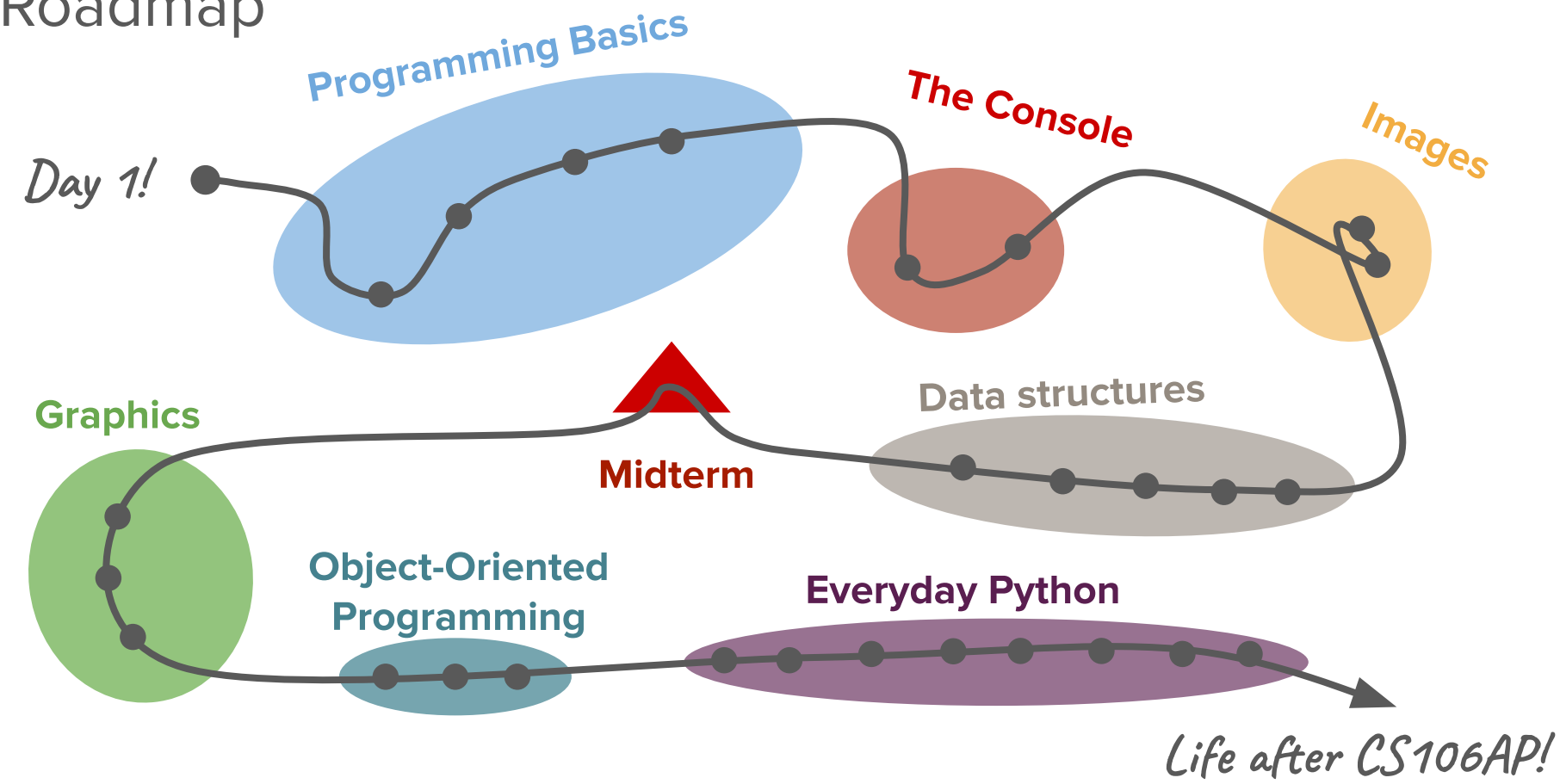
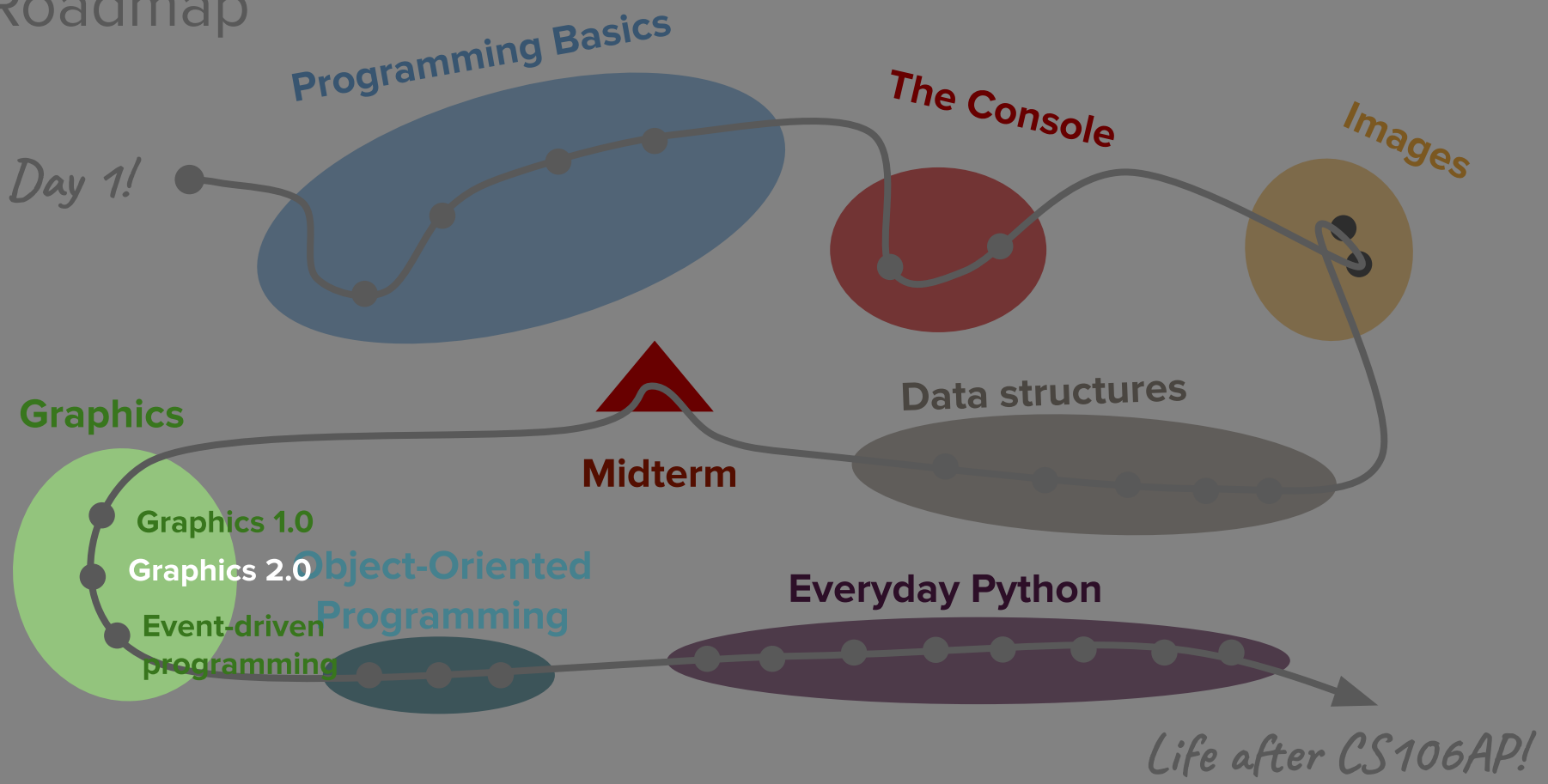
# Graphics 2.0

CS106AP Lecture 18

# Roadmap


Programming Basics
The Console
Images
Day 1!
Graphics
Midterm
Data structures
Object-Oriented Programming
Everyday Python
Life after CS106AP!

# Roadmap


Programming Basics
Day 1!
The Console
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Data structures
Graphics 1.0
Graphics 2.0
Object-Oriented Programming
Event-driven programming
Everyday Python
Life after CS106AP!

# Today’s questions

How can we more easily build complex graphical programs?

How can we get our programs to produce random output?

# Today’s topics

1. Review
2. Graphics Libraries: Campy
3. Randomness
4. What’s next?

# Review

How can we benefit from others' code and allow others to use our code?

*Modules!*

## Definition

**modules**

`.py` files containing working code for reuse across programs; sometimes also called "libraries"

## Definition

**package**
A directory of Python module(s)

# Using modules

1. Import the module

```
import module
```

2. Use the predefined functions!

```
module.function()
```

*We call this building your code "on top of" the module.*

# How can we create graphical programs?

*GUI libraries (modules)!*

## Definition

**Graphical User Interface (GUI)**

Visual elements that you interact with within applications (windows, buttons, scroll bars, etc.)

# GUI libraries

- Windows, Mac OS, Linux each have their own GUI systems

- **GUI libraries** are modules that support the GUI (i.e. their functions allow you to interact with your computer's GUI system)

- **`tkinter`** is Python's standard GUI package
  - Many other GUI libraries are built on top of **`tkinter`**! (more on this later this week)

# Tkinter fundamentals

- **`import tkinter`**

- Everything gets drawn on a **`canvas`**
  - In today's examples and Assignment 4, we'll provide the code for creating the canvas.

- When dealing with x, y coordinates on the canvas, Tk converts floats to integers internally to address pixels
  - **Note**: Python floats aren't exact!

# The Shocking Truth about Floats

# The Shocking Truth about Floats


Floats


0.2 & 0.1's only sum:

Floating point number

# The Shocking Truth about Floats

- Floats aren’t precise!
- This is a result of how they’re stored in computer memory
  - Same issue across languages
- Avoid ==

# Our Use of Floats Yesterday

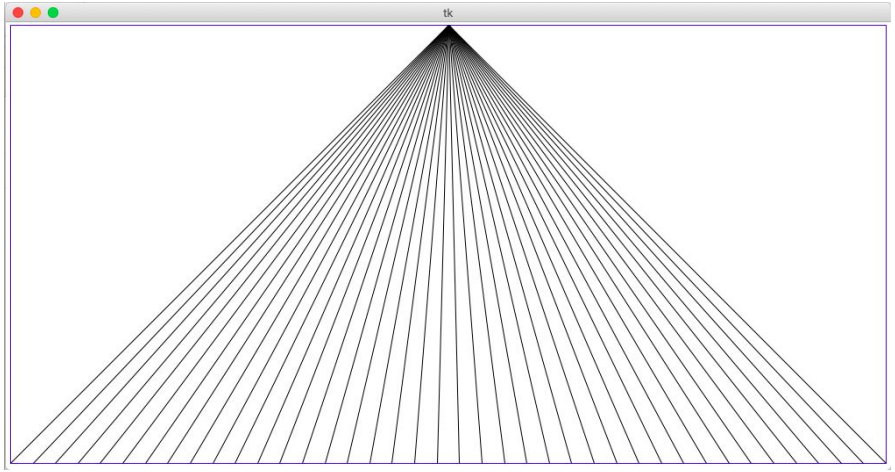
```
fraction = i / (n - 1)

x2 = (width - 1) * fraction
```

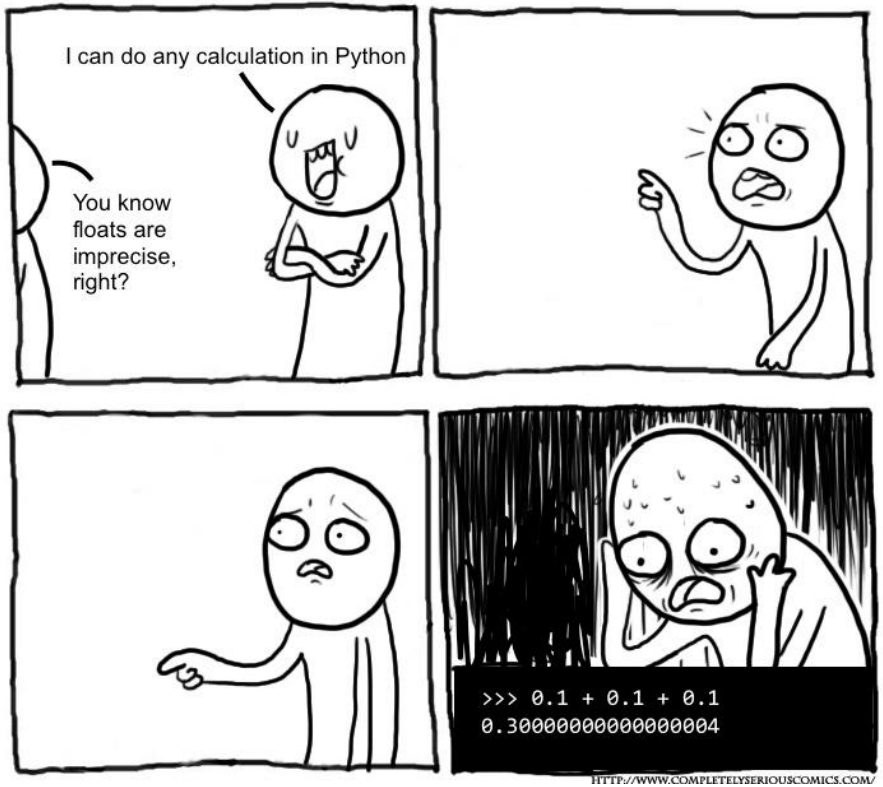
compared to

```
i * ((width - 1) / (n - 1))
```

e.g. i = 22, n = 23, width = 101



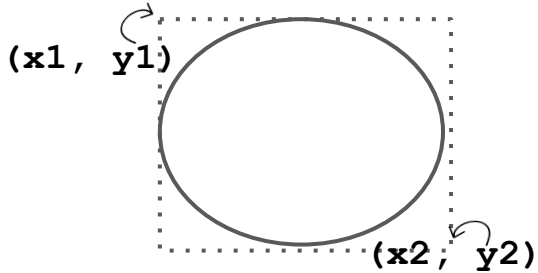
# The Shocking Truth about Floats



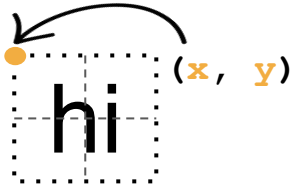
# Tkinter canvas functions

- `canvas.create_line(x1, y1, x2, y2)`


- `canvas.create_oval(x1, y1, x2, y2)`



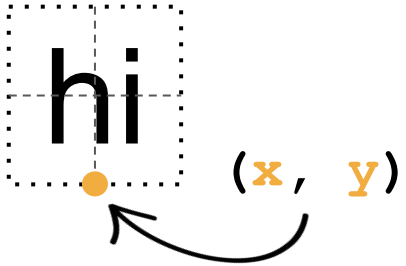

- `canvas.create_text(x, y, text='hi', anchor=tkinter.NW)`



# Tkinter canvas functions

- `canvas.create_line()`
- `canvas.create_oval()`
- **`canvas.create_text(x, y, text='hi', anchor=tkinter.S)`**

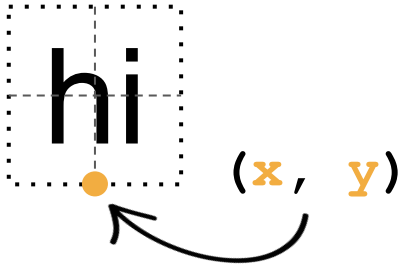
*The* **`anchor`** *argument determines where* **`(x,y)`** *is. It defaults to* **`tkinter.CENTER`**.



# Tkinter canvas functions

- `canvas.create_line()`
- `canvas.create_oval()`
- **`canvas.create_text(x, y, text='hi', anchor=tkinter.S)`**

*It can be any of* **`[tkinter.]N, S, E, W, NW, SW, NE, SW,`** *or* **`CENTER.`**



# Tkinter canvas functions

- `canvas.create_line()`
- `canvas.create_oval()`
- `canvas.create_text(x, y, text='hi', anchor=tkinter.S)`

*It can be any of* `[tkinter.]N`, `S`, `E`, `W`, `NW`, `SW`, `NE`, `SW`, *or* `CENTER`.

*They are* ***constants*** *inside the tkinter* ***module!***

# Tkinter canvas functions

- `canvas.create_line()`
- `canvas.create_oval()`
- `canvas.create_text(x, y, text='hi', anchor=tkinter.S)`

*keyword arguments!*

## Definition

**keyword arguments (kwargs)**
Arguments whose names matter but whose positions do not

# Keyword (named) arguments: `kwargs`

- Come *after* the unnamed **positional** arguments whose order matter

Definition

**positional arguments**
Unnamed arguments whose order matter

# Keyword (named) arguments: **`kwargs`**

- Come after the unnamed positional arguments whose order matter
- Name matters, but order doesn’t matter
- Help make function calls clearer
- Enable default values for parameters (make arguments optional)

# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost
```

# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost
```

default value

# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost
```

default value

```
>>> calculate_bill(10)
```

# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost
```

default value

```
>>> calculate_bill(10)
```

we don't have to pass in arguments that have default values!

# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost
```

default value

```
>>> calculate_bill(10)
12.333749999999998
```

we don't have to pass in arguments that have default values!

# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost


>>> calculate_bill(10, tax=0)
```

# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost


>>> calculate_bill(10, tax=0)
11.50
```

# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost
```

```
>>> calculate_bill(10, tax=0)
11.50
```

we can specify a value for our kwargs.

# Keyword (named) arguments: **kwargs**

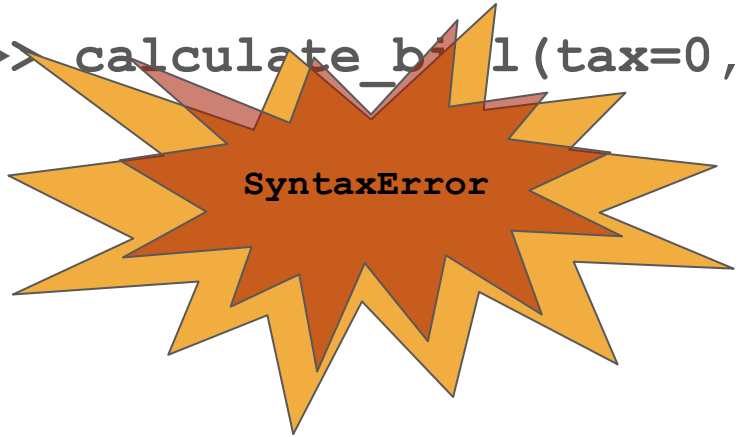
```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost


>>> calculate_bill(tax=0, 10)
```

# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost


>>> calculate_bill(tax=0, 10)
```



# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost


>>> calculate_bill(tax=0, 10)
```

kwargs must follow positional args!

# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost


>>> calculate_bill(10, 0.15, 0)
```

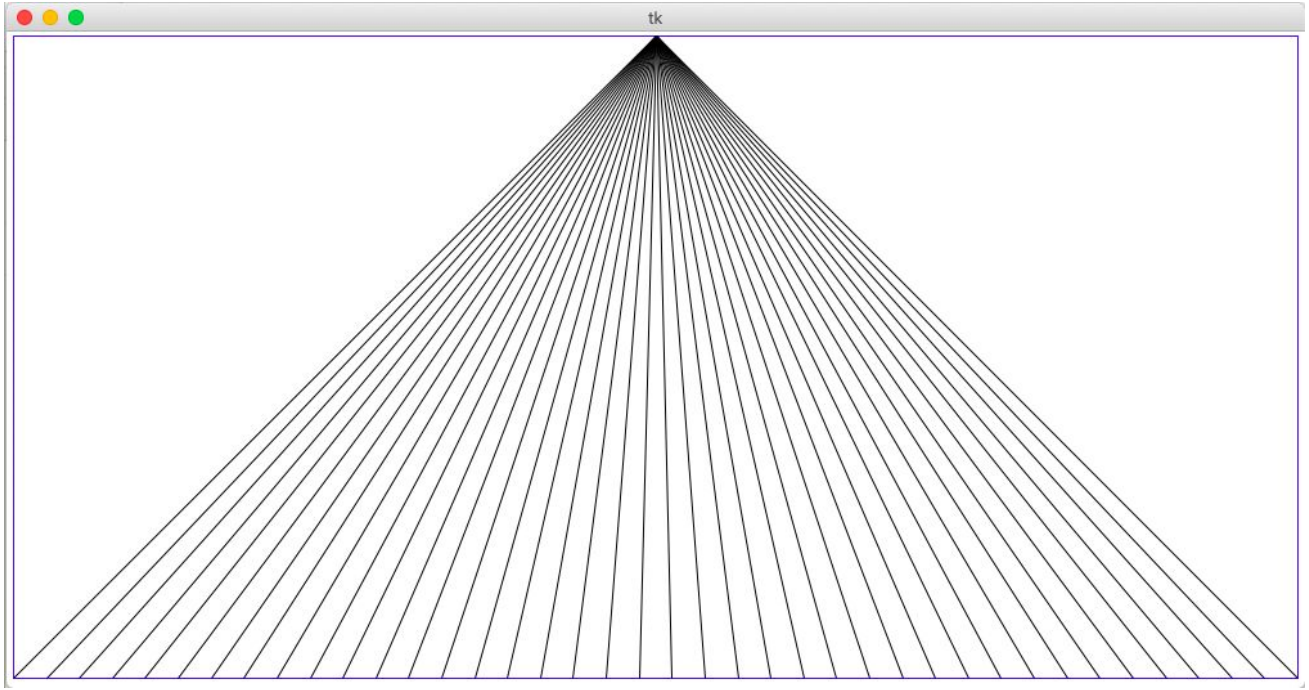
# Keyword (named) arguments: **kwargs**

```
def calculate_bill(cost, tip=0.15, tax=0.0725):
    return (1 + tax) * (1 + tip) * cost

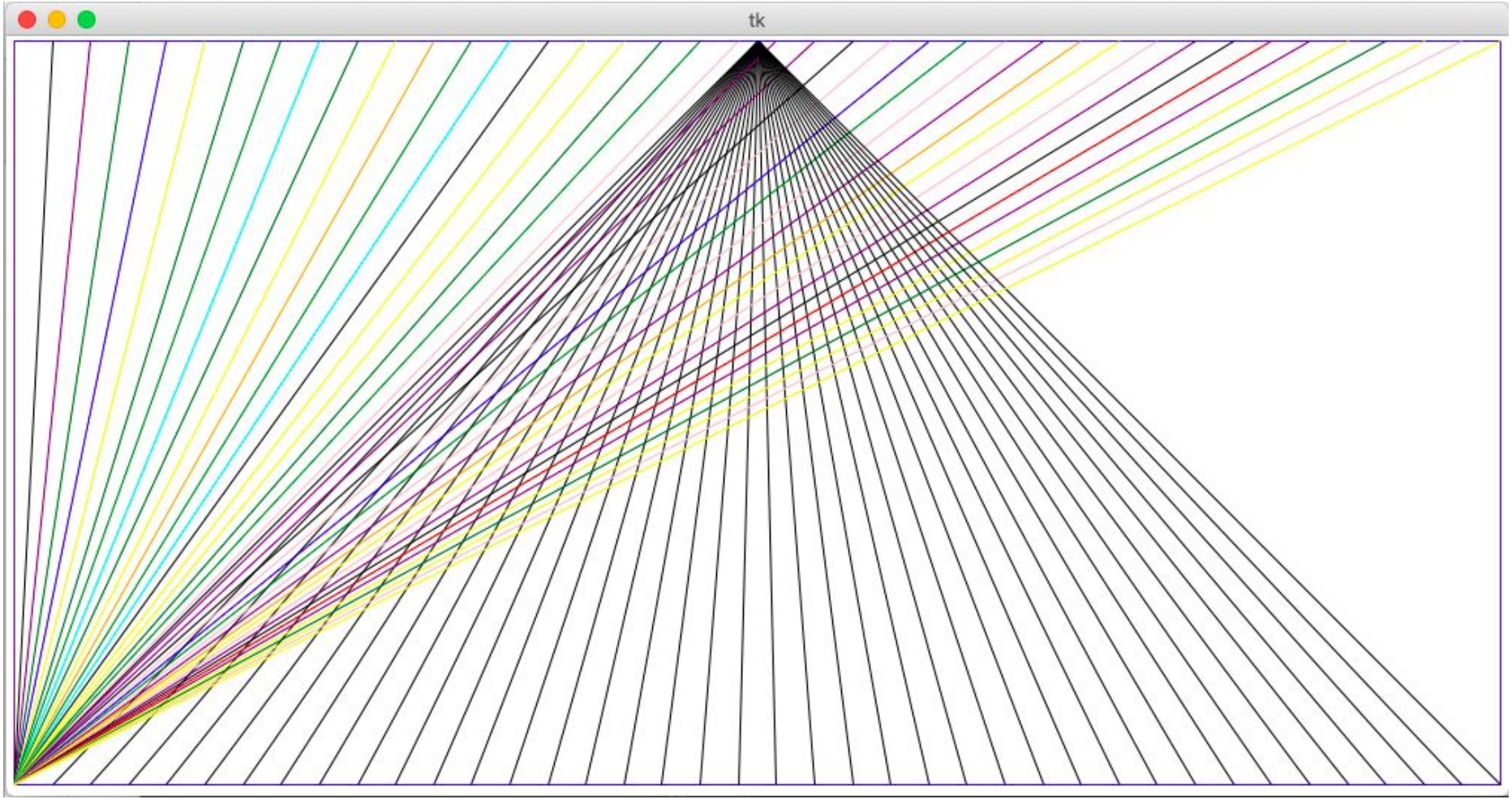

>>> calculate_bill(10, 0.15, 0)
```

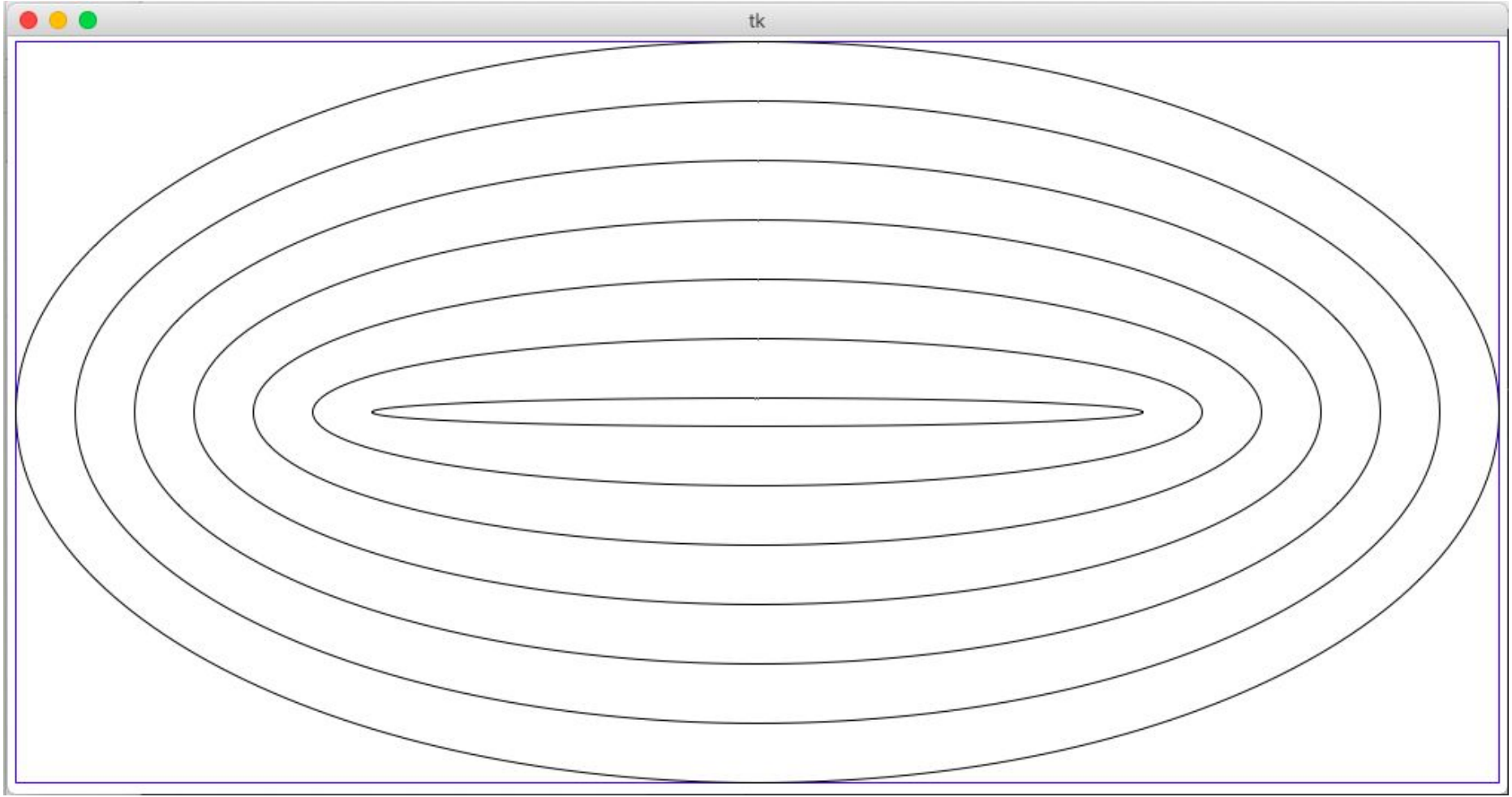
this will behave just like passing in positional args (cost, tip, tax)

# draw_pyramid()




[demo]


tk


tk

# Note about graphics in this class

- You have now learned everything you need for BabyNames
- Do not use the following material on BabyNames!
  - We will use it in subsequent assignments!

# What can we build with graphical programs?

# What can we build with graphical programs?

[DEMO]

How can we more easily build complex graphical programs?

# How can we more easily build complex graphical programs?

*Leverage others' code: other graphics libraries!*

# Other Graphics Library: Campy

- Python version of Stanford's ACM Graphics Libraries
  - by former SL Sam Redmond!
- Allows us to easily create graphical objects and add them to a canvas
- Built on top of tkinter!

# How can I leverage Campy in my programs?

- Import modules from the campy library
- New import syntax:

```
from campy.graphics.gobjects import GOval
```

# How can I leverage Campy in my programs?

- Import modules from the campy library
- New import syntax:

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```

path to specific module

object (could be a function)

# How can I leverage Campy in my programs?

- Import modules from the campy library
- New import syntax:

```
from campy.graphics.gobjects import GOval
```

*You've seen this before:*

*from simpleimage import SimpleImage*

# Using modules - two ways

1. Import the module

```
import module
```

2. Use the predefined functions!

```
module.function()
```

*Method A*

# Using modules - two ways

1. Import the module

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import module
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2. Use the predefined functions!

```
module.function()
```

*Method A*

1. Import the function/object from module

```
from module import function
```

2. Use the function/object!

```
function()
```

*Method B*

# Using modules - two ways

1. Import the module

```
import campy.graphics.gobjects
```

2. Use the predefined functions/objects!

```
campy.graphics.gobjects.GOval(width, height)
```

*Method A*

# Using modules - two ways

1. Import the function/object from module

```
from campy.graphics.gobjects import GOval
```

2. Use the function/object!

```
GOval(width, height)
```

*Method B*

# Using modules - two ways

1. Import the function/object from module

```
from campy.graphics.gobjects import GOval, GRect
```

2. Use the function/object!

```
GOval(width, height)
```

you can import multiple things!

Method B

# Using modules - two ways

1. Import the module

```
import module
```

2. Use the predefined functions!

```
module.function()
```

*Method A*

1. Import the function/object from module

```
from module import function
```

2. Use the function/object!

```
function()
```

*Method B*

# Using modules - two ways

1. Import the module

```
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2. Use the predefined functions!

```
module.function()
```

*Method A*

1. Import the function/object from module

```
from module import function
```

2. Use the function/object!

```
function()
```

*Method B*

*more concise, especially if you're only importing 1-2 things*

# Why bother with Campy?

- Tkinter can be annoying to use
  - Code can become extremely long
- Using other libraries (like Campy) is more convenient

# Campy’s Graphical Toolkit

- GRect
- GOval
- GLine
- GLabel
- GWindow

# GRect

```
def get_rect():
    rect = GRect(width=100, height=50, x=25, y=25)
    rect.filled = True
    rect.fill_color = ‘blue’
    return rect
```

# GRect

```
def get_rect():
    rect = GRect(width=100, height=50, x=25, y=25)
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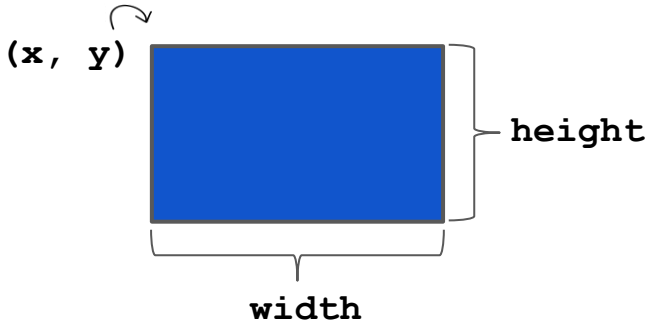

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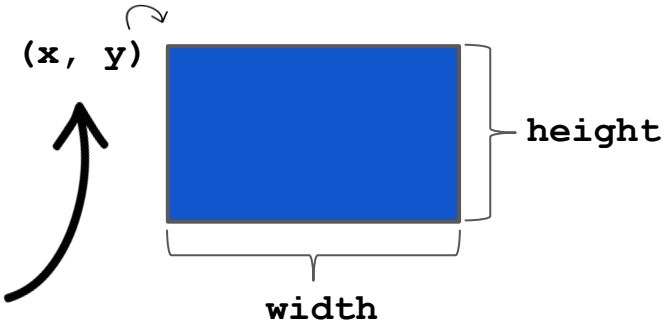
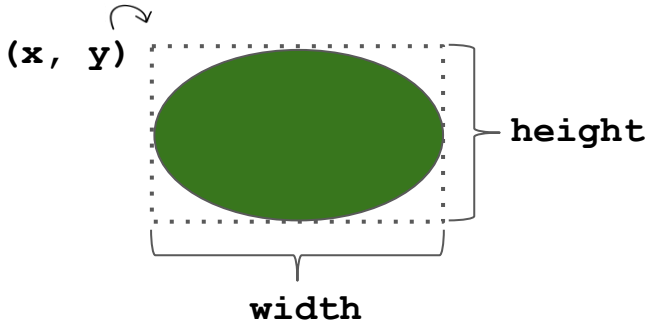



(x, y) in top left corner!

# GOval

```
def get_oval():
    oval = GOval(width=100, height=50, x=0, y=0)
    oval.filled = True
    oval.fill_color = 'green'
    return oval
```



# GOval

```
def get_oval():
    oval = GOval(width=100, height=50, x=0, y=0)
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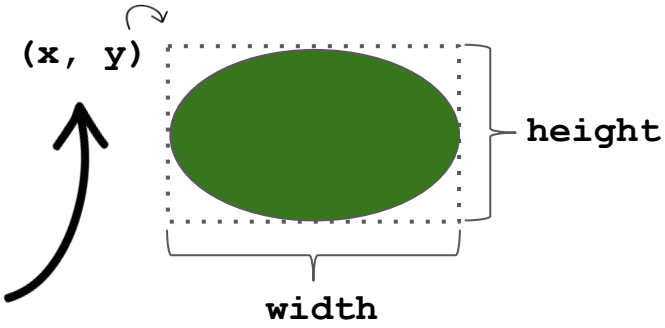
(x, y) in top left corner!



# GLine

```
line = GLine(x0, y0, x1, y1)

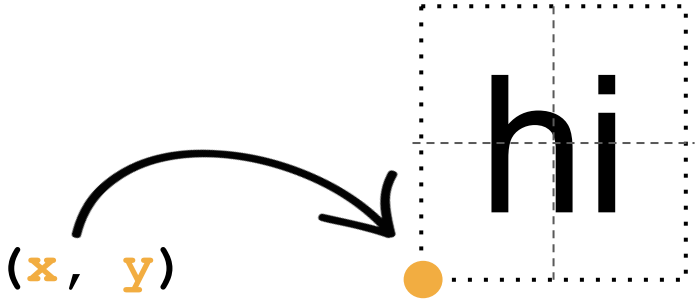
# similar to tk's create_line() function!
```

# GLabel

```
label = GLabel(text, x, y)

# similar to tk's create_text() function!

label = GLabel('hi', 0, 0)
```



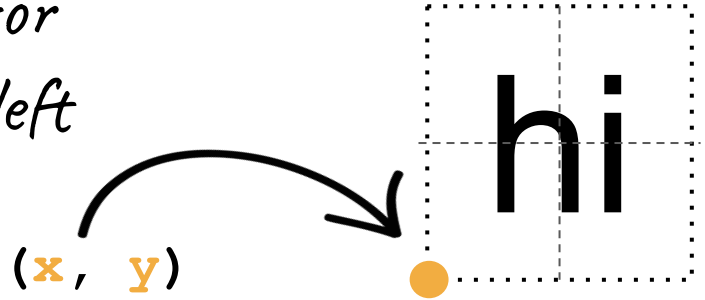
# GLabel

```
label = GLabel(text, x, y)

# similar to tk's create_text() function!

label = GLabel('hi', 0, 0)
```

*Note: coordinates for GLabel are* ***bottom*** *left*



# Campy’s Graphical Toolkit

- GRect
- GOval
- GLine
- GLabel
- GWindow

GObjects

# Getting information from GObjects

```
obj.width

obj.height

obj.x

obj.y

obj.filled

obj.fill_color
```

# A small problem…

We know how to make GObjects, but we don’t know how to display them!

# Campy’s Graphical Toolkit

- GRect
- GOval
- GLine
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- GWindow

# GWindow

We know how to make GObjects, but we don’t know how to display them!

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We know how to make GObjects, ~~but we don't know how to display them!~~

- GWindow is Campy's version of the canvas that we used in tkinter

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We know how to make GObjects, ~~but we don't know how to display them!~~

- GWindow is Campy's version of the canvas that we used in tkinter

```
window = GWindow(height, width, title)
```

# GWindow

We know how to make GObjects, ~~but we don't know how to display them!~~

- GWindow is Campy's version of the canvas that we used in tkinter

```
window = GWindow(height, width, title)
```

specifies the dimensions of the window

# GWindow

We know how to make GObjects, ~~but we don't know how to display them!~~

- GWindow is Campy's version of the canvas that we used in tkinter

```
window = GWindow(height, width, title)
```

specifies the dimensions of the window

optional argument, will create title at top of window

# GWindow - Add

```
window = GWindow(height=400, width=600)
```

# GWindow - Add

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50, x=25, y=25)
```

# GWindow - Add

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50, x=25, y=25)

window.add(rect)
```

# GWindow - Add

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50, x=25, y=25)

window.add(rect)
```

.add() displays the object in the window!

# GWindow - Add

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)
```

# GWindow - Add

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)
```

note we're not specifying x, y when we create the GRect

# GWindow - Add

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)

window.add(rect, x=25, y=25)
```

note we're not specifying x, y when we create the GRect

# GWindow - Add

```
window = GWindow(height=400, width=600)
rect = GRect(width=100, height=50)
window.add(rect, x=25, y=25)
```

note we're not specifying x, y when we create the GRect

specify x, y in add()

# GWindow - Add

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)

window.add(rect, x=25, y=25)
```

# GWindow - Remove

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)

window.add(rect, x=25, y=25)

window.remove(rect)
```

# GWindow - Remove

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)

window.add(rect, x=25, y=25)

window.remove(rect)
```

removes object
from window

# GWindow - Clear

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)

window.add(rect, x=25, y=25)
```

# GWindow - Clear

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)

window.add(rect, x=25, y=25)

oval = GOval(25, 25)
```

# GWindow - Clear

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)

window.add(rect, x=25, y=25)

oval = GOval(25, 25)

window.add(oval, x=0, y=0)
```

# GWindow - Clear

```
window = GWindow(height=400, width=600)
rect = GRect(width=100, height=50)
window.add(rect, x=25, y=25)
oval = GOval(25, 25)
window.add(oval, x=0, y=0)
window.clear()
```

# GWindow - Clear

```
window = GWindow(height=400, width=600)
rect = GRect(width=100, height=50)
window.add(rect, x=25, y=25)
oval = GOval(25, 25)
window.add(oval, x=0, y=0)
window.clear()
```

remove all objects from the window!

# GWindow - Get Object At

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)

window.add(rect, x=25, y=25)
```

# GWindow - Get Object At

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)

window.add(rect, x=25, y=25)

obj = window.get_object_at(40, 50)
```

# GWindow - Get Object At

```
window = GWindow(height=400, width=600)

rect = GRect(width=100, height=50)

window.add(rect, x=25, y=25)

obj = window.get_object_at(40, 50)

print(obj == rect)  # True
```

# GWindow - Summary

- The GWindow stores all the information about the objects in the window!
- GObjects are added in order (most recently added are on top)

```
window = GWindow(height, width, title)

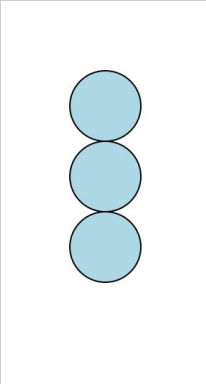
window.add(obj, x, y)  # x, y are optional

window.remove(obj)

window.clear()  # remove all objects

window.get_object_at(x, y)  # returns topmost object
```

# DEMO: Draw a simple snowman!



How can we get our programs to produce random output?

# A Random Note

# Randomness

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  - Computers are deterministic and designed to eliminate randomness!
  - We can approximate randomness through “pseudo-random numbers”
- It’s valuable to have randomness in programs, either for cool effects or for conducting statistical tests.

# The `random` module

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import random

COLORS = ['red', 'orange', 'yellow', 'green', 'blue']

color = random.choice(COLORS)
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```

randomly selects
from a list

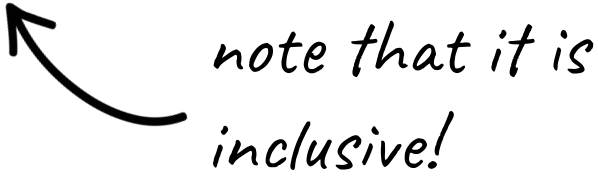
# The **`random`** module

- Generate a random float 0 <= x < 1

```
random.random()
```

- Generate a random int a <= x <= b

```
random.randint(a, b)
```




- Randomly select from a list

```
random.choice(lst)
```

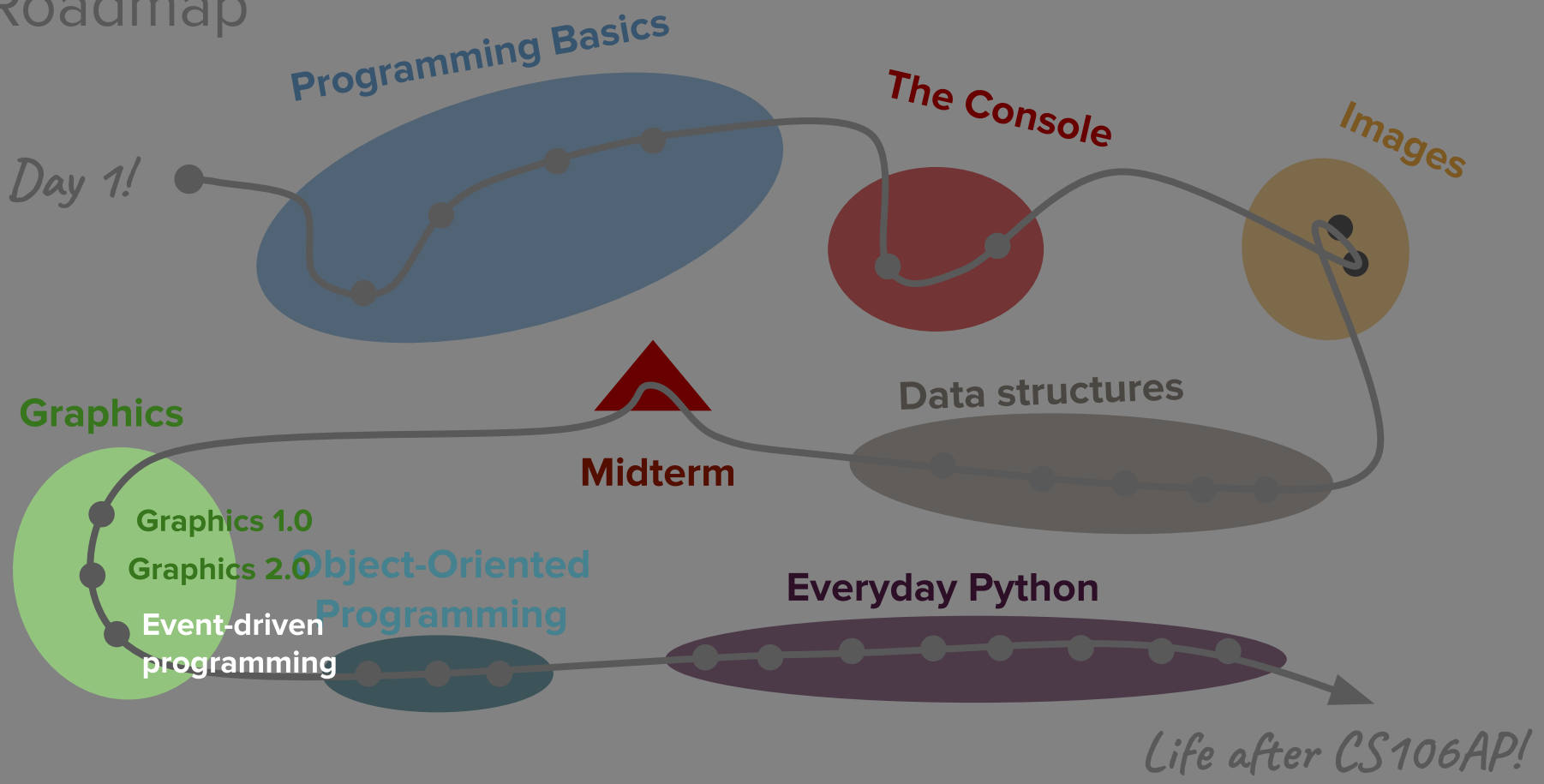
# The `random` module

- Set up a random number generator
  - This makes the output consistent between runs
  - This is very useful for testing random programs!

```
random.seed(n)
```

# What’s next?

# Roadmap


Programming Basics
The Console
Images
Day 1!
Graphics
Midterm
Data structures
Graphics 1.0
Graphics 2.0
Object-Oriented Programming
Event-driven programming
Everyday Python
Life after CS106AP!