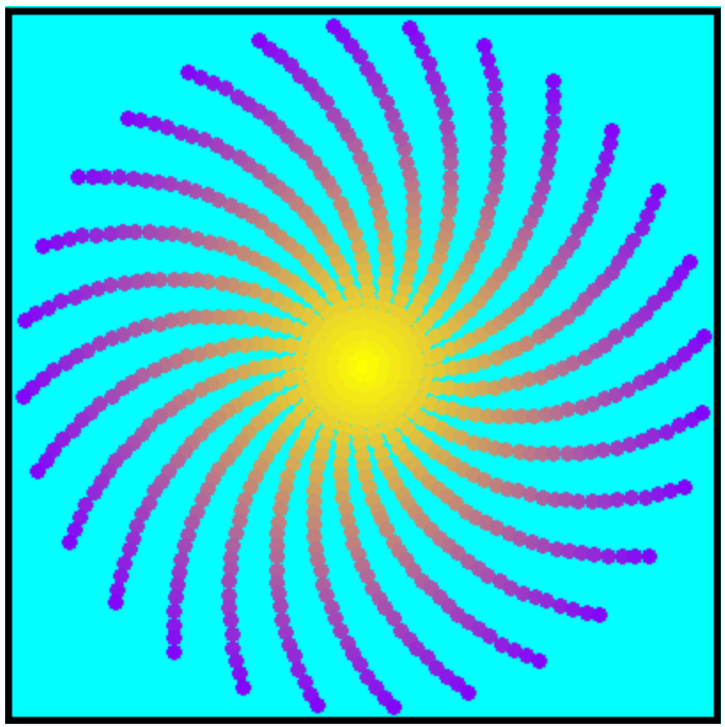
15-112
Fundamentals of Programming

Week 2 - Lecture 4:
Graphics.



May 26, 2016

Pop Quiz

Pop Quiz

Fill in the blank:

Lists are awesome .

T/F: A variable stores the value of an object.

T/F: To make a copy of the list a = [1, 2, 3], do

```
b = a       # a and b are aliases
b = copy.copy(a)
```

What will the following print?

```
a = [1, 2, 3]
b = copy.copy(a)
print(a == b, a is b)
```

Pop Quiz

Fill in the blank:

List parameters are awesome .

Pop Quiz

Fill in the blank:

List parameters are awesome .

```
def fill(a, value):
    for i in range(len(a)):
        a[i] = value

x = [1, 2, 3]
fill(x, 42)
print(x)          [42, 42, 42]
```

Destructive function

Pop Quiz

Fill in the blank:

List parameters are awesome .

```
def fill(a, value):
    a = copy.copy(a)
    for i in range(len(a)):
        a[i] = value
    return a

x = [1, 2, 3]
y = fill(x, 42)
print(x, y)
```

Nondestructive version

[1, 2, 3] [42, 42, 42]

Pop Quiz

Is the sorted function destructive?

```
a = [5, 4, 3, 2, 1]
b = sorted(a)
print(a, b)
```

[5, 4, 3, 2, 1] [1, 2, 3, 4, 5]

Is the sort method destructive?

```
a = [5, 4, 3, 2, 1]
b = a.sort()
print(a, b)
```

[1, 2, 3, 4, 5] None

Pop Quiz

How do you convert a string to a list?

```
s = “You suck anil!”
print(list(s))   ['Y', 'o', 'u', ' ', 's', 'u', 'c', 'k', ' ', 'a', 'n', 'i', 'l', '!']
print(s.split(“ ”))     ['You', 'suck', 'anil!']
```

How do you convert a list of strings into one string?

```
a = [“Stephen”, “is”, “awesome”]
print(“”.join(a))        Stephenisawesome
print(“ ”.join(a))       Stephen is awesome
print(“,”.join(a))       Stephen,is,awesome
```

Pop Quiz

What does this print?

```
a = [1, 2, 3]
b = a
a = a + [4]
print(a)        [1, 2, 3, 4]
print(b)        [1, 2, 3]
```

What does this print?

```
a = [1, 2, 3]
b = a
a += [4]
print(a)        [1, 2, 3, 4]
print(b)        [1, 2, 3, 4]
```

Pop Quiz

What is the difference between pop and other destructive methods?

It makes a cool sound.

Pop Quiz

What is the difference between pop and other destructive methods?

It returns something.

An Exercise

Coin Flips Simulation

If you flipped a coin 200 times, what would be the longest consecutive run of heads or tails?

H T T H T ... H

Exercise: Coin Flips Simulation

Warning: Just because you *can* use lists,
doesn't mean you should use lists.

GRAPHICS!

(with tkinter module)

Importing modules

In general, 2 ways to import a module:

```
import math
print(math.sqrt(5))
```

```
from math import sqrt
print(sqrt(5))
print(pi)
```

ERROR

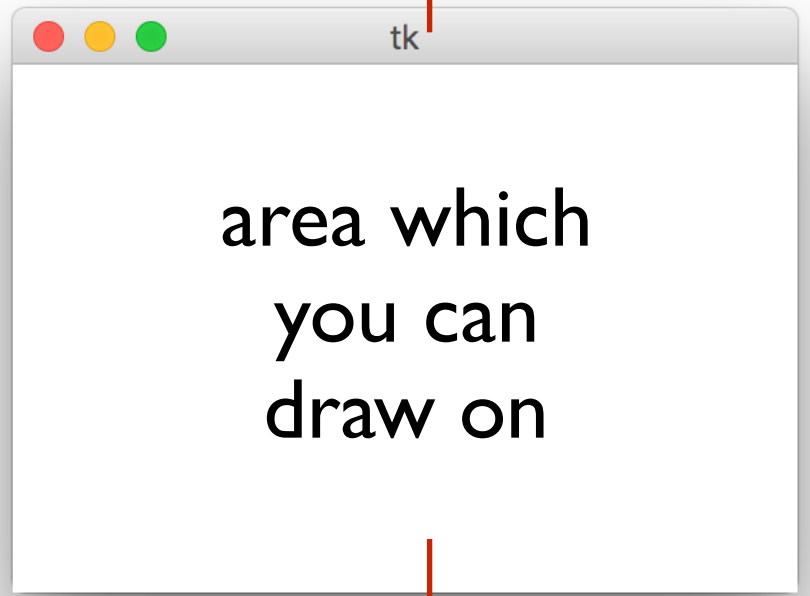
```
from math import *
print(sqrt(5))
print(pi)
```

"all"

```
from tkinter import *
```

tkinter canvas

tkinter window



canvas

(width and height specified in pixels)

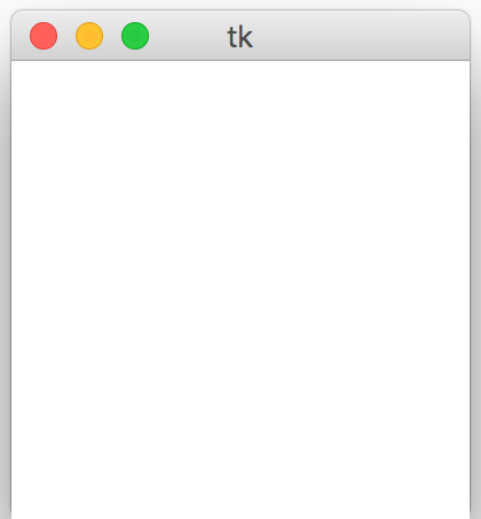
Creating an empty canvas

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=300, height=200)
canvas.pack()
root.mainloop()
```

Creating an empty canvas

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=300, height=200)
canvas.pack()
root.mainloop()
```

creates an object of type Tk (creates a window)




```
x = 5
```

creates an object(data) of type int

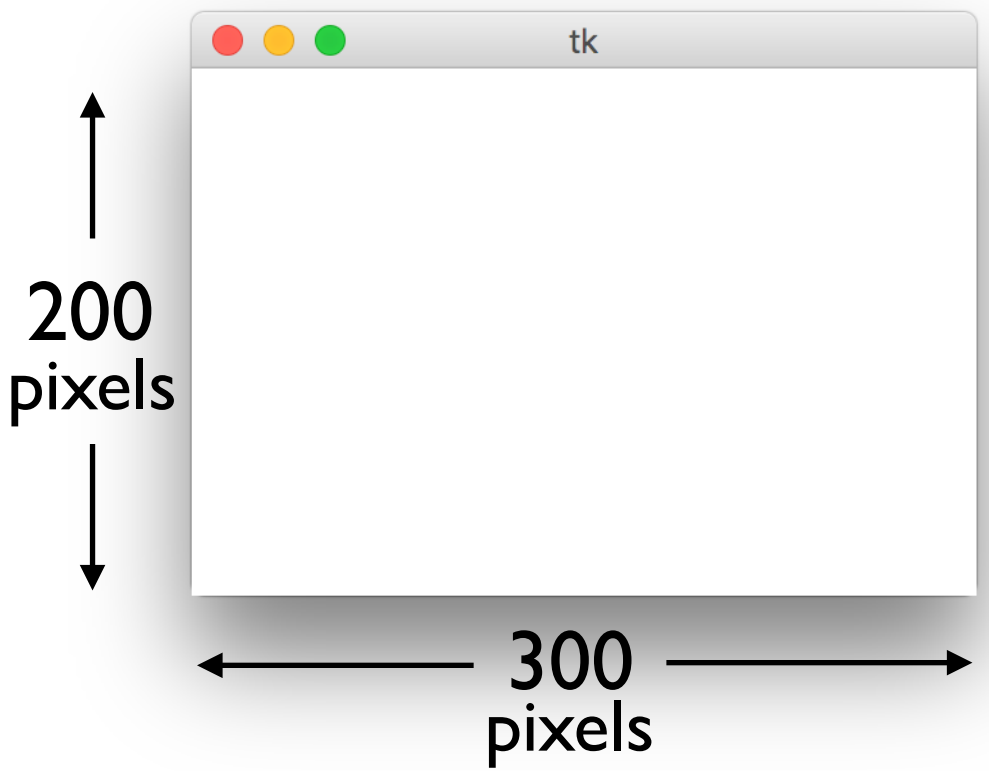
```
a = list()
```

creates an object(data) of type list

Creating an empty canvas

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=300, height=200)
canvas.pack()
root.mainloop()
```

creates an object of type Canvas



Creating an empty canvas

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=300, height=200)
canvas.pack()
root.mainloop()
```

Creating an empty canvas

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=300, height=200)
canvas.pack()
root.mainloop()
```

keep running until window is closed

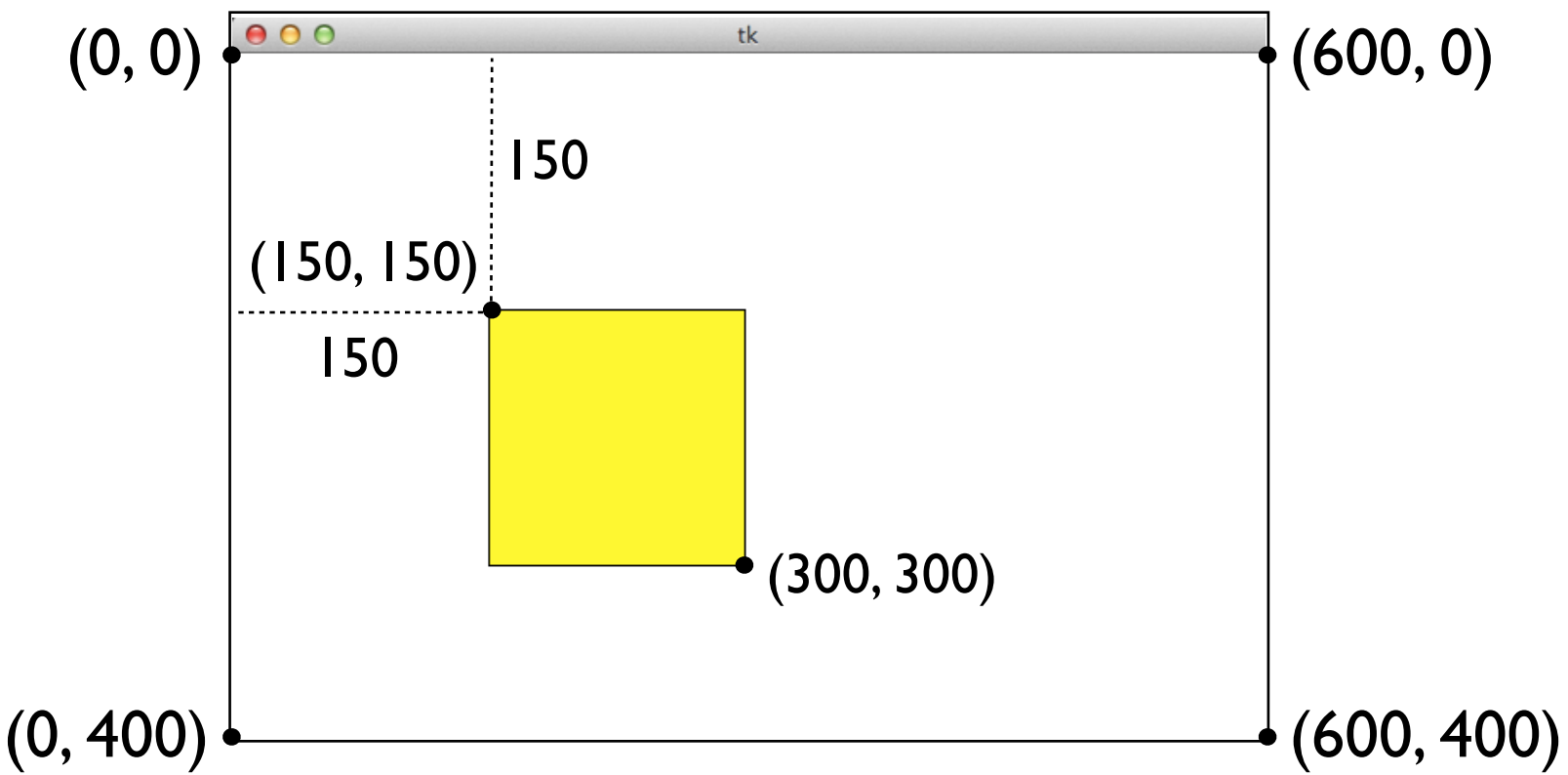
Creating an empty canvas

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=300, height=200)
canvas.pack()

...

...
root.mainloop()
```

code to draw things go here

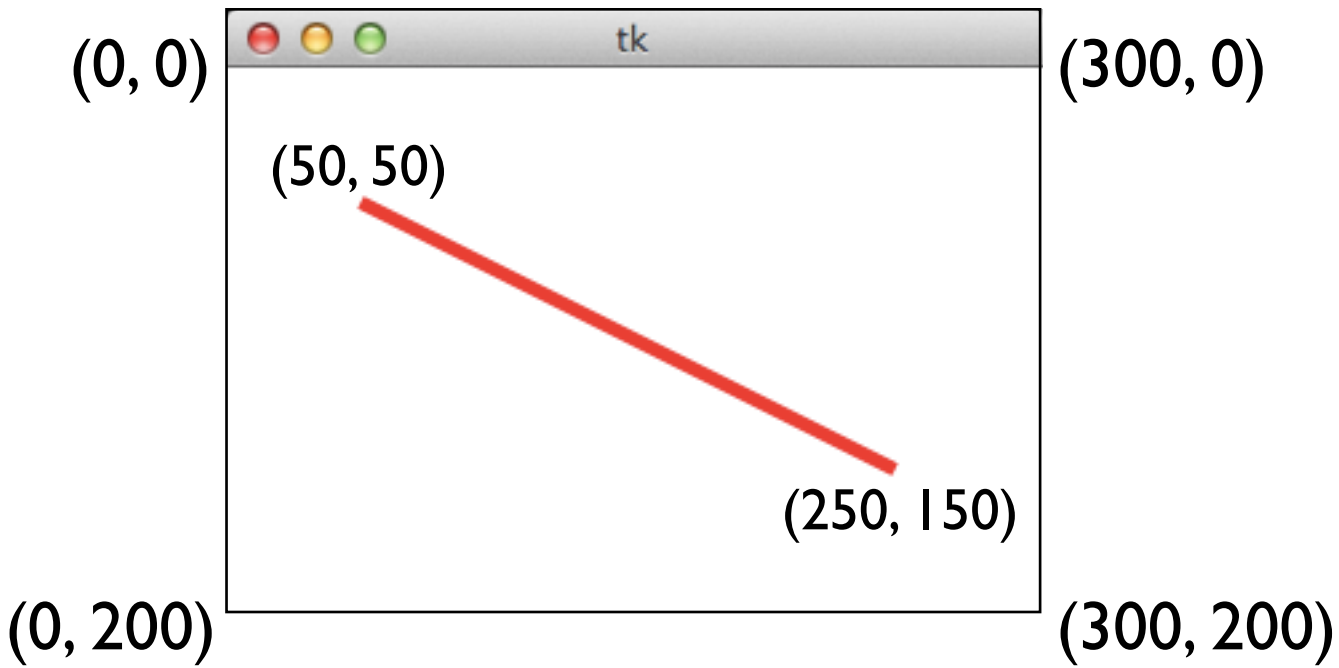
Creating a rectangle

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=600, height=400)
canvas.pack()
canvas.create_rectangle(150, 150, 300, 300, fill="yellow")
root.mainloop()
```



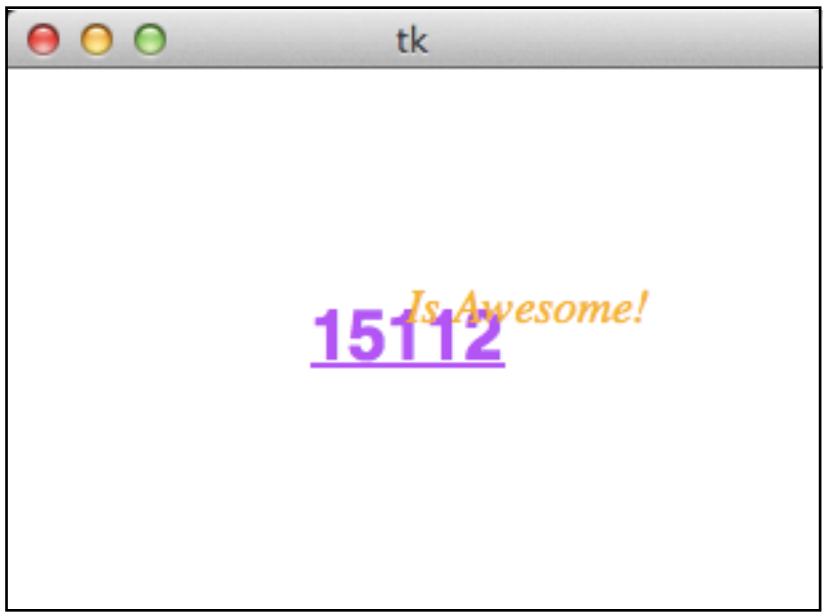
Creating a line

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=300, height=200)
canvas.pack()
canvas.create_line(50, 50, 250, 150, fill="red", width=5)
root.mainloop()
```



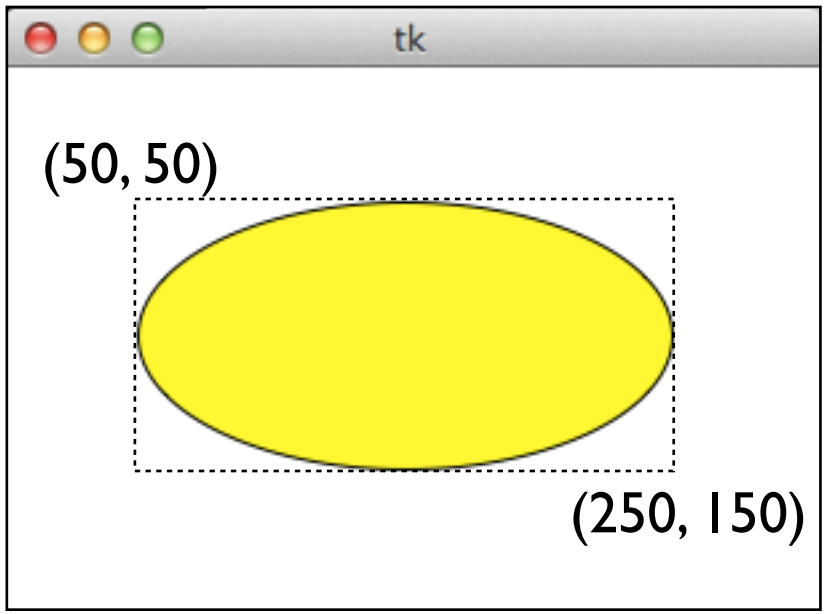
Creating text

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=300, height=200)
canvas.pack()
canvas.create_text(150, 100, text="15112", fill="purple",
                   font="Helvetica 26 bold underline")
canvas.create_text(150, 100, text="Is Awesome!",
                   anchor=SW, fill="orange", font="Times 18 italic")
root.mainloop()
```



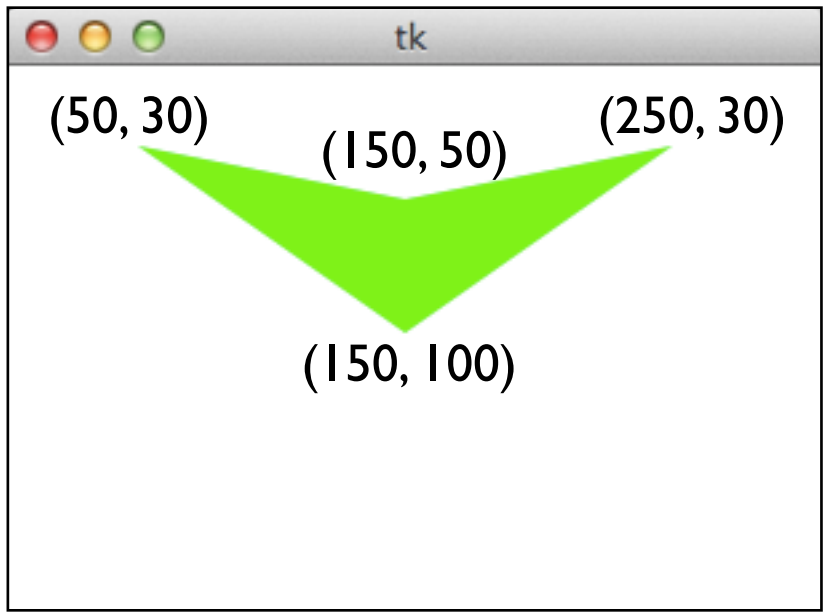
Creating an oval

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=300, height=200)
canvas.pack()
canvas.create_oval(50, 50, 250, 150, fill="yellow")
root.mainloop()
```



Creating a polygon

```
from tkinter import *
root = Tk()
canvas = Canvas(root, width=300, height=200)
canvas.pack()
canvas.create_polygon(50,30,150,50,250,30,150,100,fill="green")
root.mainloop()
```



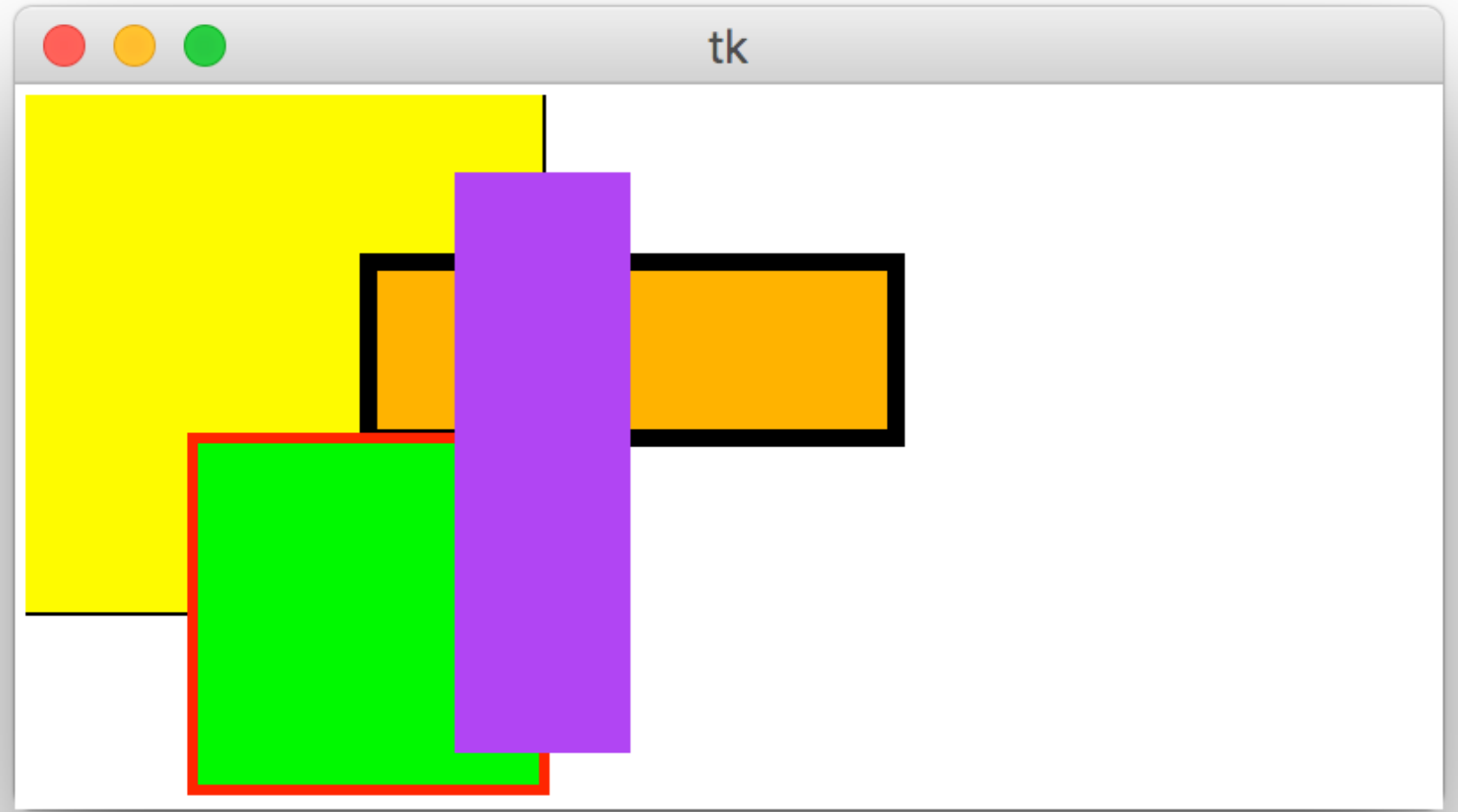
The framework we'll use

```
from tkinter import *

def runDrawing(width=300, height=300):
    root = Tk()
    canvas = Canvas(root, width=width, height=height)
    canvas.pack()
    draw(canvas, width, height)
    root.mainloop()
    print("bye!")

def draw(canvas, width, height):
    # put your code for drawing here

runDrawing(400, 200)
```

Example: drawing rectangles

```
from tkinter import *

def runDrawing(width=300, height=300):
    …

def draw(canvas, width, height):
    canvas.create_rectangle(  0,   0, 150, 150, fill="yellow")
    canvas.create_rectangle(100,  50, 250, 100, fill="orange", width=5)
    canvas.create_rectangle(  50, 100, 150, 200, fill="green",
                                                 outline="red", width=3)
    canvas.create_rectangle(125,  25, 175, 190, fill="purple", width=0)

runDrawing(400, 200)
```

Example: drawing rectangles

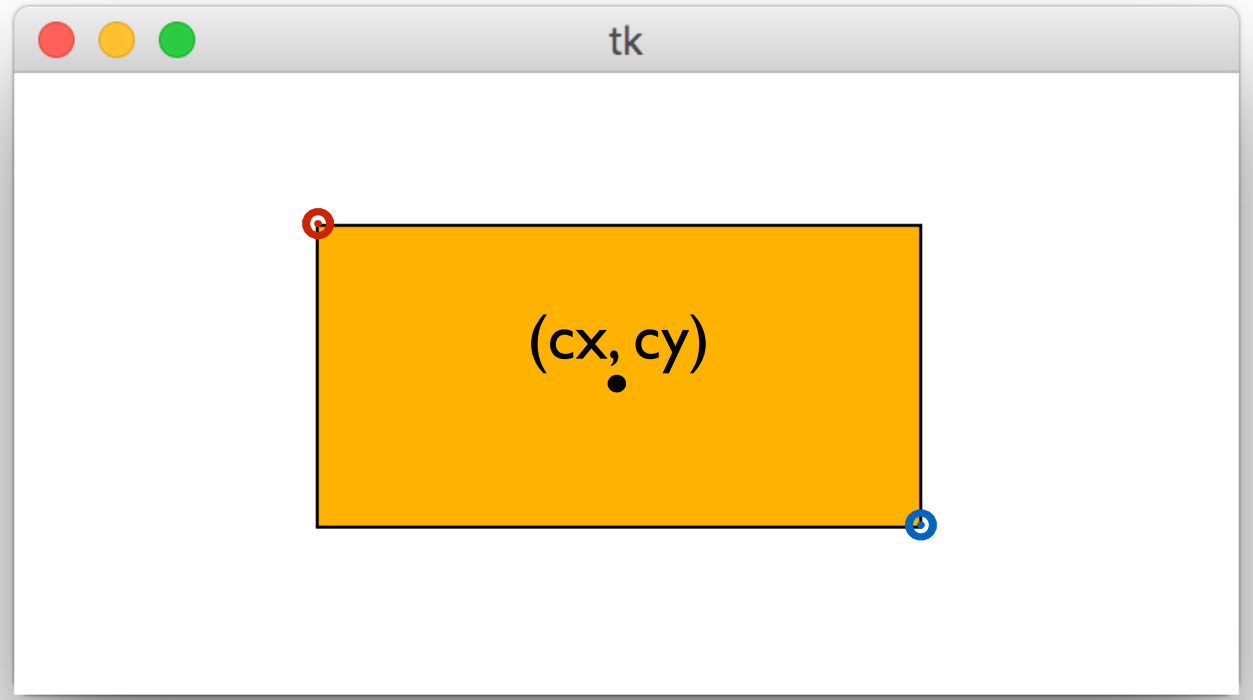


Example: drawing centered rectangles

```
def draw(canvas, width, height):
    margin = 30
    canvas.create_rectangle(margin, margin, width-margin, height-margin,
                            fill="darkGreen")
```

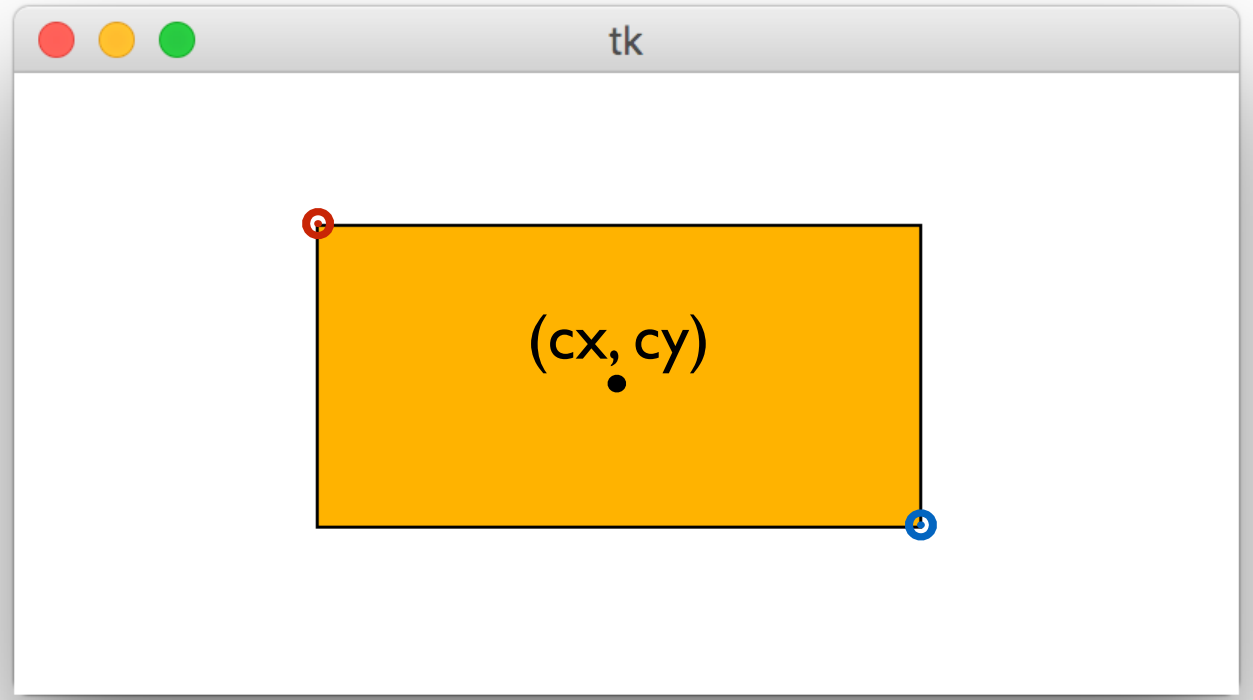
Example: drawing centered rectangles

```
def draw(canvas, width, height):
    (cx, cy) = (width/2, height/2)
    (rectWidth, rectHeight) = (200, 100)
    canvas.create_rectangle(cx - rectWidth/2, cy - rectHeight/2,
                            cx + rectWidth/2, cy + rectHeight/2,
                            fill="orange")
```



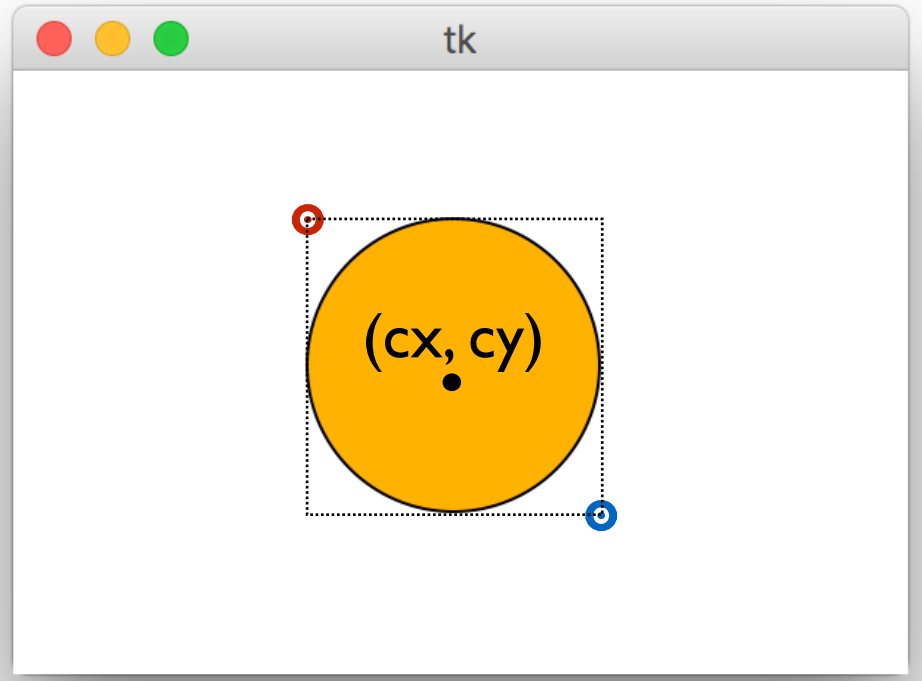
Example: drawing centered rectangles

```
def draw(canvas, width, height):
    (cx, cy) = (width/2, height/2)
    (rectWidth, rectHeight) = (width/2, height/2)
    canvas.create_rectangle(cx - rectWidth/2, cy - rectHeight/2,
                            cx + rectWidth/2, cy + rectHeight/2,
                            fill="orange")
```



Example: drawing centered circles

```
def draw(canvas, width, height):
    (cx, cy) = (width/2, height/2)
    r = min(width, height)/4
    canvas.create_oval(cx - r, cy - r, cx + r, cy + r, fill="orange")
```

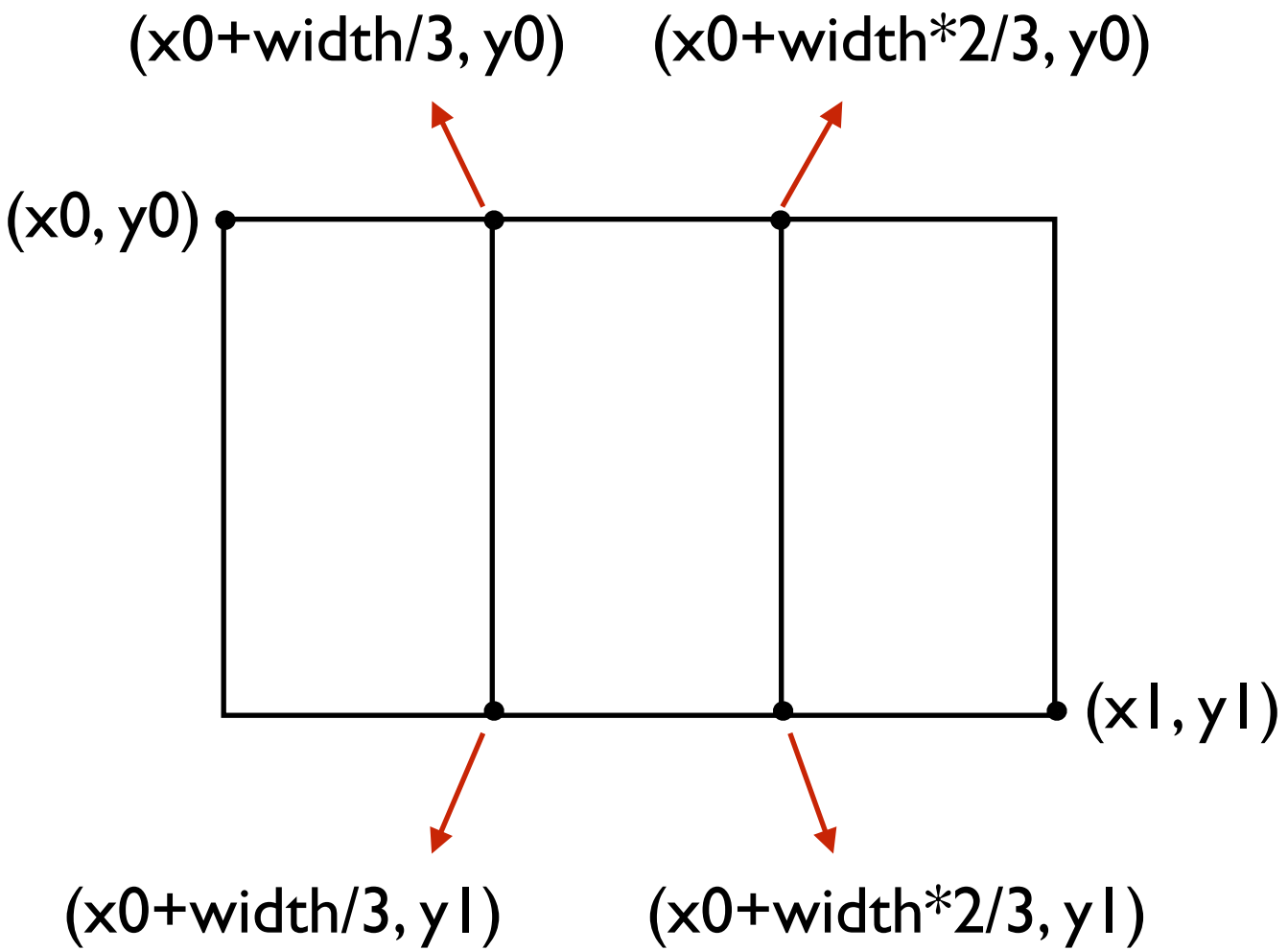


Example: drawing a Belgian flag

```
def drawBelgianFlag(canvas, x0, y0, x1, y1):
    # draw a Belgian flag in the area bounded by (x0,y0) in
    # the top-left and (x1,y1) in the bottom-right
```

Example: drawing a Belgian flag

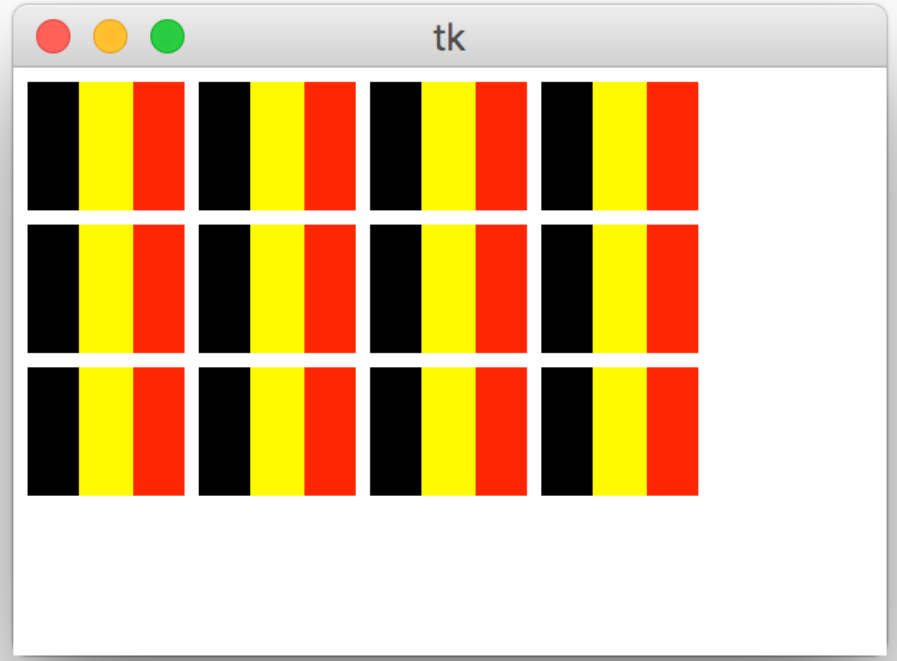
```
def drawBelgianFlag(canvas, x0, y0, x1, y1):
    # draw a Belgian flag in the area bounded by (x0,y0) in
    # the top-left and (x1,y1) in the bottom-right
    width = x1 - x0
```



Example: drawing a Belgian flag

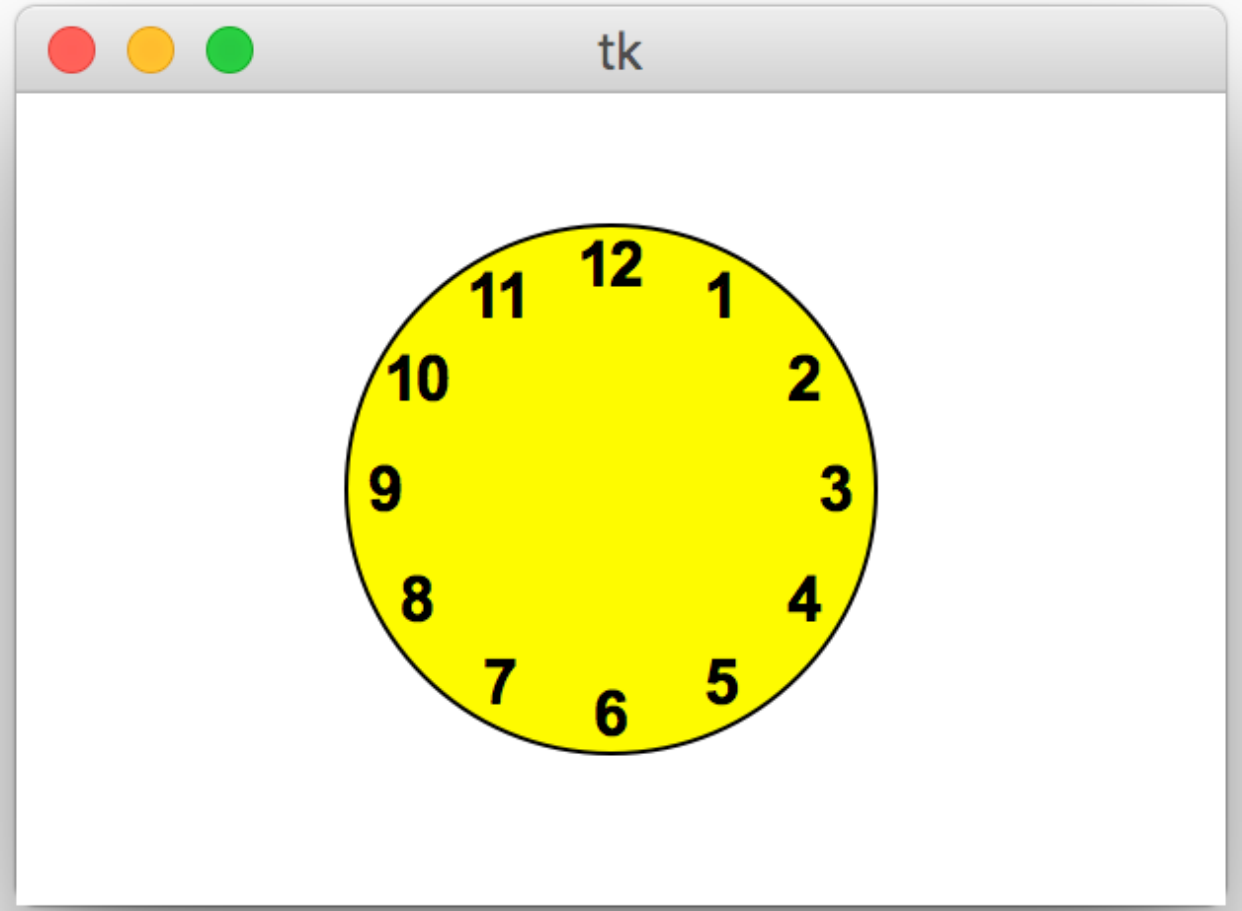
```
def drawBelgianFlag(canvas, x0, y0, x1, y1):
    width = (x1 - x0)
    canvas.create_rectangle(x0, y0, x0+width/3, y1,
                            fill="black", width=0)
    canvas.create_rectangle(x0+width/3, y0, x0+width*2/3, y1,
                            fill="yellow", width=0)
    canvas.create_rectangle(x0+width*2/3, y0, x1, y1,
                            fill="red", width=0)

def draw(canvas, width, height)
    drawBelgianFlag(canvas, 25, 25, 175, 150)
```

Example: drawing a Belgian flag



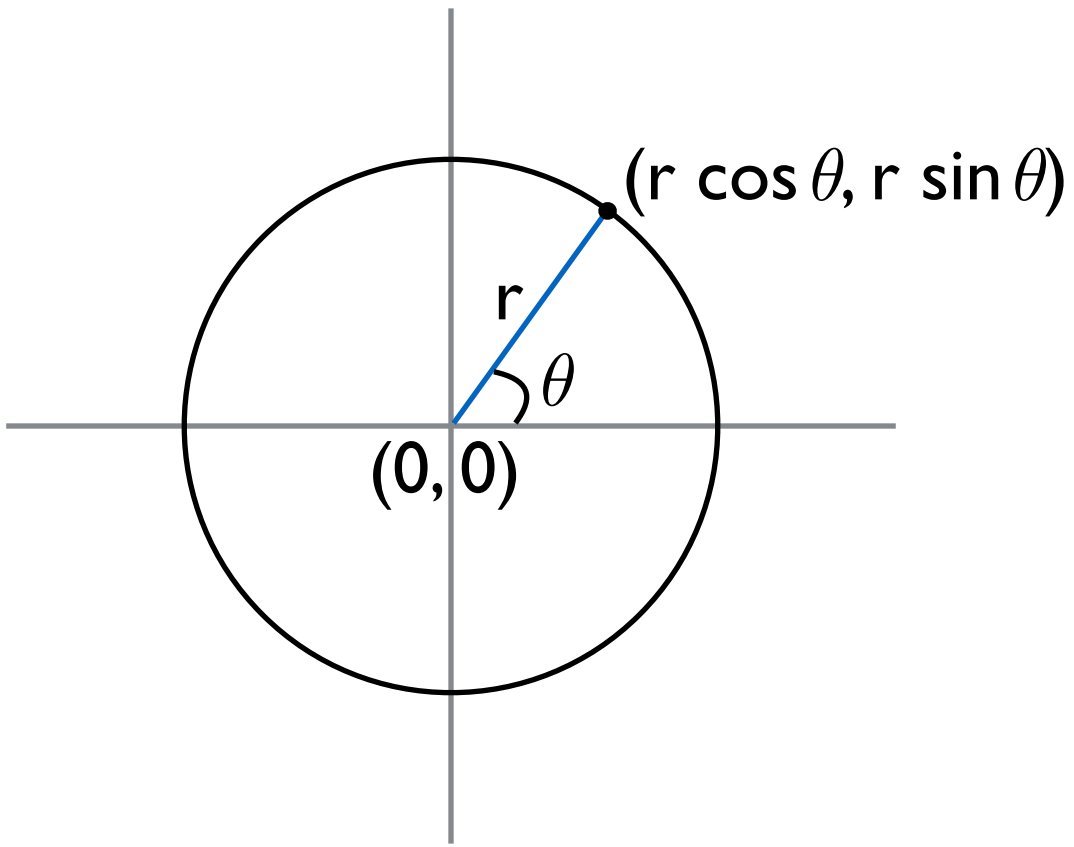

```
def draw(canvas, width, height):
    (flagWidth, flagHeight) = (60, 50)
    margin = 5
    for row in range(3):
        for col in range(4):
            x0 = col * flagWidth + margin
            y0 = row * flagHeight + margin
            x1 = x0 + flagWidth - margin
            y1 = y0 + flagHeight - margin
            drawBelgianFlag(canvas, x0, y0, x1, y1)
```

Example: drawing circular patterns

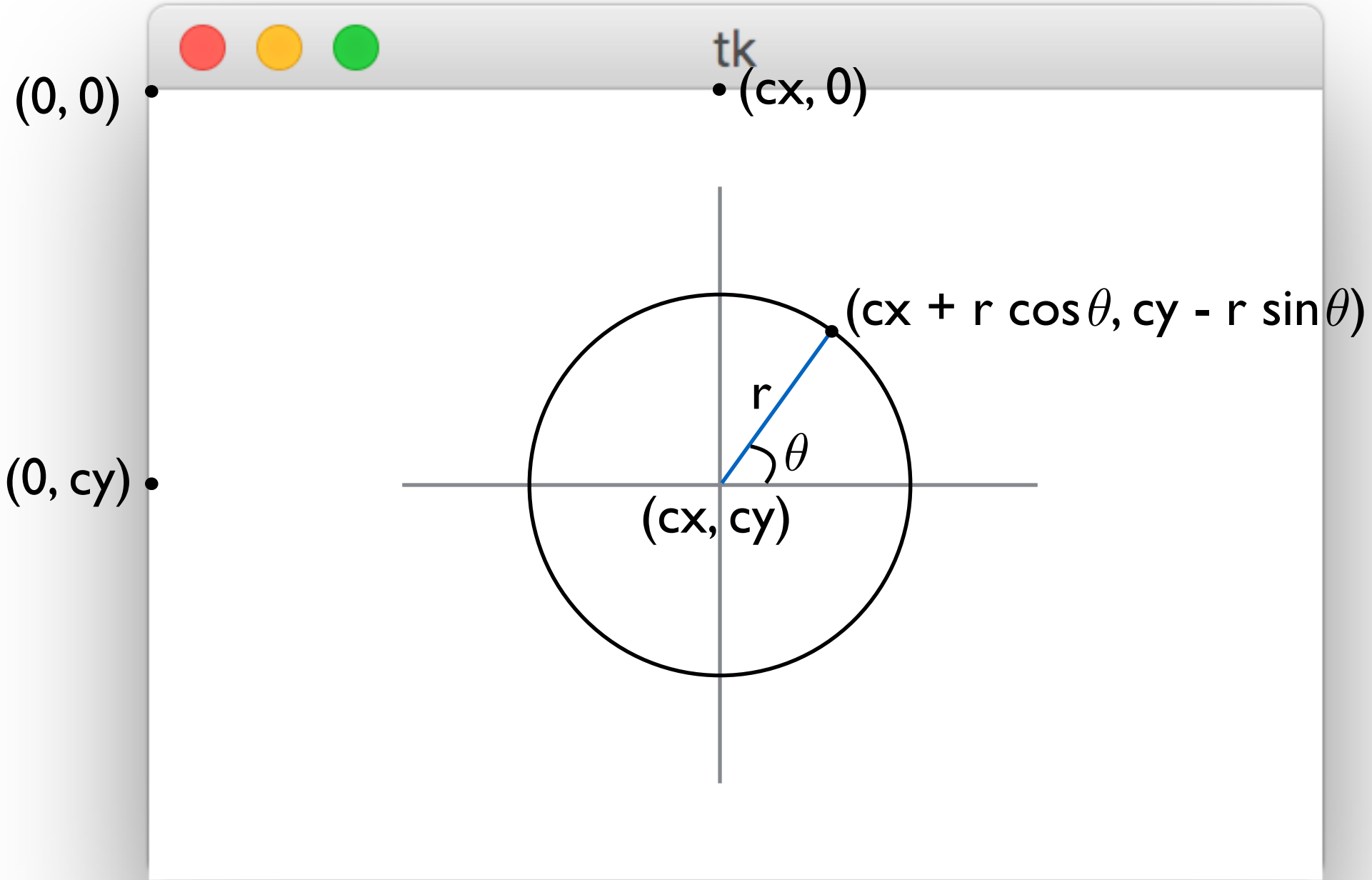


How do you determine the right positions to put the numbers?

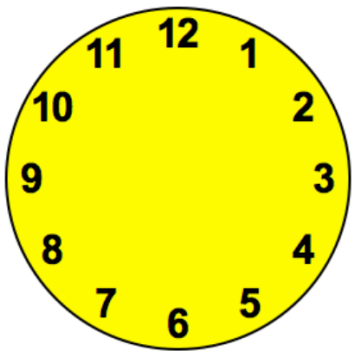
Trig 101



Trig 101

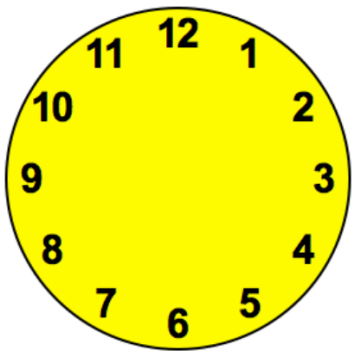


Example: drawing circular patterns



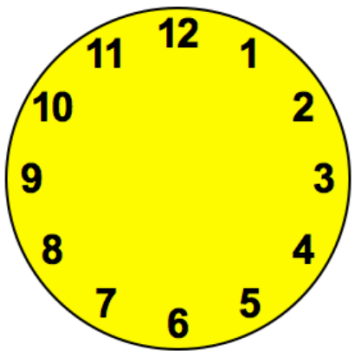

```
import math

def draw(canvas, width, height):
    (cx, cy, r) = (width/2, height/2, min(width, height)/3)
    canvas.create_oval(cx - r, cy - r, cx + r, cy + r, fill="yellow")
```

Example: drawing circular patterns



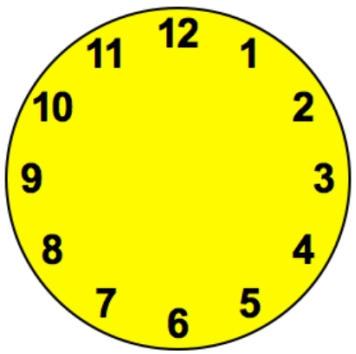

```
import math

def draw(canvas, width, height):
    (cx, cy, r) = (width/2, height/2, min(width, height)/3)
    canvas.create_oval(cx - r, cy - r, cx + r, cy + r, fill="yellow")

    for hour in range(12):
```

Example: drawing circular patterns



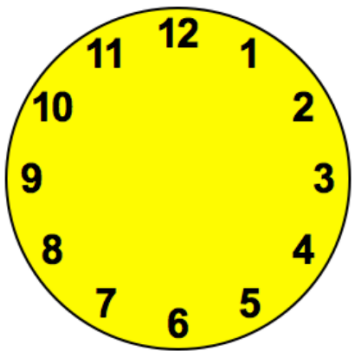

```
import math

def draw(canvas, width, height):
    (cx, cy, r) = (width/2, height/2, min(width, height)/3)
    canvas.create_oval(cx - r, cy - r, cx + r, cy + r, fill="yellow")

    for hour in range(12):

        hourX =
        hourY =
        label =
        canvas.create_text(hourX, hourY, text=label, font="Ariel 16 bold")
```

Example: drawing circular patterns



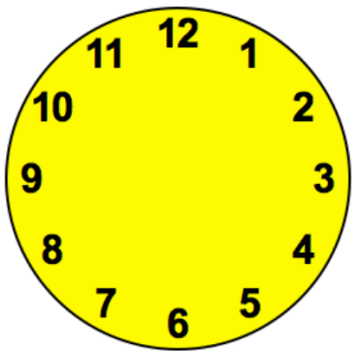

```
import math

def draw(canvas, width, height):
    (cx, cy, r) = (width/2, height/2, min(width, height)/3)
    canvas.create_oval(cx - r, cy - r, cx + r, cy + r, fill="yellow")

    for hour in range(12):

        hourX =
        hourY =
        label = str(hour if (hour > 0) else 12)
        canvas.create_text(hourX, hourY, text=label, font="Ariel 16 bold")
```

Example: drawing circular patterns



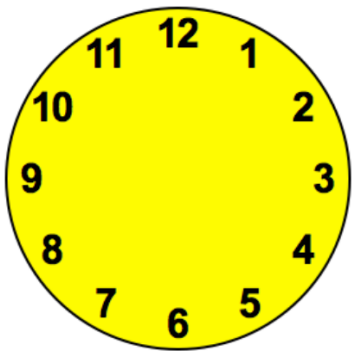

```
import math

def draw(canvas, width, height):
    (cx, cy, r) = (width/2, height/2, min(width, height)/3)
    canvas.create_oval(cx - r, cy - r, cx + r, cy + r, fill="yellow")

    for hour in range(12):

        hourX = cx + r*math.cos(theta)
        hourY = cy - r*math.sin(theta)
        label = str(hour if (hour > 0) else 12)
        canvas.create_text(hourX, hourY, text=label, font="Ariel 16 bold")
```

Example: drawing circular patterns

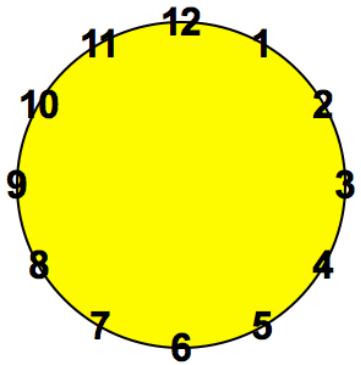



```
import math

def draw(canvas, width, height):
    (cx, cy, r) = (width/2, height/2, min(width, height)/3)
    canvas.create_oval(cx - r, cy - r, cx + r, cy + r, fill="yellow")

    for hour in range(12):
        theta = math.pi/2 - hour*(2*math.pi/12)
        hourX = cx + r*math.cos(theta)
        hourY = cy - r*math.sin(theta)
        label = str(hour if (hour > 0) else 12)
        canvas.create_text(hourX, hourY, text=label, font="Ariel 16 bold")
```

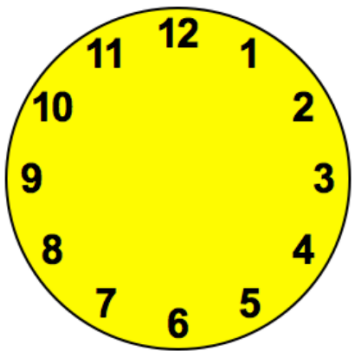
Example: drawing circular patterns




```
import math

def draw(canvas, width, height):
    (cx, cy, r) = (width/2, height/2, min(width, height)/3)
    canvas.create_oval(cx - r, cy - r, cx + r, cy + r, fill="yellow")

    for hour in range(12):
        theta = math.pi/2 - hour*(2*math.pi/12)
        hourX = cx + r*math.cos(theta)
        hourY = cy - r*math.sin(theta)
        label = str(hour if (hour > 0) else 12)
        canvas.create_text(hourX, hourY, text=label, font="Ariel 16 bold")
```

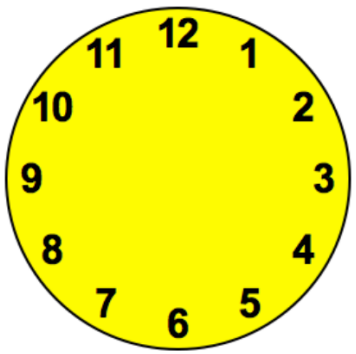


Example: drawing circular patterns




```
import math

def draw(canvas, width, height):
    (cx, cy, r) = (width/2, height/2, min(width, height)/3)
    canvas.create_oval(cx - r, cy - r, cx + r, cy + r, fill="yellow")
    r = r*0.85
    for hour in range(12):
        theta = math.pi/2 - hour*(2*math.pi/12)
        hourX = cx + r*math.cos(theta)
        hourY = cy - r*math.sin(theta)
        label = str(hour if (hour > 0) else 12)
        canvas.create_text(hourX, hourY, text=label, font="Ariel 16 bold")
```

Example: drawing circular patterns




```
import math

def draw(canvas, width, height):
    (cx, cy, r) = (width/2, height/2, min(width, height)/3)
    canvas.create_oval(cx - r, cy - r, cx + r, cy + r, fill="yellow")
    r = r*0.85
    for hour in range(12):
        hourAngle = math.pi/2 - hour*(2*math.pi/12)
        hourX = cx + r*math.cos(hourAngle)
        hourY = cy - r*math.sin(hourAngle)
        label = str(hour if (hour > 0) else 12)
        canvas.create_text(hourX, hourY, text=label, font="Ariel 16 bold")
```

Custom colors

To create a custom color,
specify the amount of Red, Green and Blue in it.

Red	Green	Blue
0-255	0-255	0-255

0	0	0	black
255	255	255	white
255	0	0	red
147	197	114	pistachio

Custom colors

```
def rgbString(red, green, blue):
    return "#%02x%02x%02x" % (red, green, blue)
```

don't worry about how this works

```
pistachio = rgbString(147, 197, 114)
maroon = rgbString(176, 48, 96)
canvas.create_rectangle(50, 50, 150, 150, fill=pistachio,
                        outline=maroon, width=4)
```