Python Turtle

Lesson 3

Topics

- storing values in variables
- when and how to use variables
- screen coordinates
- how to use coordinates to move the turtle
- how to move the turtle without drawing a line

Part 1

Variables

Conventional range

How to use `range` in a more conventual way.

Previously, we would use the following code to print four numbers.

```
for index in range(1, 5):
    print(number)
```

> ### What is index?
>
> `index` → programming convention that represents a counter in a loop

If you run the code you get the following.

```
1
2
3
4
```

Only concerned about the number of iterations

```
for index in range(0, 4):
    print(number)
```

Will produce:

```
0
1
2
3
```

Still has four iterations → starts counting at `0`

If `range` function not given a starting number → start at `0`

```
for index in range(4):
    print(number)
```

Will produce:

```
0
1
2
3
```

The way that `range` is conventionally used.

Replace magic numbers

A solution for lesson 2 exercise 1

New file **lesson_3_pt_1.py** → enter the code

```
import turtle

window = turtle.Screen()
window.setup(500, 500)
my_ttl = turtle.Turtle()

for index in range(4):
    my_ttl.forward(100)
    my_ttl.left(90)
```

Draw a triangle with side length `200` → what do we need to change?

```
import turtle

window = turtle.Screen()
window.setup(500, 500)
my_ttl = turtle.Turtle()

for index in range(3):
    my_ttl.forward(200)
    my_ttl.left(120)
```

What do the changed numbers represent?

- `4` → `3` representing the number sides.
- `100` → `200` representing the length of the sides.
- `90` → `120` representing the degrees the Turtle has to turn.

To draw a hexagon → same three numbers change

These numbers → **magic numbers**

A magic number → **hard coded** value in the program

Magic numbers → not good

- No explicit meaning → what do `3`, `200` and `120` mean?
- Changing 1000 squares into triangles → 3000 edits.

Replace magic numbers with labels called **variables**

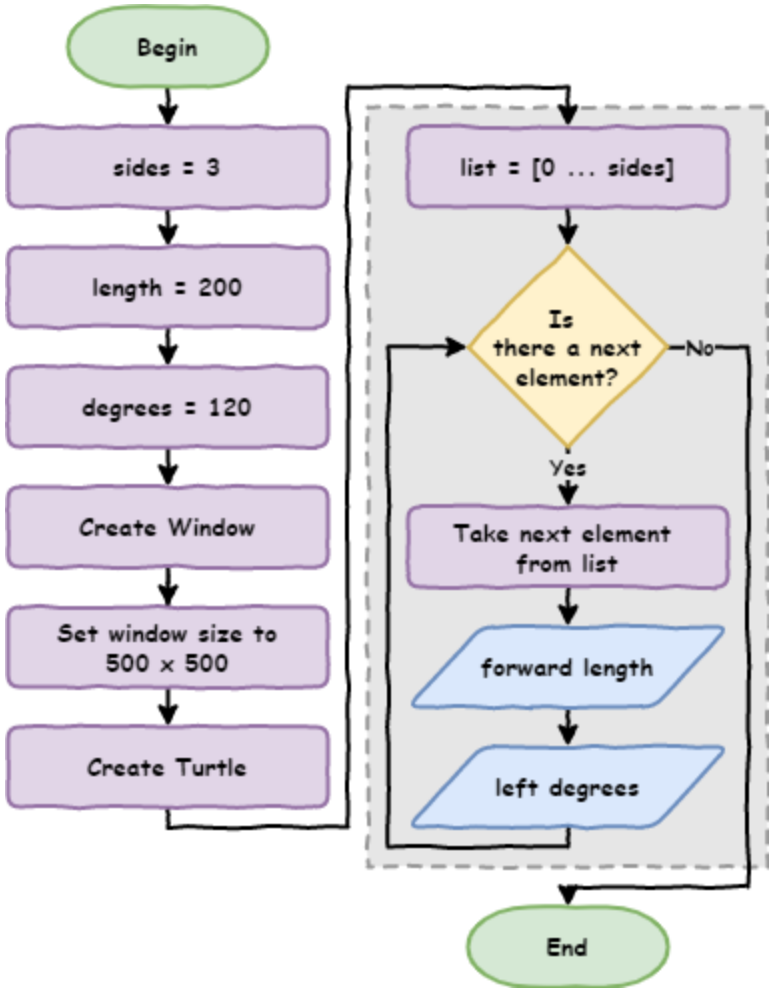
```
import turtle

sides = 3
length = 200
degrees = 120

window = turtle.Screen()
window.setup(500, 500)
my_ttl = turtle.Turtle()

for index in range(sides):
    my_ttl.forward(length)
    my_ttl.left(degrees)
```

- **Predict** and **run** the code
- `sides`, `length` and `degrees` are all **variables** → let's **investigate**


Begin
sides = 3
length = 200
degrees = 120
Create Window
Set window size to
500 x 500
Create Turtle
list = [0 ... sides]
Is
there a next
element?
No
Yes
Take next element
from list
forward length
left degrees
End

- `sides = 3` creates variable `sides` → assigns `3` to it
- `length = 200` creates variable `length` → assigns `200` to it
- `degress = 120` creates the variable `degrees` → assigns `120` to it
- `for i in range(sides):` substitutes `sides` with `3` → `for index in range(3)`
- `my_ttl.forward(length)` substitutes `length` with `200` → `my_ttl.forward(200)`
- `my_ttl.left(degrees)` substitutes `degrees` with `120` → `my_ttl.left(120)`

Python naming rules

Very specific rules variable names:

- can only contain letters, numbers and the `_` character
- cannot contain spaces
- cannot start with a number
- are case sensitive (eg. `age` is not the same as `Age`)

Using variables → copy the `for` loop as many times as we want

Values for `sides`, `length`, and `degrees` → use the values assigned to them

Single point of truth

Changing the value of `sides` → changes the value for uses of `sides`

Same for `length` and `degrees`.

Change **lesson_3_pt_1.py** to draws a hexagon with length of 100

```
import turtle

sides = 6
length = 100
degrees = 60

window = turtle.Screen()
window.setup(500, 500)
my_ttl = turtle.Turtle()

for index in range(sides):
    my_ttl.forward(length)
    my_ttl.left(degrees)
```

No 'meat space' calculations

How did we know that degrees needed to be 60?

Worked it out in your head or used a calculator?

Flaws on both:

- head calculations can be incorrect
- getting a calculator is a waste of time

Use Python to do the calculations.

Python Arithmetic Operators

Operation	Symbol
Addition	+
Subtraction	-
Multiplication	*
Division	/
Modulus	%
Exponentiation	**
Floor Division	//

Degrees is `360` divided by number of sides (`sides`)

In code → `degrees = 360 / sides`

```
import turtle

sides = 6
length = 100
degrees = 360 / sides

window = turtle.Screen()
window.setup(500, 500)
my_ttl = turtle.Turtle()

for index in range(sides):
    my_ttl.forward(length)
    my_ttl.left(degrees)
```

Remove unnecessary variables

Do we need the `degrees` variable?

Could place calculation inside the `for` loop.

```
import turtle

sides = 6
length = 100

window = turtle.Screen()
window.setup(500, 500)
my_ttl = turtle.Turtle()

for index in range(360 / sides):
    my_ttl.forward(length)
    my_ttl.left(degrees)
```

Are there any more **magic numbers**? See if you can find any more.

```
import turtle

screen = 500
sides = 6
length = 100
CIRCLE_DEG = 360

window = turtle.Screen()
window.setup(screen, screen)
my_ttl = turtle.Turtle()

for index in range(sides):
    my_ttl.forward(length)
    my_ttl.left(DEGREES_IN_CIRCLE / sides)
```

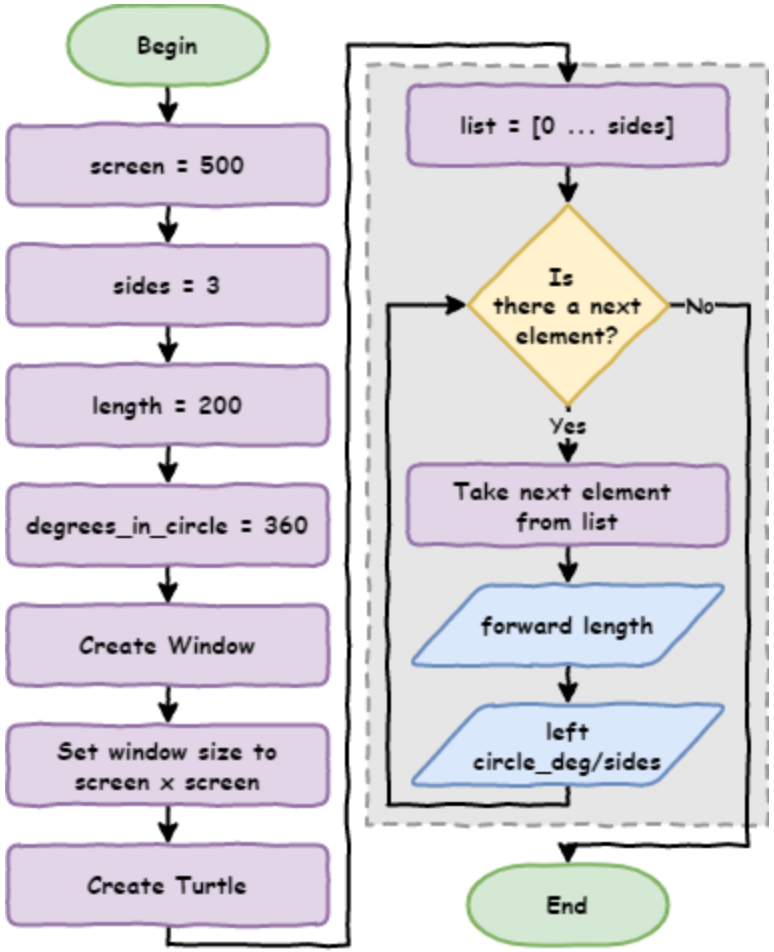
`CIRCLE_DEG` is a **constants** → its value will never change

Python's naming conventions → capitalise constants.

Naming conventions

Naming conventions → make code easier to understand.

- Use descriptive names that explains the value stored in them
  - `d = 30` → bad
  - `degrees = 30` → better
  - `degrees_celsius = 30` → best
- Use snake case for multiple word names:
  - replace the spaces with the `_` character
  - only use lower case letters
  - `this_is_snake_case`
- CAPTIALIZE names of constants (variables whose value will not change)
- Do not use the names of keywords (eg. `print`, `for`, etc)


Begin
screen = 500
sides = 3
length = 200
degrees_in_circle = 360
Create Window
Set window size to
screen x screen
Create Turtle
list = [0 ... sides]
Is
there a next
element?
No
Yes
Take next element
from list
forward length
left
circle_deg/sides
End

Exercises

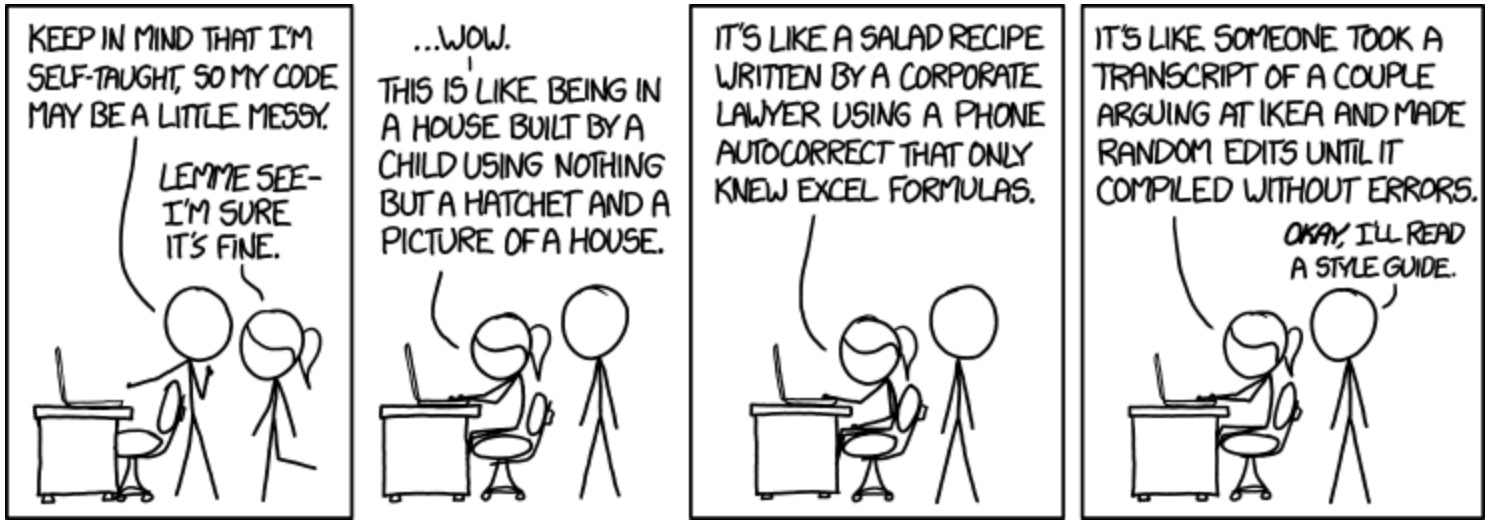
Exercises are the **make** component of the PRIMM model

Complete exercises 1 to 3

Part 2

Coordinates

Maintainability



Maintainability → how easy your code is to understand for other programmers

To improve maintainability → structure code

- group code under their functionality (what they do)
- use comments to signpost this functionality

```
import turtle

# set up screen
screen = 500
window = turtle.Screen()
window.setup(screen, screen)

# create turtle instance
my_ttl = turtle.Turtle()
my_ttl.shape("arrow")

# shape parameters
sides = 6
length = 100
DEGREES_IN_CIRCLE = 360

# draw the shape
for index in range(sides):
    my_ttl.forward(length)
    my_ttl.left(DEGREES_IN_CIRCLE / sides)
```

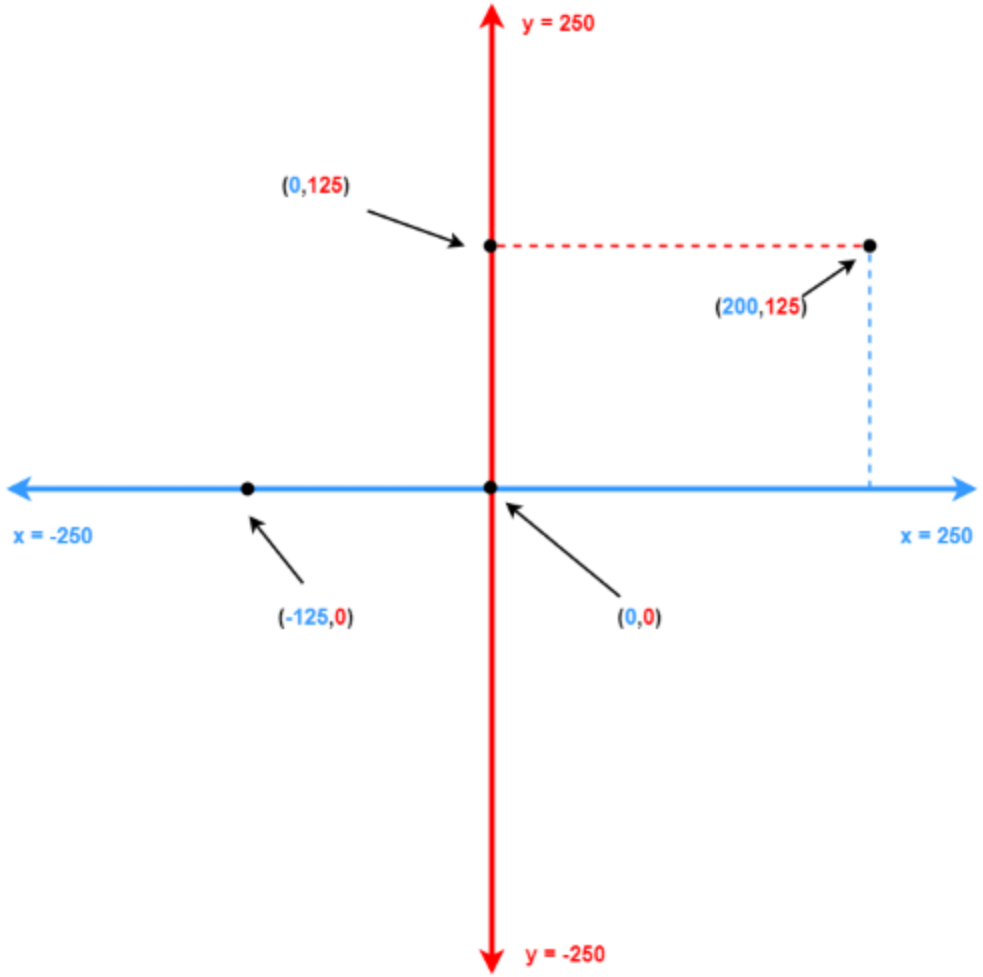
People reading the program will know the code that:

- sets up the screen
- creates the turtle instance
- defines the shape parameters
- draws the shape

Save the file as **lesson_3_pt_2.py** (**File** → **Save as...**).

How Turtle coordinates work

Like piece of graph paper measured in pixels 500px wide and 500px high



- the centre of the screen → origin of `(0,0)`
- moving up from centre → `y` value increases to max `250`
- moving down from centre → `y` value decreases to min `-250`
- moving left from centre → `x` increases to max `250`
- moving right starting from centre → `x` decreases to min `-250`
- coordinate → `x` and `y` value for a pixel
    - coordinates represented as a tuple of `(x, y)`
    - For example `(200,125)`

What's a tuple?

`(500,500)` → **tuple**

Like a list but can't change the values → **immutable**

Tuples:

- start with `(`
- end with `)`
- `,` separates the elements

Using `goto`

```
import turtle

# set up screen
screen = 500
window = turtle.Screen()
window.setup(screen, screen)

# create turtle instance
my_ttl = turtle.Turtle()
my_ttl.shape("arrow")

# shape parameters
sides = 6
length = 100

my_ttl.goto(0, 125)

# draw shape
# for index in range(sides):
#     my_ttl.forward(length)
#     my_ttl.left(360 / sides)
```

Investigate

- `my_ttl.goto(0,125)` → turtle move to position `x = 0` and `y = 125`.
- `#` → turns the code into comments
    - called **commenting out** code → useful for debugging

Modify the code → moves to all points in coordinates diagram

```
import turtle

# set up screen
screen = 500
window = turtle.Screen()
window.setup(screen, screen)

# create turtle instance
my_ttl = turtle.Turtle()
my_ttl.shape("arrow")

# draw boarder
my_ttl.goto(240, 240)
my_ttl.goto(-240, 240)
my_ttl.goto(-240, -240)
my_ttl.goto(240, -240)
my_ttl.goto(240, 240)
my_ttl.goto(0, 0)
```

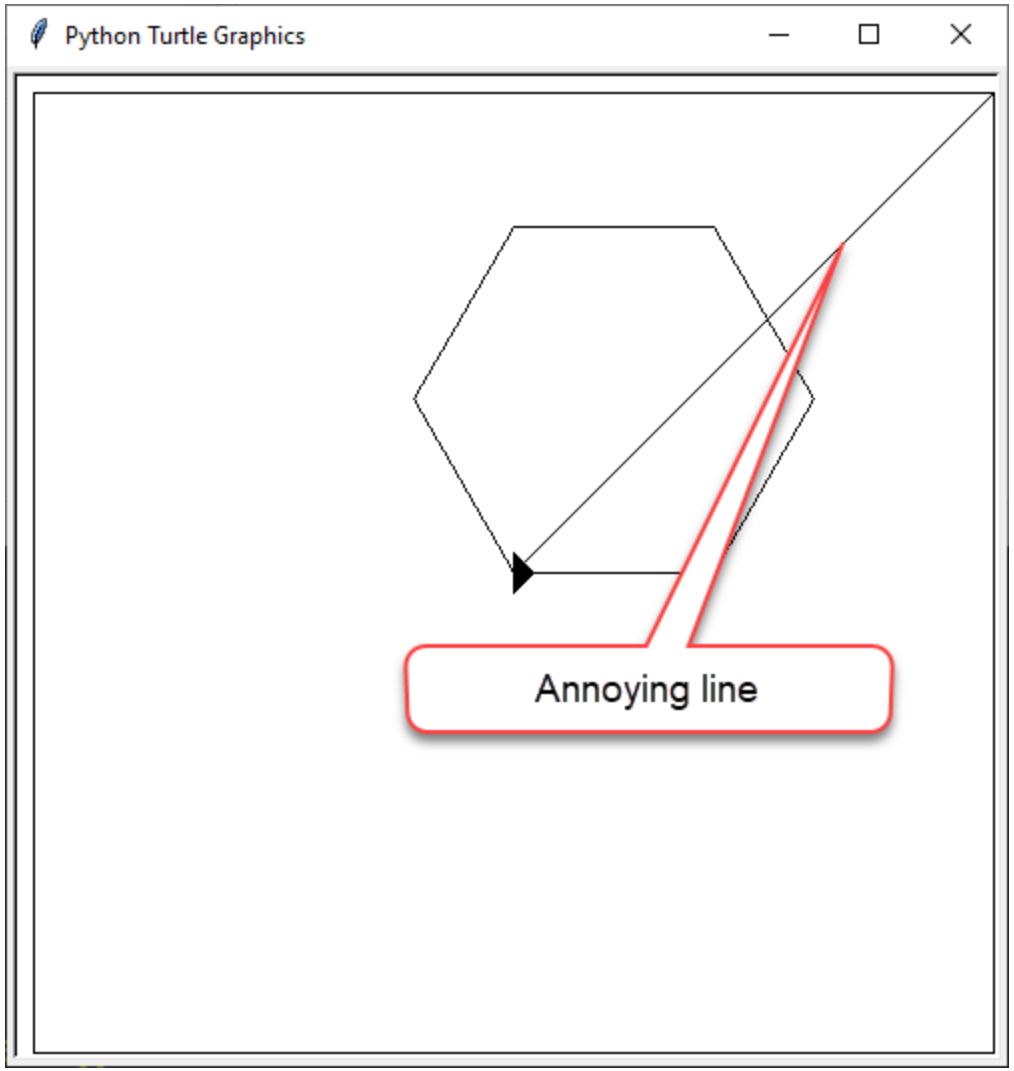
```
# shape parameters
sides = 6
length = 100

# draw shape
for index in range(sides):
    my_ttl.forward(length)
    my_ttl.left(360 / sides)
```

- **Predict** then **run** the code
  - Did it do what you predicted?
- **Investigate** the code by changing it

Using `penup` and `pendown`

Use `penup` and `pendown` function to remove annoying line



```
import turtle

# set up screen
screen = 500
window = turtle.Screen()
window.setup(screen, screen)

# create turtle instance
my_ttl = turtle.Turtle()
my_ttl.shape("arrow")

# draw boarder
my_ttl.penup()
my_ttl.goto(240, 240)
my_ttl.pendown()
my_ttl.goto(-240, 240)
my_ttl.goto(-240, -240)
my_ttl.goto(240, -240)
my_ttl.pen(up)
my_ttl.goto(0, 0)
my_ttle.pendown()
```

```
# shape parameters
sides = 6
length = 100

# draw shape
for index in range(sides):
    my_ttl.forward(length)
    my_ttl.left(360 / sides)
```

Predict what you think will happen, then **run** the code


Begin
screen = 500
Create Window
Set window size to screen x screen
Create Turtle
Change Turtle shape to arrow
penup
Go to (240,240)
pendown
Go to (-240,240)
Go to (-240,-240)
Go to (240,-240)
penup
Go to (0,0)
pendown
sides = 6
length = 100
list = [0 ... sides]
Is there a next element?
No
Yes
Take next element from list
forward length
left 360 / sides
End

Exercises

Exercises are the **make** component of the PRIMM model

Complete exercise 4