us learn object-oriented (**OO**) programming

USING A GRAPHICS MODULE

Using a Graphics Module/Library

- Handout lists the various classes
  - **Constructor** is in bold
    - Creates an object of that type
  - For each class, lists *some* of their methods and parameters
  - Drawn objects have some common methods
    - Listed at end of handout
- Known as an **API**
  - **Application Programming Interface**

Example of Output



Using the Graphics Library

- In general, graphics are drawn on a canvas
  - A canvas is a 2-dimensional grid of pixels
- For our Graphics library, our canvas is a *window*
  - Specifically an **instance of** the `GraphWin` class
  - By default, a `GraphWin` object is 200x200 pixels

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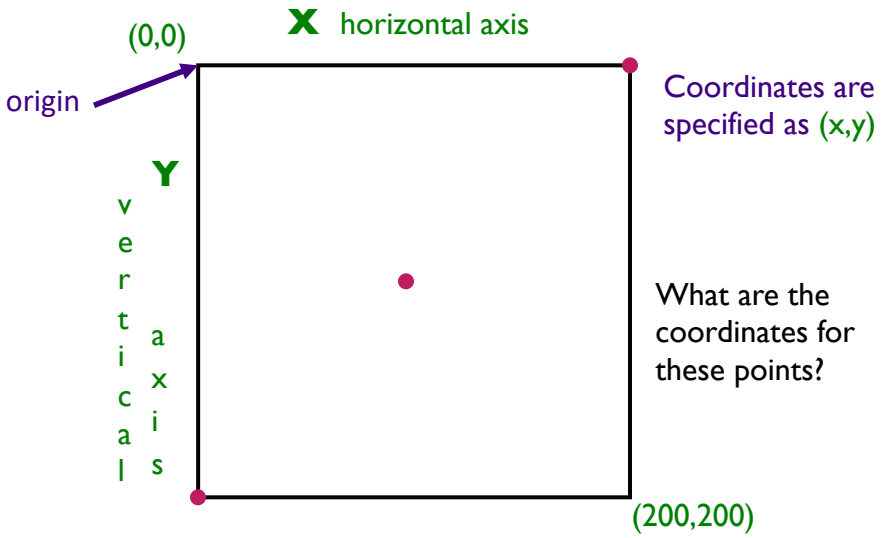
A `GraphWin` Object's Canvas



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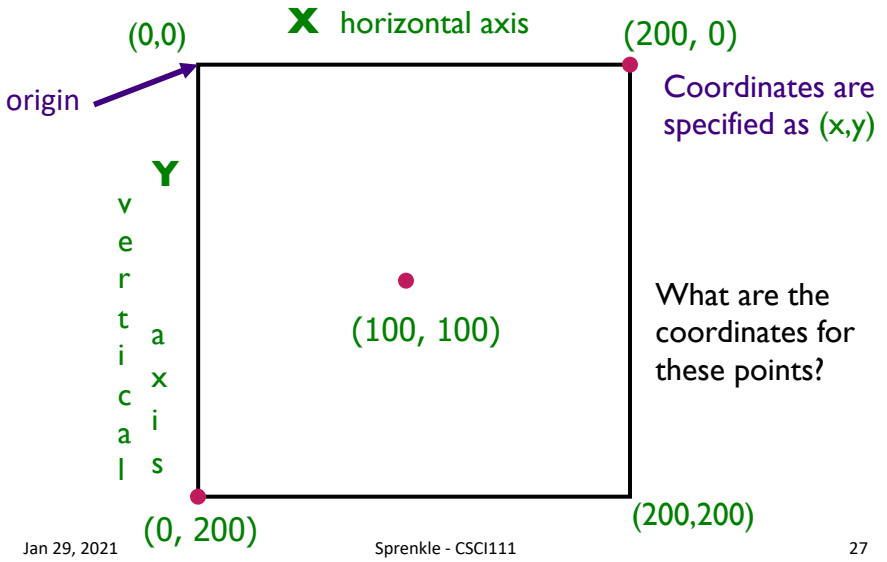
A GraphWin Object's Canvas



Using the API: **Constructors**

- To create an object of a certain type/class, use the **constructor** for that type/class
  - Syntax:

```
objName = ClassName([parameters])
```

  - Note:
    - Class names typically begin with capital letter
    - Object names begin with lowercase letter
  - **objname** is known as an **instance** of the class
- Example: To create a GraphWin object that's identified by window

```
window = GraphWin("My Window",200,200)
```

The GraphWin Class

- All parameters to the ***constructor*** are optional
- Could call constructor as

Call	Meaning
`GraphWin()`	Title, width, height to defaults ("Graphics Window", 200, 200)
`GraphWin(<title>)`	Width, height to defaults
`GraphWin(<title>,<width>)`	Height to default
`GraphWin(<title>, <width>, <height>)`	

Using the API: Methods

- To call a **method** on an object,
  - Syntax:

```
objName.methodName([parameters])
```

  - Method names typically begin with lowercase letter
  - Similar to calling *functions*
- Example: To change the background color of a GraphWin object named window

```
window.setBackground("blue")
```

Using the API: Methods

- A method sometimes **returns** output, which you may want to save in a variable
  - Class's API should say if method returns output
  - Referred to as an ***accessor***
- Example: if you want to know the *width* of a `GraphWin` object named `window`

```
width = window.getWidth()
```


The `GraphWin` API

- **Accessor** methods for `GraphWin`
  - Return some information about the `GraphWin`
- Example methods:
  - `<GraphWinObj>.getWidth()`
  - `<GraphWinObj>.getHeight()`

The GraphWin API

- <GraphWinObj>.setBackground(<color>)
  - Colors are strings, such as "red" or "purple"
    - Can add numbers to end of string for darker colors, e.g., "red2", "red3", "red4"

```
win = GraphWin()
win.setBackground("purple")
```

  - Does *not return* anything to shell
  - Called for change in **win**'s state, i.e., this method is a ***mutator***

General Categories of Methods

- Accessor
  - Returns information about the object
  - Example: getWidth()
- Mutator
  - Changes the state of the object
    - i.e., changes something about the object
  - Example: setBackground()

What Does This Code Do?

1. Identify examples of the OO terminology in this code: class, objects, methods, constructors
2. Describe the output from this code

```
from graphics import *

win = GraphWin("My Circle", 200, 200)
point = Point(100,100)
c = Circle(point, 10)
c.draw(win)
win.getMouse()
```

graphics_test.py

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What Does This Code Do?

Need to import the code from graphics.py into our program

```
from graphics import *

win = GraphWin("My Circle", 200, 200)
point = Point(100, 100)
c = Circle(point, 10)
c.draw(win)
win.getMouse()
```

Constructor

GraphWin object

Also known as an **instance of** the GraphWin **class**

Method called on GraphWin object

Note: Class names start with capital letters, Method names start with lowercase letters

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Benefits of Object-Oriented Programming

- **Abstraction**
  - Hides details of underlying implementation
  - Easier to change implementation
- Easy reuse of code
  - Can import the library in multiple files
- Collects related data/methods together
  - Easier to reason about data
- Less code in main program
  - Our program code is relatively simple

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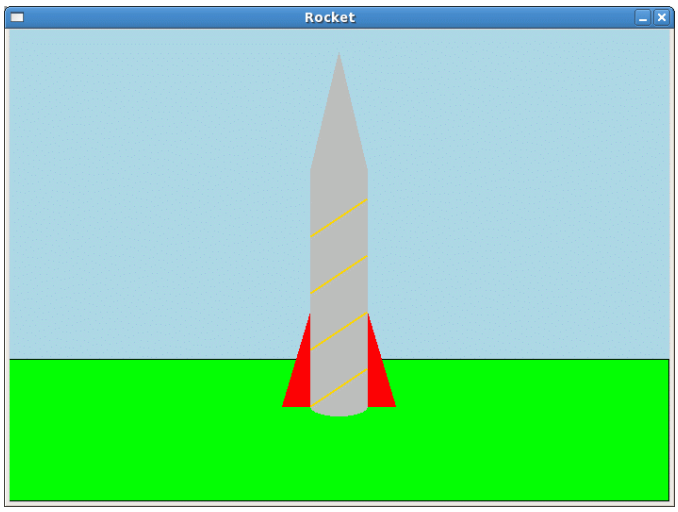
What objects make up this image?



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Colors

- Strings, such as "blue4"
- Can also create colors using the *function* `color_rgb(<red>,<green>,<blue>)`
  - Parameters in the range [0,255]
  - Example use:

```
darkBlueGreen = color_rgb(10, 100, 100)
win.setBackground(darkBlueGreen)
```

    - Background is a dark blue/green color
  - Example color codes:
    - `http://en.wikipedia.org/wiki/List_of_colors`

OO Terminology Summary

Term	Definition	Examples
Class	A data type. Defines the data and operations for members of the class	`str`, `SmartPhone`, `GraphWin`
Object	An *instance* of a specific class	`animal`, `myPhone`, `window`
Method	Operations you can call on an object	`setBackground(<color>)`, `getWidth()`
Constructor	Special method to create an object of a certain type/class	`GraphWin()`, `str(1234)`

Looking Ahead

- Pre Lab 2 due on Tuesday before lab