5. Introduction to Procedures

Topics:

- The module simpleGraphics
- Creating and Showing figures
- Drawing Rectangles, Disks, and Stars
- Optional arguments
- Application Scripts
Procedures

We continue our introduction to functions with a focus on procedures.

Procedures are functions that do not return a value.

Instead, they “do something.”

Graphics is a good place to illustrate the idea.
The Module `simpleGraphics` Has Five Procedures

```
simpleGraphics.py
```

- `MakeWindow`
- `ShowWindow`
- `DrawRect`
- `DrawDisk`
- `DrawStar`

We will use this module to make designs that involve rectangles, disks, and stars.
Examples that We Can do Right Now*

Looks like we will be able to draw tilted rectangles

* Right Now we only know about assignment statements and if-constructs.
An Example We Can Do Right Now

How does color work?

What if we had 100 rows each with 100 stars?

Anticipating loops.
An Example We Can Do Right Now

Xeno’s Paradox: Will we ever reach the right edge?
An Example We Can Do Right Now

White Rectangle + Red Rectangle + White Disk + Red Disk + Tilted White Star
An Example We Can Do Right Now

Let’s write a function to draw this:

Then apply it four times.

Functions calling other functions.
After We Learn About Iteration...

What if there were billions and billions of stars? Will need loops.
After We Learn About Iteration...

How long before the square is covered? Need loops.
After We Learn About Recursion...

Random Mondrian. Repeatedly cut a rectangle into 4 smaller rectangles.
Now let's show how to use the five procedures in simpleGraphics:

MakeWindow
ShowWindow
DrawRect
DrawDisk
DrawStar
First: Create a Figure Window

You cannot create any designs until you have a figure into which you can “drop” rectangles, disks, and stars.
from simpleGraphics import *
n = 5
MakeWindow(n)

Here we have created a figure with labeled axes that is ready to display things in the square defined by

\[-5 \leq x \leq +5, \quad -5 \leq y \leq 5\]
MakeWindow

from simpleGraphics import *
n = 5
MakeWindow(n, labels=False)

The “default” is to label the axes.

So this is what you must do to suppress the labeling.

We are using import * to save space and because it is such a tiny module.
MakeWindow

```python
from simpleGraphics import *
n = 5
MakeWindow(n, bgcolor=PURPLE)
```

The “default” is to “paint” the figure white.

So this is what you must do to set the background color to something different.
Color in simpleGraphics

The module has thirteen “built-in” colors.

If a simpleGraphics procedure wants a color, just “hand over” one of these:

YELLOW    PURPLE    CYAN    ORANGE
RED       BLUE      GREEN    MAGENTA
PINK      WHITE     BLACK    LIGHTGRAY
            DARKGRAY

There is more flexibility than this. More later.
from simpleGraphics import*
n = 5
MakeWindow(n, labels=False, bgcolor=ORANGE)

You can turn off labeling and specify a color in the same call to MakeWindow.
Optional Arguments

The function `MakeWindow` has three arguments.

Two of the arguments are “optional”.

When there are several optional arguments, their order is immaterial. Equivalent:

```python
MakeWindow(n, labels=False, bgcolor=ORANGE)
MakeWindow(n, bgcolor=ORANGE, labels=False)
```

Note: You need the “assignment” for an optional argument. This is illegal: `MakeWindow(5, False, ORANGE)`
Let’s Draw a Rectangle with DrawRect

You must tell DrawRect

- the center of the rectangle.
- the horizontal dimension of the rectangle
- the vertical dimension of the rectangle

You have the option of telling DrawRect

- the fill color
- the width of the perimeter highlight
- the rotation angle
from simpleGraphics import*
MakeWindow(5, bgcolor=yellow)
x=0; y=0; L=5; W=3
DrawRect(x, y, L, W)
ShowWindow()

The default is a rectangle with no fill color. So all you get is the perimeter.
from simpleGraphics import *

MakeWindow(5, bgcolor=YELLOW)
x=0; y=0; L=5; W=3

DrawRect(x,y,L,W,color=MAGENTA)
ShowWindow()

Use the optional color argument to specify a fill color.
from simpleGraphics import*
MakeWindow(5,bgcolor=YELLOW)
x=0; y=0; L=5; W=3
DrawRect(x,y,L,W,color=MAGENTA,stroke=6)
ShowWindow()

Use the optional stroke argument to specify the boldness of the perimeter highlight. The default is stroke = 1

If you don't want any perimeter highlight, set stroke=0
from simpleGraphics import*
MakeWindow(5,bgcolor=YELLOW)
x=0; y=0; L=5; W=3
DrawRect(x,y,L,W,color=MAGENTA,rotate=30)
ShowWindow()

Use the optional rotate argument to specify the counterclockwise rotation of the rectangle about its center. (Angle in degrees.)

The default rotation angle is zero.
Let's Write a Script to Do This

The squares are 9x9, 7x7, 5x5, 3x3, and 1x1.
Nested Squares

\textbf{DrawRect}\hspace{1pt}(0,0,9,9,\text{color=\text{MAGENTA}},\text{stroke=10})
DrawRect(0,0,7,7,color=CYAN,stroke=8)
DrawRect(0, 0, 5, 5, color=YELLOW, stroke=6)
DrawRect(0,0,3,3,color=PURPLE,stroke=4)
Nested Squares

\textbf{DrawRect}(0,0,1,1,\text{stroke}=5)
Nested Squares

MakeWindow(6, bgcolor=WHITE)

DrawRect(0,0,9,9,color=MAGENTA,stroke=10)

DrawRect(0,0,7,7,color=CYAN,stroke=8)

DrawRect(0,0,5,5,color=YELLOW,stroke=6)

DrawRect(0,0,3,3,color=PURPLE,stroke=4)

DrawRect(0,0,1,1,stroke=5)

ShowWindow()
Let's Draw a Disk with DrawDisk

You must tell DrawDisk

- the center of the disk.
- the radius of the disk

You have the option of telling DrawDisk

- the fill color
- the width of the perimeter highlight
The default is a circle with no fill color. So all you get is the perimeter.
from simpleGraphics import*
MakeWindow(5,bgcolor=YELLOW)
x=0; y=0; r=4
DrawDisk(x,y,r,color=MAGENTA)
ShowWindow()

Use the optional color argument to specify a fill color.
from simpleGraphics import *
MakeWindow(5, bgcolor=YELLOW)
x=0; y=0; r=4
DrawDisk(x, y, r, color=MAGENTA, stroke=6)
ShowWindow()

Use the optional stroke argument to specify the boldness of the perimeter highlight. The default is stroke = 1

If you don’t want any perimeter highlight, set stroke=0
Let's Draw This

Rules:

Big circle center at (−4,0) with radius 4.

Circles are tangent to each other. Centers on x-axis.

Each circle has half the radius of its left neighbor.
Draw the First Disk

\[ x = -4 \]
\[ r = 4 \]

\texttt{DrawDisk}(x,0,r,\text{color=MAGENTA},\text{stroke}=0)
Draw the Second Disk

x = x + 1.5*r
r = r/2
DrawDisk(x, 0, r, color=CYAN, stroke=0)
Draw the Third Disk

\[ x = x + 1.5r \]
\[ r = r/2 \]
\[ \text{DrawDisk}(x, 0, r, \text{color=MAGENTA}, \text{stroke}=0) \]
Overall

\[ x = -4; \\ r = 4 \]

\text{DrawDisk}(x,0,r,\text{color=MAGENTA},\text{stroke}=0)

\[ x = x + 1.5*r; \\ r = r/2 \]

\text{DrawDisk}(x,0,r,\text{color=CYAN},\text{stroke}=0)

\[ x = x + 1.5*r; \\ r = r/2 \]

\text{DrawDisk}(x,0,r,\text{color=MAGENTA},\text{stroke}=0)

\[ x = x + 1.5*r; \\ r = r/2 \]

\text{DrawDisk}(x,0,r,\text{color=CYAN},\text{stroke}=0)

Notice the repetition of the \( x \) and \( r \) updates. Simpler than figuring out the centers and radii "by hand". Also gets us ready for loops.
Let's Draw a Star with DrawStar

You must tell DrawStar
- the center of the star.
- the radius of the star

You have the option of telling DrawStar
- the fill color
- the width of the perimeter highlight
- the rotation angle
The default is a star with no fill color. So all you get is the perimeter.

Note: the radius of a star is the distance from its center to any tip.
DrawStar

```python
from simpleGraphics import *
MakeWindow(5, bgcolor=YELLOW)
x=0; y=0; r=4
DrawStar(x, y, r, color=MAGENTA)
ShowWindow()
```

Use the optional color argument to specify a fill color.
from simpleGraphics import *
MakeWindow(5, bgcolor=YELLOW)
x=0; y=0; r=4
DrawStar(x,y,r,color=MAGENTA, stroke=6)
ShowWindow()

Use the optional stroke argument to specify the boldness of the perimeter highlight. The default is stroke = 1

If you don't want any perimeter highlight, set stroke=0
```python
from simpleGraphics import *
MakeWindow(5, bgcolor=YELLOW)
x=0; y=0; r=4
DrawStar(x, y, r, color=MAGENTA, rotate=18)
ShowWindow()
```

Use the optional rotate argument to specify the counterclockwise rotation of the rectangle about its center. (Angle in degrees.)

The default rotation angle is zero.
Let’s Talk About Color
The rgb Representation

A color is a triple of numbers, each between zero and one.

The numbers represent the amount of red, green, and blue.

This is purple:

\[ [0.57, 0.17, 0.93] \]
The Module `simpleGraphics` Has Five Procedures and Data

`simpleGraphics.py`

- **Data**
- **MakeWindow**
- **ShowWindow**
- **DrawRect**
- **DrawDisk**
- **DrawStar**

In this case, the data encodes the rgb values of thirteen colors.
The simpleGraphics Colors

YELLOW = [1.00,1.00,0.00]
CYAN = [0.00,1.00,1.00]
MAGENTA = [1.00,0.00,1.00]
RED = [1.00,0.00,0.00]
GREEN = [0.00,1.00,0.00]
BLUE = [0.00,0.00,1.00]
WHITE = [1.00,1.00,1.00]
BLACK = [0.00,0.00,0.00]
PURPLE = [0.57,0.17,0.93]
LIGHTGRAY = [0.33,0.33,0.33]
DARKGRAY = [0.67,0.67,0.67]
ORANGE = [1.00,0.50,0.00]
PINK = [1.00,0.71,0.80]

These are called “Global Variables”

Convention: Global Variable Names should be upper case.
from simpleGraphics import *
MakeWindow(5,bgcolor=YELLOW)
x=0; y=0; L=5; W=3
DrawRect(x,y,L,W,color=MAGENTA)
ShowWindow()

When a module is imported, it gives access to both its functions and its global variables.

Take a look at the Demos ShowRect.py, ShowDisk.py, and ShowStar.py
rgb Arrays

Things like \([0.74, 1.00, 0.34]\) are called rgb arrays.

Rule: Square brackets, 3 numbers separated by commas, each number between 0 and 1.

First number = red value
Second number = green value
Third number = blue value
Using rgb Arrays

Instead of using the predefined colors you can make up and use your own fill color, e.g.

\[ C = [0.74, 1.00, 0.34] \]
\[ \text{DrawDisk}(0,0,1,\text{color}=c) \]

Google “rgb values” to look at huge tables of colors and rgb values.
A Note on Managing Figures

Three figure windows will be produced.

The green code defines what is in the first window.

The pink and blue code set up the second and third windows.

The `ShowWindow()` says, “Show all the windows.”

Take a look at the Demos `ShowRect.py` and `ShowStar.py`
A Final Example

Shows two things.

1. You can write a module that uses other modules that YOU have written.

2. You can have a module that has both function definitions and a script.
A Final Example

We write a procedure to draw this

and a script that calls it twice:

and we put them both in the SAME module....
from simpleGraphics import *

def DrawTile(x,y,r,c1,c2,c3):
    DrawRect(x,y,2*r,2*r,color=c1)
    DrawDisk(x,y,r,color=c2)
    DrawStar(x,y,r,color=c3)

if __name__ == '__main__':
    MakeWindow(6,bgcolor=BLACK,labels=False)
    DrawTile(3,0,2,MAGENTA,PURPLE,YELLOW)
    DrawTile(-3,0,2,MAGENTA,PURPLE,YELLOW)
    ShowWindow()
from simpleGraphics import *

def DrawTile(x,y,r,c1,c2,c3):
    DrawRect(x,y,2*r,2*r,color=c1)
    DrawDisk(x,y,r,color=c2)
    DrawStar(x,y,r,color=c3)

if __name__ == '__main__':
    MakeWindow(6,bgcolor=BLACK,labels=False)
    DrawTile(3,0,2,MAGENTA,PURPLE,YELLOW)
    DrawTile(-3,0,2,MAGENTA,PURPLE,YELLOW)
    ShowWindow()
So a Module Can Look Like This

if __name__ == '__main__':

Data
Function Definitions

Gotta have
Application Script

Those are “double underscores” in the if statement.
Summary

1. Procedures “look like” functions without the “return.” They “do stuff” but do not return values.

2. Graphics procedures were used to illustrate the idea.

3. Color can be encoded with three numbers that indicate the amount of red, green, and blue.

4. A single module can house data, functions, and a script at the same time.
Terminology

procedure

A function that has no explicit return statements that yield a value. A function call on a procedure always evaluates to None.

Terminology

**script**

A program that contains a segment of code like this: `if __name__ == "__main__":`

Scripts can be run outside of the interactive mode. To run a script, type `python <application name>` at the OS command shell. When a script is run, it will execute all of the code indented under the `if`-statement above.