At the end of this lecture, students should be able to

- draw 2D shapes using characters
- draw 2D shapes on a Canvas

COMPSCI 101
Principles of Programming

Lecture 26 - Using the Canvas widget to draw rows and columns of shapes

Drawing 2D shapes using Characters

- We write programs to draw 2D shapes using characters
  - (e.g. asterisks)

```
***
***
***
***
```

```
*
**
***
****
```

```
*
 *
  *
   *
```

- The way to conceptualize this is to think about the shape **as a sequence of rows** and to think carefully about **how to** describe the i^th^ row, e.g. drawing a triangle.
- These kinds of problems will help you learn how to write loops by finding **appropriate formulas** to describe each iteration of the loop in terms of the iteration variable.

Example00.py

DEMO

Printing a Row of characters

- The following example prints only one row of '#' characters using a SINGLE for loop.

```
def print_row(number_of_cols):
   for j in range(number_of_cols):
      print('#', end="")
   print()
```

```
###
```

Print a new line character (i.e. move to next line)

Printing Multiple Rows of Characters

- To create rows and columns of shapes we need nested loops
  - That is, loops within loops to execute lines of code.

```
Set up all the variables needed for the nested loop

for … in loop which dictates how many rows:
        Set everything up ready for drawing the row
        for … in loop which handles one single row:
                draw a single character
        move to next line
```

```
***
***
***
***
```

  - The first (outer) loop is looping through rows, the inner loop is looping through columns.
  - As we go through each column of a given row, we print an asterisk. The result is that we can build any size rectangle we want.

1) Printing a Rectangle of Characters

- To print a rectangle, we need two parameters:
  - number of rows = 4 rows
  - number of columns = 3 columns

```
***
***
***
***
```

```
***

***

***

***
```

```
Set up all the variables needed for the nested loop
for … in loop …
    for … in loop which handles one single row:
        draw 3 asterisks
    move to next line
```

- The outer for loop contains two statements:
  - 1) inner for loop
  - 2) print(): move cursor to the next line
- The inner for loop contains one statement:
  - statement which prints a character

Example01.py

DEMO

1) Printing a Rectangle of Characters

- To print a rectangle, we need two parameters:
  - number of rows = 4 rows
  - number of columns = 3 columns

```
***
***
***
***
```

```
***
```

```
***
```

```
***
```

```
***
```

Set up all the variables needed for the nested loop

```
for … in range … 4 rows
    for … in range … 3 columns
        draw 1 asterisk
    move to next line
```

```python
def print_square(number_of_rows, number_of_cols):
    for i in range(number_of_rows):
        for j in range(number_of_cols):
            print('*', end="")
        print()
```

2) Printing a right-angle Triangle

- To print a right-angle triangle, we need one parameter:
  - number of rows = 4 rows

```
*
**
***
****
```

```
*
```

```
**
```

```
***
```

```
****
```

```
Set up all the variables needed for the nested loop

for … in loop … 4 rows
    for … in loop which handles one single row:
        if it is the first row, draw 1 asterisk
        if it is the second row, draw 2 asterisks
        if it is the ith row, draw i asterisks
    move to next line
```

- The outer for loop contains two statements:
  - 1) inner for loop
  - 2) print(): move cursor to the next line
- The inner for loop contains one statement:
  - statement which prints one or more character(s)

Example02.py

DEMO

2) Printing a right-angle Triangle

- To print a right-angle triangle, we need one parameter:
  - number of rows = 4 rows

```
*
**
***
****
```

```
*
```

```
**
```

```
***
```

```
****
```

Set up all the variables needed for the nested loop

```
for … in range … 4 rows
    for … in range …
        row = 0, number of columns = 1
        row = 1, number of columns = 2
        row = 2, number of columns = 3
    move to next line
```

```python
def print_right_angle_triangle(number_of_rows):
    for row in range(number_of_rows):
        for column in range(row+1):
            print('*', end="")
        print()
```

Exercise 1

- Task:
  - Complete the following code fragment to print …

```
def print_right_angle_triangle(number_of_rows):
    for row in range(number_of_rows):



         print()
```

```
   *
  **
 ***
****
```

Program skeleton

- All the programs in this lecture have the following code skeleton.
  - The draw_shapes() function is different for each exercise.

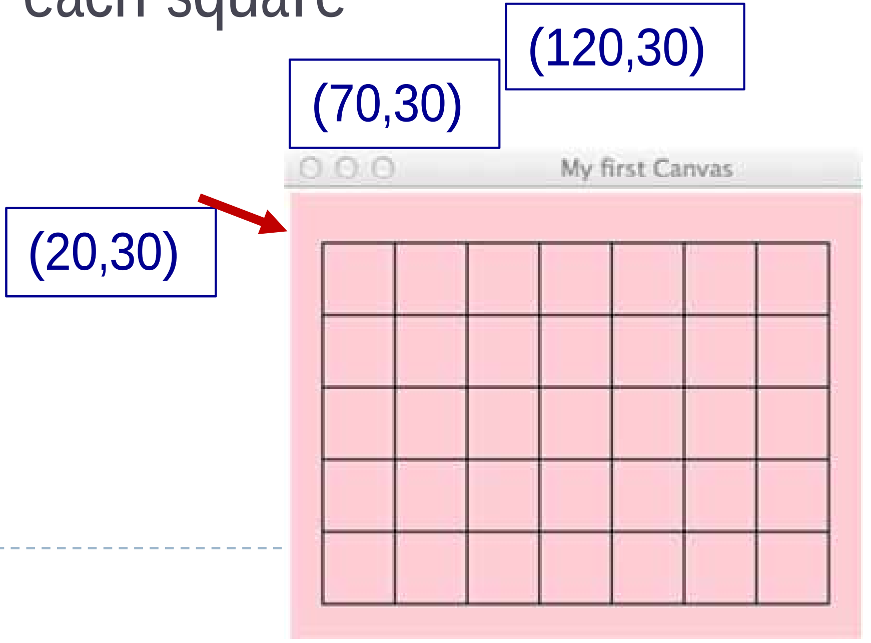
```
def main():
    root = Tk()
    root.title("My first Canvas")
    root.geometry("400x300+10+20")
    a_canvas = Canvas(root)
    a_canvas.config(background="pink")     #some colour
    a_canvas.pack(fill=BOTH, expand = True)
    draw_shapes(a_canvas)
    root.mainloop()

main()
```

Drawing 2D shapes on a Canvas

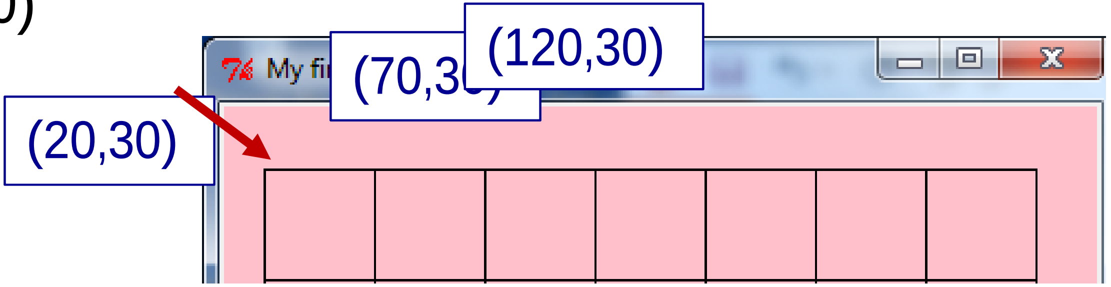
- In order to draw a 2D shape (e.g. multiples of squares) on a canvas, we need:
  - The number of rows and number of columns
  - Size of each square (size=50)
  - Start point (x_margin, y_margin) = (20, 30)
  - Nested loops
  - Coordinates of the top left corner of each square
    - Example:
      - 1st (20, 30), (70, 30), (120,30) …
      - 2nd (20, 80), (70,80), (120, 80)
      - …

Size of the squares is 50 pixels by 50 pixels



Example 3

- Let’s look at ONE row of the shape FIRST:
  - x = 20 (starts at 20 on each row)
    - Coordinates of the first square: (20, 30, 70, 80)
    - …Second square: (70, 30, 120, 80)
    - …Third square(120, 30, 170, 80)



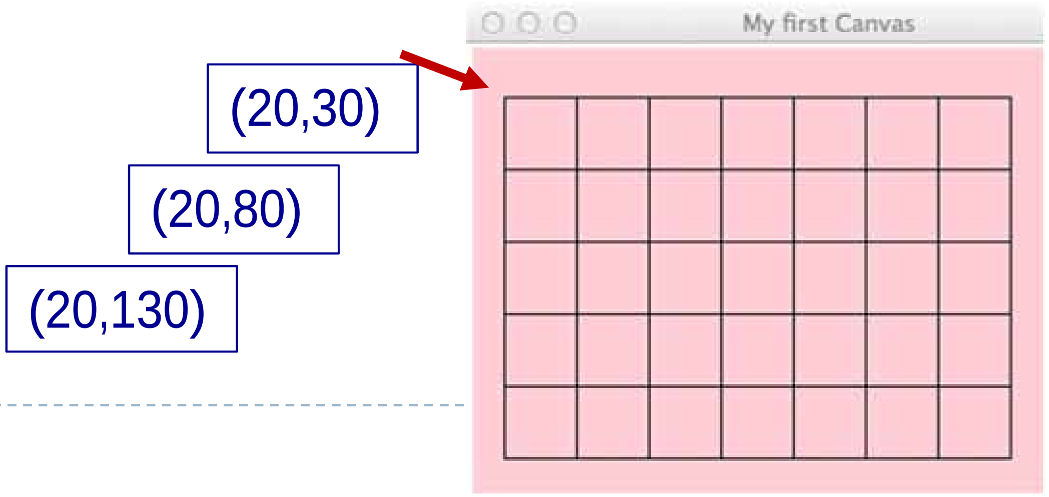
```
x_left = left_hand_side

for j in range(number_of_colums):
    rect = (x_left, y_down , x_left + size, y_down  + size)
    a_canvas.create_rectangle(rect)
    x_left += size
```

modify x-coordinate of the square in each iteration

Drawing … on a Canvas

- Now, we look at the entire shape. We need nested loops!
- The outer loop iterates number of rows.
  - 1st row : coordinate of the top left corner: (20, **<u>30</u>**) and the next one is (70, **<u>30</u>**) and (120, 30) …
  - 2nd row: coordinate of the top left corner: (20, **<u>80</u>**) and the next one is (70, **<u>80</u>**) and (120, 80) …
  - 3rd row: : coordinate of the top left corner: (20, **<u>130</u>**) and the next one is (70, **<u>130</u>**) and (120, 130) …
  - …



Drawing … on a Canvas

- We put them together:

```
Set up all the variables needed for the nested loop
for … in loop which dictates how many rows:
    Set everything up ready for drawing the row
    for … in loop which handles one single row:
        draw a single shape
        change the x value to move along the row
    change the y value ready for the next row down
```

Outer loop:

```python
for i in range(number_of_rows):
  x_left = left_hand_side

  for j in range(number_of_columns):
    rect = (x_left, y_down, x_left + size, y_down + size)
    a_canvas.create_rectangle(rect)
    x_left += size

  y_down += size
```

reset the starting position of each row

Inner loop:

adjust the y coordinates

Example03.py

DEMO

Drawing … on a Canvas

reset the starting position of each row

y_down += size

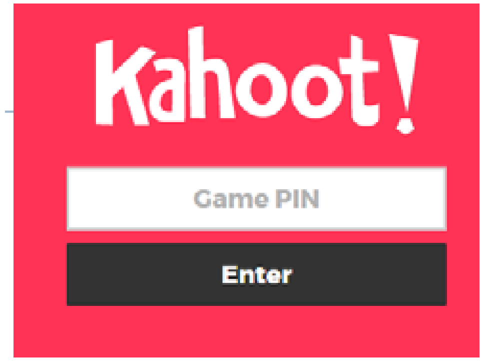
y_down += size

(20,30) x_left = left_hand_side	(70, 30) x_left += size y no change	(120, 30) x_left += size y no change
(20,80) x_left = left_hand_side	(70, 80) x_left += size y no change	(120, 80) x_left += size y no change
(20,130) x_left = left_hand_side	(70, 130) x_left += size y no change	(120, 130) x_left += size y no change

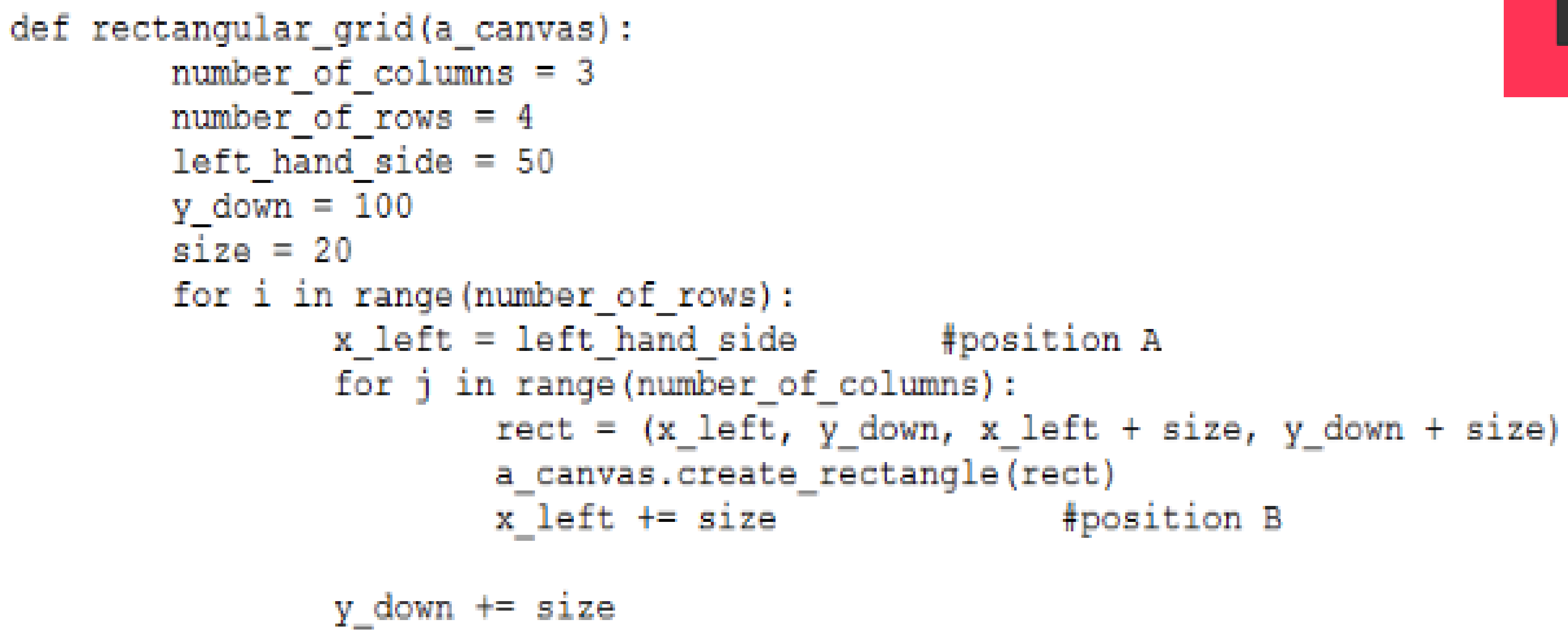
- Algorithm:

```
Set up all the variables needed for the nested loop
for … in loop which dictates how many rows:
    Set everything up ready for drawing the row
    for … in loop which handles one single row:
        draw a single shape
        change the x value to move along the row
    change the y value ready for the next row down
```

Quizzes



- Consider the following code fragment:

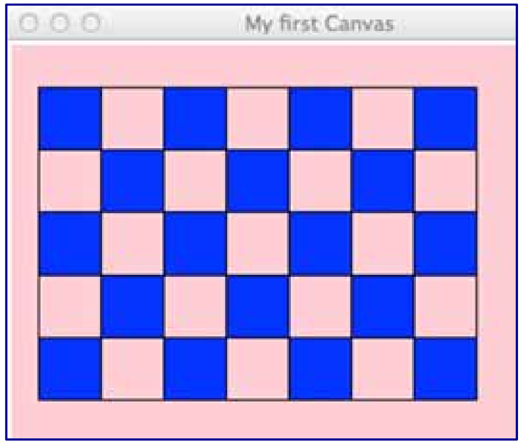


```
def rectangular_grid(a_canvas):
        number_of_columns = 3
        number_of_rows = 4
        left_hand_side = 50
        y_down = 100
        size = 20
        for i in range(number_of_rows):
                x_left = left_hand_side       #position A
                for j in range(number_of_columns):
                        rect = (x_left, y_down, x_left + size, y_down + size)
                        a_canvas.create_rectangle(rect)
                        x_left += size              #position B

                y_down += size
```

Example 4

- What should we do in order to draw the following shapes?
  - First row:
    - Fill, draw, fill, draw…
  - Second row:
    - Draw, fill, draw, fill …
  - Third row
    - Fill, draw, fill, draw…



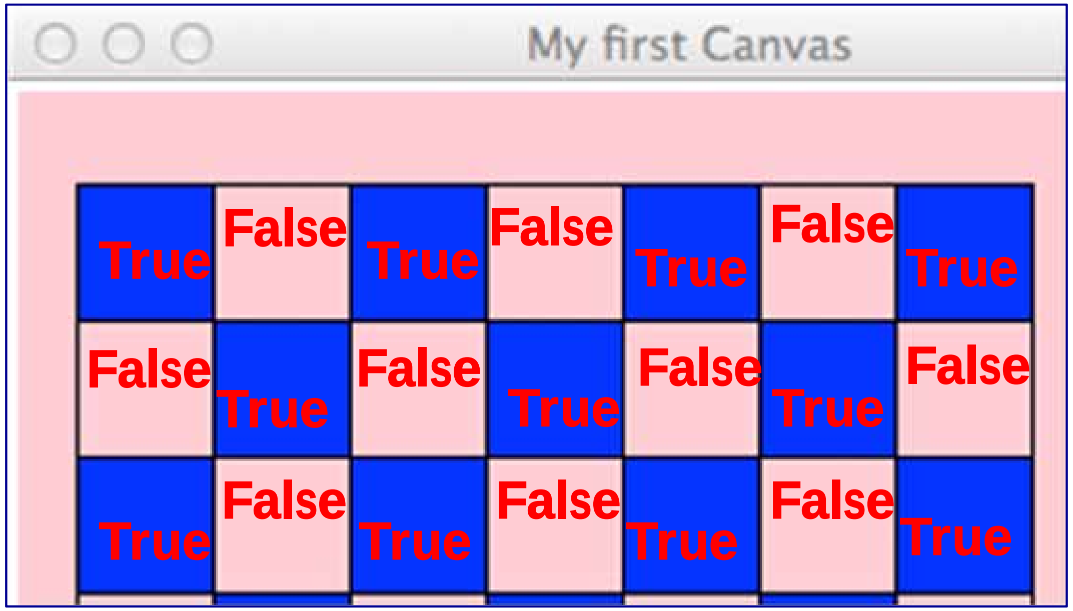
```
rect = (x_left, y_down, x_left + size, y_down + size)
a_canvas.create_rectangle(rect, fill="blue")
```

Command to create the filled square

```
rect = (x_left, y_down, x_left + size, y_down + size)
a_canvas.create_rectangle(rect)
```

4) Drawing … on a Canvas

- Using a Boolean variable
  - First row:
    - True, False, True, False…
  - Second row:
    - False, True, False, True…
  - Third row
    - True, False, True, False…



4) Drawing … on a Canvas

- What is the output of the following code fragment?

```
is_filled = True
for i in range(5):
    print(is_filled, end=" ")
    is_filled = not is_filled
```

```
True False True False True
```

i	is_filled
	True
0	False
1	True
2	False
3	True
4	False

Drawing … on a Canvas

- We put them together:

Outer loop:

```
x-margin, y-margin, width, height, first_in_row_filled=True
Set up all the variables needed for the nested loop
set up y-position
for … in loop which dictates how many rows:
    Set everything up ready for drawing the row
    set up x-positon, is_filled

    for … in loop which handles one single row:
        draw a single shape
        change the x value to move along the row
        modify the is_filled boolean
    change the y value ready for the next row down
    modify the first_in_row_filled boolean
```

Inner loop

Drawing … on a Canvas

Example04.py

DEMO

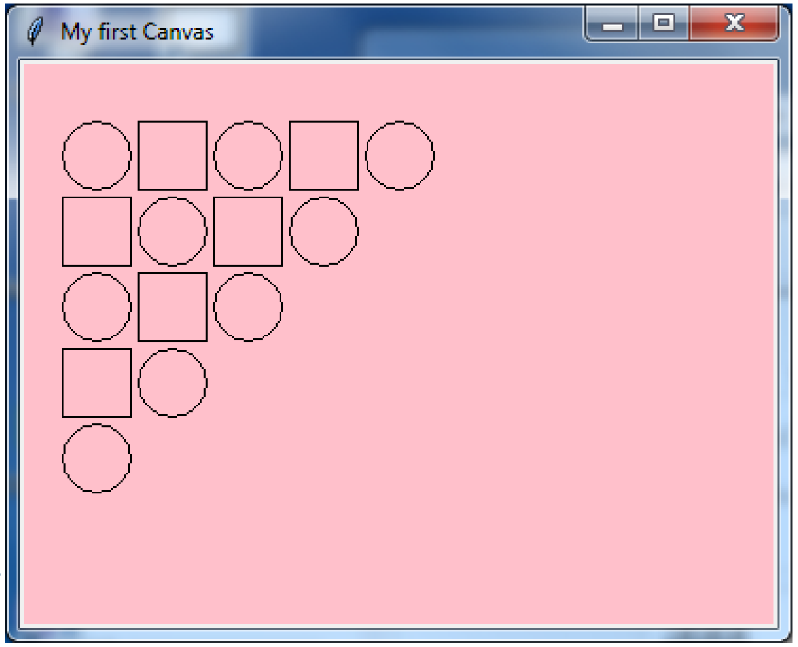
- Nested Loops:

```
first_in_row_filled = True
for i in range(number_of_rows):
  x_left = left_hand_side
  is_filled = first_in_row_filled
  for j in range(number_in_row):
    rect = (x_left, y_down, x_left + size, y_down + size)
    if is_filled:
      a_canvas.create_rectangle(rect, fill="blue")
    else:
      a_canvas.create_rectangle(rect)
    x_left = x_left + size
    is_filled = not is_filled

  y_down = y_down + size
  first_in_row_filled = not first_in_row_filled
```

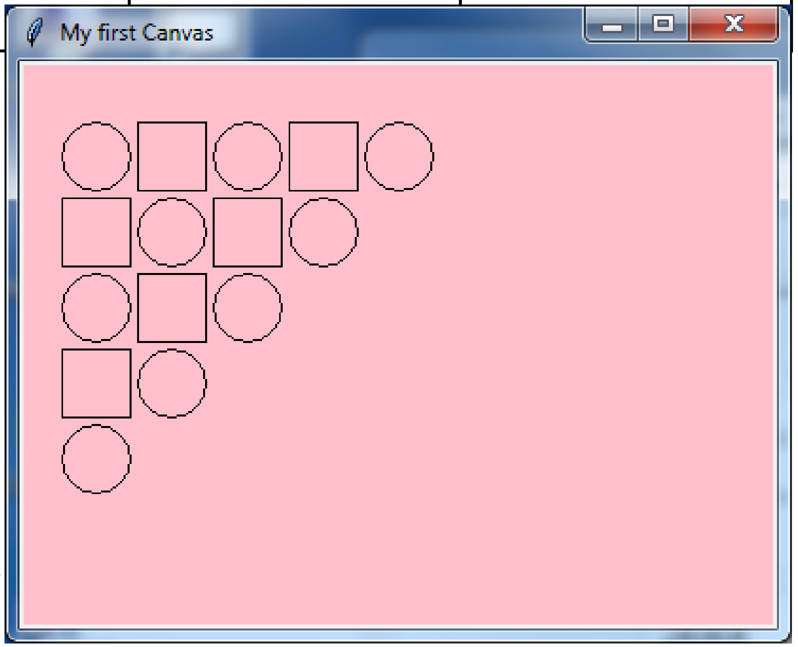
Example 5

- Steps:
  - 1st iteration of outer loop -> repeat 5 iterations in the inner loop
  - 2nd iteration of outer loop -> repeat 4 iterations in the inner loop
  - 3rd iteration of outer loop -> repeat 3 iterations in the inner loop
  - 4th iteration of outer loop -> repeat 2 iterations in the inner loop
  - 5th iteration of outer loop -> repeat 1 iteration in the inner loop



is_circle boolean

first_is_circle	is_circle				
True	True	False	True	False	True
False	False	True	False	True	
True	True	False	True		
False	False	True			
True	True				



Exercise 2

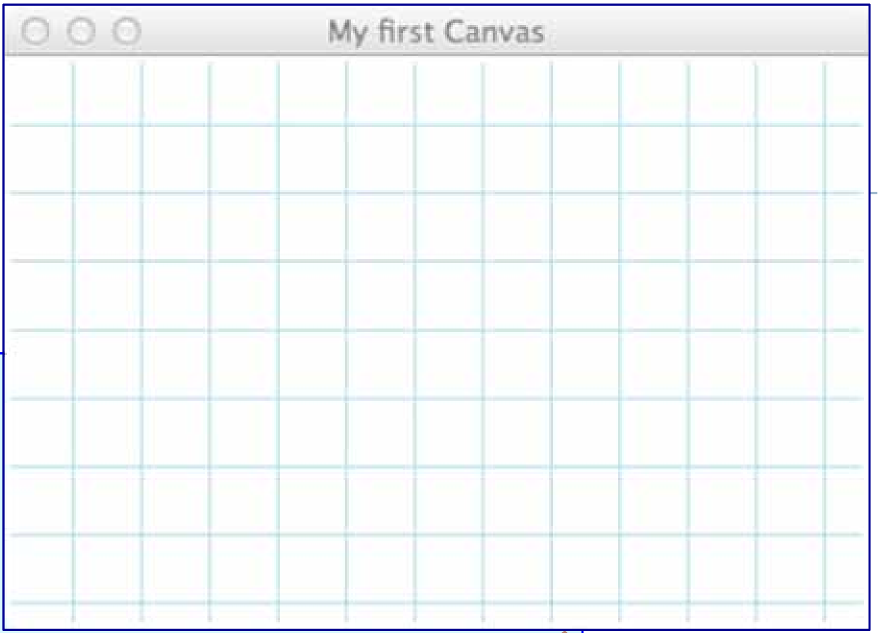
- Draw the canvas

```
def draw_shapes(a_canvas):
    number_of_rows = 6
    size = 30
    y_down = 0
    left_hand_side = size

    for number_along_row in range(1, number_of_rows + 1):
        x_left = left_hand_side

        for j in range(number_along_row):
            rect = (x_left + 2, y_down + 2, x_left + size - 2, y_down
                                                          + size - 2)
            a_canvas.create_oval(rect, fill="blue")
            x_left = x_left + size * 2

        y_down = y_down + size
```



gridlines are of size 30 pixels