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Python Lessons for Kids

Animation Projects with Turtle Graphics

This book is intended for education and fun. Python is an amazing, text-based coding language, perfectly suited for children older than the age of 10. The Standard Python library has a module called Turtle which is a popular way to introduce programming to kids. This library enables children to create pictures and shapes by providing them with a virtual canvas. With the Python Turtle library, you can create nice animation projects using images that are taken from the internet, scaled-down stored as a gif-files download to the projects. The book includes 19 basic lessons with examples that introduce to the Python codes through Turtle library which is convenient to the school students of 10+years old. The book has also a lot of projects that show how to make different animations with Turtle graphics: games, applications to math, physics, and science.

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Lesson 1: Motion Commands with Python turtle module

There are many different graphical toolkits available for Python. For these lessons we chose one of the simplest: the turtle module. The turtle module provides an environment where turtles move upon a 2-dimensional grid. Turtle has a position and a heading (the direction in which the turtle is facing) as shown below:

Main Motion Commands Summary:

Code Instruction	What it does
import turtle	Importing a module tells Python that you want to use it
t=turtle.Turtle()	Specifies the name of turtle, could be any name that you want to use
t.goto(x,y) t.setposition(x,y)	Send the turtle to the coordinates x and y
t.forward(value) t.fd(value)	Move the turtle forward by specified distance value, in the direction the turtle is headed
t.right(value) t.rt(value)	Turn turtle right by angle value units. (Units are in degrees, by default)
t.left(value) t.lt(value)	Turn turtle left by angle units. (Units are in degrees, by default)
t.pensize(value)	Set the line thickness value to the number you supply
t.setheading(value)	Set the orientation of the turtle to angle value. (The angle is in degrees, by default.)

To place the turtle on the turtle screen, we need to understand the x- and y-coordinate system used in our Turtle environment. X, Y coordinate system is drawn in Fig 1.

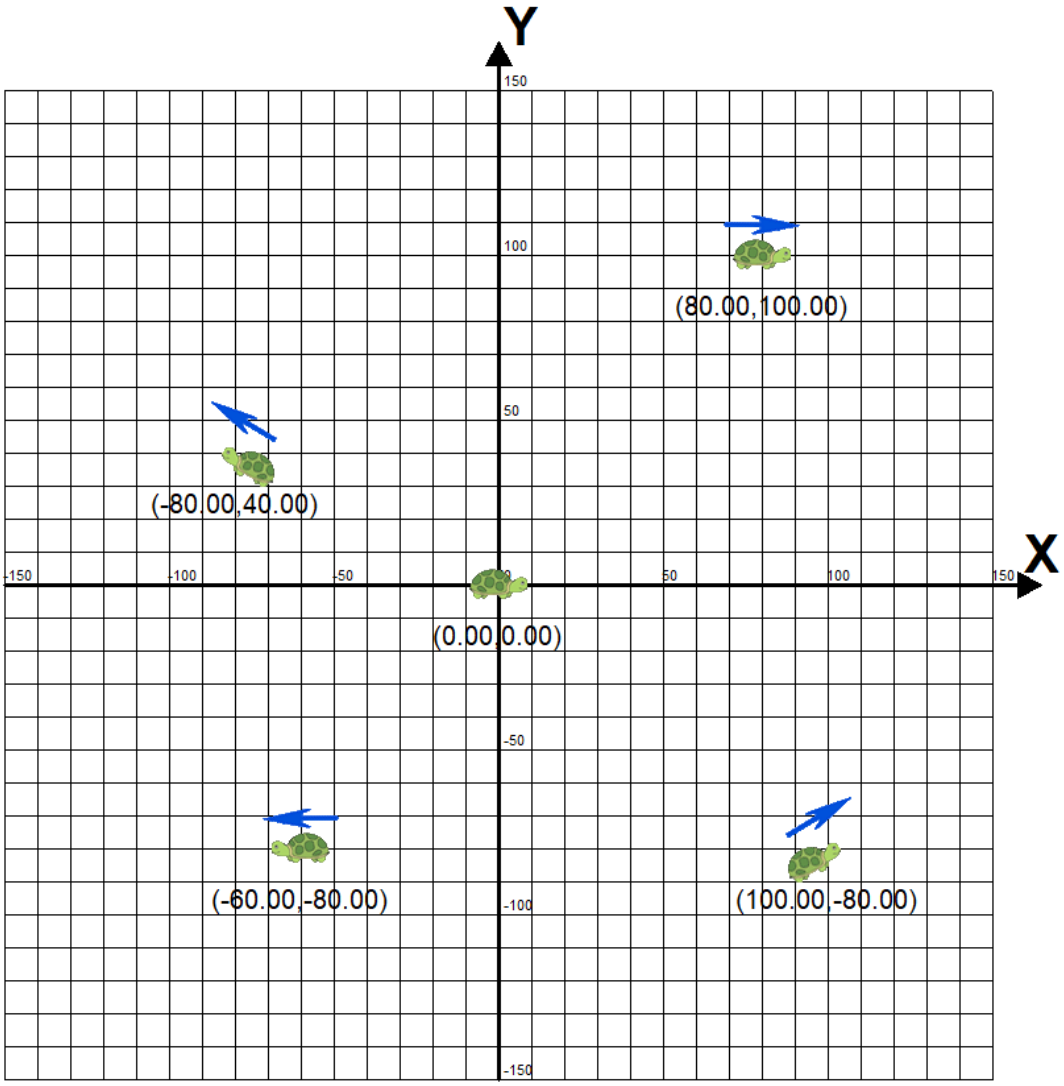


Fig. 1

In the graph the dark horizontal line is called the *x-axis*, and it runs from left to right. The dark vertical line is the *y-axis*, running from bottom to top. We call the point (initial position of the turtle) where these lines meet, (0, 0), the *origin* because all other points on the grid are labeled with coordinates measured from, or

originating from, that point. Think of the origin, (0, 0), as the center of your screen. Every other point you want to find can be labeled with an x- and y-coordinate by starting at the origin and moving left or right, down or up. We label points on a graph with this pair of coordinates inside parentheses, separated by a comma: (*x*, *y*). The first number, the x-coordinate, tells us how far to move left or right, while the second number, the y-coordinate, tells us how far to move up or down. Positive x-values tell us to move right from the origin; negative x-values tell us to move left. Positive y-values tell us to move up from the origin, and negative y-values tell us to move down. Look at the points labelled in the Figure. The point in the upper right is labelled with the x and y-coordinates (80,100). To find the location of this point, we start at the origin (0, 0) and move 80 spaces to the right (because the x-coordinate, 80, is positive) and then 100 spaces up (because the y-coordinate, 100, is positive). To get to the point in the lower right, (100,-80), we go back to the origin and then move right 100 spaces or units. This time, the y-coordinate is –80, so we move *down* 80 units. Moving right 100 and down -80 puts us at (100,-80). For (–80, 40), we move *left* 80 units from the origin and then up 40 units to the point in the upper left. Finally, for (–60, –80), we move left 60 units and then down 80 units to the lower-left point.

By default, turtle screen occupies 0.5 of full width and 0.75 of full height computer screen.

Code t.fd(value) moves the turtle (with a name t) forward by specified distance value, in the direction the turtle is headed turtle as shown in the Fig 1. One of the simplest things you can do using the turtle module is drawing a line. First, open a new file window to begin the lesson by clicking the File button on the Shell window. (Screenshot of the Shell window is shown below). The new file window appears.
Type the following three commands that draw a line

```
import turtle
t=turtle.Turtle()
t.fd(200)
```

First line makes all the “turtle” commands available for us. This line allows us to use Python turtle library. Second line (command) creates a new turtle named by t. We will call it “t”. You can give the turtle any name you want.

Third line movs the turtle previously named as “t” by 200 pixels. You can type any pixel number you want. Pixel is a single point on the screen-the smallest element that can be represented. Everything you see on your computer monitor is made up of pixels, which are tiny, square dots.

After typing these three lines in the new file window, you can run this code using the button “Run”. The editor will ask you to save the file. You need to save the file with your desired name in any folder you please. For example, create a new folder in the documents directory and name this folder “Python Projects” which puts your file to this directory. The result of code execution:

Example 1-1

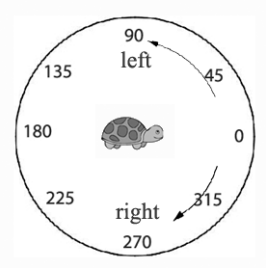
```
1  import turtle
2  t=turtle.Turtle()
3  t.fd(200)
```

By default, if you don’t specify, turtle starts to move from position (x=0, y=0) the orientation of the turtle to angle value equal 0.

If you haven’t learned about degrees yet, here’s how to think about them. Imagine that a turtle is in the center of a circle.

- The direction turtle is facing is 0 degrees.
- If turtle looks up, that’s 90 degrees left.
- If turtle looks down, that’s 90 degrees right.

You can see this 90-degree turn to the left or right here:



Below it is shown a few Python code examples that creates simple geometry shapes with different line thickness.

#Example 1-2

```
import turtle
t=turtle.Turtle()
t.setheading(30)
t.fd(200)
```

#Example 1-3

```
import turtle
t=turtle.Turtle()
t.pensize(30)
t.setheading(30)
t.fd(200)
```

#Example 1-4

```
import turtle
t=turtle.Turtle()
t.pensize(30)
t.setheading(30)
t.fd(200)
t.right(134)
t.fd(100)
```

#Example 1-5

```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.fd(100)
t.lt(120)
t.fd(100)
t.lt(120)
t.fd(100)
```

#Example 1-6

```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.fd(100)
```

```
t.lt(90)
t.fd(100)
t.lt(90)
t.fd(100)
t.lt()90)
t.fd(100)
```

#Example 1-7

```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.lt(45)
t.fd(100)
t.lt(90)
t.fd(100)
t.lt(90)
t.fd(100)
t.lt()90)
t.fd(100)
```

#Example 1-8

```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.fd(100)
t.lt(144)
t.fd(100)
t.lt(144)
t.fd(100)
t.lt(144)
t.fd(100)
t.lt(144)
t.fd(100)
```

#Example 1-9

```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.pensize(10)
t.fd(100)
t.lt(60)
t.fd(100)
t.lt(60)
t.fd(100)
t.lt(60)
t.fd(100)
t.lt(60)
t.fd(100)
t.lt(60)
t.fd(100)
```

Challenges:write codes to create the following geometry shapes

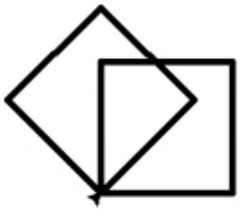
1. Expected output

2. Expected output

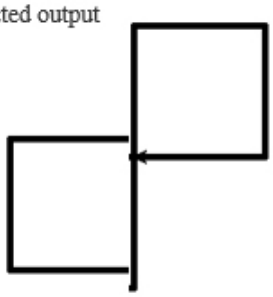
3. Expected output

4. Expected output

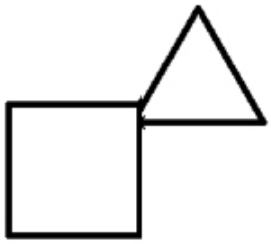
5. Expected output



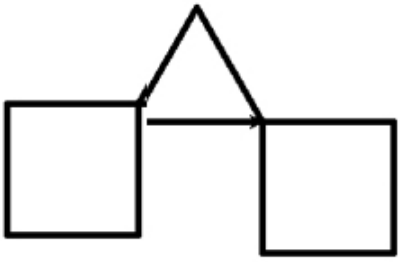
6. Expected output



7. Expected output



8. Expected output



9. Expected output

Lesson 2: Main Colour Commands

Commands Summary:

Code Instruction	What it does
t.color('green')	Set the line color to be green
t.fillcolor('gold')	Set fill color to be gold
t.begin_fill()	Start filling a shape
t.end_fill()	Stop filling a shape
t.color('green','red')	Set the line color to be green and shape color to be red
t.penup()	Stop the turtle from drawing
t.pendown()	Start the turtle drawing again
t=turtle.Tutrtle('turtle')	Set turtle shape as turtle***

Below we show a few code listings that demonstrate drawing of simple color geometry shapes and results of computer programs.

Simple geometry shapes (color lines)

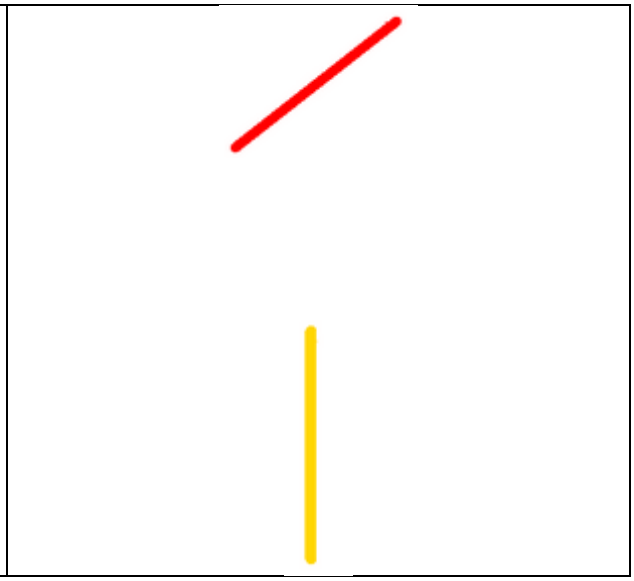
#Example 2-1(a)

```
import turtle
t=turtle.Turtle()
t.color('green')
t.pensize(10)
t.fd(200)
```

#Example 2-1(b)

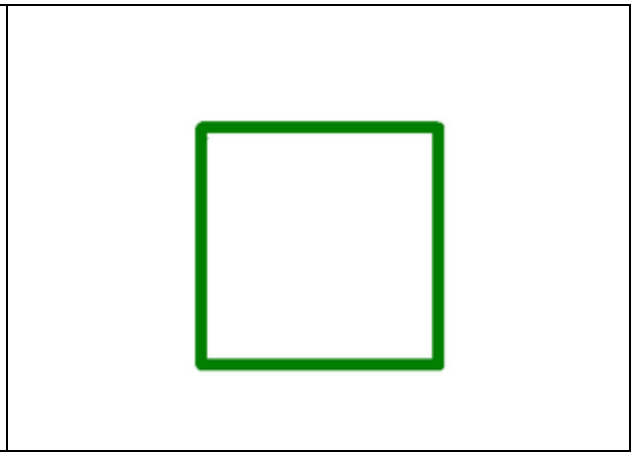
```
import turtle
t=turtle.Turtle()
t.color('red')
```

```
t.pensize(10)
t.left(38)

t.fd(200)

#Example 2-1(c)
import turtle
t=turtle.Turtle()
t.color('gold')
t.pensize(10)
t.left(90)
t.fd(200)
```



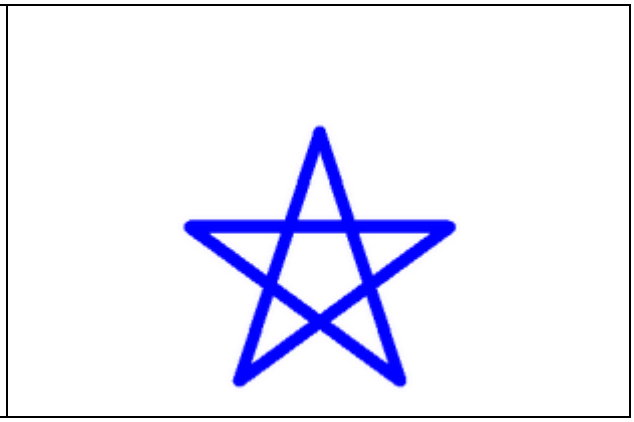
Square, color lines

```
#Example 2-2
import turtle
t=turtle.Turtle()
t.color('green')
t.pensize(10)
t.fd(200)
t.rt(90)
t.fd(200)
t.rt(90)
t.fd(200)
t.rt(90)
t.fd(200)
```



Star, color lines

```
#Example 2-3
import turtle
t=turtle.Turtle()
t.color('blue')
t.pensize(10)
t.fd(200)
t.rt(144)
t.fd(200)
t.rt(144)
t.fd(200)
t.rt(144)
t.fd(200)
```

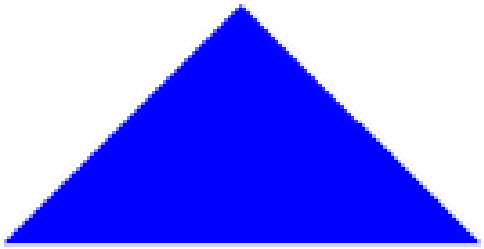


```
t.rt(144)
t.fd(200)
```

Code examples for simple geometry shapes (filled with color)

Blue triangle

```
#Example 2.4
import turtle
t=turtle.Turtle()
t.color('blue')
t.pensize(1)
t.left(45)
t.begin_fill()
t.fd(200)
t.rt(90)
t.fd(200)
t.goto(0,0)
t.end_fill()
t.hideturtle()
```



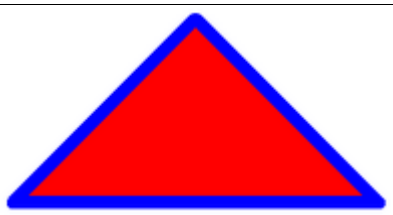
Gold rectangle, outline green

```
#Example 2.5
import turtle
t=turtle.Turtle()
t.color('green','gold')
t.pensize(10)
t.left(45)
t.begin_fill()
t.fd(150)
t.lt(90)
t.fd(100)
t.lt(90)
t.fd(150)
t.lt(90)
t.fd(100)
t.end_fill()
t.hideturtle()
```

Red triangle, outline blue

```
#Example 2-6
import turtle
t=turtle.Turtle()
```

```
t.color('blue', 'red')
t.pensize(1)
t.left(45)
t.begin_fill()
t.fd(200)
t.rt(90)
t.fd(200)
t.goto(0,0)
t.end_fill()
t.hideturtle()
```



Violet star, outline pink

```
#Example 2-7
import turtle
t=turtle.Turtle()
t.color('pink','violet')
t.pensize(10)
t.begin_fill()
t.fd(200)
t.rt(144)
t.fd(200)
t.rt(144)
t.fd(200)
t.rt(144)
t.fd(200)
t.rt(144)
t.fd(200)
t.end_fill()
t.hideturtle()
```

Results of python code (Simple geometry colored shapes)

Russian flag

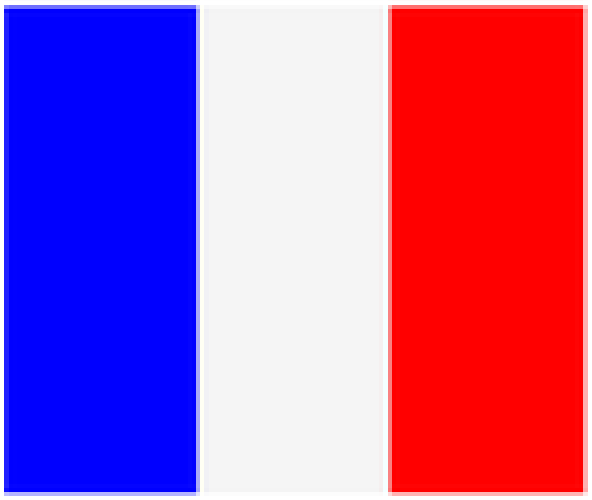
```
#Example 2-8
import turtle
t=turtle.Turtle()
t.hideturtle()
t.color('whitesmoke')
t.begin_fill()
t.fd(300)
```

```
t.left(90)
t.fd(80)
t.left(90)
t.fd(300)
t.left(90)
t.fd(80)
t.end_fill()

t.up()
t.goto(0,-80)
t.down()
t.setheading(0)
t.color('blue')
t.begin_fill()
t.fd(300)
t.left(90)
t.fd(80)
t.left(90)
t.fd(300)
t.left(90)
t.fd(80)
t.end_fill()

t.up()
t.goto(0,-160)
t.down()
t.setheading(0)
t.color('red')
t.begin_fill()
t.fd(300)
t.left(90)
t.fd(80)
t.left(90)
t.fd(300)
t.left(90)
t.fd(80)
t.end_fill()
```

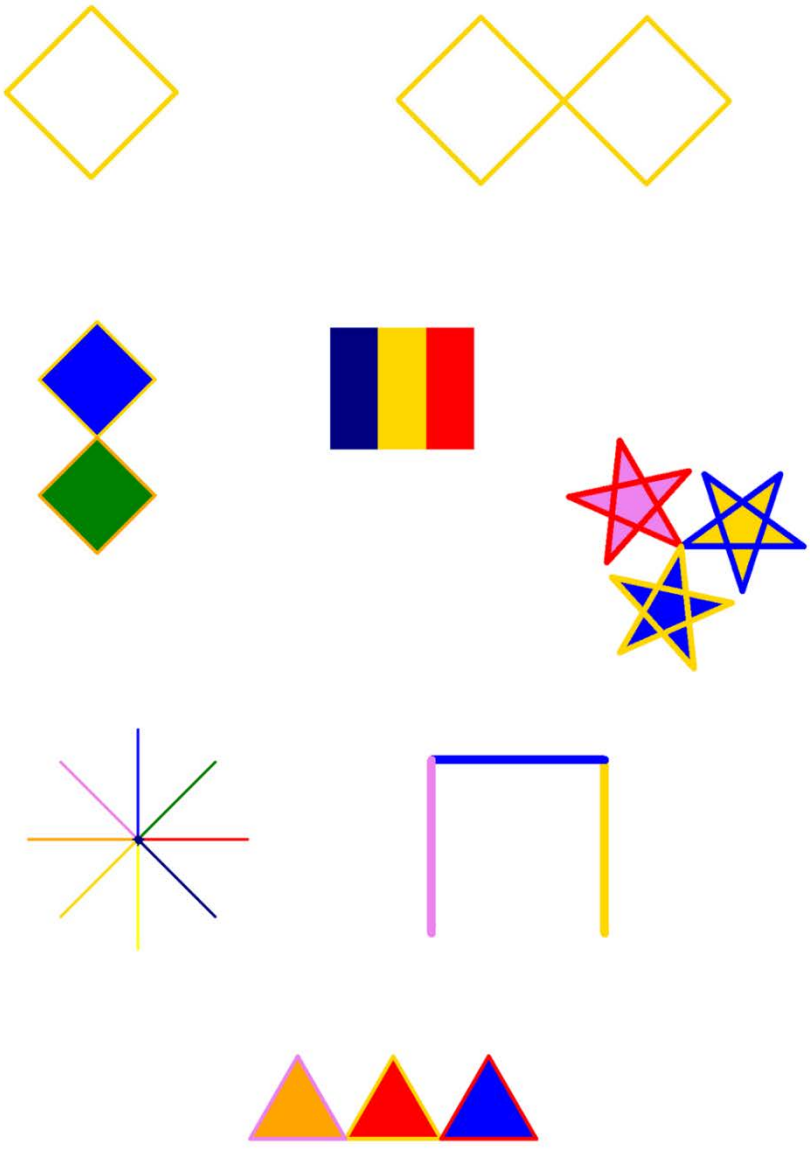
Flag of France

```
#Example 2-9
import turtle
t=turtle.Turtle()
t.hideturtle()

t.color('blue')
t.begin_fill()
```

```
t.fd(80)
t.left(90)
t.fd(200)
t.left(90)
t.fd(80)
t.left(90)
t.fd(200)
t.end_fill()

t.up()
t.goto(80,0)
t.down()
t.setheading(0)
t.color('whitesmoke')
t.begin_fill()
t.fd(80)
t.left(90)
t.fd(200)
t.left(90)
t.fd(80)
t.left(90)
t.fd(200)
t.end_fill()

t.up()
t.goto(160,0)
t.down()
t.setheading(0)
t.color('red')
t.begin_fill()
t.fd(80)
t.left(90)
t.fd(200)
t.left(90)
t.fd(80)
t.left(90)
t.fd(200)
t.end_fill()
```



Challenges: Write codes to create the following geometry shapes

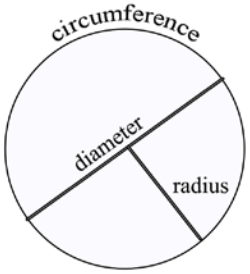


Lesson 3: Main Circle Commands

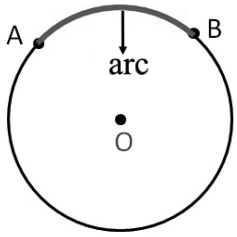
Summary:

Code Instruction	What it does
t.circle(radius)	Draw a circle with the given radius value. Radius value can be positive or negative, depends on the direction of the turtle motion.
t.circle(radius, arc)	Arc option allows to draw part of the circle. If arc=360 turtle draws all 360 degree circle, if arc=180, turtle draws half of the circle, if arc=90→ quarter of the circle. Arc value can be positive or negative, depends on the motion direction.
t.circle(radius, arc, steps)	With option steps (integer value) circle is approximated by an inscribed regular polygon, *steps* determine the number of steps to use. May be used to draw regular polygons. Step=3 means that we draw triangle, step=4 corresponds square, step=5→pentagon…

A **circle** is a shape that is made up of a curved line. It's round, and all points on the curved line are an equal distance from the centre point. The circumference is the distance around a circle



The arc of a circle is a portion of the circumference of a circle specified by yellow colour.



Arc value is measured in degrees and if arc=360 turtle draws all 360 degree circle, if arc=180, turtle draws half of the circle, if , for example, arc=90→ quarter of the circle. Arc value can be positive or negative, depends on the motion direction.

Let's show circle codes that create different geometry shapes.

#Example 3-1
```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.circle(200)
```

#Example 3-2(a)
```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.color('red')
t.circle(200)
```

#Example 3-2(b)
```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.color('red','blue')
t.begin_fill()
t.circle(200)
t.end_fill()
```

#Example #3-3(a)
```
import turtle
t=turtle.Turtle()
```

```
t.pensize(10)
t.color('red')
t.circle(200,180)
```

#Example #3-3(b)

```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.color('red')
t.circle(200,90)
```

#Example 3-4

```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.color('gold','orange')
t.begin_fill()
t.circle(200,270)
t.end_fill()
```

#Example 3-5(a)

```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.color('gold','green')
t.begin_fill()
t.circle(200,360,5)
t.end_fill()
```

#Example 3-5(b)

```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.color('green','yellow')
t.begin_fill()
t.circle(200,360,8)
t.end_fill()
```

Olympic Flag

#Example 3-6

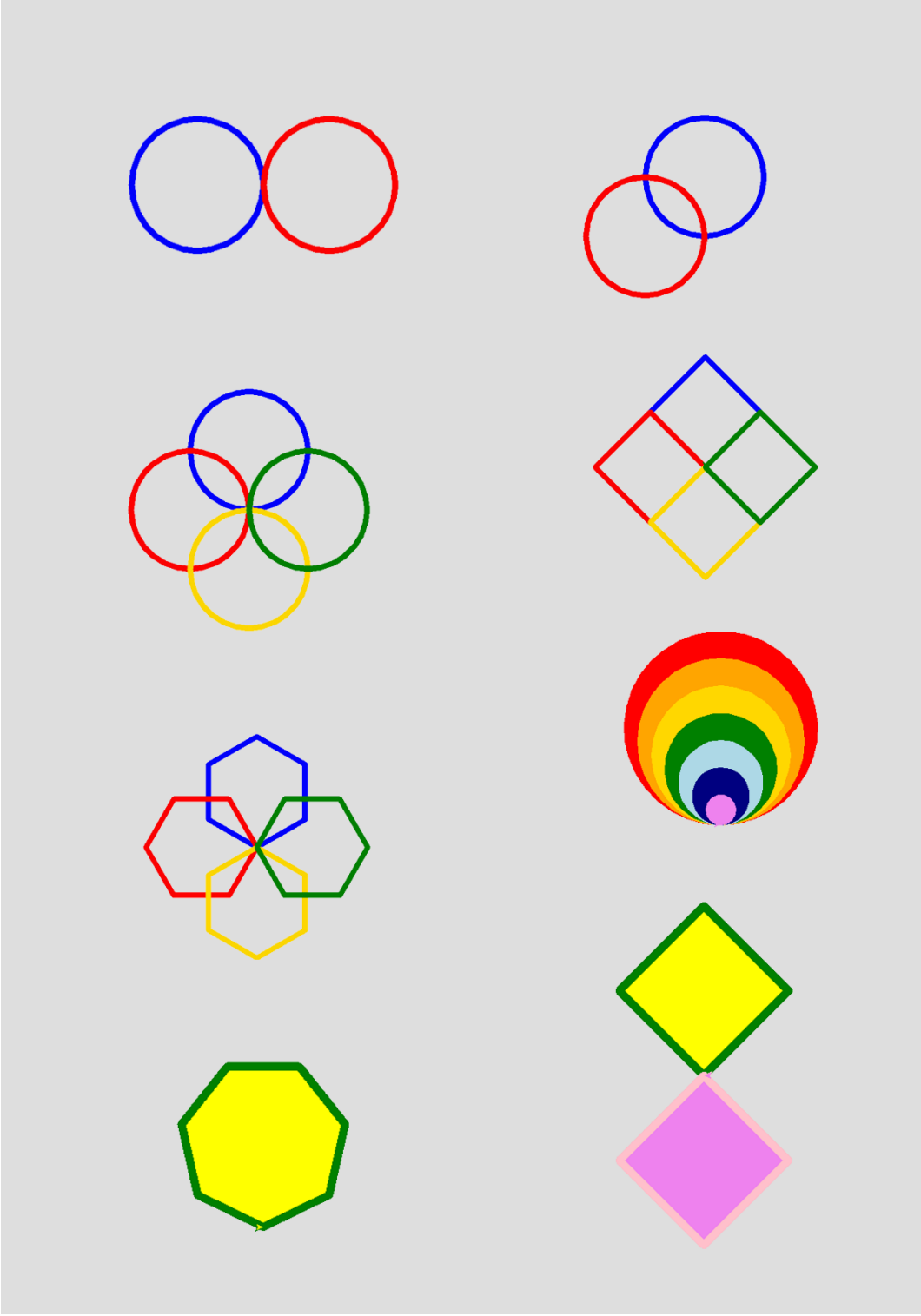
```
import turtle
t = turtle.Turtle()
t.pensize(20)
t.color('green')
t.circle(100)
t.color('gold')
t.penup()
t.setposition(-240,0)
t.pendown()
t.circle(100)
t.color('red')
t.penup()
t.setposition(120,120)
t.pendown()
t.circle(100)
t.color('black')
t.penup()
t.setposition(-120,120)
t.pendown()
t.circle(100)
t.color('blue')
t.penup()
t.setposition(-360,120)
t.pendown()
t.circle(100)
```

Rainbow

#Example 3-6

```
import turtle
t=turtle.Turtle()
t.speed(10)
t.pensize(5)
t.up()
t.color('red')
t.setheading(90)
t.goto(140,0)
t.begin_fill()
t.circle(140,180)
t.end_fill()

t.setheading(90)
t.goto(120,0)
t.begin_fill()
t.color('orange')
t.circle(120,180)
t.end_fill()

t.setheading(90)
t.goto(100,0)
t.begin_fill()
t.color('gold')
t.circle(100,180)
t.end_fill()

t.setheading(90)
t.goto(80,0)
t.begin_fill()
t.color('green')
t.circle(80,180)
t.end_fill()

t.setheading(90)
t.goto(60,0)
t.begin_fill()
t.color('light blue')
t.circle(60,180)
t.end_fill()

t.setheading(90)
t.goto(40,0)
t.begin_fill()
t.color('navy')
t.circle(40,180)
t.end_fill()

t.setheading(90)
```

	`t.goto(20,0)`
	`t.begin_fill()`
	`t.color('violet')`
	`t.circle(20,180)`
	`t.end_fill()`
	`t.hideturtle()`
	 



Lesson 4: More Color Examples

Christmas Tree

#Example 4-1

```
#chrismas tree
import turtle
t=turtle.Turtle()
t.pensize(5)
t.goto(0,0)
t.color('green')
t.begin_fill()
t.fd(100)
t.lt(120)
t.fd(100)
t.lt(120)
t.fd(100)
t.lt(120)
t.end_fill()
t.up()
t.goto(0,-50)
t.down()
t.begin_fill()
t.fd(100)
t.lt(120)
t.fd(100)
t.lt(120)
t.fd(100)
t.lt(120)
t.end_fill()
t.up()
t.goto(0,-100)
t.down()
t.begin_fill()
t.fd(100)
t.lt(120)
t.fd(100)
t.lt(120)
t.fd(100)
t.lt(120)
t.end_fill()
#log
t.up()
t.goto(35,-175)
t.down()
t.color('brown')
t.begin_fill()
t.fd(30)
```

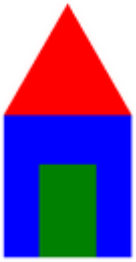
House

#Example 4-2

```
#House
import turtle
t1=turtle.Turtle()
t1.hideturtle()
t1.up()
t1.goto(-350,-200)
t1.setheading(0)
t1.down()
t1.color('blue','blue')
t1.begin_fill()
t1.fd(180)
t1.left(90)
t1.fd(200)
t1.left(90)
t1.fd(180)
t1.left(90)
t1.fd(200)
t1.left(90)
t1.end_fill()
#Door
t1.up()
t1.goto(-300,-200)
t1.setheading(0)
t1.down()
t1.color('green','green')
t1.begin_fill()
t1.fd(80)
t1.left(90)
t1.fd(130)
t1.left(90)
t1.fd(80)
t1.left(90)
t1.fd(130)
t1.left(90)
t1.end_fill()
#-------------
#Roof
t1.up()
t1.goto(-350,0)
t1.setheading(0)
t1.down()
t1.color('red','red')
t1.begin_fill()
```

```
t.lt(90)
t.fd(70)
t.lt(90)
t.fd(30)
t.lt(90)
t.fd(70)
t.lt(90)
t.end_fill()
t.hideturtle()
```

```
t1.fd(180)
t1.left(120)
t1.fd(180)
t1.left(120)
t1.fd(180)
t1.end_fill()
#--------------
```



Traffic Light

```
#Example 4-3
import turtle
t=turtle.Turtle()
t.hideturtle()

#Traffic Light
t.color('grey')
t.up()
t.goto(-50,400)
t.down()
t.begin_fill()
t.fd(100)
t.right(90)
t.fd(300)
t.right(90)
t.fd(100)
t.right(90)
t.fd(300)
t.end_fill()

#Red Light
t.penup()
t.goto(0,300)
t.setheading(0)
t.color('red')
t.begin_fill()
t.circle(50)
t.end_fill()
```

Cat Face

```
#Example 4-4
import turtle
t=turtle.Turtle('circle')
t.hideturtle()
wn=turtle.Screen()
wn.bgcolor('light blue')
t.color('black')
t.pensize(30)

t.up()
t.goto(-300,300)
t.down()
t.setheading(-135)
t.circle(200,270)
position=t.position()
print(position)

t.up()
t.goto(-300,300)
t.down()
t.setheading(100)
t.fd(100)
t.setheading(-30)
t.fd(100)
t.setheading(28)
t.circle(-150,55)
t.setheading(35)
t.fd(80)
```

```
#Yellow Light
t.penup()

t.goto(0,200)
t.color('yellow')
t.begin_fill()
t.circle(50)
t.end_fill()

#Green Light
t.penup()
t.goto(0,100)
t.color('green')
t.begin_fill()
t.circle(50)
t.end_fill()
```

```
t.goto(-17,300)

turtle.tracer(3)
t.shapesize(3.5)
t.up()
t.goto(-250,200)
t.stamp()
t.goto(-90,200)
t.stamp()
t.shapesize(1.5)
t.color('white')
t.goto(-240,200)
t.stamp()
t.goto(-80,200)
t.stamp()

t.color('black')
t.goto(-280,100)
t.setheading(-90)
t.pensize(15)
t.down()
t.circle(70,190)
t.setheading(170)
t.circle(180,20)
t.setheading(270)
t.circle(80,160)
```

Don't turn left

```
#Example 4-5
import turtle
t=turtle.Turtle('arrow')
t.shapesize(5)
```

Don't turn right

```
#Example 4-6
import turtle
t=turtle.Turtle('arrow')
t.shapesize(5)
```

```
t.speed('fastest')

# Draw Arrow
t.up()
t.goto(60,70)
t.pensize(35)
t.down()
t.color('black')
t.setheading(90)
t.fd(180)
t.left(90)
t.fd(150)
t.showturtle()
t.stamp()
t.up()

#Draw Circle with\
#cross Line
t.hideturtle()
t.color('red')
t.goto(0,0)
t.setheading(0)
t.pensize(50)
t.down()
t.circle(200)
t.circle(200,142)
t.left(90)
t.fd(400)
```

```
t.speed('fastest')

# Draw Arrow
t.up()
t.goto(-60,70)
t.pensize(35)
t.down()
t.color('black')
t.setheading(90)
t.fd(180)
t.right(90)
t.fd(150)
t.showturtle()
t.stamp()
t.up()

#Draw Circle with cross Line
t.hideturtle()
t.color('red')
t.goto(0,0)
t.setheading(0)
t.pensize(50)
t.down()
t.circle(200)
t.circle(200,232)
t.left(90)
t.fd(400)
```

Only forward

#Example 4-7

```
import turtle
t=turtle.Turtle()
wn=turtle.Screen()
wn.bgcolor('lightgreen')
t.pensize(8)
```

#Example 4-8

```
#Speed Limit
import turtle
t=turtle.Turtle()
t.pensize(30)
t.up()
```

```
t.color('white','blue')
t.begin_fill()
t.circle(200,360,12)
t.end_fill()
t.penup()
t.goto(-10,5)
t.pendown()
t.fillcolor('white')
t.begin_fill()
t.fd(20)
t.lt(90)
t.fd(250)
t.lt(90)
t.fd(20)
t.lt(90)
t.fd(250)
t.end_fill()

t.penup()
t.goto(-50,255)
t.setheading(0)
t.pendown()
t.fillcolor('white')
t.begin_fill()
t.fd(100)
t.lt(120)
t.fd(100)
t.lt(120)
t.fd(100)
t.end_fill()
```

```
t.goto(-200,200)
t.setheading(90)
t.down()
t.circle(-100,230)
t.circle(450,30)
t.setheading(0)
t.fd(180)

t.up()
t.goto(100,200)
t.down()
t.setheading(90)
t.circle(-100,180)
t.fd(170)
t.circle(-100,180)
t.fd(170)

t.up()
t.goto(440,100)
t.down()
t.pensize(40)
t.color('red')
t.circle(400)
```

Lesson 5: Turtle Shapes

Summary:

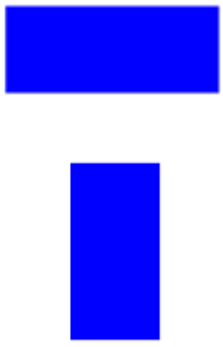
Code Instruction	What it does
1 t=turtle.Turtle()	Set turtle costume as a small arrow shape 
2 t=turtle.Turtle('classic') or t=turtle.Turtle() t.shape('classic')	Set turtle costume as a small arrow shape 
3 t=turtle.Turtle('turtle') or t=turtle.Turtle() t.shape('turtle')	Set turtle costume as a turtle shape 
4 t=turtle.Turtle('circle') or t=turtle.Turtle() t.shape('circle')	Set turtle costume as a circle shape 
5 t=turtle.Turtle('square')	Set turtle costume as a square shape

or t=turtle.Turtle() t.shape('square')	
6 t=turtle.Turtle('triangle') or t=turtle.Turtle() t.shape('triangle')	Set turtle costume as a triangle shape 
7 t=turtle.Turtle('arrow') or t=turtle.Turtle() t.shape('arrow')	Set turtle costume as an arrow shape 
8 t.shapesize(value) t.shapesize(1) t.shapesize(3)	Set the size value of the turtle shape 
9 a) t.shapesize(value1,value2) **Example** t.shape('circle') t.shapesize(1,3)	Set width value=value1 and length value=value2 
10 t.shapesize(value1,value2,value3)	Set width value=value1, length value=value2 and value3 determines the width of the shape's outline

Example t.turtle('square') t.shapesize(2,2) t.shapesize(2,2,10)	
11 t.sharefactor(value) **Example** t.shape('square') t.shapesize(3) t.shearfactor(0.4)	Distorts the image shape, value should be between -1 and 1 

Keep in mind!

With free of charge Trinket software:
Options 2-7 of Summary work only with two lines
Options 8, 9, 10, 11 work only with Pygame Trinket option, which costs $3 (USA) per month. In this case at the end of the program you have to add the following line
input()

#Example 5-1(a)
`import turtle`
`t=turtle.Turtle('square')`
`t.color('blue')`
`t.shapesize(2,5)`
 	
#Example 5-1(b)
`import turtle`
`t=turtle.Turtle('square')`
`t.color('blue')`
`t.shapesize(6,3)`
 	
#Example 5-2
`import turtle`
	

```
t=turtle.Turtle('square')
t.color('blue')
t.shapesize(6,1)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
```

#Example 5-3

```
import turtle
t=turtle.Turtle('circle')
t.color('blue')
t.shapesize(6,1)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()
```

Snowflakes

#Example 5-4

```
import turtle
t=turtle.Turtle('square')
t.up()
t.color('blue')
t.shapesize(4,0.5)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()

t.goto(100,50)
t.color('gold')
t.setheading(0)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
```

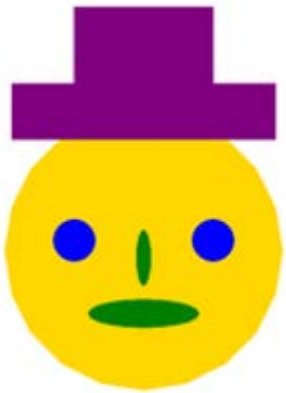
Nice Face

#Example 5-5

```
import turtle
t1=turtle.Turtle('circle')
t1.shapesize(20)
t1.color('gold')
t1.stamp()
t1.penup()

t1.goto(-100,15)
t1.shapesize(3)
t1.down()
t1.color('blue')
t1.stamp()

t1.up()
t1.goto(100,15)
t1.down()
t1.shapesize(3)
t1.color('blue')
t1.stamp()

t1.up()
t1.color('green')
```

```
t.stamp()

t.goto(-100,50)
t.color('lightblue')
t.setheading(0)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()

t.goto(-100,-50)
t.color('violet')
t.setheading(0)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()

t.goto(100,-50)
t.color('green')
t.setheading(0)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()
```

```
t1.goto(0,-90)
t1.shapesize(2,8)
t1.stamp()

t1.up()
t1.color('green')
t1.goto(0,-10)
t1.shapesize(4,1)
t1.stamp()

t1.shape('square')
t1.shapesize(4,19)
t1.color('purple')
t1.goto(0,200)
t1.stamp()
t1.up()

t1.shapesize(7,10)
t1.color('purple')
t1.goto(0,280)
t1.stamp()
t1.hideturtle
```



Challenges: write codes to create the following geometry shapes with circle code:

1. Expected output

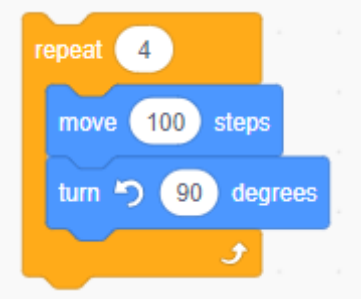
2. Expected output

3. Expected output

Lesson 6: Loopy loops in Python

In programming, a **loop** means repeating something multiple times. One of the main Python primitive loop commands is *for* loop:

Summary:

Code Instruction	What it does
for m in range(4): t.forward(1000) t.left(90)	*Here for* loop is used for a block of two lines code [t.forward(100) and t.left(90)] which you want to repeat 4 times. This short program is equivalent to the following 

for m in range(2):
for n in range(4):
t.forward(100)
t.left(90)
 	
The body of a loop have another loop within it. This is called a nested loop
	Nested Loop, equivalent to the following block-based code. Nested loop is loop inside a loop, the outer loop only repeats (2 times) after inner loop has gone round its required number of times 4.

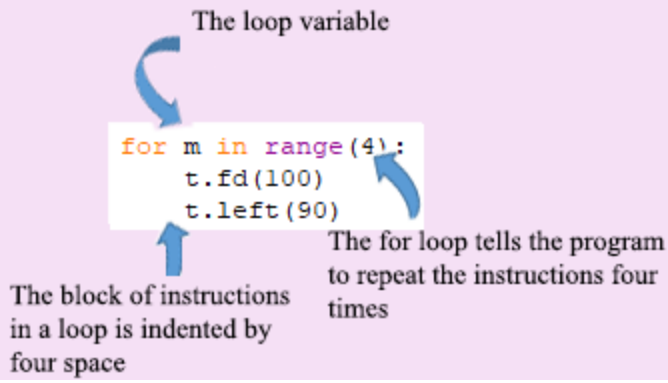
	

Let's learn how to write more efficient Python code by using loop structure Let's simplify code that draws simple square. Code looks as follows:

```
import turtle
t = turtle.Turtle()
t.hideturtle()
t.color('red')
t.forward(100)
t.left(90)
t.forward(100)
t.left(90)
t.forward(100)
t.left(90)
t.forward(100)
t.left(90)
```

What we can see from the structure of this code. Shown code uses four time identical commands **t.forward (100)** and **t.left(90)**– once for each side of the square. Whenever we need to do something over and over again in a program, *for loop* allow us to repeat those steps without having to type each one separately.

To build our own loop, we first need to identify the repeated steps. The instructions that we're repeating in the preceding code are t.forward(100) to draw a turtle line with a length of 100 pixels and t.left(90) to turn the turtle left 90 degrees. To build a square we have to repeat those steps four times. So let's start with four.

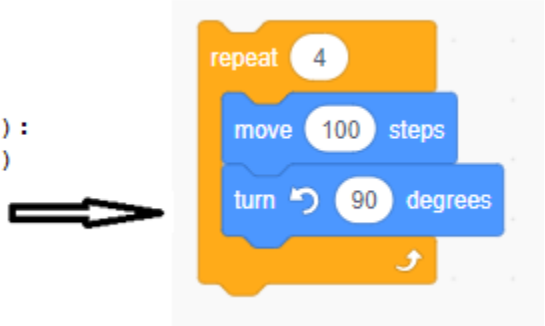


We start with the keyword ***for*** and then we give an integer number ***m*** that will be our counter. Here variable ***m*** (integer number) is something you want the computer to remember while your program is running. We use a name of this variable as an ***m,*** however it could be any name as you want, for example, ***a, b, x, y*** … Name of the variable does not matter, the key point that this variable ***m*** successively takes the following values: first step value ***m*** equal 0, second step ***m***=1, third step ***m***=2, ad fourth step ***m***=3. For each step computer draws line t.forward(100) and turn turtle by 90 degrees t.left(90). So, code with a loop is as following

```
import turtle
t = turtle.Turtle()
t.hideturtle()
t.color('red')
for m in range (4):
    t.forward(100)
    t.left(90)
```

This *for* loop is equivalent to the block-based code shown below

```
for m in range (4):
    t.forward(100)
    t.left(90)
```



Keep in mind that there are four additional spaces at the beginning lines of the loop block as shown below (when you compare with the line `for m in range (4):` **). Code that is not indented, which comes after the loop, will be run once just like regular code (Example #4).**

```
import turtle
t = turtle.Turtle()
t.hideturtle()
t.color('red')
for m in range (4):
    t.forward(100)
    t.left(90)
```

4 spaces

Python editor will have automatically indented this for you.

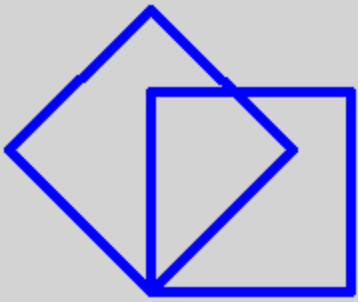
Loop variable (in our code loop variable named as ***m*** counts the number of times a loop has repeated itself. It starts at the first value in the range (0) and stops one before the last value (in our loop-> 3).

Nested Loops

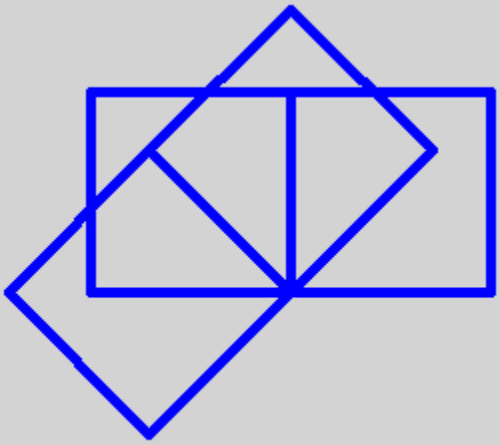
Can the body of a loop have another loop within it? Yes!! This is called a nested loop. It's like Russian dolls, where each doll fits inside a larger doll. In a nested loop, an inner loop runs inside an outer loop.

Let's give an example. We will draw several squares, each of which is rotated 45 degrees from the previous one.

```
import turtle
t = turtle.Turtle()
wn=turtle.Screen()
wn.bgcolor('lightgrey')
t.hideturtle()
t.color('blue')
t.pensize(5)

for m in range(2):
    for n in range (4):
        t.fd(100)
        t.left(90)
    t.left(45)
```



```
import turtle
t = turtle.Turtle()
wn=turtle.Screen()
wn.bgcolor('lightgrey')
t.hideturtle()
t.color('blue')
t.pensize(5)

for m in range(4):
    for n in range (4):
        t.fd(100)
        t.left(90)
    t.left(45)
```



In this example the inner loop (variable ***n*** goes around 4 times (we draw square). Code t.left(45) is a body of outer loop (variable ***n***) and turns turtle by 45 degrees, and then we again go to the inner loop. Let's detail an operation of the code.

Step #1: The first time through the outer loop, counter ***m*** has a starting value of 0, turtle goes to the inner loop, variable ***n*** takes value equal 0, turtle draws first line 100 px, then turns left by 90 degrees.

Step #2 Python goes back to the beginning of the inner loop and sets ***n*** to 1. Then it draws second line and turns left by 90 degrees.

Step#3 Python goes back through the loop again, increasing ***n*** to 2. It draws third line and turn by 90 degrees.

Step #4 Python goes back through the loop again, increasing ***n*** to 2. It draws third line and turn by 90 degrees.

Step#5 Python goes out of inner loop, turns turtle to 45 degrees, go back to the beginning of the outer loop and sets outer variable ***m*** to 1. Then Python enters to the inner loop and repeats all steps #1 to #4. Because, outer variable changes in the range from 0 to 1Pyrho draws only 2 squares. For loops are useful when you know how many times a task needs to be repeated. But sometimes you need a loop to keep repeating until something changes. A while loop keeps on going around as many times as it needs to. A *while* loop keeps repeating as long as certain condition is true. This condition is called the loop condition and is either true or false.

***While* loops**

```
1  import turtle
2  t=turtle.Turtle()
3  t.hideturtle()
4  t.color('gold')
5  t.pensize(10)
6
7  n=0
8  while n<5:
9      t.fd(150)
10     t.left(90)
11     n=n+1
```


This code creates square using *while* loop. We start by creating a variable (line 7) named n which is set to 0. Code line 8: While loop checks for condition n<5. The current value of n is 0. Condition is true. Flow of control enters into while loop. Turtle draws horizontal line and turns heading by 90 degrees. Code line 11: n is incremented by1. Flow of control goes back to line 8. Now the value of n is 1 which is less then 5. The condition is true, and again the while loop is executed. This continues till n becomes 5, and the while condition becomes false. Execution of this code is completed.

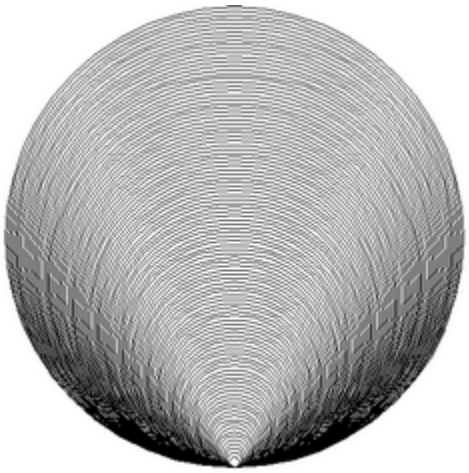
while True: This loop runs forever. This program will never end.

If you set the condition in a while loop to be True, it can never be false and the loop will never end. In some situations, it can be very useful.

Example:

```
import turtle
t=turtle.Turtle()
t.hideturtle()
turtle.tracer(2)
n=0
while True:
    t.circle(5+n)
    n=n+2
```

Result:



The number of circles can be arbitrarily huge (if you do not interrupt the program).

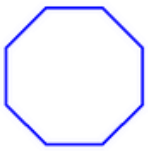
Code examples with ***for*** loop are shown below.

```
#Snowflake(no loop)
import turtle
t=turtle.Turtle('square')
t.shapesize(6,1)
t.color('blue')
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
t.stamp()
t.rt(45)
```

```
#Snowflake( loop)
import turtle
t=turtle.Turtle('square')
t.shapesize(6,1)
t.color('blue')
for i in range (3):
    t.stamp()
    t.right(45)
```

```
#Spiral
import turtle
t=turtle.Turtle()
t.hideturtle()
t.pensize(1)
t.color('red')
for i in range (100):
    t.fd(i)
    t.right(45)
```

```
#Octagon
import turtle
t=turtle.Turtle()
t.hideturtle()
t.pensize(5)
t.color('blue')
for i in range (8):
    t.fd(100)
    t.right(45)
```

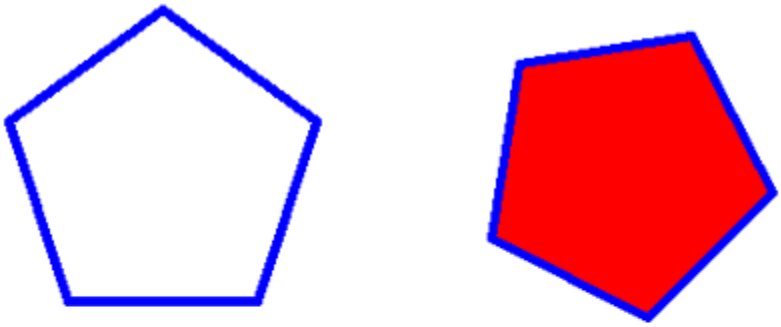


```
#Number of circles
import turtle
t=turtle.Turtle()
t.hideturtle()
t.pensize(5)
t.color('red')
for i in range (10):
    t.circle(50)
    t.right(36)
```

```
#Scristmas Tree
import turtle
t=turtle.Turtle('triangle')
t.shapesize(5)
t.hideturtle()
t.pensize(1)
t.color('green')
t.left(90)
for i in range (3):
    t.stamp()
    t.goto(0,50)
    t.stamp()
    t.goto(0,100)
    t.stamp()
```

```
#Star
import turtle
t=turtle.Turtle()
t.hideturtle()
t.pensize(5)
t.color('red')
t.begin_fill()
for i in range (5):
    t.fd(100)
    t.right(144)
t.end_fill()
```

Challenges: write codes to create the following geometry shapes with circle code:



Lesson 7: Numbers, Variables, functions print and input

Numbers and Math Operators in Python, Simple Calculations

There are two primary numeric types that we'll be using in Python: integers and floats. First type are integers: positive (for example, 3,7,9,783,23 etc.) or negatives as -4, -12, -342, -781 etc. Integers, or whole numbers, are useful for counting and for basic math (2 + 2 = 4). We usually state our age in whole numbers, so when you say you're 5 or 16 or 42, you're using an integer. When you count to 10, you're using integers.

Floating numbers, or simply floats, are numbers that can have whole and fractional parts and are written using decimal points, for example, 3.47, 62.34, 761.23 etc.

Math Operators

The math symbols like + (plus) and - (minus) are called *operators* because they operate, or perform calculations, on the numbers in our programs. When we say "4 + 2" aloud or enter it on our calculator, we want to perform addition on the numbers 4 and 2 to get their sum, 6. Python uses most of the same operators that you would use in a math class, including +, -, and parentheses, (), as shown in Table below. However, some operators are different from what you may have used in school, like the multiplication operator (the asterisk, *, instead of ×) and the division operator (the forward slash, /, instead of ÷). We'll get to know these operators better in future.

Summary for math operations:

Code Instruction		What it does		
Math symbol	Python operator	*Operation*	*Example*	*Result*

+	+	*Addition*	*11+12*	*23*
-	-	*Subtraction*	*25-10*	*15*
x	*	*Multiplication*	*12*3*	*36*
÷	/	*Multiplication*	*12*3*	*36*
6^2	**	*Exponent of power*	*6**2*	*36*
()	()	*Parentheses(grouping)*	*(8+3)*6*	*66*
%	%	*Modulus of operation**	*14%5* *12%5*	*4* *2*

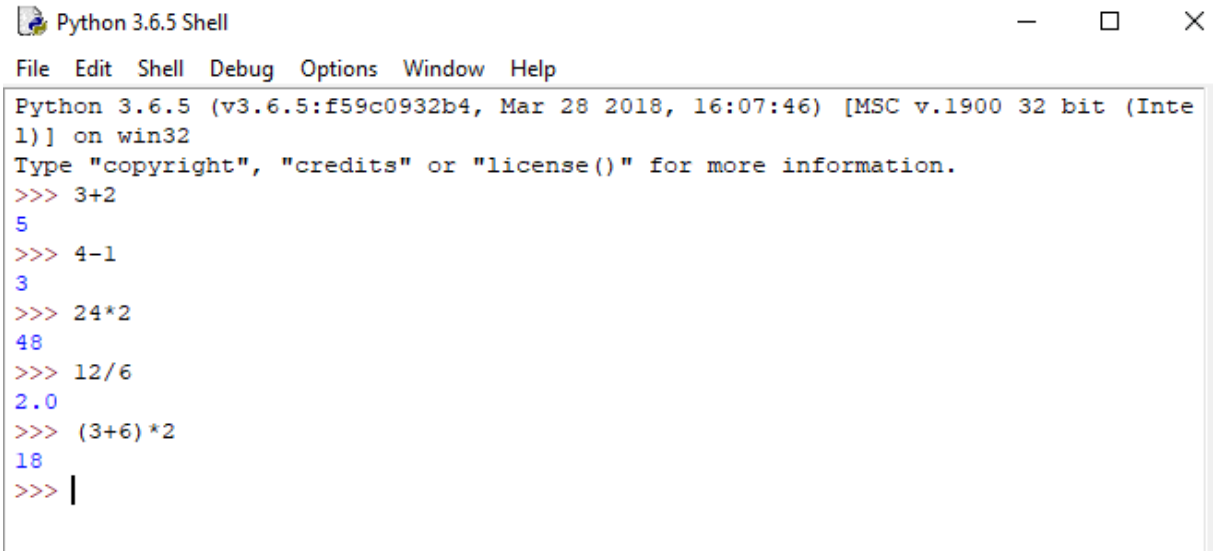
*In computing, the **modulo operation** finds the remainder after division of one number by another (called the **modulus** of the **operation**).

Math operations with variables.

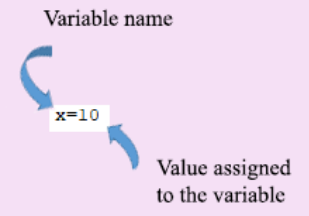
Syntax	Math	Operation Name
a+b	$a + b$	addition
a-b	$a - b$	subtraction
a*b	$a \times b$	multiplication
a/b	$a \div b$	division

Math in the Python Shell.

Let's use the Python shell this time. The Python shell gives you direct access to Python's power without writing a whole program. It's sometimes called the *command line* because you can type commands line by line and instantly see the result. For example, you can type a math problem (called an *expression* in programming) like 4 + 2 directly at the command prompt (the >>> symbol with the flashing cursor) in the Python shell, and when you press ENTER, you'll see the *result* of the expression, or the answer to the math problem. Try typing some of the examples listed in Table below and see what Python says. Feel free to try your own math problems as well.



A ***variable*** is something you want the computer to remember while your program is running. When Python "remembers" something, it's storing that information in the computer's memory. Variable is like box where data can be stored and labelled. Python can remember *values* of several types, including **number values** (like 7, 42, or even 98.6) and **strings** (letters, symbols, words, sentences). In Python, as in most modern programming languages, we assign a value to a variable with the equal sign (=). An assignment like x = 10 tells the computer to remember the number 10 and give it back to us anytime we call out x. So, the assignment operator = assigns the value on the right to a variable on the left.



The command to assign a variable in Python does the same job as this block-based Scratch

We can use any letter or word to use as a variable. For example, v=23 assigns the value of integer 23 to the variable v. In the case score=5 we assign the integer value 5 to the variable score. What is the reason to use variable instead of number? Let's show this with an example. Below two simple codes: one from left side created with number and from right side code uses variable N.

```
import turtle
t=turtle.Turtle()
t.fd(100)
t.lt(90)
t.fd(100)
t.lt(90)
t.fd(100)
```

```
import turtle
t=turtle.Turtle()
N=100
t.fd(N)
t.lt(90)
t.fd(N)
t.lt(90)
t.fd(N)
```

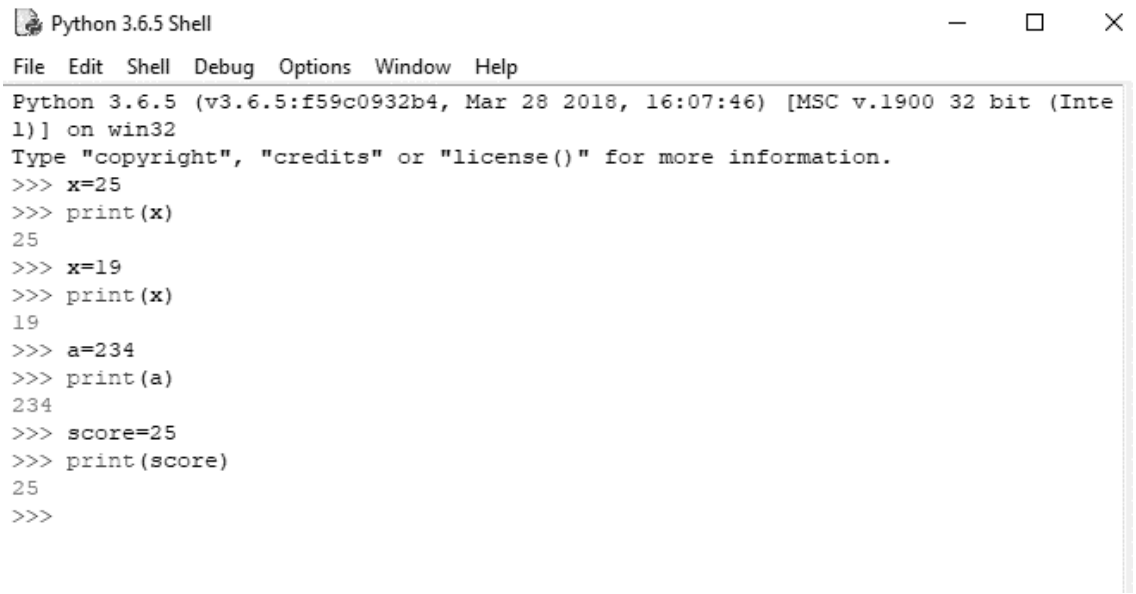
Both of them return the same result. However, if you want to change the number 100 by the other value from left side you must replace three lines, from right side replace only one line. For example, let's use number 50 instead of 100. In this case codes from left and right sides are shown below

```
import turtle
t=turtle.Turtle()
t.fd(50)
t.lt(90)
t.fd(50)
t.lt(45)
t.fd(50)
t.lt(45)
```

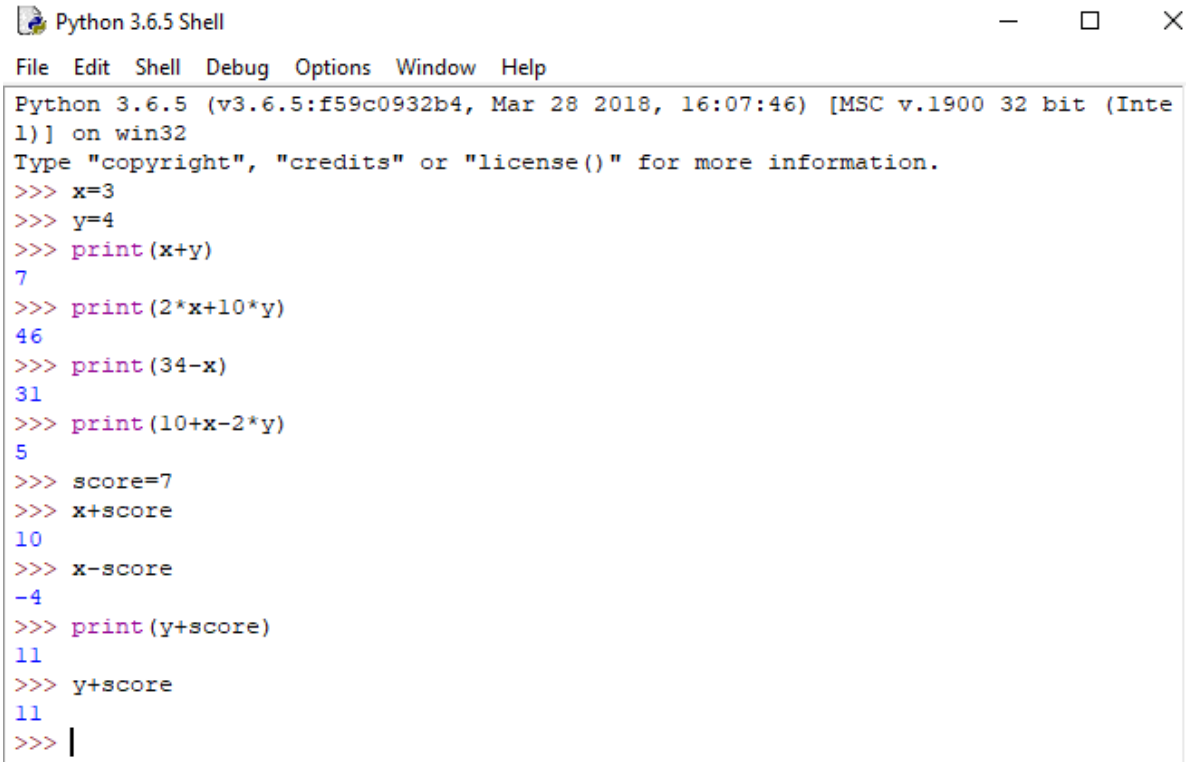
```
import turtle
t=turtle.Turtle()
N=50
t.fd(N)
t.lt(90)
t.fd(N)
t.lt(90)
t.fd(N)
t.lt(90)
```

Function *Print*

The '**print**' function is used to display something on the Shell screen. It has nothing to do with the printer. You can use it to show the value of a variable.



Only in the program code we have to assign number to each variable that use in the program. Examples are shown below



When you assign some value to the variable, computer remember this variable value in the memory and when you use variable with certain name for math operation computer takes the value assigned to the variable and process math operation.

Function *input*

Very convenient and important command, can be used when math calculations.

Let's create code that adds two positive integer numbers n1 and n2. Code is shown below from left side, result—from right side.

```
n1=100
n2=50
print(n1+n2)
```

```
Python 3.6.5 (v3.6.5:f59c0932b4,
l)] on win32
Type "copyright", "credits" or "
>>>
 RESTART: C:/Users/Victor/Google
numbers(2).py
150
>>>
```

Now, we want to change our numbers n1 and n2. What to do? We have to change our code. However, **introduce command input**, that allows us to replace our numbers using keyboard control. Code is shown below.

```
n1=input('Please, input number n1')
n2=input('Please,input number n2')

n1=int(n1)
n2=int(n2)

print(n1+n2)
```

Result is presented on the Shell Screen

Python 3.6.5 Shell

```
File  Edit  Shell  Debug  Options  Window  H
Python 3.6.5 (v3.6.5:f59c0932b4, M
l)] on win32
Type "copyright", "credits" or "li
>>>
 RESTART: C:/Users/Victor/Google D
numbers(2).py
Please, input number n1    45
Please,input number n2     5
50
>>>
```

First code line prompts the user to input first number n1 and waits while you type the number. After you type first number, second code line prompts you to input second number and waits till you type it. Line 3 and 4 convert first number and second numbers into digital type (numbers typed according to input request are string variable, and we will discuss such kind of variables a little bit later). Last line print results on the Shell screen. What is the reason to use input data option? Program became flexible and we can repeat it a lot of times without changing of

code. The input option is similar to the “ask and wait” block in Scratch program. It lets the user to give instructions or data to the program by typing them in. Code shown below is written with Python(left side), code from right side is written with Scratch.

```
n1=input('Please, input number n1')
n2=input('Please, input number n2')
n1=int(n1)
n2=int(n2)
print(n1+n2)
```

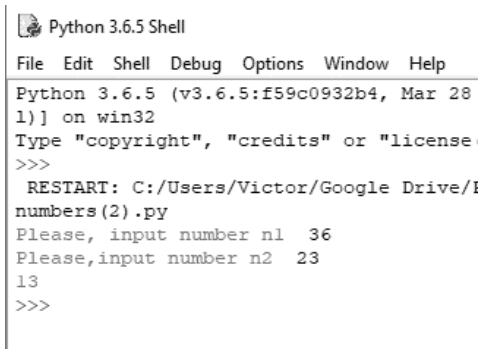
Now a few simple programs that demonstrate “input()”→”print” application.

Subtraction of two numbers

#Example 7-1

```
n1=input('Please, input number n1')
n2=input('Please, input number n2')
n1=int(n1)
n2=int(n2)
print(n1-n2)
```

Result



Product of two numbers

#Example 7-2

```
n1=input('Please, input number n1=')
n2=input('Please, input number n2=')
n1=int(n1)
n2=int(n2)
print(n1*n2)
```

Result

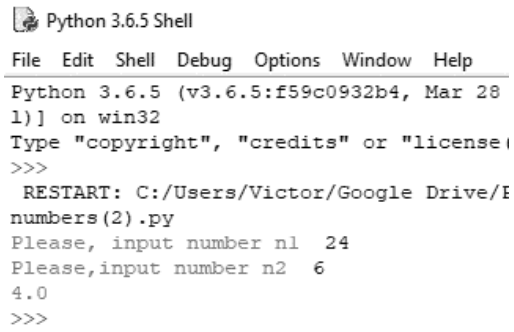
```
====== RESTART: C:/Users/Victor/
Please, input number n1=12
Please, input number n2=14
168
>>>
```

Division of two numbers

#Example 7-3

```
n1=input('Please, input number n1')
n2=input('Please, input number n2')
n1=int(n1)
n2=int(n2)
print(n1/n2)
```

Result



Add two numbers in a loop

#Example 7-4

```
for i in range (5):
    print('Attempt number=', i+1)
    n1=input('Please, input number n1')
    n2=input('Please, input number n2')
    n1=int(n1)
    n2=int(n2)
    print('answer=',n1+n2)
```

Result

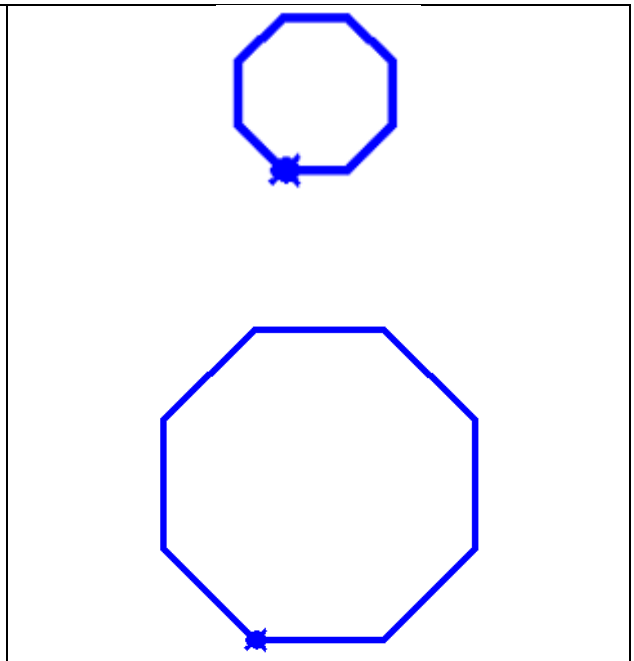
```
Python 3.6.5 Shell
File  Edit  Shell  Debug  Options  Window  H
Python 3.6.5 (v3.6.5:f59c0932b4, Ma
l)] on win32
Type "copyright", "credits" or "lic
>>>
 RESTART: C:/Users/Victor/Google Dr
numbers(2).py
Attempt number= 1
Please, input number n1  4
Please,input number n2  5
answer= 9
Attempt number= 2
Please, input number n1  7
Please,input number n2  9
answer= 16
Attempt number= 3
Please, input number n1  8
Please,input number n2  12
answer= 20
Attempt number= 4
Please, input number n1  24
Please,input number n2  48
answer= 72
Attempt number= 5
Please, input number n1  78
Please,input number n2  -6
answer= 72
>>>
```

Let's write a few programs that use variables and math operations with our lovely turtle library.

Octagon

```
#Example 7-5(a)
import turtle
t=turtle.Turtle('turtle')
t.color('blue')
t.pensize(5)
x=20
for i in range (8):
    t.fd(x)
    t.lt(45)


#Example 7-5(b)
import turtle
t=turtle.Turtle('turtle')
t.color('blue')
t.pensize(5)
x=35
```

```
for i in range (8):
    t.fd(x)
    t.lt(45)

#Example 7-5(c)
import turtle
t=turtle.Turtle('turtle')
t.color('blue')
t.pensize(5)
x=60
for i in range (8):
    t.fd(x)
    t.lt(45)
```



Examples below demonstrate formatting of print function

#Example 7-6(a)

```
for i in range (3):
    print('i=',i)
```

Result

```
====== RESTART: C:/
i= 0
i= 1
i= 2
>>>
```

#Example 7-6(b)

```
for i in range (10):
    print('i=',i,end=' ')
```

Result

```
====== RESTART: C:/Users/Victor/Google Drive/Python
 i= 0 i= 1 i= 2 i= 3 i= 4 i= 5 i= 6 i= 7 i= 8 i= 9
 >>>
```

#Example 7-6(c)

```
print('Number\tSquare\tCube')
for i in range (1,11):
    print(i,'\t',i**2,'\t',i**3)
```

Result

```
====== RESTART: C:/Users/
Number  Square  Cube
1       1       1
2       4       8
3       9       27
4       16      64
5       25      125
6       36      216
7       49      343
8       64      512
9       81      729
10      100     1000
```

#Example 7-6(d)

```
print('aaa','\n','bbb')
```

Result

```
==== RESTART: C:\Users\Victor\Google
aaa
 bbb
>>>
```

#Example 7-6(e)

```
number=12.5
print('number=12.5','\n','answer=','%d'% number)
```

Result

```
====== RESTART:
number=12.5
 answer= 12
>>>
```

#Example 7-6(f)

```
print("Total students : %d, Boys : %d" %(240, 120))
```

Result

```
====== RESTART: C:\Users\Victor\Google

Total students : 240, Boys : 120
```

#Example 7-7(a)

```
for row in range(6):
    for col in range(7):
        if (row==0 and col%3!=0) or (row==1 and col%3==0)\
```

```
                                        or (row-col==2) or (row+col==8):
            print('*',end='')
        else:
            print(' ',end='')
    print()
```

Result

```
====== RESTART: C:/Users/
 ** **
*  *  *
*     *
 *   *
  * *
   *
>>>
```

#Example 7-7(b)

```
a='''****
*
*
****
     *
     *
    *
***'''

print(a)
```

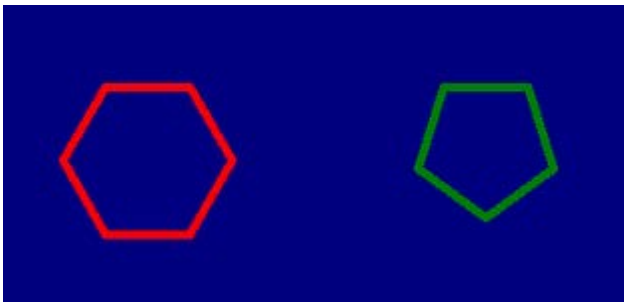
Result

```
==== RESTART: C:\Users\Victor\Google
****
*
*
****
     *
     *
    *
***
>>>
```

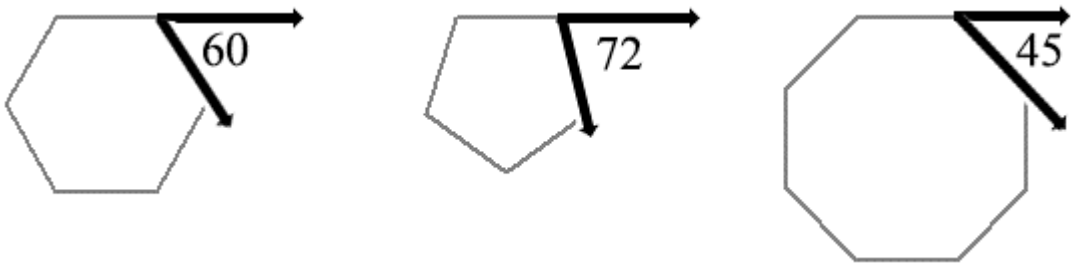
Number of polygons (Code is written with variables)

#Example 7-8

```
import turtle
t=turtle.Turtle()
turtle.bgcolor('navy')
t.pensize(5)
side_length=50        #1

#hexagon drawing
t.color('red')
num_sides=6           #2
angle=360/num_sides   #3
for m in range (num_sides):
    t.fd(side_length)
    t.rt(angle)

#pentagon drawing
t.color('green')
num_sides=5
angle=360/num_sides
t.up()
t.goto(200,0)
t.down()
for m in range (num_sides):
    t.fd(side_length)
    t.rt(angle)
t.hideturtle()
```



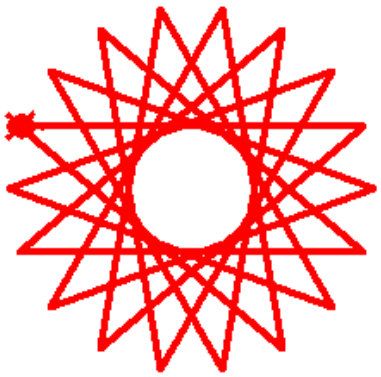
Let's explain this code. Code has three variables: the name of the first is side_length(line 1); second one is num_sides(line 2) and third is angle(line 3), which is equal 360/num_sides. If num_sides=5 we draw pentagon, because for pentagon angle has to be 360/5=72. If num_sides=6 we draw hexagon, because for hexagon angle has to be 360/6=60. If num_sides=8 we draw octagon, because for octagon angle has to be 360/8=45.



Number of Stars

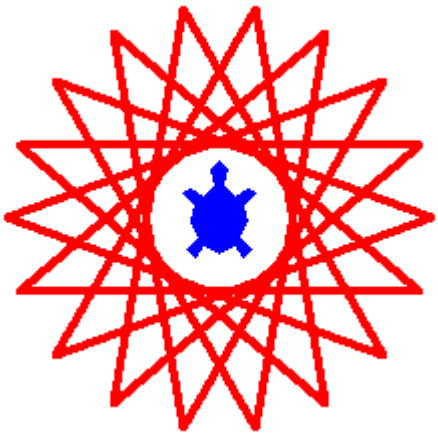
#Example 7-9(a)

```
import turtle
t=turtle.Turtle('turtle')
turtle.tracer(2)
t.color('red')
t.pensize(4)
d=200
angle=220
for i in range(18):
    t.fd(d)
    t.lt(angle)
```



#Example 7-9(b)

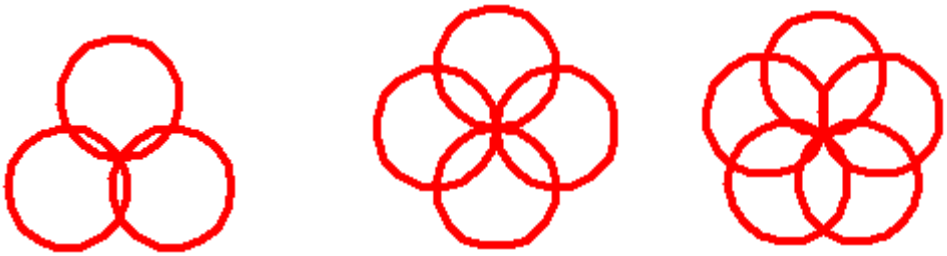
```
import turtle
t=turtle.Turtle('turtle')
t.color('red')
t.pensize(4)
d=200
angle=220
for i in range(18):
    t.fd(d)
    t.lt(angle)
t.up()
t.goto(100,-40)
t.setheading(90)
t.color('blue')
t.shapesize(2)
```



Challenges:

1. Modify code of an example #7 to get Square, Triangle and Octagon

2. Build a code for the following outputs



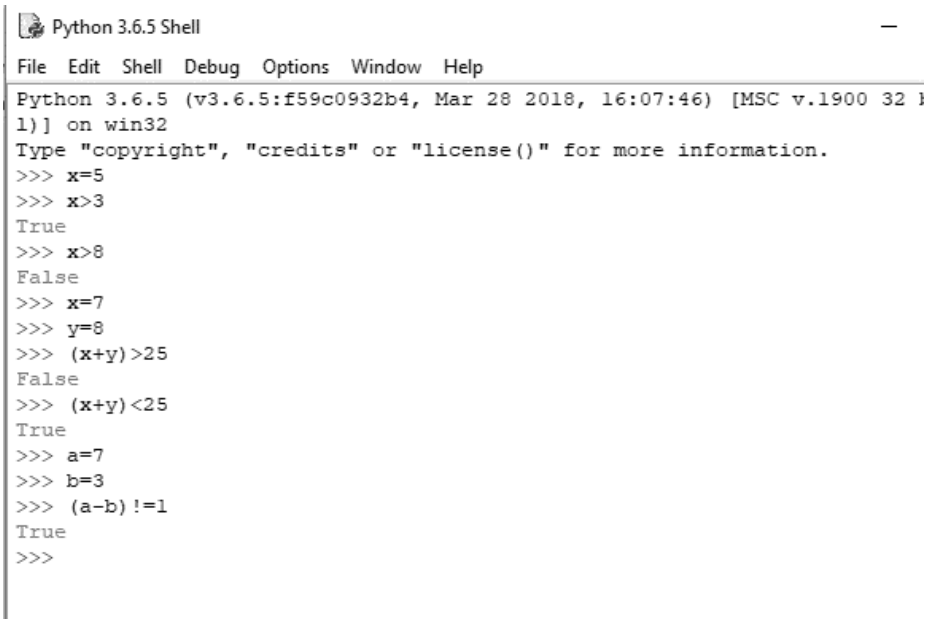
Lesson 8: Logical Operators, Conditional Statements

Logical operators are used to compare variables against numbers or against other variables. The resulting answer is either True or False.

Summary for Comparison Operations:

Code Instruction		What it does		
Math symbol	Python operator	*Meaning*	*Example*	*Result (Boolean Values)*
>	>	*Greater than*	*12>11*	*True*
<	<	*Less than*	*25<10*	*False*
≤	<=	*Less than or equal to*	*1<=2*	*True*
≥	>=	*Greater or equal to*	*1>=3*	*False*
=	= =	*Equal to*	*5= =10*	*False*
≠	!=	*Not equal to*	*5 !=10*	*True*

Let's go to the Python Shell and try entering some of the expressions shown in the Summery.



Every conditional expression will evaluate to either True or False in Python. Those are only two Boolean values, and the capital T in True and capital F in False are requared.

Conditional statement *if*

The ***if*** command means that if a condition is True, then the program runs a block of commands. If the condition isn't True, the block is skipped. The block after the ***if*** command is always indented by four spaces.

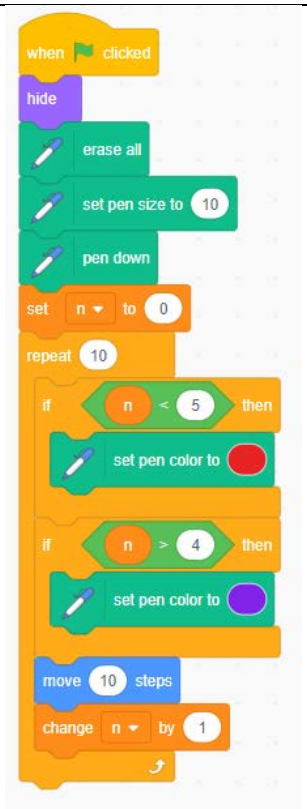
Let's go to example:

Two lines with different colors(left side-Python, right side Scratch)

#Example 8-1
`import turtle`
`t=turtle.Turtle()`
`t.pensize(10)`
`for n in range(10):`
`    if n<5:`
`        t.color('red')`	

```
    if n>=5:
        t.color('blue')
t.fd(20)
```

Result



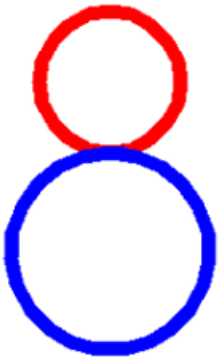
As we can see program (***for*** loop) assigns the following values 0,1,2,3,4,5,6,7,8,9 to the variable n. If variable n<5 colour of line is red, if variable n>=5 colour of line is blue.

Two lines intersect at a right angle

```
#Example 8-2
import turtle
t=turtle.Turtle()
t.pensize(10)
for n in range(2):
    if n<1:
        t.color('red')
    if n>0:
        t.color('blue')
    t.fd(100)
```

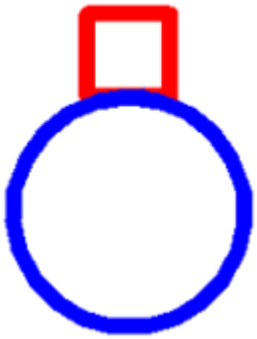
Two circles

```
#Example 8-3
import turtle
t=turtle.Turtle()
t.pensize(10)
for n in range(2):
    if n<1:
        t.color('red')
        t.circle(50)
    if n>0:
        t.color('blue')
        t.rt(180)
        t.circle(70)
```



Square and Circle

```
#Example 8-4
import turtle
t=turtle.Turtle()
t.pensize(10)
for n in range(2):
    if n<1:
        t.color('red')
        for q in range(4):
            t.fd(50)
            t.lt(90)
    if n>0:
        t.color('blue')
        t.rt(180)
        t.up()
        t.fd(-25)
        t.down()
        t.circle(70)
```



Square, Circle and Turtle

```
#Example 8-5
import turtle
t=turtle.Turtle()
t.hideturtle()
for n in range(3):
    t.pensize(10)
    if n==0:
        t.color('red')
        t.begin_fill()
```

```
        for q in range(4):
            t.fd(50)
            t.lt(90)
        t.end_fill()
    if n==1:
        t.color('blue')
        t.rt(180)
        t.up()
        t.fd(-25)
        t.down()
        t.circle(70)
        t.end_fill()
        t.hideturtle()
     if n==2:
        t.color('blue')
        t.rt(180)
        t.up()
        t.fd(-25)
        t.down()
        t.circle(70)
        t.end_fill()
        t.hideturtle()
```

Conditional statement *if-else*

The ***if*** command can be combined with an ***else*** command. This combination means that if something is True, one thing happens, and if not else happens.
Let's see our Example #3 and build the same program using ***if-else*** code

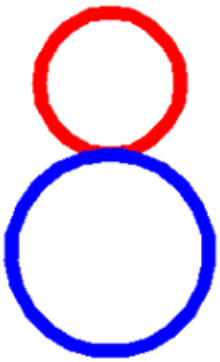
Two lines intersect at a right angle created with condition *if-else*

```
#Example 8-6
import turtle
t=turtle.Turtle()
t.pensize(10)
for n in range(2):
    if n<1:
        t.color('red')
    else:
        t.color('blue')
    t.fd(100)
```

Two circles created with condition *if-else*

#Example 8-7

```
import turtle
t=turtle.Turtle()
t.pensize(10)
for n in range(2):
    if n<1:
        t.color('red')
        t.circle(50)
    else:
        t.color('blue')
        t.rt(180)
        t.circle(70)
```



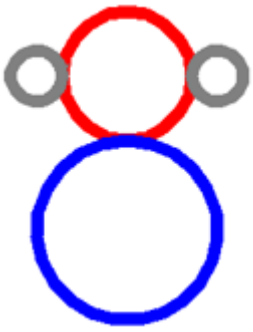
Conditional statement *if-elif-else*

The ***elif*** command is short for ***else-if.*** It means that if something is True, do one thing; otherwise, check if something else is True and do something else if it is. The following program (Example #5 written using this conditional statement command)

Toy

#Example 8-8

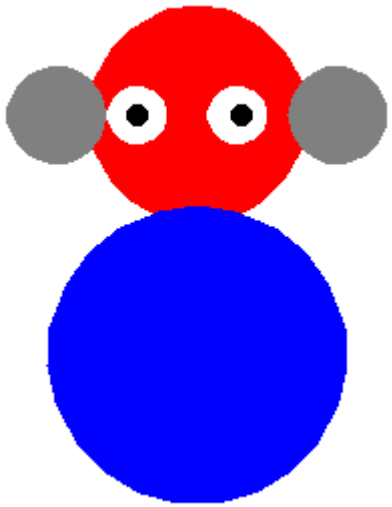
```
#Example 8-8
import turtle
t=turtle.Turtle()
t.pensize(10)
t.hideturtle()
for n in range(4):
    t.pensize(10)
    if n==0:
        t.color('red')
        t.circle(50)

    elif n==1:
        t.color('blue')
        t.rt(180)
        t.circle(70)

    elif n==2:
        t.up()
        t.color('grey')
        t.setpos(50,50)
        t.down()
        t.setheading(-90)
        t.circle(20)
```



```
    else:
        t.up()
        t.color('grey')
        t.setpos(-50,50)
        t.down()
        t.setheading(-90)
        t.circle(-20)
```

#Example 8-9

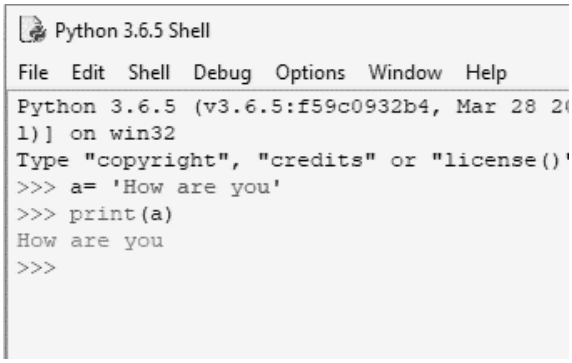
```
import turtle
t=turtle.Turtle()
t.pensize(10)
t.hideturtle()
for n in range(6):
    t.pensize(10)
    if n==0:
        t.color('red')
        t.begin_fill()
        t.circle(50)
        t.end_fill()

    elif n==1:
        t.color('blue')
        t.rt(180)
        t.begin_fill()
        t.circle(70)
        t.end_fill()

    elif n==2:
        t.up()
        t.color('grey')
        t.setpos(50,50)
        t.down()
        t.setheading(-90)
        t.begin_fill()
        t.circle(20)
        t.end_fill()

    elif n==3:
        t.up()
        t.color('grey')
        t.setpos(-50,50)
        t.down()
        t.setheading(-90)
```



```
        t.begin_fill()
        t.circle(-20)
        t.end_fill()

    elif n==4:
        t.up()
        t.color('white')
        t.goto(-20,50)
        t.down()
        t.setheading(-90)
        t.begin_fill()
        t.circle(-10)
        t.end_fill()

    else:
        t.up()
        t.color('white')
        t.setpos(30,50)
        t.down()
        t.setheading(-90)
        t.begin_fill()
        t.circle(-10)
        t.end_fill()

t.shape('circle')
t.up()
t.goto(-30,50)
t.color('black')
t.shapesize(0.5)
t.stamp()

t.goto(22,50)
t.stamp()
```

Lesson 9: Strings, Lists

As we discussed before (Lesson #7), Python can remember *values* of several types, including **number values** (as 7; 42 or even 98.6) and **strings.** A word-or any collection of letters and symbols- is called a string (letters, symbols, words, sentences). Strings can include letters, numbers, spaces, and symbols such as stops and commas. You define a string by enclosing the characters in single (' ') or double quotes (" "), like so. For example, variable a=' How are you' is a string.



We can add two string variables. Example below shows how to do it. (Code –from left side, result is from right side)

When we add two string variable a to string variable b, we get new string variable, which is a combination of two variables a and b. **Keep in mind that you can't add string type data and number type data.**

```
a='How are you   '
b=4
c=a+b
print(c)
```

```
File  Edit  Shell  Debug  Options  Window  Help
Python 3.6.5 (v3.6.5:f59c0932b4, Mar 28 2018, 16
1)] on win32
Type "copyright", "credits" or "license()" for m
>>>
====== RESTART: C:/Users/Victor/Google Drive/Pyt
Traceback (most recent call last):
  File "C:/Users/Victor/Google Drive/Python Proj
dule>
    c=a+b
TypeError: must be str, not int
>>>
```

We can add two numbers if both of them are string type, like this:

```
a='23'
b='14'
c=a+b
print(c)
```

```
File  Edit  Shell  Debug  Options
Python 3.6.5 (v3.6.5:f59c0
1)] on win32
Type "copyright", "credits
>>>
====== RESTART: C:/Users/V
2314
>>>
```

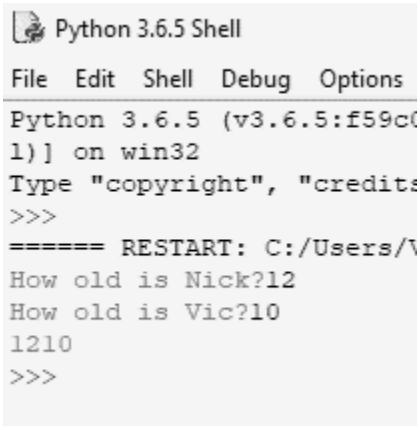
In this example both '23' and '14' are string made of numbers, not number types. So, when you add them together you get a longer string '2314' that is combination of the two strings.

Sometimes you need to operate with numbers and string in one program. How to do it. Let's discuss the following example (**this code uses function called input**). Don't forget click button ENTER after input data.

So, this code looks, like this:

```
Nick_age=input('How old is Nick?')
Vic_age=input('How old is Vic?')

print(Nick_age+Vic_age)
```

Code requests the age of Nick and Vic and must print the sum of their age. Let's see the result



Result is wrong because both input ages are string variables. How to fix this problem? Very simple. You need to convert string variable number 12 and string variable number 10 to the integer numbers.

```
Nick_age=input('How old is Nick?')
Vic_age=input('How old is Vic?')

Nick_age=int(Nick_age)
Vic_age=int(Vic_age)

print(Nick_age+Vic_age)
```

If you want the input to be on its own line, then you could just add symbol **\n** as shown below:

```
Nick_age=input('How old is Nick?\n')
Vic_age=input('How old is Vic?\n')

Nick_age=int(Nick_age)
Vic_age=int(Vic_age)

print(Nick_age+Vic_age)
```

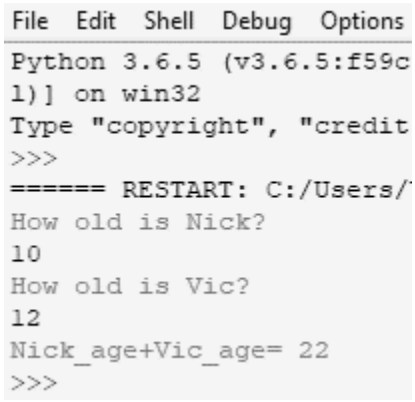
Result:

If you want to add comments to the result you need modify code as:

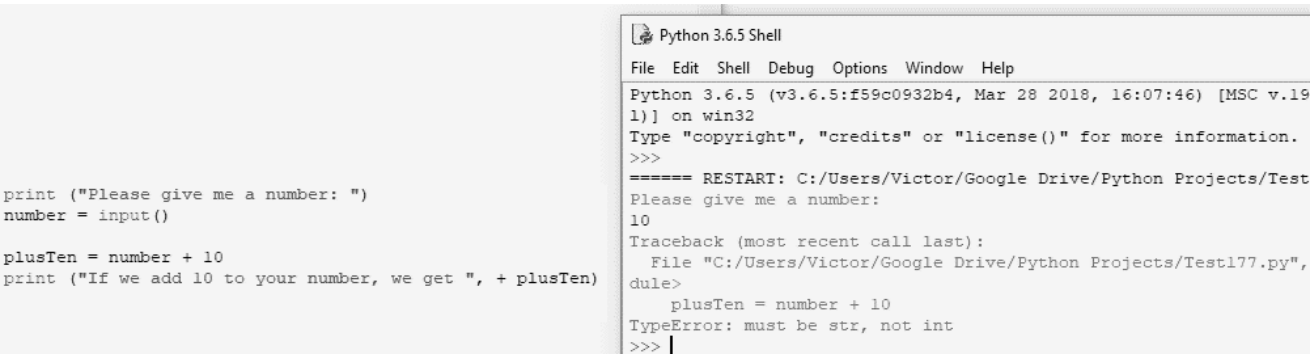
```
Nick_age=input('How old is Nick?\n')
Vic_age=input('How old is Vic?\n')

Nick_age=int(Nick_age)
Vic_age=int(Vic_age)

print('Nick_age+Vic_age=',Nick_age+Vic_age)
```

Last line includes string data 'Nick_age+Vic_age=' and integer number Nick_age+Vic_age.

Result:



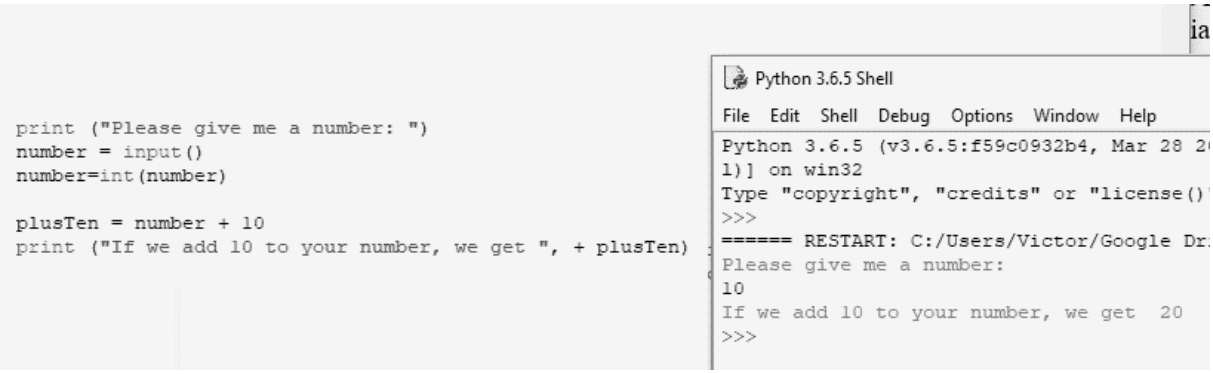
Another example



```
print ("Please give me a number: ")
number = input()

plusTen = number + 10
print ("If we add 10 to your number, we get ", + plusTen)
```

```
Python 3.6.5 Shell
File  Edit  Shell  Debug  Options  Window  Help
Python 3.6.5 (v3.6.5:f59c0932b4, Mar 28 2018, 16:07:46) [MSC v.19
1)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
====== RESTART: C:/Users/Victor/Google Drive/Python Projects/Test
Please give me a number:
10
Traceback (most recent call last):
  File "C:/Users/Victor/Google Drive/Python Projects/Test177.py",
dule>
    plusTen = number + 10
TypeError: must be str, not int
>>>
```

We can't get correct result because line #3 of the code adds string variable "number" with integer 10. Again, to fix this problem we have to convert string variable "number" to integer number. Below, we show corrected code and accurate result



```
print ("Please give me a number: ")
number = input()
number=int(number)

plusTen = number + 10
print ("If we add 10 to your number, we get ", + plusTen)
```

```
Python 3.6.5 Shell
File  Edit  Shell  Debug  Options  Window  Help
Python 3.6.5 (v3.6.5:f59c0932b4, Mar 28 2
1)] on win32
Type "copyright", "credits" or "license()
>>>
====== RESTART: C:/Users/Victor/Google Dr
Please give me a number:
10
If we add 10 to your number, we get  20
>>>
```

Example: Bad or good weather with Python

```
answer=input ('Rainy?--yes or no\n')
if answer=='yes':
    print('bad weather')
else:
    print('good weather')
```

```
File  Edit  Shell  Debug  Optic
Python 3.6.5 (v3.6.5:f5
1)] on win32
Type "copyright", "cred
>>>
====== RESTART: C:\User
Rainy?--yes or no
yes
bad weather
>>>
```

Example: what is the year now→regular or intercalary(leap)

```
keep=True
while keep:

    year = input('what is the year now=\n')
    year=int(year)

    if year % 4 != 0:
        print("usual year")
    elif year % 100 == 0:
        if year % 400 == 0:
            print("intercalary year")
        else:
            print("usual year")
    else:
        print("intercalary year")

    answer=input('Dou you want to continue?, yes or no \n')
    if answer=='yes':
        keep=True
    else:
        break
```

```
what is the year now=
2019
usual year
Dou you want to continue?, yes or no
yes
what is the year now=
2018
usual year
Dou you want to continue?, yes or no
yes
what is the year now=
2016
intercalary year
Dou you want to continue?, yes or no
no
>>>
```

Example: Winter, Spring, Summer, Fall

```
keep=True
while keep:

    a = input('Input month number any number from 1 to 12\n')
    b=int(a)
    if b>= 1 and b<=2 or b==12:
        print('Winter')
    elif b>= 3 and b<=5 :
        print('Spring')
    elif b>= 6 and b<=8 :
        print('Summer')
    elif b>=9 and b<=11 :
        print('Fall')
    else:
        break
```

```
====== RESTART: C:\Users\Victor\Google Drive
Input month number any number from 1 to 12
12
Winter
Input month number any number from 1 to 12
5
Spring
Input month number any number from 1 to 12
6
Summer
Input month number any number from 1 to 12
8
Summer
Input month number any number from 1 to 12
14
>>>
```

You know that 10 multiplied by 3 is equal to 30, of course. But what's 10 multiplied by '3' ('3' is a string). Here's Python's answer:

```
>>> 10*'3'
'3333333333'
>>>
```

We see that the result is 10 times of digit 3.

Example: Heart pattern with strings

```
#CODE
print('RESULT')

print(' ','8'*2,'','8'*2)
print('8',' ','8',' ','8')
print('8',' ','   ','8')
print('','8','   ','8')
print(' ','8',' ','8')
print('   ','8')



print(' ','*'*2,'','*'*2)
print('*',' ','*',' ','*')
print('*',' ','   ','*')
print('','*','   ','*')
print(' ','*',' ','*')
print('   ','*')
```

```
RESULT
  88  88
8   8   8
8       8
 8     8
  8   8
    8
  **  **
*   *   *
*       *
 *     *
  *   *
    *
>>>
```

Example: Find prime number

Code

```
def prime_number(x):
    global n
    if x >= 2:

        for y in range(2,x):

            k=x%y

            if k==0:
                n=0
                print('usual')
                break
            n=1
forward=True

while forward:
    answer=input("Do you want to find prime number? yes or no\n")

    if answer=='no':
        break

    q= input("Please enter a number:\n")
    a=int(q)
    prime_number(a)

    if n==1:
        print('prime')
```

Result

```
Do you want to find prime number? yes or no
yes
Please enter a number:
163
prime
Do you want to find prime number? yes or no
yes
Please enter a number:
12345763
usual
Do you want to find prime number? yes or no
yes
Please enter a number:
9301
usual
Do you want to find prime number? yes or no
no
>>>
```

Now, Let's demonstrate example how to turn turtle with input code

1. **Example #9-1** (Turtle turns 45 degrees)

Code

```
1  import turtle
2  t1=turtle.Turtle('turtle')
3  t1.shapesize(5)
4  t1.color('red')
5
6  a=input('Please input turtle angle?=\n')
7  b=int(a)
8  print('turtle angle=',b)
9  t1.setheading(b)
```

Result

```
File  Edit  Shell  Debug  Options  Window
Python 3.6.5 (v3.6.5:f59c0932b4,
1)] on win32
Type "copyright", "credits" or '
>>>
 RESTART: C:\Users\Victor\Google
Please input turtle angle?=
45
turtle angle= 45
>>>
```

You can include input code line in the loop. In this case program requests you to input data a few times and you will see the results for each request:

```
import turtle
t1=turtle.Turtle('turtle')
t1.shapesize(5)
t1.color('red')

for i in range (10):

    a=input('Please input turtle angle?=\n')
    b=int(a)
    print('turtle angle=',b)
    t1.left(b)
```

LISTS

When you want to store a lot of data, you may need to use a list. A list can hold many items together and keep them in order. Python gives each item a number that shows its position in the list. A list is a group of values, separated by commas, between square brackets, []. We can store any value types in lists, including numbers and strings. We can store a few objects as turtles in list (**Lesson 12**). Let's go to list example, called color_list:

color_list=['red', 'blue', 'gold', 'green', 'yellow', 'pink']

This list consists of 6 string variables. If you want to do anything with one of the words from that list, you can use something called the index- the position of the item in the list. So, a list is a structure in Python where items are kept in order. Each entry is given a number that you can use to refer back to it.

color_list[0]= 'red'
color_list[1]= 'blue'
color_list[2]= 'gold'
color_list[3]= 'green'
color_list[4]= 'yellow'
color_list[5]= 'pink'

Below it is shown a list that includes integer numbers

number_list=[3,5,7,11,13,17,19,23,29,31]

Now we create our first program with a list. Let's calculate the following sums:

$S1=3+5+7+11+13+17+19+23+29+31$

$S2=3^2+5^2+7^2+11^2+13^2+17^2+19^2+23^2+29^2+31^2$

$S3=3^4+5^4+7^4+11^4+13^4+17^4+19^4+23^4+29^4+31^4$

All of these integers are prime numbers. Code, shown below, calculates these values S1, S2, and S3. To make calculations we use list called *num.*

2. **Example #9-2** (Math calculations using List with integer values)

```
num=[3,5,7,11,13,17,19,23,29,31]

S1=0
S2=0
S3=0

for n in range(10):
    S1=S1+num[n]
    S2=S2+num[n]**2
    S3=S3+num[n]**4

print('S1=',S1)
print('S2=',S2)
print('S3=',S3)
```

```
S1= 158
S2= 3354
S3= 2170794
>>>
```

Result

3. **Example #9-3** (Sort list numbers in the order from smallest item to largest values)

Code:

```
list1 = [10, 20, 4, 45, 99,15,44,38,72,125,1,999,348]

# sorting the list
list1.sort()
print(list1)
print('Minimum number in the list=',list1[0])
```

Result:

```
====== RESTART: C:/Users/Victor/Google Drive/Python Projec
[1, 4, 10, 15, 20, 38, 44, 45, 72, 99, 125, 348, 999]
Minimum number in the list= 1
>>>
```

In this program we used line list1.sort that sorts all numbers in order from minimum to maximum value.

4. **Example #9-4** (Find smallest and greatest items in the list with numbers)

Code:

```
list = [10, 20, 4, 45, 99,15,44,38,72,125,1,999,348]

# sorting the list
a=min(list)
b=max(list)

print(list)
print('Smallest number in the list=',a)
print('Greatest number in the list=',b)
```

Result:

```
====== RESTART: C:/Users/Victor/Google Drive/Python Projec
[10, 20, 4, 45, 99, 15, 44, 38, 72, 125, 1, 999, 348]
Smallest number in the list= 1
Greatest number in the list= 999
>>>
```

If you want to calculate the number of items in the list you have to use command len(list), for example, as shown below

5. **Example #9-5** (Calculate the number of items in the list)

Code:

```
list = [10, 20, 4, 45, 99,15,44,38,72,125,1,999,348]

# sorting the list
a=min(list)
b=max(list)
c=len(list)

print(list)

print('Smallest number in the list=',a)
print('Greatest number in the list=',b)
print('Number of list items=',c)
```

Result:

```
====== RESTART: C:/Users/Victor/Google Drive/Python Pr
[10, 20, 4, 45, 99, 15, 44, 38, 72, 125, 1, 999, 348]
Smallest number in the list= 1
Greatest number in the list= 999
Number of list items= 13
>>>
```

6. **Example #9-6** (Sorting of the list with strings variables)

```
#CODE
list = ['g','c','h','a','f','i','b','e','d']
list.sort()
print('----------------------------------------')
print('RESULT')
print(list)
```

```
----------------------------------------
RESULT
['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i']
>>>
```

All letters are sorted according to the alphabet.

7. **Example #9-7** (Add to the end of a list additional items)

You can add any item numbers to the end of the list whatever you want, for example,

Code:

```
list=[]
list1=[]
list2=[]

for i in range(10):
    list.append(i)
    list1.append(i*i)
    list2.append(i**3)

print('list=',list)
print('list1=',list1)
print('list2=',list2)
```

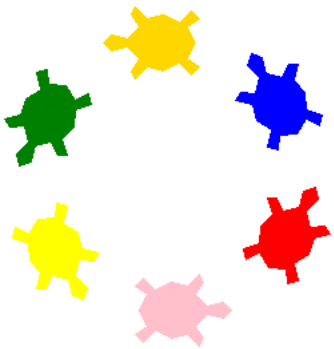
Result:

```
list= [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
list1= [0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
list2= [0, 1, 8, 27, 64, 125, 216, 343, 512, 729]
>>>
```

In this example we have three lists: list; list1; and list2. All of them initially are empty. However using lines “list.append(i)” , “list1.append(i*i)”, and “list2.append(i**3)” we add to the end of each list integer numbers equal i for list,
i*i for list1,
i**3 for list2.

8. **Example #9-8** (Number of different colour turtles, code uses list with string variables)

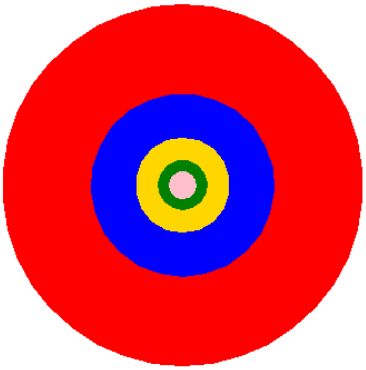
```
import turtle
t=turtle.Turtle('turtle')
t.shapesize(3)
t.up()

color_list=['red','blue','gold','green','yellow','pink']

for i in range(6):
    t.color(color_list[i])
    t.circle(100, 60)
    t.stamp()
```



Here we set up the colour of turtle with a line t.color(color_list[i]), where i is an integer number that takes sequentially the following values 0,1,2,3,4,5.

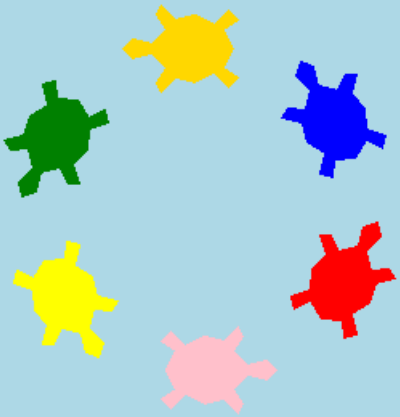
9. **Example #9-9** (Example shows the combination of number and string lists)

```
import turtle
t=turtle.Turtle('turtle')
t.pensize(5)


color_list=['red','blue','gold','green','pink']
num=[32,16,8,4,2]

for i in range (5):

            t.color(color_list[i])
            t.up()
            t.goto(0,-5*num[i])
            t.down()
            t.begin_fill()
            t.circle(5*num[i])
            t.end_fill()
t.hideturtle()
```



10. Example #9-10 (Colour turtles with colour background)

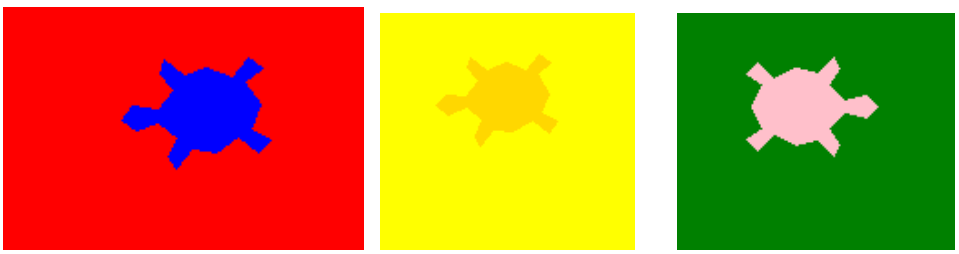
```
import turtle
t=turtle.Turtle('turtle')
t.shapesize(3)
t.up()
turtle.bgcolor('light blue')
color_list=['red','blue','gold','green','yellow','pink']

for i in range(6):
    t.color(color_list[i])
    t.circle(100, 60)
    t.stamp()
```



Line turtle.bgcolor('light blue') creates background light blue colour.

11. Example #9-11 (Colour turtles with changing colour background)

```
import turtle
t=turtle.Turtle('turtle')
t.shapesize(3)
t.up()

clr=['red','yellow','green']
color_list=['blue','gold','pink']

for m in range (3):

    turtle.bgcolor(clr[m])
    t.color(color_list[m])
    t.circle(100)
```



Lesson 10: Random Numbers

Summary:

Code Instruction	What it does
import random	Specifies random number library module
random.randint(a,b)	Return (specifies) a random integer number n such that a<=n<=b.
random.uniform(a,b)	Return (specifies) a random number n (not necessary integer) such that a<=n<=b.
random.randrange(a,b,c) random.randrange(a,b) random.randrange(b)	Return (specifies) a random integer number n in range a<=n<=b with step c. If c is not specified returns random integer number in a range between a and b. If a is not specified returns random integer number in a range between 0 and b.
random.shuffle(list)	The shuffle function shuffles a list, mixing up the items of the list.
random.choice(list)	If you want to pick a random item from a list instead of a random number from a given range, you can use choice.

Python comes with a “Standard Library” that has lots of useful bits of code ready to use. Stand-alone sections of a library called “modules” can be added to Python to make it more powerful. For example, Turtle module is used to draw different shapes on the screen. Random module can pick a random number, or shuffle a list into a random order.

Simple examples with random functions:

Example 10-1

Code:

```
import random

for i in range (5):
    n=random.randint(1,10)
    print('i=',i,'n=',n)
```

Result:

```
====== RESTART: C:/
i= 0 n= 2
i= 1 n= 10
i= 2 n= 8
i= 3 n= 7
i= 4 n= 7
>>>
```

Example 10-2

Code:

```
import random

for i in range (5):
    n=random.uniform(1,10)
    print('i=',i,'n=',n)
```

Result:

```
====== RESTART: C:\Users\Vic
i= 0 n= 3.82008576377915
i= 1 n= 5.314758699405314
i= 2 n= 2.1598116940137446
i= 3 n= 4.789807314517651
i= 4 n= 5.289299766714907
>>>
```

Example 10-3

Code:

```
import random

for i in range (5):
    n=random.randrange(1,10)
    print('i=',i,'n=',n)
```

Result:

```
====== RESTART:
i= 0 n= 8
i= 1 n= 6
i= 2 n= 4
i= 3 n= 1
i= 4 n= 1
>>>
```

Example 10-4

```
#CODE

import random
for i in range(5):
    n=random.randrange(1,10,2)
    print('i=',i,'n=',n,  end = '   ')

#RESULT
i= 0 n= 3   i= 1 n= 3   i= 2 n= 9   i= 3 n= 7   i= 4 n= 1
>>>
```

Example 10-5

```
#CODE

import random
list=[1,2,3,4,5,6,7,8,9,10]
random.shuffle(list)
print('list=',list)

#RESULT
 list= [10, 9, 7, 4, 3, 6, 1, 5, 2, 8]
 >>>
```

As you can see list items are shuffled randomly.

Example 10-6

```
list= ['black', 'gold', 'green', 'yellow', 'red', 'gray', 'blue']
>>>
```

Example 10-7

```
#CODE

import random
list=['red','yellow','green','blue','black','gray','gold']
a=random.choice(list)
print('a=',a)

#RESULT
 a= black
 >>>
```

Example 10-8

```
#CODE

import random
list=['red','yellow','green','blue','black','gray','gold']
for i in range (10):
    a=random.choice(list)
    print('a=',a,end=' ')

#RESULT
 a= red a= yellow a= red a= yellow a= black a= yellow a= gold a= gold a= red a= black
 >>>
```

Example 10-9 (Guess a number 1 or 2)

```
import random
S0=0
S1=0
print('Hello!')
print('You need to choose number 1 or 2, Total tries = 20')
print('Based on your answers code calculates the\
probability of right and wrong answers')

for i in range(10):
    number=random.randint(1,2)
    #print(number)
    guess=input('Guess number between 1 or 2=\n')
    guess=int(guess)
    if guess==number:
        S0=S0+1
        print('Good Job')
    else:
        print('Wrong')
        S1=S1+1

print('Number of right Answers=',S1)
print('Number of wrong Answers=',S0)
```

Result:

```
====== RESTART: C:\Users\Victor\Google Drive\Python Projects\Test174.py ======
Hello!
You need to choose number 1 or 2, Total tries = 20
Based on your answers code calculates theprobability of right and wrong answers
Guess number between 1 or 2=
1
Wrong
Guess number between 1 or 2=
2
Wrong
Guess number between 1 or 2=
2
Good Job
Guess number between 1 or 2=
1
Good Job
Guess number between 1 or 2=
2
Good Job
Guess number between 1 or 2=
1
Wrong
Guess number between 1 or 2=
2
Good Job
Guess number between 1 or 2=
1
Good Job
Guess number between 1 or 2=
1
Good Job
Guess number between 1 or 2=
2
Good Job
Number of right Answers= 3
Number of wrong Answers= 7
>>>
```

Example 10-10 (Guess random number)

Code:

```
import random
n = random.randint(1, 99)
guess = int(input("Enter an integer from 1 to 99:\n "))
while n != "guess":
    print
    if guess < n:
        print("guess is low")
        guess = int(input("Enter an integer from 1 to 99:\n "))
    elif guess > n:
        print ("guess is high")
        guess = int(input("Enter an integer from 1 to 99:\n "))
    else:
        print ("you guessed it!")
        break
    print
```

Result:

```
Enter an integer from 1 to 99:
 50
guess is high
Enter an integer from 1 to 99:
 25
guess is high
Enter an integer from 1 to 99:
 10
guess is high
Enter an integer from 1 to 99:
 5
guess is low
Enter an integer from 1 to 99:
 7
guess is low
Enter an integer from 1 to 99:
 8
you guessed it!
>>>
```

Examples shown below use Turtle and Random modules

Random colour lines

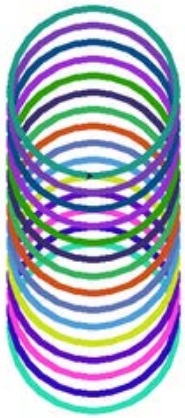
To draw random colour lines we will use turtle.coloremode function instead of regular colours, such as red, blue,green e.t.c. One of the most common way to represent colour is to use three 8-bit integers (values of 0-255) to characterize the

intensity of the red, green and blue channels. With colormode color components are specified using a number between 0 and 255, so red would be (255, 0, 0), blue would be (0,0,255), for yellow (255,255,0). In our example we generate colour with three integer random numbers, each of them in a range (0,255), as shown below.

```
#Example 10-11
import turtle
import random
t=turtle.Turtle()
turtle.tracer(10)
turtle.colormode(255)
t.pensize(8)
t.up()
for i in range(20):
    a=random.randint(0,255)
    b=random.randint(0,255)
    c=random.randint(0,255)
    t.goto(-200,-250+20*i)
    t.down()
    t.color(a,b,c)
    t.fd(400)
    t.up()
    t.goto(-200,-250+20*i)
```

Circles with random colors

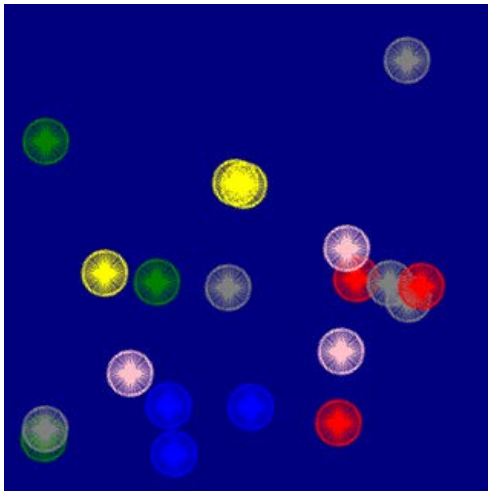
```
#Example 10-12
import turtle
import random
t=turtle.Turtle()
turtle.tracer(10)
turtle.colormode(255)
t.pensize(8)
t.penup()
R=100

for i in range (15):
    a=random.randint(0,255)
    b=random.randint(0,255)
    c=random.randint(0,255)
```



```
    t.goto(0,-250+20*i)
    t.pendown()
    t.pencolor(a,b,c)
    t.circle(R)
    t.penup()
    t.goto(0,-250+20*i)
```

Random Spiral

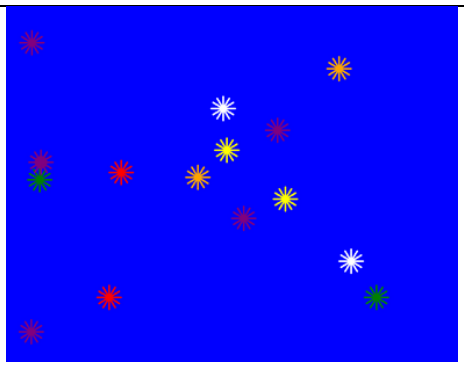
```
#Example 10-13
import turtle
import random
t = turtle.Turtle()
turtle.bgcolor('navy')
turtle.tracer(3)

clr=['red','blue','yellow',\
    'green','gray',\
    'violet','pink']
for j in range (20):
  a=random.randint(-300,300)
  b=random.randint(-300,300)
  t.penup()
  t.color(random.choice(clr))
  for i in range(100):
      t.forward(30)
      t.left(70)
      t.forward(10)
      t.right(40)
      t.penup()
      t.setposition(a,b)
      t.pendown()
      t.right(2)
```



Snowflakes

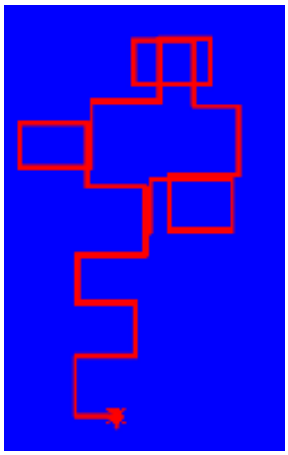
```
#Example 10-14
import turtle,random
wn=turtle.Screen()
wn.setup(1000,1000)
wn.bgcolor('blue')
turtle.tracer(3)
t=turtle.Turtle()
import random
t.shape('circle')
t.speed(11)
clr=['red','white','green','blue',\
     'yellow','orange','purple']
t.pensize(3)
```

```
for n in range(20):
    t.penup()
    a1=random.randint(-300,300)
    a2=random.randint(-300,300)
    t.goto(a1,a2)
    t.pendown()
    colr = random.choice(clr)
    t.color(colr)
    for i in range(12):
        t.right(30)
        t.forward(20)
        t.backward(20)
```



Random motion

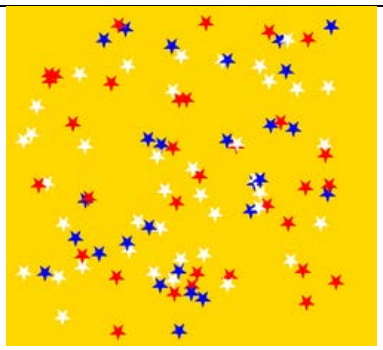
```
#Example 10-15
import turtle,random,time
t = turtle.Turtle('turtle')
t.pensize(5)
turtle.bgcolor("blue")
for i in range (30):
    t.color('red')
    t.fd(random.randint(40,80))
    a=random.randint(0,1000)
    b=a%2
        if a%2==0:
             t.left(90)
         else:
         #if a%2>0:
             t.left(-90)
    time.sleep(1)
```



Random Stars Location

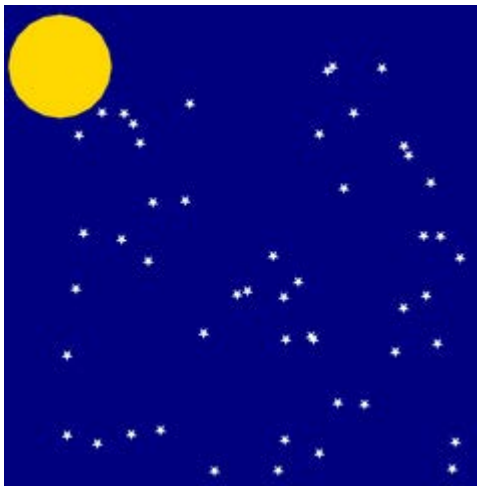
```
#Example 10-16
import turtle
import random
t = turtle.Turtle()
turtle.bgcolor('gold')
turtle.tracer(2)
t.hideturtle()
clr=['red','blue','white']

for j in range (100):
```

```
  x=random.randint(-300,300)
  y=random.randint(-300,300)
  t.up()
  t.goto(x,y)
  t.down()
  t.color(random.choice(clr))
  t.begin_fill()
  for i in range(5):

      t.forward(30)
      t.left(144)
  t.end_fill()
```



Blue Sky with Stars and Moon

```
#Example 10-17
import turtle
import random
t = turtle.Turtle()
turtle.bgcolor('navy')
turtle.tracer(2)
t.hideturtle()
t.color('white')
moon=turtle.Turtle('circle')
moon.shapesize(10)
moon.up()
moon.color('gold')
moon.goto(-400,400)
for j in range (50):
  x=random.randint(-400,400)
  y=random.randint(-400,400)
  t.up()
  t.goto(x,y)
  t.down()
  t.begin_fill()
  for i in range(5):

      t.forward(20)
      t.left(144)
  t.end_fill()
```



This example uses two turtles: one with a name t and another one with a name moon. Multiple turtles objects will be explained in the Chapter #12.

Lesson 11: Functions

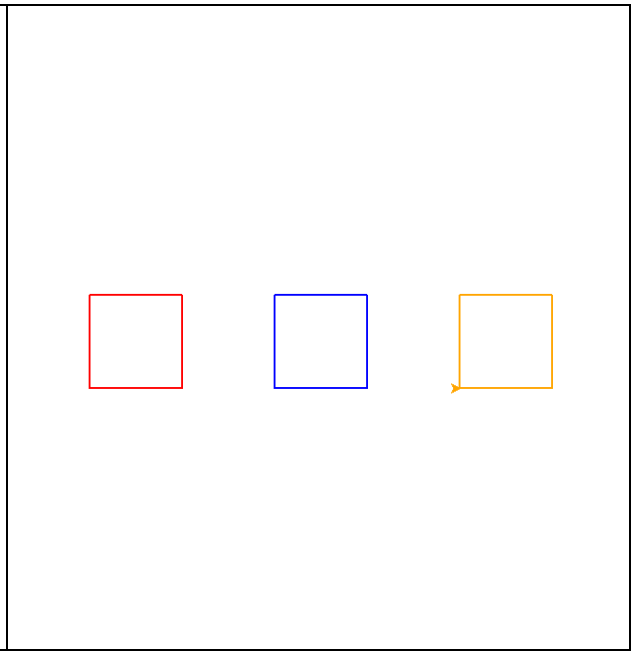
Programmers like to make writing code easier. One of the most common shortcuts is to give a name to a block of code that does a repeatable job. Then, instead of having to type out the whole block each time, you need it, you can simply type its name. These named blocks of code are called functions.

Functions

Python language and each library Python module (for example, Turtle module, Random module Math module and so on) contains lots of useful build in functions for performing certain tasks. Before using a module and all library module functions you have to tell the computer to import it so it can be used by your program. After you import certain module all module build in functions (commands) are getting available for you. However very often you need to create your own function to make your code much shorter and elegant. Let's consider that you need to draw several squares in a turtle graphics program.

Squares with in-build loop function

```
#Example 11-1
import turtle

t=turtle.Turtle()
t.color('red')
t.pensize(2)

t.up()
t.goto(-200,0)
t.down()

for i in range(4):
    t.fd(100)
    t.left(90)

t.up()
t.goto(0,0)
t.color('blue')
t.down()
```

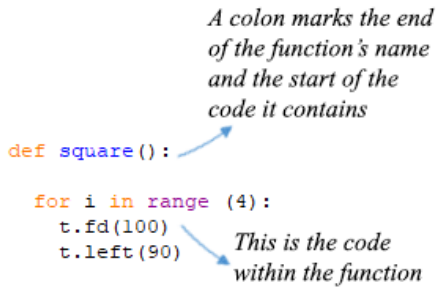


```
for i in range(4):
    t.fd(100)
    t.left(90)

t.up()
t.goto(200,0)
t.color('orange')
t.down()

for i in range(4):
    t.fd(100)
    t.left(90)
```

This program contains three pieces of reusable code:

```
for i in range (4):
  t.fd(100)
  t.left(90)
```

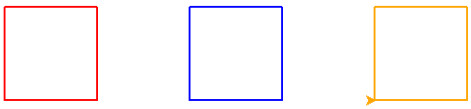
Of course, you copy and paste this code to each place in your program where you want to draw a square. In this example reusable code include only three line, therefore it is not a problem to copy and paste it. However, if this part has 10, 20 or more lines it could be a problem: program becomes too long. In such situations there is exist a solution: to define your own function and call it when it necessary. So, function is a chunk of code that tell Python to do something again and again. A function can be used to avoid entering the same lines of code more than once. The definition of a function will always have the keyword *def* and the function's name at the beginning of the code. In our case it could be



After defining a function, we have to call it in our program using the function's name followed by parenthesis: square(). Here's the code with a function:

Squares with created function named square

```
#Example 11-2(a)
import turtle
t=turtle.Turtle()
t.color('red')
t.pensize(2)

def square():
    for i in range(4):
        t.fd(100)
        t.left(90)

t.up()
t.goto(-200,0)
t.down()
square()

t.up()
t.goto(0,0)
t.color('blue')
t.down()
square()

t.up()
t.goto(200,0)
t.color('orange')
t.down()
square()
```

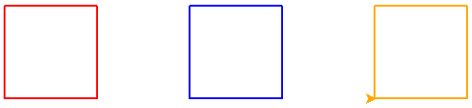


As you can see we call our function three times to get three squares. This program is easier to read but it is still long. Now we try to make our program shorter using function with parameters. You can notice that these three drawn squares have different coordinates of the screen: first square starts from X=-200,Y=0; second square → from X=0,Y=0 and third square → from X=200,Y=0. Therefore, X position of square could be parameter in our new function. Parameters allow us to send information to the function by passing values to it as arguments inside its parentheses. Now we can modify our code:

Squares with function (one parameter)

```
#Example 11-2(b)
import turtle
t=turtle.Turtle()
t.pensize(2)#

def square(X):
```

```
    t.up()
    t.goto(X,0)
    t.down()
    for i in range(4):
        t.fd(100)
        t.left(90)
t.color('red')
square(-200)

t.color('blue')
square(0)

t.color('orange')
square(200)
```

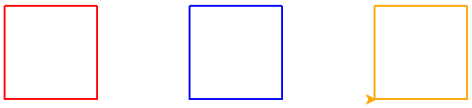


To make our program shorter we can introduce second parameter colour. Name this parameter clr. Let's try

Squares with function (two parameters)

Example 11-2(c)

```
import turtle
t=turtle.Turtle()
t.pensize(2)

def square(X,clr):
    t.up()
    t.goto(X,0)
    t.down()
    t.color(clr)
    for i in range(4):
        t.fd(100)
        t.left(90)

square(-200,'red')
square(0,'blue')
square(200,'orange')
```



You can compare initial code (a) and final code (d). Version (a) consist of 24 lines, version (d)→ 14 lines which is significantly shorter. Bellow we would like to show a few Python programs that effectively use functions.

Polygons, parameters: size, points, clr.

#Example 11-3(a)

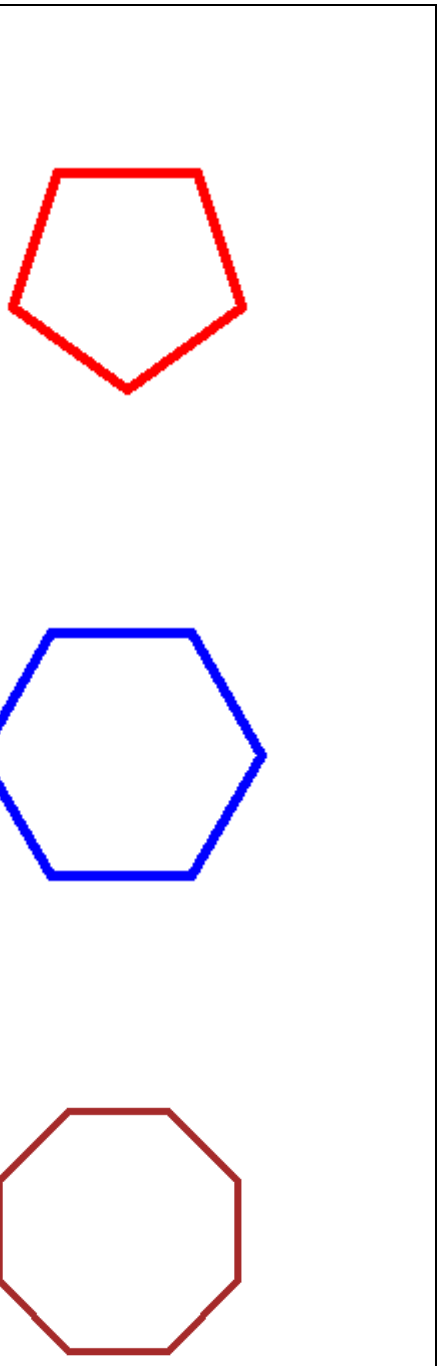
```
import turtle,time
t=turtle.Turtle()
t.pensize(5)
def polygon(size,points,clr):
    for i in range(points):
        t.color(clr)
        t.fd(size)
        angle=360/points
        t.rt(angle)

polygon(70,5,'red')
t.hideturtle()
```

#Example 11-3(b)

```
import turtle,time
t=turtle.Turtle()
t.pensize(5)
def polygon(size,points,clr):
    for i in range(points):
        t.color(clr)
        t.fd(size)
        angle=360/points
        t.rt(angle)

polygon(70,6,'blue')
t.hideturtle()
```

#Example 11-3(c)

```
import turtle,time
t=turtle.Turtle()
t.pensize(5)
def polygon(size,points,clr):
    for i in range(points):
        t.color(clr)
        t.fd(size)
        angle=360/points
        t.rt(angle)

polygon(70,8,'brown')
t.hideturtle()
```



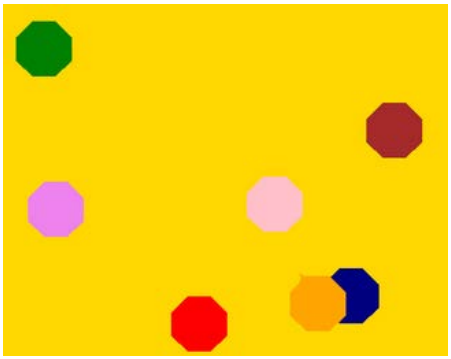
Number of corners equal 5 corresponds pentagon, if vertices number is 6, we have hexagon, for octagon number of size is equal 8. Formula to calculate turn

angle for polygon (variable angle in our example) is given by expression **angle=360/points**.
Now let's draw a few polygons on the window screen placed on the randomly located positions.

Polygons, randomly located on the window screen)

#Example 11-4

```
import turtle,random
t=turtle.Turtle()
turtle.bgcolor('gold')
turtle.tracer(3)
t.pensize(5)
clr=['red','navy','brown',\
     'green','violet','pink',\
     'orange',]
def polygon(size,points,clr):
    for i in range(points):
        t.color(clr)
        t.fd(size)
        angle=360/points
        t.rt(angle)

for i in range(7):
    t.up()
    t.setpos(random.randint(-400,400)\
             ,random.randint(-200,200))
    t.down()
    t.begin_fill()
    polygon(25,8,clr[i])
    t.end_fill()
t.hideturtle()
```

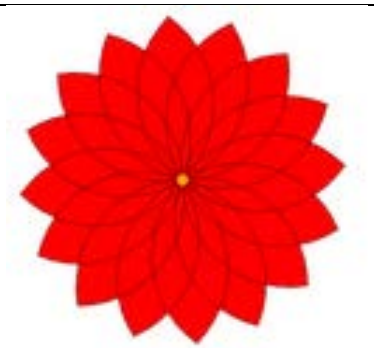


Sun Flower

Example 11-5

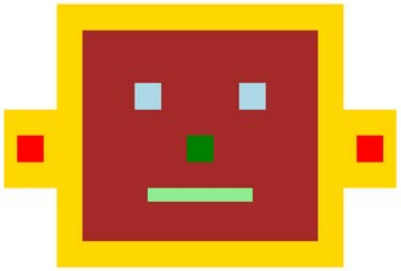
```
import turtle
t=turtle.Turtle('turtle')
t.color('black','red')
turtle.tracer(2)
def petal(r,angle):
    for i in range(2):
        t.circle(r,angle)
        t.left(180-angle)

t.begin_fill()
for q in range (16):
```

```
    t.setheading(22.5*q)
    petal(200,100)
t.end_fill()

t1=turtle.Turtle('circle')
t1.color('orange')
t1.shapesize(8)
```



Face created with function

```
#Example 11-6(a)
import turtle
import time
t=turtle.Turtle()
t.hideturtle()
turtle.tracer(2)
def rectangle(x,y,length,width,clr):
    t.up()
    t.goto(x,y)
    t.down()
    t.color(clr)
    t.begin_fill()
    for i in range(2):
        t.fd(length)
        t.right(90)
        t.fd(width)
        t.right(90)
    t.end_fill()

# Main form gold color
rectangle(-350,250,750,500,'gold')

#Face Brown
rectangle(-200,200,450,400,'brown')

#Nose
rectangle(0,0,50,50,'green')

#Mouth
rectangle(-75,-100,200,25,'lightgreen')

#left upper Cut
rectangle(-350,250,100,200,'white')

#Leftbottom Cut
```



```
rectangle(-350,-100,100,200,'white')

#Right upper Cut
rectangle(300,250,100,200,'white')

#Right bottom Cut
rectangle(300,-100,100,200,'white')

#Left and Right ears
rectangle(325,0,50,50,'red')
rectangle(-325,0,50,50,'red')

#Left and right eyes
rectangle(-100,100,50,50,'lightblue')
rectangle(100,100,50,50,'lightblue')
```

#Example 11-6(b)

```
import turtle,random
t=turtle.Turtle('circle')
t.setheading(0)
def face(clr,size1,size2,X,Y):
    t.color(clr)
    t.up()
    t.shapesize(size1,size2)
    t.goto(X,Y)
    t.stamp()
face('yellow',30,30,0,0)
face('red',3,12,0,-150)
face('black',4,4,-130,120)
face('black',4,4,130,120)
face('gray',10,2,0,0)
```

#Example 11-7

```
import turtle
t = turtle.Turtle()
turtle.bgcolor('chocolate')
t.pensize(40)
t.color('blue')
clr=['firebrick','navy','green','gold','violet']
def drawing(r,x,y,n):
  t.color(clr[n])
  t.up()
  t.goto(x,y)
  t.down()
  t.circle(r)

drawing(50,100,100,0)
```

`drawing(50,-100,100,1)`
`drawing(50,-100,-100,2)`
`drawing(50,100,-100,3)`
`drawing(50,0,0,4)`	

Functions in Math Calculations

Example 11-8(simple calculator)

Here's we use two functions: one for addition of two numbers and another one for subtraction of two numbers. Loop while is to provide call functions a lot of times, till you want to make calculations.

```
# Program make a simple calculator that adds and subtract\
#two numbers using functions

# This function adds two numbers
def add(x, y):
    return x + y

# This function subtracts two numbers
def subtract(x, y):
    return x - y

a=1
while a==1:
    num1 = int(input("Enter first number:\n "))
    num2 = int(input("Enter second number:\n "))
    # Take input from the user
    choice = input("Enter math operation + or -:\n")

    if choice == '+':

        print(num1,"+",num2,"=",add(num1,num2))

    elif choice == '-':
        print(num1,"-",num2,"=", subtract(num1,num2))
    else:
        break

    b=input('Do you want to continue: yes or no? \n')

    if b=='yes':
        a=1
    else:
        break

```

Result:

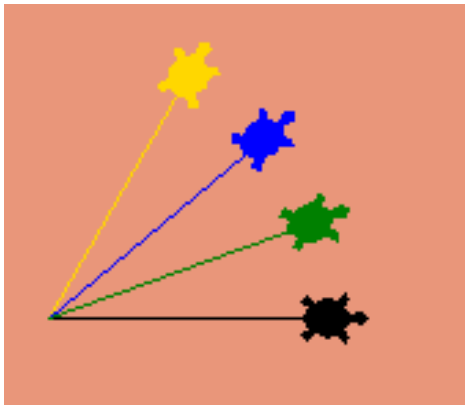
```
Enter first number:
 56
Enter second number:
 23
Enter math operation + or -:
+
56 + 23 = 79
Do you want to continue: yes or no?
yes
Enter first number:
 23
Enter second number:
 11
Enter math operation + or -:
-
23 - 11 = 12
Do you want to continue: yes or no?
no
>>>
```

Lesson 12: Multiple Turtles

How to instantiate more than one turtle in the same program? Very simple. So far we used one turtle with a name called **t** in our programs. The line t=turtle.Turtle() creates a turtle object *t*. This line imports the module called turtle, which has all built in functions (forward, left, right, …) for drawing on the screen with the Turtle object t. Let's create second turtle object with a name t1, t1=turtle.Turtle(). Turtle t1 has the same capability and properties as turtle t. Objects that have the same capabilities and similar properties are defined as ***classes*** in Python language. Keep in mind that you can name turtle objects as you wish, for example, first one can be Tina and second one –Tommy. You can add third, fourth and so on turtle objects each with its own name. Below, it is shown an example with four turtles.

Four turtles

```
#Example 12-1
import turtle
turtle.bgcolor('darksalmon')

Tina=turtle.Turtle('turtle')
Molly=turtle.Turtle('turtle')
George=turtle.Turtle('turtle')
Wilson=turtle.Turtle('turtle')

Tina.color('black')
Tina.fd(100)

Molly.lt(60)
Molly.color('gold')
Molly.fd(100)

George.lt(40)
George.color('blue')
George.fd(100)

Wilson.lt(20)
Wilson.color('green')
Wilson.fd(100)
```



First turtle name is Tina, second→Molly, third→George, and forth→Wilson.

#Example 12-2

```
import turtle
tina = turtle.Turtle()
tina.shape('turtle')
tina.shapesize(1)
tina.color('blue')
tina.up()
tina.left(90)
tina.forward(100)
tina.forward(20)
tina.write(\
    'I am Tina!',\
    font=('Times New Roman'\
          ,12,'bold'))
tina.forward (50)
tina.right(90)

tommy = turtle.Turtle()
tommy.shape('turtle')
tommy.shapesize(5)
tommy.color('red')
tommy.up()
tommy.forward(50)
tommy.write(\
    'I am Tommy!'\
    , font=('Times New Roman'\
            ,12,'bold'))
           tommy.forward(150)
```

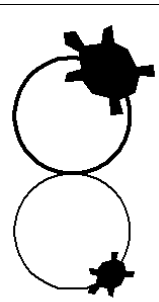
In the example12-2 we added couple of lines that allow to write message on the screen. Each line includes message you want to type, font name font size and font type.

Simple animation with two turtles

#Example 12-3

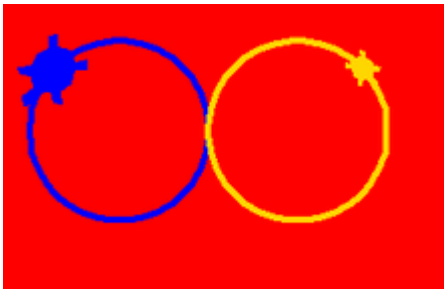
```
import turtle
t1=turtle.Turtle('turtle')
t1.pensize(4)
t1.shapesize(4)
t2=turtle.Turtle('turtle')
t2.pensize(2)
t2.shapesize(2)
X=10
for i in range (50):
```

```
  t1.fd(X)
  t1.lt(10)
  t2.fd(X)
  t2.rt(10)
```



Two turtles motion using function

```
#Example 12-4
import turtle
turtle.bgcolor('red')
t1=turtle.Turtle('turtle')
t2=turtle.Turtle('turtle')
def multiple(turtle,clr,size):
      turtle.color(clr)
      turtle.shapesize(size)
      turtle.pensize(4)
      turtle.left(90)

X=10
multiple(t1,'blue',2)
multiple(t2,'gold',1)
for i in range (50):
      t1.fd(X)
      t1.lt(10)
      t2.fd(X)
      t2.rt(10)
```



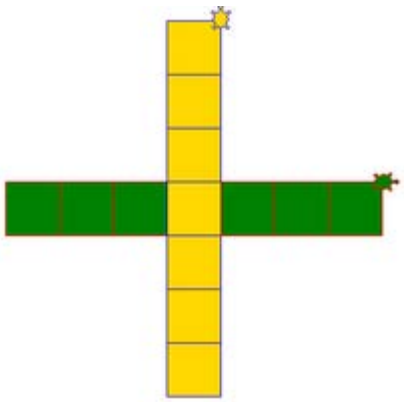
Example 12-4 shows how to create code with two turtle using function **multiple**. Function specifies turtle named t1 and turtle named t2. Parameters of function are following:

a. Turtle name;
b. Turtle colour;
c. Turtle shape size.

After we determined function we call function with name turtle **t1** and call function with name turtle **t2.**

Moving Turtles

```
#Example 12-5
import turtle
maya=turtle.Turtle('turtle')
maya.color('red','green')
maya.penup()
maya.setpos(-200,0)
maya.down()
maya.speed(10)

pepe=turtle.Turtle('turtle')
pepe.color('blue','gold')
pepe.penup()
pepe.setpos(0,-200)
pepe.down()
pepe.speed(10)
pepe.lt(90)

for j in range(7):
    maya.begin_fill()
    pepe.begin_fill()

#Rectangle drawing
    for i in range(4):
        maya.fd(50)
        maya.rt(90)
        pepe.fd(50)
        pepe.lt(90)
#-------------------------
    maya.fd(50)
    pepe.fd(50)
    maya.end_fill()
    pepe.end_fill()
```



Two turtles, first named Maya and second Pepe move in perpendicular directions. Each of them draws square.

Moving Car

```
#Example 12-6
import turtle
import time
t=turtle.Turtle()

t.color('coral')
t1=turtle.Turtle()
t2=turtle.Turtle()
t3=turtle.Turtle()
t1.color('gray')
t2.color('gray')
t3.hideturtle()

t.penup()
t1.penup()
t2.penup()

t.shape('square')
t1.shape('circle')
t2.shape('circle')

t.turtlesize(4,12)
t1.turtlesize(2)
t2.turtlesize(2)

t3.up()
t3.goto(-460,-95)
t3.down()
t3.color('green')
t3.begin_fill()
for j in range (2):
       t3.fd(900)
       t3.left(90)
       t3.fd(15)
       t3.left(90)
t3.end_fill()

for i in range (150):
     t.goto(-400+5*i,0)
     t1.goto(-460+5*i,-60)
     t2.goto(-340+5*i,-60)
```

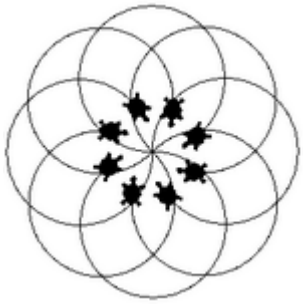
Multiple Turtles code with LIST

#Example 12-7(a)

```
import turtle
q=[turtle.Turtle('square'),\
   turtle.Turtle('circle'),\
   turtle.Turtle('turtle'),\
   turtle.Turtle('arrow')]

clr=['red','gold','blue','violet']
for i in range(4):
    q[i].shapesize(2)
    q[i].up()
    q[i].color(clr[i])
    q[i].goto(100*i,0)
```

#Example 12-7(b)

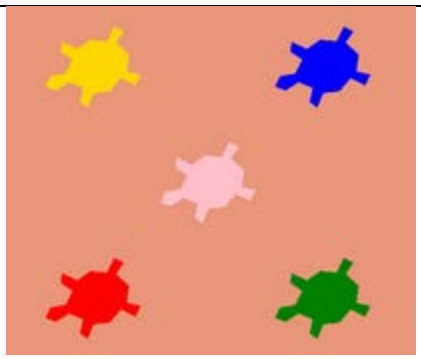
```
import turtle
turtle.delay(0)
t = [turtle.Turtle('turtle')\
     for q in range(8)]
for i, j in enumerate(t):
    j.right(i*45)
    j.speed(0)

for i in range(720):
    for j in t:
        j.forward(1)
        j.right(1)
```



#Example 12-7(c)

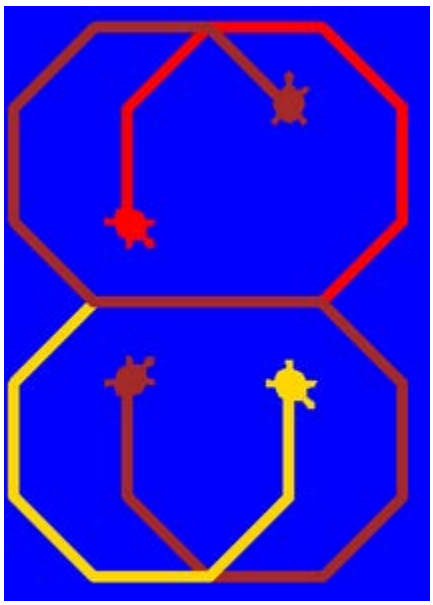
```
import turtle
turtle.bgcolor('darksalmon')
wn=turtle.Screen()
turtle.tracer(4)
q=[]
clr=['pink','blue','gold',\
     'red','green']
pos=[(0,-100),(150,50),\
     (-150,50),(-150,-250),\
     (150,-250)]

for n in range (5):
```

```
    q.append(turtle.Turtle())
    q[n].shape('turtle')
    q[n].shapesize(5)
    q[n].color(clr[n])
    q[n].up()
    q[n].goto(pos[n])

while True:
    for i in range(5):
        q[i].fd(2)
        q[i].left(1)
```



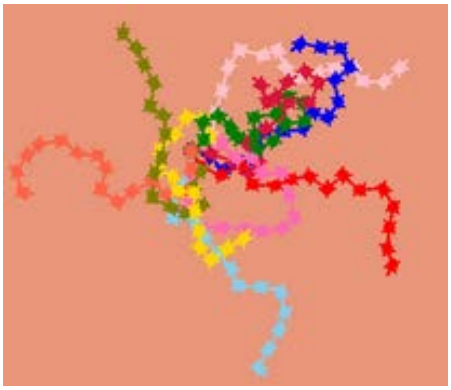
#Example 12-7(d)

```
import turtle
t1=turtle.Turtle()
turtle.bgcolor('blue')
t1.hideturtle()
t2=turtle.Turtle()
t2.hideturtle()
t3=turtle.Turtle()
t3.hideturtle()
t4=turtle.Turtle()
t4.hideturtle()

def run(turtle,delta,\
        angle,clr,shape):
        turtle.showturtle()
        turtle.shape(shape)
        turtle.shapesize(2)
        turtle.color(clr)
        turtle.pensize(10)
        turtle.fd(delta)
        turtle.left(angle)

while True:
    run(t1,100,45,'red','turtle')
    run(t2,100,-45,'brown','turtle')
    run(t3,-100,45,'gold','turtle')
    run(t4,-100,-45,'brown','turtle')
```



#Example 12-8

```
import turtle,random
turtle.bgcolor('darksalmon')
q=[]
clr=['pink','blue','gold',\
          'red','green','skyblue',\
           'hotpink','crimson',\
           'olive','tomato']
for n in range (len(clr)):
     t=turtle.Turtle('turtle')
      q.append(t)
      q[n].color(clr[n])
      q[n].down()
      angle=random.randint(-90,90)
      q[n].setheading(angle)

      for j in range (15):
          for i in range(10):
              d=random.randint(20,30)
              angle=random.randint\
                    (-90,90)
              q[i].stamp()
              q[i].pensize(3)
              q[i].fd(d)
              q[i].left(angle)
```



Lesson 13: How to download an Image into a Python Turtle Project

Python Turtle Graphics allows to use images that can be downloaded from any resource as your computer or internet web pages. Two conditions are required: the image file must have gif extension and be located in the same directory as the main file with py extension. Example shown below demonstrates how to insert aquarium (background image) and fish image into the main file.

Fish in aquarium

```
#Example 13-1
import turtle
wn=turtle.Screen()
wn.setup(700,500)
wn.bgpic('aquarium.gif')
image='fish1.gif'
wn.addshape(image)

fish=turtle.Turtle()fish.shape(image)
fish.up()
fish.goto(100,0)
fish.showturtle()
```

Again, keep in mind that Python Turtle accepts files written with extension.gif only. If you have chosen an image that has a .png. jpg, or jpeg, extension, you have to convert it to a file with the extension .gif. All image files(extension gif) should be imported into the same directory where the main file is located. (py extension) is located.

Key lines in the code:

- Line #4 specifies background image (The name of gif file is aquarium.gif).
- Line #5 specifies a variable with fish image (file name is fish.gif)

- Line #6 adds fish file to the screen.
- Line #8 allows using fish image as a turtle object. After we determined turtle object as a fish (instead of our original options, like turtle, circle, square, triangle…) we can apply our main turtle commands to the fish image.

Example 13-2 shows a motion of the fish in a horizontal direction from left to right side, for example 13-3 fish moves in the horizontal direction from left to right side then turns left and moves from the bottom of the aquarium to the top.

#Example 13-2

```
import turtle
wn=turtle.Screen()
wn.setup(700,500)
wn.bgpic('aquarium.gif')
image='fish1.gif'
wn.addshape(image)

fish=turtle.Turtle()
fish.shape(image1)
fish.up()
fish.hideturtle()
fish.goto(-300,0)
fish.showturtle()
for i in range(800):
    fish.fd(1)
```

#Example 13-3

```
import turtle
wn=turtle.Screen()
wn.setup(700,500)
wn.bgpic('aquarium.gif')
image='fish1.gif'
wn.addshape(image)

fish=turtle.Turtle()
fish.shape(image)
fish.up()
fish.hideturtle()
fish.goto(-300,0)
fish.showturtle()
for i in range(500):
    fish.fd(1)
fish.lt(90)
for i in range(400):
    fish.fd(1)
```

As you see from the image shown for example 13-3, fish moves from the aquarium bottom to the top, however, fish does not turn itself. If we want fish to turn on 90

degrees we have to add a second image and in code listing switch from first to the second image depends on the motion direction. New code with two inserted fish images is shown in Example 13-4.

#Example 13-4

```
import turtle
wn=turtle.Screen()
wn.setup(700,500)
wn.bgpic('aquarium.gif')
image1='fish1.gif'
wn.addshape(image1)

image2='fish2.gif'
wn.addshape(image2)
fish=turtle.Turtle()
fish.shape(image1)
fish.up()
fish.hideturtle()
fish.goto(-300,-200)
fish.showturtle()
for i in range(500):
   fish.fd(1)

   fish.shape(image2)
    fish.lt(90)
for i in range(400):
    fish.fd(1)
```

Horizontal motion

Vertical motion

As you can see we added to the screen image #2 with second position of the fish (Line #8), use fish1.gif for horizontal movement (Lines 15-16) and file fish2.gif for vertical movement (Lines 19-20). Two pictures: first one corresponds horizontal movement, and second one – to vertical movement) are shown below

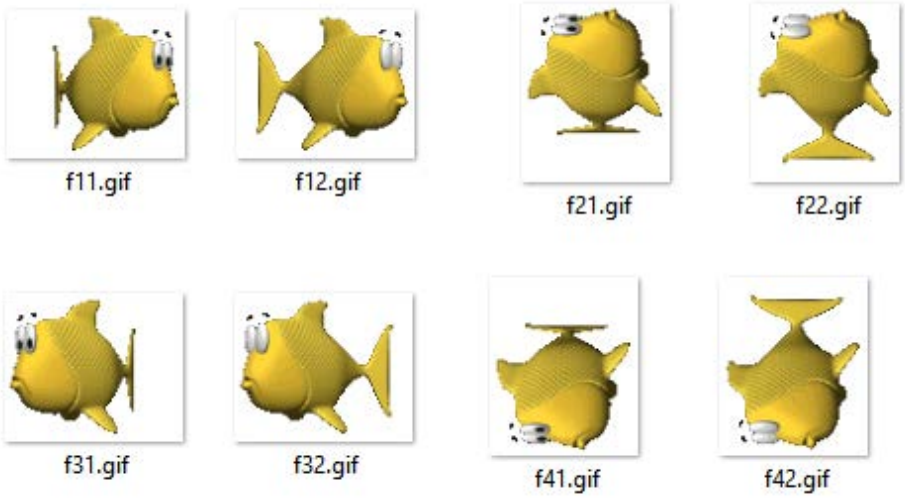
Motion around the aquarium.

```
#Example 13-5
import turtle
wn=turtle.Screen()
wn.setup(700,500)
wn.bgpic('aquarium.gif')
image1='fish1.gif'
image2='fish2.gif'
image3='fish3.gif'
image4='fish4.gif'
wn.addshape(image1)
wn.addshape(image2)
wn.addshape(image3)
wn.addshape(image4)

fish=turtle.Turtle()
fish.shape(image1)
fish.up()
fish.hideturtle()
fish.goto(-300,-200)
fish.showturtle()
for i in range(500):
    fish.fd(1)

fish.shape(image2)
fish.lt(90)
for i in range(400):
    fish.fd(1)

fish.shape(image3)
fish.lt(90)
for i in range(500):
    fish.fd(1)

fish.shape(image4)
fish.lt(90)
for i in range(400):
    fish.fd(1)
```

Code shown in Example 13-5 uses four fish images with different orientation

and switches one image to the other depending on the motion direction. It is very important that images have to be trimmed off transparent pixels around the it when one image passes over or near another as it moves across the screen, we don't want the background of one image to wipe out one part of another. For example, in these images, the checkerboard pattern in the background represents the transparent area:

Code shown below demonstrates how to animate fish moving across the aquarium. Each of the four fish files is represented by two different files as shown below: 2 files for horizontal movements from left to right, 2 files for horizontal movements from right to left, 2 files for vertical movement from bottom to top and 2 files for vertical movements from top to bottom.



Fish swim throughout the aquarium

```
#Example 13-6

import turtle
import time           # new module time
turtle.tracer(2)
t=turtle.Turtle()
wn=turtle.Screen()
wn.setup(1200,900)
wn.bgpic("Aquarium.gif")

image11="f11.gif"
image21="f21.gif"
image31="f31.gif"
image41="f41.gif"
wn.addshape(image11)
wn.addshape(image21)
wn.addshape(image31)
wn.addshape(image41)

image12 ="f12.gif"
image22="f22.gif"
image32="f32.gif"
image42="f42.gif"
wn.addshape(image12)
wn.addshape(image22)
wn.addshape(image32)
wn.addshape(image42)
t.showturtle()
t.up()
t.goto(-400,-200)
for r in range(4):
    for i in range(100):
        t.shape(image11)
        t.fd(4)
        time.sleep(0.1)  # Suspend execution of the code for the given number of
#seconds (in our case 0.1 seconds).
        t.shape(image12)
        t.fd(4)
        time.sleep(0.1)

    t.left(90)
    for i in range(50):
        t.shape(image21)
        t.fd(4)
        time.sleep(0.1)
        t.shape(image22)

# Continue next page
```

```
        t.fd(4)
        time.sleep(0.1)

    t.left(90)
    for i in range(100):
        t.shape(image31)
        t.fd(4)
        #time.sleep(0.1)
        t.shape(image32)
        t.fd(4)
        #time.sleep(0.1)

    t.left(90)
    for i in range(50):
        t.shape(image41)
        t.fd(4)
        time.sleep(0.1)
        t.shape(image42)
        t.fd(4)
        time.sleep(0.1)
    t.left(90)
```

Static result:

Current code contains Python module called time. This module handles time-related tasks. To use functions defined in the module, we need to import the

module first (second line of the listing). Code **time.sleep(0.1)** means suspending of code execution for the given number of seconds (in our case 0.1 sec).
Link to access images for this code and code listing:

https://github.com/victenna/Aquarium-with-Fish

The link below shows the final result (click on the link to watch video)

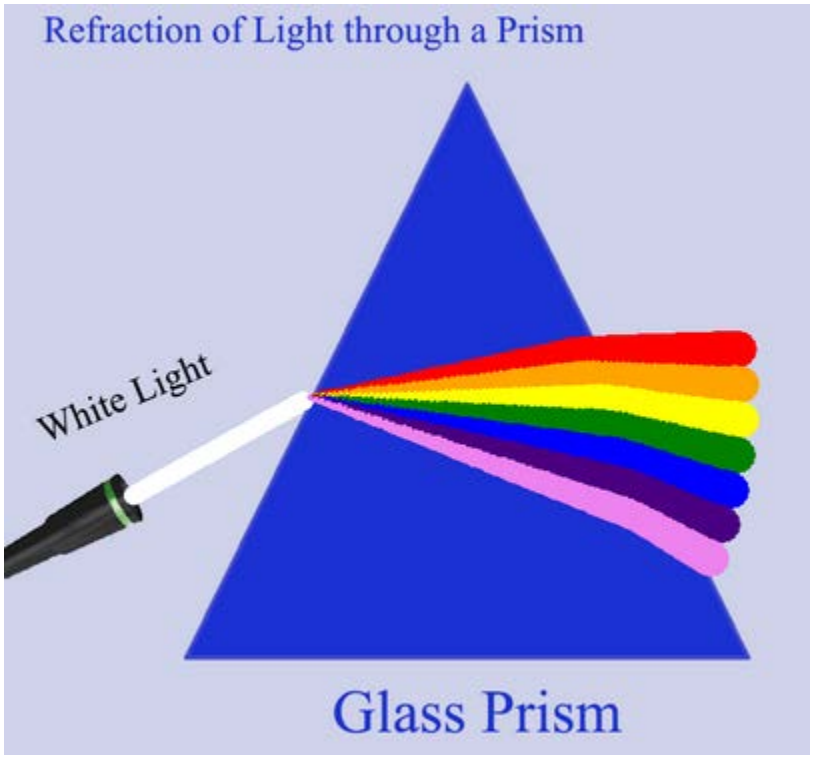
https://www.youtube.com/watch?v=4wKyoa5SHqc&feature=youtu.be

Code shown below in Example 13-7 simulates rainbow prism. It is known that light is made up of a collection of many colors: red, orange, yellow, green, blue, indigo, violet. Prism can take in white light on one side and produce its own mini-rainbow on the other side.

```
#Example 13-7

import turtle
import time
wn=turtle.Screen()
wn.setup(800,800)
wn.bgpic('raincolors.gif') #background image
t=turtle.Turtle()

clr=['red','orange','yellow','green',\
     'blue','indigo','violet']
t.color('white')
rainbow=[]
q=0
t.penup()
t.hideturtle()
t.goto(-275,-85)
t.setheading(29)
t.pensize(15)
t.pendown()
turtle.tracer(20)

for n in range (155):
    t.fd(1)
    X=t.xcor()              # return the turtle's X coordinate.
    Y=t.ycor()              # return the turtle's Y coordinate.
    if X>-140:
        t.penup()
        X1=t.xcor()
        Y1=t.ycor()
```

```
for n in range (7):
        rainbow.append(turtle.Turtle())
        rainbow[n].hideturtle()
        rainbow[n].penup()
        rainbow[n].setposition(X1+5,Y1+3)
        rainbow[n].setheading(10-5*n)
        rainbow[n].pendown()
        rainbow[n].color(clr[n])
for m in range(70):
    for n in range (7):
        rainbow[n].pensize(5+0.35*m)
        if m>43+2*n:
            rainbow[n].setheading(-5*n)
        rainbow[n].fd(5)
```

Result of Example 13-7:



Link to access image for this code and code listing:

https://github.com/victenna/Rainbow-Prism

Lesson 14: More Examples with inserted Images

Let's continue to look at examples showing animations using the Python turtle graphics.

Example 14-1 shows Sun planet system

As you know our Sun planet system contains the Sun and the following planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Let's generate simulation of the orbiting these 8 planets around the Sun using Python code. Code listing contains 9 almost identical blocks: blocks for each of 8 planets and one for sun. Each planet is a turtle object, only instead turtle shapes we use an image downloaded from the Internet. With turtle object we can use all turtle module codes, that determine motion commands and any other commands specify for this module.

Solar Planet System

```
#Example 14-1
import turtle
wn=turtle.Screen()
wn.setup(1200,1000)
wn.bgcolor('black')
wn.bgpic('sky.gif')
wn.tracer(30)
#-------------------------------------
sun=turtle.Turtle('circle')         #Sun
sun.penup()
sun.color('yellow')
sun.penup()
Sun_image='Sun.gif'
wn.addshape(Sun_image)
sun.shape(Sun_image)
sun.setposition(0,0)
#-----------------------------------------
mercury=turtle.Turtle()             #Mercury
mercury.up()
Mercury_image='mercury.gif'
wn.addshape(Mercury_image)
mercury.shape(Mercury_image)
```

```
mercury.setposition(0,-110)
#-----------------------------------------
venus=turtle.Turtle()                #Venus
venus.up()
Venus_image='venus.gif'
wn.addshape(Venus_image)
venus.shape(Venus_image)
venus.setposition(0,-135)
#venus.up()
#-----------------------------------------
earth=turtle.Turtle()                #Earth
earth.up()
Earth_image='earth.gif'
wn.addshape(Earth_image)
earth.shape(Earth_image)
earth.setposition(0,-190)
#-----------------------------------------
moon=turtle.Pen()                   #Moon
moon.up()
moon.setposition(0,60)
moon.shape('circle')
moon.shapesize(0.5)
moon.color('yellow')
moon.speed(0)
#-------------------------------------------------
mars=turtle.Turtle()               #Mars
mars.up()
Mars_image='Mars.gif'
wn.addshape(Mars_image)
mars.shape(Mars_image)
mars.setposition(0,-280)
#-------------------------------------------------
jupiter=turtle.Turtle()               #Jupiter
jupiter.up()
Jupiter_image='Jupiter.gif'
wn.addshape(Jupiter_image)
jupiter.shape(Jupiter_image)
jupiter.setposition(0,-350)
#-------------------------------------------------
saturn=turtle.Turtle()                #Saturn
saturn.up()
Suturn_image='Saturn.gif'
wn.addshape(Suturn_image)
saturn.shape(Suturn_image)
```

```
saturn.setposition(0,-450)
#-----------------------------------------------
uranus=turtle.Turtle()                #Urans
uranus.up()
Uranus_image='Uranus.gif'
wn.addshape(Uranus_image)
uranus.shape(Uranus_image)
uranus.setposition(0,-540)
#-------------------------------------------------
neptune=turtle.Turtle()               #Neptune
neptune.up()
Neptune_image='Neptune.gif'
wn.addshape(Neptune_image)
neptune.shape(Neptune_image)
neptune.setposition(0,-590)
#-----------------------------------------------
while True:
    mercury.circle(110,0.478)       #Planetary motion
    venus.circle(135,0.35)
    earth.circle(190,0.3)
    mars.circle(280,0.24)
    jupiter.circle(350,0.15)
    saturn.circle(450,0.1)
    uranus.circle(540,0.08)
    neptune.circle(590,0.05)
#-----------------------------------------------
    moon.hideturtle()              #Moon motion around Earth
    moon.goto(earth.xcor(),earth.ycor())
    moon.fd(45)
    moon.showturtle()
    moon.left(1)
```

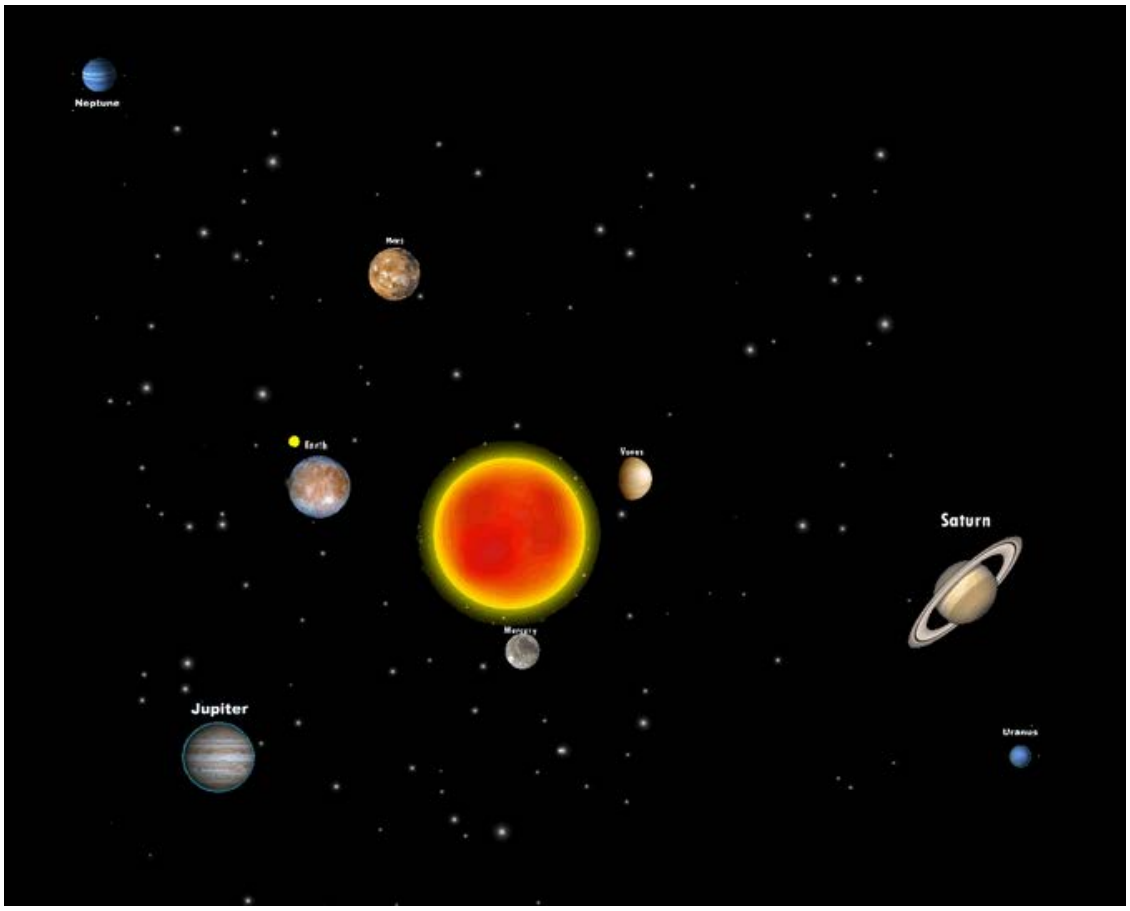
Link to access image for this code and code listing:

https://github.com/victenna/Solar-Planet-System

You can watch video result of this code:

https://youtu.be/gffjt8oOKyU

Static result of this code is shown below:



Code in Example 14-1 can be significantly simplified if we combine all images inthe list. New simplified code listing is shown in Example 14-2.

```
#Example 14-2
#Solar Planet Motion
import turtle
wn=turtle.Screen()
wn.setup(1300,1300)
wn.bgpic('sky.gif')
wn.bgcolor('black')
wn.tracer(20)

Img=['Sun.gif','mercury.gif','venus.gif','earth.gif','Mars.gif',\

'Jupiter.gif','Saturn.gif','Uranus.gif','Neptune.gif','Moon.gif']
```

```
planet=[]
turtle.hideturtle()

for n in range(10):
    planet.append(turtle.Turtle())
    planet[n].up()
    wn.addshape(Img[n])
    planet[n].shape(Img[n])
    if n==0:
        planet[0].setposition(0,0)
    elif n==9:
        planet[n].goto(0,-310)
    else:
        planet[n].goto(0,-120-70*(n-1))

while True:
    for m in range (1,10):

        planet[m].circle(120+70*(m-1),0.8-0.1*(m-1))
        planet[9].hideturtle()
        planet[9].goto(planet[3].xcor(),planet[3].ycor())
        planet[9].fd(45)
        planet[9].showturtle()
        planet[9].left(0.1)
```

Example 14-3 demonstrates Dolphins jumping out of the water. There is an ongoing debate about why dolphins jump out of the water. Scientists think about different reasons for this behaviour. Among them, some believe that dolphins jump while traveling to save energy as going through the air consume less energy than going through the water. Some others believe that jumping is to get a better view of distant things in the water, mainly prey. So, in this way, dolphins jump to locate food or food related activity like seagulls eating or pelicans hunting. Other explanations suggest that dolphins use jumping to communicate either with a mate or with another pod as they can hear and interpret the splashes. Some people even think that dolphins jump for cleaning, trying to get rid of parasites while jumping. Below we will create Python code that demonstrates animation of three dolphins that jump out of the water.

Dolphins in the sea

#Example 14-3

```
import turtle
import time
wn = turtle.Screen()
wn.setup(800,800)
wn.tracer(2)
wn.bgpic('more.gif')

image=['do1.gif','do2.gif']  (#1)
wn.addshape(image[0])
wn.addshape(image[1])
t1=turtle.Turtle()
t1.up()
while True:
    t1.shape(image[0])
    t1.goto(-300,-300)

#----jump out of water
    t1.setheading(45)
    for i in range(30):
        t1.shape(image[0])
        t1.fd(20)
        time.sleep(0.05)

#-------for fall into water
    t1.setheading(-45)
    for i in range(30):
        t1.shape(image[1])
        t1.fd(20)
        time.sleep(0.05)
    time.sleep(0.5)
```

Code Result

Let's take a look for the code. Line, noted as (31) includes two images: first image for three dolphins that jump out of the water and second- for dolphins that drop into the water. Motion of the dolphins also includes two blocks of codes: lines for dolphins jumping out of the water and lines for dolphins that drop into the water. All images are presented in the Lesson #14. Images for code (Example 14-3) can be downloaded at:

https://github.com/victenna/Dolphins/tree/master/No%20waves

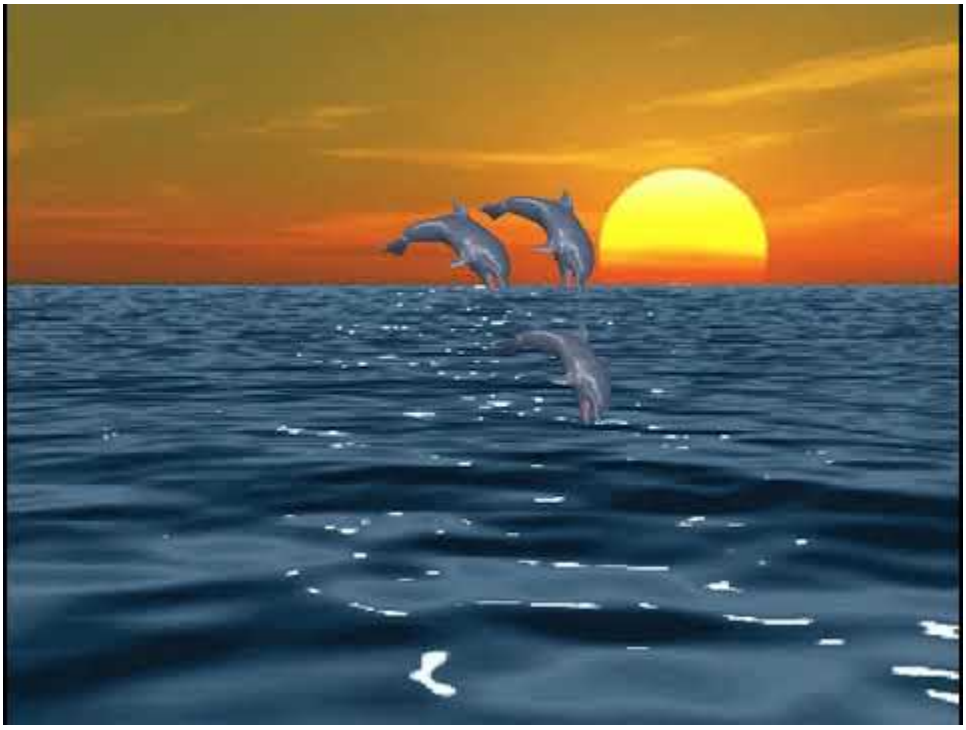
Sophisticated code with water waves animation is shown in Example 14-4.

Example 14-4

```
import turtle
import time
wn = turtle.Screen()
wn.setup(1000,800)
turtle.tracer(3)
#-----------------15 image frames for water waves
image0=[]
for i in range (15):
    i1=str(i)
    image0.append(i1+'.gif')

image=['do1.gif','do2.gif']

t1=turtle.Turtle()
t1.up()
k=-1
def motion (direction,img):
    global k
    t1.setheading(direction)
    for i in range(10):
        k=k+1
        k1=k%15
        wn.bgpic(image0[k1])
        wn.addshape(img)
        t1.shape(img)
        t1.showturtle()
        t1.fd(40)
        time.sleep(0.05)

while True:
    k=k+1
    k1=k%15
    wn.bgpic(image0[k1])
    t1.hideturtle()
    t1.goto(-300,-200)
    motion(45,image[0])
    motion(-45,image[1])
```

Real result of the code with water motion is shown below:

https://youtu.be/qhXDb4E2XdY



Images for code (Example 14-4) can be downloaded at:

https://github.com/victenna/Dolphins/tree/master/Three%20dolphins

Our next example shows how to create a program that creates the running boys with Python turtle graphics. To do it we have to use run animation frame images that can be downloaded from the Internet.

Code shown below (Example 14-5) demonstrates how to create motion animation (walking boy). To generate such an animation, we need to select several separate static images (frames or sprites) of a running boy so that with a quick changing of frames the effect of the animation will turn out. Thus, if one sprite is a still picture, then a rapidly replacing series of these pictures makes up an animation. All image sprites are loaded into the program as separate files with the gif extension. The figure below shows 10 separate images (frames) of a boy who, with the help of the Python code, turn them into an animation (Boy) runs).


1.gif


2.gif


3.gif


4.gif


5.gif


6.gif


7.gif


8.gif


9.gif


10.gif

Walking Boy

```
#Example 14-5
import turtle,time
wn=turtle.Screen()
wn.setup(850,800)
wn.bgpic('cross1.gif')
turtle.tracer(2)
image0=['01.gif','02.gif','03.gif',\
        '04.gif','05.gif','06.gif',\
        '07.gif','08.gif','09.gif',\
        '010.gif']
t=turtle.Turtle()
t.up()
t.hideturtle()
t.goto(-40,-275)
t.showturtle()
t.speed(10)
t.penup()
dx,dy=2,4
k=0
while True:
    k=k+1
    k1=k%10
    wn.addshape(image0[k1])
    t.shape(image0[k1])
    t.fd(10)
    X,Y=t.position()
    time.sleep(0.2)
```

```
    if X>500:
        t.hideturtle()
        t.goto(-40,-275)
        t.showturtle()
```

Images for the example #14-5 are at:

https://github.com/victenna/Animation-with-Images/tree/master/Pumkin%20boy

Code shown below (Example 14-6) demonstrates how to animate three running boys. To create animation for running boy we have to use run animation frame images that can be downloaded from the Internet.

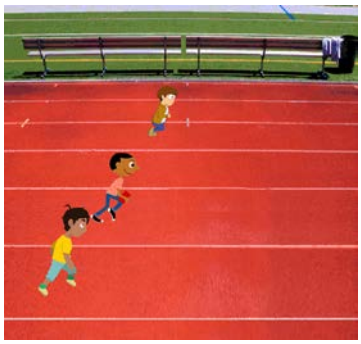
Three Running Boys

```
#Example 14-6
import turtle,time
t1=turtle.Turtle()
t2=turtle.Turtle()
t3=turtle.Turtle()
wn = turtle.Screen()
wn.bgcolor('green')
wn.setup(800,800)
wn.bgpic('field.gif')
turtle.tracer(2)
image1=['boy11.gif','boy12.gif','boy13.gif','boy14.gif']  #1
image2=['boy21.gif','boy22.gif','boy23.gif','boy24.gif']  #2
image3=['boy31.gif','boy32.gif','boy33.gif','boy34.gif']  #3
for i in range (4):
  wn.addshape(image1[i])
  wn.addshape(image2[i])
  wn.addshape(image3[i])
t1.up()
t1.goto(-600,-150)
t2.up()
t2.goto(-450,110)
t3.up()
t3.goto(-300,200)
delta=7
i=0
import winsound                                          #4
winsound.PlaySound('music3.wav', winsound.SND_ASYNC)     #5
while True:
  X1=t1.xcor()
  if X1>400:                                             #6
    t1.goto(-600,-150)                                   #7
    t2.goto(-450,110)                                    #8
    t3.goto(-300,200)                                    #9
```

```
    i1=i%4
    t1.shape(image1[i1])
    t1.fd(delta)
    t2.shape(image2[i1])
    t2.fd(delta)
    t3.shape(image3[i1])
    t3.fd(delta)
    i=i+1
    time.sleep(0.035)
```

Take a look at this code. To generate the motion animation effect we have to choose a few images(sprites), each of themIt has three lists of images (Lines noted as #1-#3). To generate the animation effect we have chosen four different boy images-positions that create running boys. Each line (#15-#17) describes 4 positions of each boy, so we can simulate boy running. Lines named as #4 and #5 provide sound effect when running. Line #4 imports sound module and line #5 calls sound file music3.wav. Turtle module allows sound recording for files with an extension **wav**. If boy is out of the screen, conditions (lines #6 to #9) return him to the left corner of the screen and motion continues again.

Static Result of Code:



Video below shows the final result (click on the image or link to watch video)

https://youtu.be/4L2BMKNKJH8

The code and images for program Three running boys are located at:

https://github.com/victenna/Runners

Astronaut in free Space

```
#Example 14-7(a)
import turtle
import random
turtle.tracer(4)
wn=turtle.Screen()
wn.setup(900,900)
import time
#Moonsky
image1='moonsky.gif'      #1
wn.bgpic(image1)
#Spaseshuttle
Shuttle=turtle.Turtle()
image2='shuttle1.gif'     #2
wn.addshape(image2)
Shuttle.shape(image2)
Shuttle.penup()
Shuttle.goto(-600,-600)
Shuttle.setheading(40)
#Astronaut
image3='astr1.gif'        #3
wn.addshape(image3)
Astro=turtle.Turtle()
Astro.shape(image3)
```

```
Astro.up()
while True:
    Shuttle.fd(5)
    time.sleep(0.03)
    X,Y=Shuttle.position()
    #X=Shuttle.xcor()
    #Y=Shuttle.ycor()
    Astro.setposition(X+90,Y+90)
    Astro.fd(60)
    Astro.right(5)
    if abs(X-600)<10 or abs(Y-600) <10:
        Shuttle.goto(-600,-600)
        Astro.goto(-600,-400)
Shuttle.setheading(random.randint(40,80))
```

The animation **Astronaut in free space** represents the motion of a spaceship and an astronaut floating with zero gravity. Astronaut weighs nothing, why? The teacher, creating the code with the children, explains physics of the phenomenon (what is weightlessness and why does it appear during the flight of an astronaut in a spaceship). This method of such teaching significantly improves of subject learning quality, in our case, physics of motion. The code for this animation with the images needed for the animation can be downloaded at:
As we can see code includes three inserted images (lines named #1, #2 and #3. Code and images address:
https://github.com/victenna/Astronaut-in-free-space

You can watch code result at:

https://www.youtube.com/watch?v=vbO7jR3zMho&feature=youtu.be

#Example 14-7(b)

```
import turtle,random,time
t=turtle.Turtle()
wn=turtle.Screen()
wn.setup(800,800)
wn.bgcolor('dark blue')
turtle.tracer(4)
t.speed(10)
def star(x,y,size):
    t.up()
```

```
    t.goto(x,y)
    t.color('white')
    t.begin_fill()
    t.left(36)
    for i in range(5):
        t.fd(size)
        t.left(144)
    t.end_fill()
for i in range(50):
    sx=random.randint(-
300,300)
    sy=random.randint(-
300,300)
ssize=random.randint(10,20)
    star(sx,sy,ssize)
earth=turtle.Turtle()
earth.penup()
image1='Earth.gif'
wn.addshape(image1)
earth.shape(image1)
earth.setposition(0,0)
t1=turtle.Turtle()
t1.penup()
image1='astronaut.gif'
wn.addshape(image1)
t1.shape(image1)
t1.left(90)
t1.setposition(300,0)
shuttle=turtle.Turtle()
shuttle.up()
image2='shuttle_.gif'
wn.addshape(image2)
shuttle.shape(image2)
shuttle.goto(0,-250)
shuttle.showturtle()
while True:
  shuttle.circle(300,1)
  X,Y=shuttle.position()
  t1.goto(X+40,Y-60)
  time.sleep(0.02)
```

Aquarium with water waves

```
#Example 14-8

import turtle,time,random
wn=turtle.Screen()
wn.setup(850,600)
AQ=[]                      #1
for i in range(74):        #2
    i1=str(i)              #3
    AQ.append(i1+'.gif')#4
image11 = ("fi11.gif")  #5
image12 = ("fi12.gif")  #6
image31 = ("fi31.gif")  #7
image32 = ("fi32.gif")  #8
wn.addshape(image11)
wn.addshape(image12)
wn.addshape(image31)
wn.addshape(image32)
t=turtle.Turtle()
t.showturtle()
t.speed(10)
t.penup()
X,Y=90,-90
dx,dy=2,4
k,r=0,0
while True:
    r=r+1
    k=k+1
    k1=k%74
    r1=r%100
    wn.bgpic(AQ[k1])
    t.setposition(X+dx,Y+dy)
    X,Y=t.position()
    if dx>0 and r1<50:
        t.shape(image11)
    if dx>0 and r1>50:
       t.shape(image12)
     if dx<0 and r1<50:
        t.shape(image31)
    if dx<0 and r1>50:
        t.shape(image32)
    if X>250 or X<-260:
        dx=-dx
    if Y<-205 or Y>210:
        dy=-dy
```

The program shown in example 14-8 is constructed as follows:

In order to create water motion in the aquarium (water animation), several static fixed sprites of water images are introduced into the program, each frame differs from the previous one so that quick changing of frames creates animation effect. In our case, each frame contains an image of water with fish, and only one red with blinking eyes moves around the aquarium due to the control Python codes. All image sprites are downloaded into the program as separate files with GIF extension. For water we downloaded 74 files, for red fish 4 images. The names of the sprites for water are as follows: 0.gif, 1.gif, 2.gif…. 73.gif. Files for these sprites are downloaded into the program using code lines # 1- # 4. Lines # 5 - # 8 specify the image of a fish that moves and blinks its eyes due to the Python code. Images for the project Aquarium with wqter waves can be download at:

https://github.com/victenna/Aquarium-with-water-waves

You can watch real code result at:

https://youtu.be/XeTwY9bwFLk

Below it is shown an animation that demonstrates the motion of a helicopter and skydivers. The design of this animation can be combined with an explanation of the motion laws and forces that affect different objects during motion. Code and images can be downloaded at:
https://github.com/victenna/Helicopter

Helicopter

```
#Example 14-9

import turtle,time
wn=turtle.Screen()
wn.bgpic('road.gif')
t=turtle.Turtle()
t.up()
turtle.tracer(2)
turtle.bgcolor('brown')
image1=['helicopter11.gif','helicopter12.gif']
image2=['helicopter21.gif','helicopter22.gif']
for i in range(2):
    wn.addshape(image1[i])
    wn.addshape(image2[i])

image3=['boy.gif','girl.gif','boy1.gif']
for i in range(3):
```

```
    wn.addshape(image3[i])

t1=turtle.Turtle()
t1.shape(image3[0])
t1.up()
t1.hideturtle()
t1.goto(120,400)
t1.setheading(-90)

t2=turtle.Turtle()
t2.shape(image3[1])
t2.up()
t2.hideturtle()
t2.goto(-175,400)
t2.setheading(-90)

t3=turtle.Turtle()
t3.shape(image3[2])
t3.up()
t3.hideturtle()
t3.goto(-295,400)
t3.setheading(-90)
X=0
t.setheading(90)
def up_down(direction):
    for i in range (100):
        i1=i%2
        t.shape(image2[i1])
        t.fd(direction)
        time.sleep(0.015)
up_down(4.5)
t.setheading(0)
q1=1
q2=0
q3=1
for i in range(450):
    if i>=25 and t1.ycor()>-10:
        t1.showturtle()
        t1.fd(q3*2)
        if t1.ycor()<-10:
            t1.fd(0)
    if i>=230 and t2.ycor()>-10:
        t2.showturtle()
        t2.fd(q3*2)
        if t2.ycor()<-10:
            t2.fd(0)
    if i>=330 and t3.ycor()>-10:
        t3.showturtle()
        t3.fd(q3*5)
        if t3.ycor()<-10:
            t3.fd(0)
```

```
    i1=i%2
    X=t.xcor()
    t.shape(q1*image1[i1]+abs(q2)*image2[i1])
    t.fd(q1*5+q2*5)
    time.sleep(0.02)
    if X>=480:
        q1=0
        q2=-1
    if X<=-480:
        q1=1
        q2=0
t.setheading(-90)
up_down(4.5)
```

Static result of this code

Video result is available:

https://youtu.be/5P1O4dh_1cU

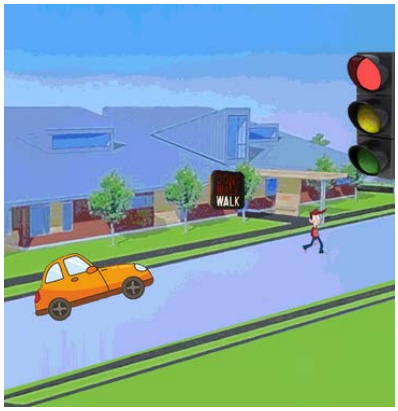
Pedestrian Crossing (One pedestrian)

```
#Example 14-10(a)
import turtle,time
wn=turtle.Screen()
wn.setup(800,800)
turtle.bgcolor('light blue')
wn.bgpic('street.gif')
turtle.tracer(2)
#car ====================================
```

```
car=turtle.Turtle()
cars=['car2.gif','car3.gif','car4.gif']
for i in range(3):
    wn.addshape(cars[i])
car.up()
car.setposition(-400,-210)
car.setheading(12)

#light=======================================
light=turtle.Turtle()
lights=['red_light.gif','yellow_light.gif','green_light.gif']
for i in range(3):
    wn.addshape(lights[i])
light.up()
light.setposition(350,150)
light.shape(lights[2])
#sign=================================
sign=turtle.Turtle()
signs=['w_no.gif','w_yes.gif']
for i in range(2):
    wn.addshape(signs[i])
sign.up()
sign.setposition(90,20)
sign.shape(signs[1])

#man=============================================
man=turtle.Turtle()
mans=['man1.gif','man2.gif','man3.gif','man4.gif','man5.gif','man6
.gif']
for i in range(6):
    wn.addshape(mans[i])
man.shape(mans[3])
man.up()
man.goto(180,-20)

deltaX=5 #determines direction 0f walking (X coordinate)
deltaY=-2.5 #determines  direction of walking (Y coordinate)
q=-1
move=1
r=0
while True:
    q=q+1
    q0=q%3
    time.sleep(0.03)
    if car.xcor()<-151:
        car.shape(cars[q0])
        move=1
        car.fd(10*move)
        light.shape(lights[2])
        sign.shape(signs[0])
```

```
    if car.xcor()>-152:

        if r<30:
            car.shape(cars[0])
            r=r+1
            light.shape(lights[1])
            sign.shape(signs[0])
        if r>=29 and r<81:
            r=r+1
            q1=q%6
            light.shape(lights[0])
            sign.shape(signs[1])
            r1=r-29
            man.shape(mans[q1])
            man.goto(180+r1*deltaX,-20+r1*deltaY)
            time.sleep(0.1)

        if r>=81:
            car.shape(cars[q0])
            move=1
            car.fd(10*move)
            light.shape(lights[2])
            sign.shape(signs[0])

    if car.xcor()>500:
        q=-1
        man.shape(mans[3])
        man.hideturtle()
        man.goto(180,-20)
        man.showturtle()
        r=0
        car.hideturtle()
        car.setposition((-400,-210))
        car.showturtle()
```

Static code result is:



You can download images fo Example 14-10(a) at:

https://github.com/victenna/Pedestrian-Crossing

Pedestrian Crossing (Three pedestrians)

```
#Example 14-10(b)
import turtle,time
car=turtle.Turtle()
turtle.tracer(2)
car.up()
car.hideturtle()
wn=turtle.Screen()
wn.setup(800,800)
turtle.bgcolor('light blue')
wn.bgpic('street.gif')
#car image=====================================
cars=['car2.gif','car3.gif','car4.gif']

car=turtle.Turtle() #car turtle

for i in range(3):
    wn.addshape(cars[i])
car.up()
car.setposition(-400,-210)
car.setheading(12)
#boy image=============================================
image1=['man1.gif','man2.gif','man3.gif','man4.gif','man5.gif','ma
n6.gif']
image2=['boy21.gif','boy22.gif','boy23.gif','boy24.gif','boy25.gif
','boy26.gif']
image3=['boy41.gif','boy42.gif','boy43.gif','boy44.gif','boy45.gif
','boy46.gif']
t11=turtle.Turtle() #boy turtle
t12=turtle.Turtle() #boy turtle
t13=turtle.Turtle() #boy turtle
X1=180
Y1=-20
def boy_(turtle,X,Y,img):
    wn.addshape(img)
    turtle.shape(img)
    turtle.up()
    turtle.goto(X,Y)
    turtle.showturtle()
boy_(t11,180,-20,image1[0])
boy_(t12,230,-10,image2[0])
boy_(t13,130,-40,image3[0])
#sign image for pedestrians==============================
sign=['w_no.gif','w_yes.gif']
```

```
t2=turtle.Turtle() #sign turtle
t2.hideturtle()
t2.up()
t2.setposition(90,20)
t2.showturtle()
def sign_(img1):
    wn.addshape(img1)
    t2.shape(img1)
sign_(sign[1])
#traffic light image=============================================
light=['red_light.gif','yellow_light.gif','green_light.gif']
t3=turtle.Turtle() #traffic light
t3.hideturtle()
t3.up()
t3.setposition(350,150)
t3.showturtle()
def light_(img2):
    wn.addshape(img2)
    t3.shape(img2)
light_(light[2])
turtle.tracer(2)
# function man walks============================
deltaX=5 #determines walking direction
deltaY=-2.5 #determines walking direction
q=-1
move=1
r=0
while True:
    q=q+1
    q0=q%3
  time.sleep(0.03)
    if car.xcor()<-151:
        car.shape(cars[q0])
        move=1
        car.fd(10*move)
        light_(light[2])
        sign_(sign[0])
        if car.xcor==-152:
            car.shape(car[0])
    if car.xcor()>-152:
        if r<30:
            car.shape(cars[0])
            r=r+1
            light_(light[1])
            sign_(sign[0])
        if r>=29 and r<81:
            r=r+1
            q1=q%6
            light_(light[0])
        sign_(sign[1])
            r1=r-29
```

```
            boy_(t11,180+r1*deltaX,-20+r1*deltaY,image1[q1])
      boy_(t12,230+r1*deltaX,-10+r1*deltaY,image2[q1])
            boy_(t13,130+r1*1.2*deltaX,-
40+1.2*r1*deltaY,image3[q1])
            time.sleep(0.05)
        if r>=81:
            car.shape(cars[q0])
            move=1
            car.fd(10*move)
            light_(light[2])
            sign_(sign[0])
    if car.xcor()>500:
        q=-1
        boy_(t11,180,-20,image1[0])
        boy_(t12,230,-10,image2[0])
        boy_(t13,130,-40,image3[0])
        r=0
        car.hideturtle()
        car.setposition((-400,-210))
        car.showturtle()
```

Static code result is:

You can watch result of animation at

https://youtu.be/zvTHDusc-H0

Images are at:

https://github.com/victenna/Pedestrian-Crossing

Chess Board

```
import turtle
wn=turtle.Screen()
wn.setup(700,700)
q=turtle.Turtle('square')
q.hideturtle()
q.hideturtle()
q.shapesize(3)
q.color('black')
q.penup()
q.hideturtle()
q.goto(0,0)
turtle.tracer(2)

def condition(a,clr1,clr2):
    if j%2==0:
        q.color(clr1)
    else:
        q.color(clr2)
    q.goto(a+j*60,a+60*i)
    q.stamp()

for i in range(8):
    for j in range (8):
        if i%2==0:
            condition(-200,'coral','lightgray')
        if i%2>0:
            condition(-200,'lightgray','coral')
t=[]
im=['Rook.gif','Rook.gif','Knight.gif','Knight.gif','Bishop.gif',\

'Bishop.gif','King.gif','Queen.gif','Pawn.gif','Pawn.gif','Pawn.gi
f','Pawn.gif',\
   'Pawn.gif','Pawn.gif','Pawn.gif','Pawn.gif',\

'Rookw.gif','Rookw.gif','Knightw.gif','Knightw.gif','Bishopw.gif',
\

'Bishopw.gif','Kingw.gif','Queenw.gif','Pawnw.gif','Pawnw.gif','Pa
wnw.gif','Pawnw.gif',\
   'Pawnw.gif','Pawnw.gif','Pawnw.gif','Pawnw.gif']

for n in range (32):
    t.append(turtle.Turtle())
    wn.addshape(im[n])
    t[n].shape(im[n])
    t[n].penup()
```

```
t[0].goto(220,-200)
t[1].goto(-205,-200)
t[2].goto(-140,-200)
t[3].goto(160,-200)
t[4].goto(-85,-200)
t[5].goto(90,-200)
t[6].goto(-25,-200)
t[7].goto(40,-200)
for s in range (8,16):
    t[s].goto(-200+(s-8)*60,-140)
t[16].goto(220,220)
t[17].goto(-205,220)
t[18].goto(-140,220)
t[19].goto(160,220)
t[20].goto(-85,220)
t[21].goto(90,220)
t[22].goto(-25,220)
t[23].goto(40,220)
for s in range (24,32):
    t[s].goto(-200+(s-24)*60,160)

for n in range(32):
    t[n].ondrag(t[n].goto)
```

Code Result :

Images for chess code can be download at:

https://github.com/victenna/Chess-Board

Lesson 15: Mouse and Keyboard Control (Function onclick)

Now we are going to learn to handle user events and make our programs more interactive. Event-driven programs basically do nothing, waiting until something – an event – happens. When an event does happen, they spring into action, doing whatever is necessary to handle the event. Python's turtle module includes some functions for handling user events, including mouse clicks and keypresses.

First use built in the Turtle module following function: wn.onscreenclick() or shortly wn.onclick().

As the name suggests, this function allows us to handle events created by the user clicking on the turtle's screen. There's a difference between this function and the ones we've used and built before: the argument that we send to wn.onscreenclick() isn't a value — it's the name of another function:

```
wn.onscreenclick(t.goto)
```

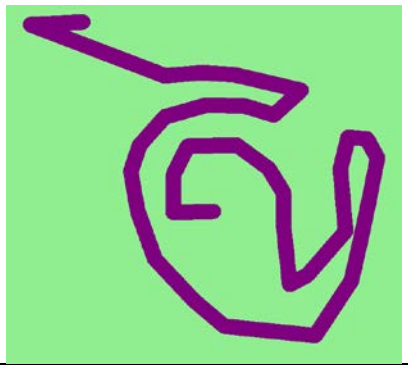
Remember the goto(x,y) function that we've used to move the mouse to a certain (*x*, *y*) location on the screen? Now we're telling the computer that when the turtle screen gets a mouse click, it should set the turtle to the position of that click on the screen. A function we pass as an argument to another function is sometimes called a *callback* function (because it gets *called back* by the other function). Notice that when we send a function as an argument to another function, the inside **function doesn't need the parentheses after its name.** By sending the function name t.goto to wn.onscreenclick(), we're telling the computer what we want screen clicks to do: we want to set the position of the turtle to wherever the user clicked. Let's try it in a short program:

!!!All codes with function *wn.screenonclick* (shortly *wn.onclick()*) operates only when you mouse click on any point of the screen!!!

#Example 15-1

```
import turtle
t=turtle.Turtle()
wn=turtle.Screen()
wn.title('How to handlemouse\
   clicks on the window')
wn.bgcolor('lightgreen')
t.color('purple')
t.pensize(30)
t.shape('square')
wn.onclick(t.goto)
```

Result

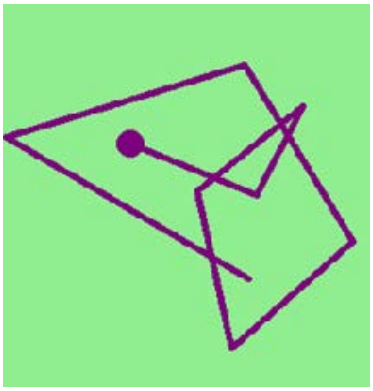


A drawing result after mouse click in random positions of the screen is shown from right side of the code. We can change the background colour of the screen, the turtle's pen colour, the width of the pen, and more. Operational code for onclick function can be written as a function:

#Example 15-2

```
import turtle
t=turtle.Turtle()
wn=turtle.Screen()
wn.title('How to handlemouse\
   clicks on the window')
wn.bgcolor('lightgreen')
t.color('purple')
t.pensize(5)
t.shape('circle')
def h(x,y):
    t.goto(x,y)
wn.onscreenclick(h)
```

Result

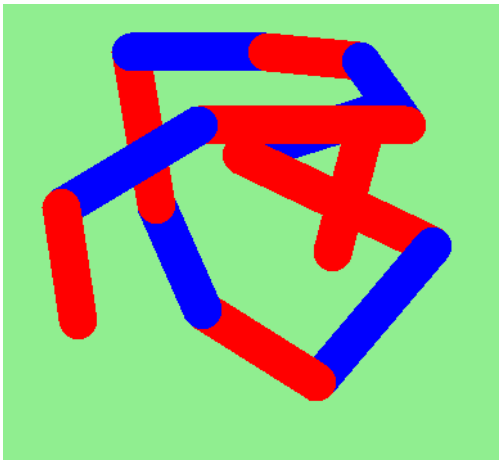


In example #2 code for onscreenclick function is created using h(x,y) function.

#Example 15-3

```
import turtle
t=turtle.Turtle()
wn=turtle.Screen()
wn.title('How to handlemouse\
   clicks on the window')
wn.bgcolor('lightgreen')
t.color('purple')
t.pensize(30)
t.shape('circle')
n=0
def h(x,y):
    global n        #1
    if n%2==0:      #2
        t.color('red')
    else:
        t.color('blue')
    t.goto(x,y)
    n=n+1
wn.onscreenclick(h)
```

Result



Variable n (line#1) shown code is global variable. In Python language if a variable is defined outside a function, usually it can be seen(visible) inside the function. On the other hand, if variable is defined inside a function, usually it can't be seen outside the function. The global keyword is one exception to this rule. A variable that is defined as a global can be seen everywhere. It's our example. Line #2 determines the modulo operation of variable n. If variable n can be any integer number, value n%2 takes value only 0, or 1 depends on the n value.
Table below shows the ratio between n and n%2

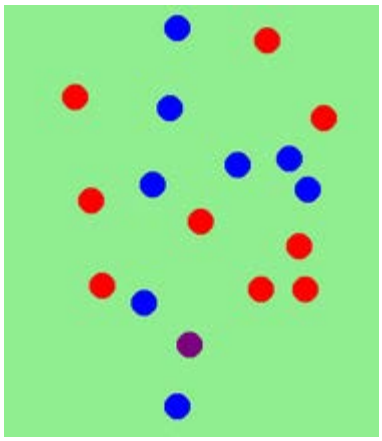
n	n%2
0	0
1	1
2	0
3	1
4	0
5	1

Below we show a few examples that demonstrate **onclick** function applications

#Example 15-5

```
import turtle
t=turtle.Turtle()
wn=turtle.Screen()
wn.title('How to handlemouse\
   clicks on the window')
wn.bgcolor('lightgreen')
t.color('purple')
t.pensize(30)
t.shape('circle')
q=0
def h(x,y):
    global q
    t.stamp()
    t.up()
    t.goto(x,y)
    if q%2==0 :
        t.color('red')
    else:
        t.color('blue')
    q=q+1
wn.onclick(h)
```

Result

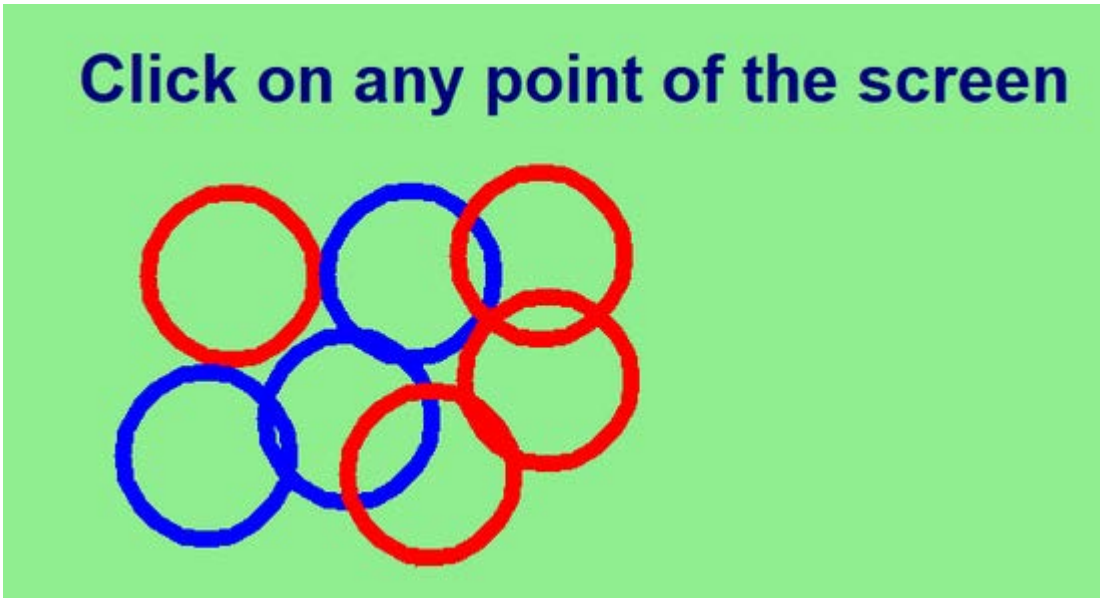


#Example 15-6

```
import turtle
t=turtle.Turtle()
t.hideturtle()
wn=turtle.Screen()
wn.title('How to handlemouse clicks on the window')
wn.bgcolor('lightgreen')
t.color('purple')
t.pensize(10)
t1=turtle.Turtle()
t1.up()
t1.goto(-300,300)
t1.color('navy')
```

```
t1.write('Click on any point of the screen',\
    font=('Arial', 20,'bold'))
n=0
def h(x,y):
    global n
    t.up()
    t.hideturtle()
    if n%2==0:
        t.color('red'))
    else:
        t.color('blue')
    t.goto(x,y)
    t.down()
    t.showturtle()
    t.circle(50)
    n=n+1
wn.onclick(h)
```

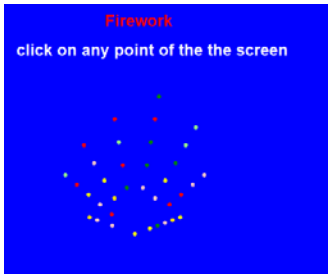
Code result

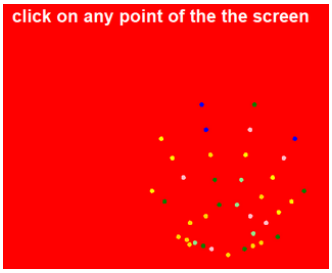


Firework

```
#Example 15-7(a)
import turtle
import time
import random
wn=turtle.Screen()
wn.bgcolor('black')
t=turtle.Turtle('circle')
t.shapesize(0.3)
t.up()
turtle.tracer(50)
clr=['red','blue','gold','yellow','green','pink','lightgreen']
t1=turtle.Turtle()
t1.up()
t1.hideturtle()
t1.color('red')
t1.goto(-150,300)
t1.write('Firework', font=("Arial",20,'bold'))
t1.goto(-300,250)
t1.color('white')
t1.write('click on any point of the the screen',
font=("Arial",20,'bold'))
def firework(x,y):
    t.clear()
    t.goto(x,y)
    for j in range(5):
        a=random.choice(clr)
        t.color(a)
        time.sleep(0.1)

        for i in range(9):
        b=random.choice(clr)
        t.color(b)
        t.circle(40+20*j,40)
        t.stamp()
    for i in range(10):
        wn.bgcolor('red')
        time.sleep(0.2)
        wn.bgcolor('blue')
        time.sleep(0.2)
wn.onclick(firework)
```

Code result



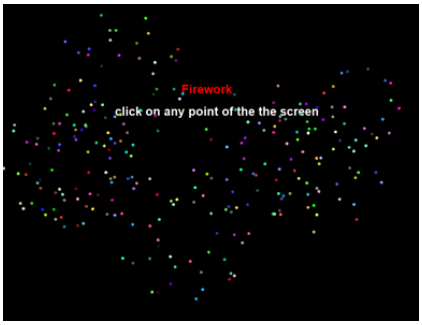


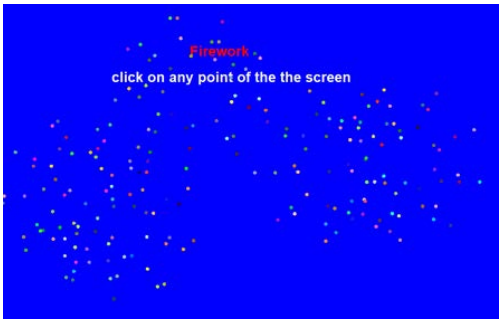
#Example 15-7(b)

```
import turtle
import time
import random
wn=turtle.Screen()
wn.bgcolor('black')
wn.colormode(255)
t=turtle.Turtle('circle')
t.shapesize(0.3)
t.up()
turtle.tracer(50)
t1=turtle.Turtle()
t1.up()
t1.hideturtle()
t1.color('red')
t1.goto(-150,300)
t1.write('Firework', font=("Arial",20,'bold'))
t1.goto(-300,250)
t1.color('white')
t1.write('click    on    any    point    of    the    the    screen',
font=("Arial",20,'bold'))

def firework(x,y):
    wn.bgcolor('black')
    q=random.randint(5,25)

    t.goto(x,y)
    for i in range(5):
        t.goto(random.randint(-400,400),random.randint(-400,400))
        for j in range(5):
            q1=random.randint(1,255)
            q2=random.randint(1,255)
            q3=random.randint(1,255)
            t.color(q1,q2,q3)
            time.sleep(0.1)
            for i in range(q):
                q4=random.randint(1,255)
                q5=random.randint(1,255)
                q6=random.randint(1,255)
                t.color(q4,q5,q6)
```

```
                t.circle(40+20*j,40)
                t.stamp()
                t.fd(20)
        #time.sleep(0.2)

    for r in range(5):
        wn.bgcolor('dark blue')
        time.sleep(0.2)
        wn.bgcolor('blue')
        time.sleep(0.2)

    wn.bgcolor('black')
    t.clear()
wn.onclick(firework)
```

Code result



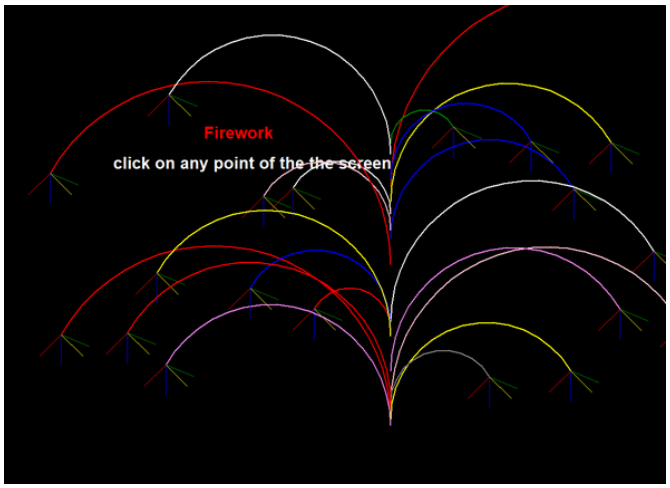


#Example 15-7(c)

```
#Firework
import     turtle,time
import random
wn=turtle.Screen()
turtle.tracer(2,5)
t=turtle.Turtle()
turtle.bgcolor('black')
turtle.colormode(255)                          #1
t.goto(0,-400)
t.shapesize(1)
t.pensize(2)
t.hideturtle()

t1=turtle.Turtle()
t1.up()
t1.hideturtle()
t1.color('red')
t1.goto(-150,300)
t1.write('Firework', font=("Arial",20,'bold'))
t1.goto(-300,250)
t1.color('white')
```

```
t1.write('click on any point of the the screen',
font=("Arial",20,'bold'))

def motion(delta,angle,clr):
    t.fd(delta)
    t.back(delta)
    t.rt(angle)
    t.color(clr)

def firework(x,y):
    t.up()
    #t.clear()
    t.goto(x,y)
    t.down()
    for i in range (20):
        t.penup()
        a=random.randint(0,255)
        b=random.randint(0,255)
        c=random.randint(0,255)
        t.pencolor(a,b,c)                    #2
        u=random.randint(50,350)
        t.setheading(90)
        d=random.randint(100,600)
        t.fd(d)
        t.pendown()
        if i%2==0:
            t.circle(-u,150)
        if i%2>0:
            t.circle(u,150)
        t.setheading(-90)
        t.pensize(1)
        motion(50,45,'red')
        motion(50,-45,'blue')
        motion(50,-45,'yellow')
        motion(50,-22.5,'green')
        motion(50,130,'gold')
        t.penup()
        t.pensize(2)
        t.goto(x,y)
    time.sleep(2)
    t.clear()
wn.onclick(firework)
```

Code result:



Code in Example 222 sets pencolor to RGB color represented by r,g,b values (line #2). Each of r,g,b must be in range 0..colormode. We set colormode equal 255 (line #1).

Python turtle module allows to detect when the user has hit certain keys on the keyboard or moved/clicked the mouse. Whenever the user performs an action as such it is called an event. When the user interacts with the program code waits the user's instructions and responds to his commands (for example, pressing the keyboard or mouse buttons). Thus, you can move, turn on, turn off, or combine objects created by the program, and you can watch the result on the monitor screen. The animation shown below is the result of Python code obtained with a function that moves an object (butterfly) to the position of the screen that was clicked on with the mouse.

Butterfly with function onclick.

#Example 15-8
`import turtle`
`wn=turtle.Screen()`
`import time`
`wn.setup(1200,1100)`
`wn.bgcolor('pink')`
`wn.bgpic('grass.gif')`
`t1=turtle.Turtle()`
`t2=turtle.Turtle()`
`t3=turtle.Turtle()`
`t4=turtle.Turtle()`
`t5=turtle.Turtle()`
`t6=turtle.Turtle()`
`t7=turtle.Turtle()`	

```
t1.up()
t2.up()
t3.up()
t4.up()
t5.up()
t6.up()
t7.up()

image1='flo11.gif'
image2='flo2.gif'
image3='flo3.gif'
image4='flo4.gif'
image5='flo5.gif'
image6='flo6.gif'
image=[]
for i in range (118):
    #print(i)
    i1=str(i)
    image.append(i1+'.gif')


wn.addshape(image1)
t1.shape(image1)
t1.goto(-100,-230)

wn.addshape(image2)
t2.shape(image2)
t2.goto(-300,-420)

wn.addshape(image3)
t3.shape(image3)
t3.goto(300,-170)

wn.addshape(image4)
t4.shape(image4)
t4.goto(0,235)

wn.addshape(image5)
t5.shape(image5)
t5.goto(-150,380)

wn.addshape(image6)
t6.shape(image6)
t6.goto(400,-450)

while True:

    for i in range (18):

        wn.addshape(image[i])
        t7.shape(image[i])
        time.sleep(0.1)
```

```
def fly(x, y):
    t7.goto(x, y)

wn.onclick(fly)
```

Video code result

https://youtu.be/tDESlsOs_0Y

Images for butterfly with function onclick are at:

https://github.com/victenna/Flowers-and-Butterfly

Helicopter with skydivers (skydiver descends to the ground when clicking the screen by mouse)

```
#Example 15-9
import turtle,time
wn=turtle.Screen()
wn.bgpic('road.gif')
t=turtle.Turtle()
t.up()
turtle.tracer(2)
turtle.bgcolor('brown')
image1=['helicopter11.gif','helicopter12.gif']
image2=['helicopter21.gif','helicopter22.gif']
for i in range(2):
    wn.addshape(image1[i])
    wn.addshape(image2[i])
diver=[]
image3=['boy.gif','boy1.gif','boy2.gif', 'boy3.gif','girl.gif']

def condition(turtle):
    turtle.setheading(-90)
    if turtle.ycor()>-10:
        turtle.fd(5)
    if turtle.ycor()<-10:
            turtle.fd(0)


for i in range(5):
    wn.addshape(image3[i])
    diver.append(turtle.Turtle())
    diver[i].shape(image3[i])
    diver[i].up()
    diver[i].hideturtle()
    diver[i].setheading(-90)
t.setheading(90)
def up_down(step):
    for i in range (100):
        i1=i%2
        t.shape(image1[i1])
        t.fd(step)
        time.sleep(0.015)
up_down(4.5)
```

```
t.setheading(0)
s=1
q=0
q1=1
q2=0
i=0
while True:
    i=i+1
    i1=i%2
    X=t.xcor()
    if i1==0:
        t.shape(image1[0])
    if i1==1:
        t.shape(image1[1])

    t.shape(q1*image1[i1]+abs(q2)*image2[i1])
    t.fd(q1*5+q2*5)
    time.sleep(0.02)
    if X>=480:
        q1=0
        q2=-1
    if X<=-480:
        q1=1
        q2=0
    for m in range(5):
        condition(diver[m])
    def h(x,y):
        global q
        global X
        q=q+1
        for n in range (1,6):
            if q==n:
                diver[n-1].goto(X,400)
                diver[n-1].showturtle()
    wn.onclick(h)
```

Static code result:

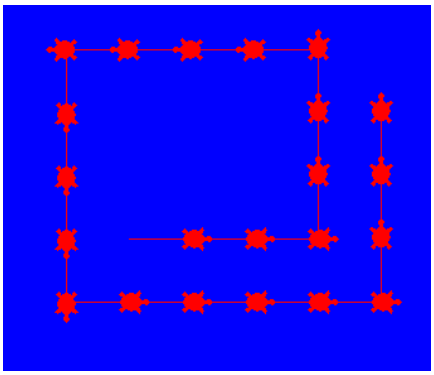
Lesson 16: Keyboard Control (Function onkeypress)

Continue to make our programs more interactive. As we told before event-driven programs basically do nothing, waiting until something –an event – happens. When an event does happen, they spring into action, doing whatever is necessary to handle the event. Python's turtle module includes some functions for handling user events, including mouse clicks and keypresses. **Now** investigate the Turtle module **function**: wn.onkeypress() or shortly wn.onkey(). The function onkey expects two arguments: a function and a keyboard value. The keyboard value is either a string containing the single character on a given keyboard key or a string reserved for a special key, such as an arrow key. The onkey function binds a given key to a given function, meaning that when the key is released, the function is called. For example, if you issue the command onkey(down, 'a'), where down is the name of the function. Python binds the 'a' key to the down function, and the pen is placed down when the user releases the 'a' key. You need to set up all your event handlers for the different keys and then call the listen function to start listening for events. To experiment with key events, we can bind the arrow keys to move the turtle forward or backward, turn it left or right, and clear the drawing, as shown in the following example:

Example 16-1

```
import turtle
wn=turtle.Screen()
wn.bgcolor('blue')


t1=turtle.Turtle('turtle')
t1.color('red')

def up():
    t1.setheading(90)
    t1.forward(50)
    t1.stamp()

def down():
    t1.setheading(270)
```

Result



```
    t1.forward(50)
    t1.stamp()

def left():
    t1.setheading(180)
    t1.forward(50)
    t1.stamp()

def right():
    t1.setheading(0)
    t1.forward(50)
    t1.stamp()

wn.listen()
wn.onkey(up, 'Up')
wn.onkey(down, 'Down')
wn.onkey(left, 'Left')
wn.onkey(right, 'Right')
```

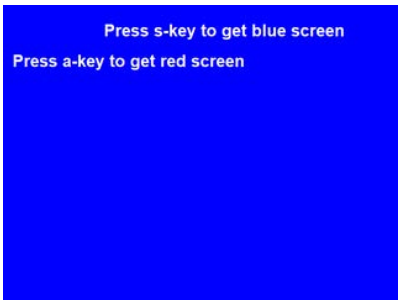
Using function onkey from an example 16-1 user can move the turtle on the screen by pressing the arrow keys instead of clicking the mouse button. We built functions for moving the turtle for each arrow keypress on the keyboard, (**up** (↑), **down** (↓) **left** (←), and **right** (→) keyboard and then we told the computer to listen (line #27) for those keys to be pressed.

Code shown below demonstrates how to change the color on computer screen using keyboard control with Python code.

Example 16-2

```
import turtle
wn=turtle.Screen()
wn.setup(800,800)
wn.bgcolor('black')

t1=turtle.Turtle()
t1.up()
t1.hideturtle()
t1.color('white')
t1.goto(-150,300)
```

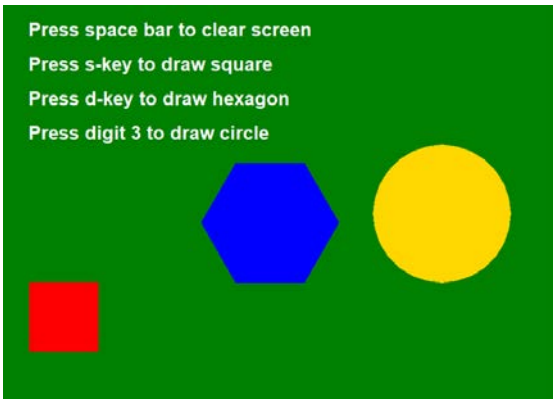
```
t1.write('Press s-key to get blue \
screen', font=('Aril',20,'bold'))
t1.goto(-300,250)
t1.write('Press a-key to get red \
screen', font=('Aril',20,'bold'))

def blue_screen():
    wn.bgcolor('blue')

def red_screen():
    wn.bgcolor('red')

wn.listen()
wn.onkey(blue_screen, 's')
wn.onkey(red_screen, 'a')
```



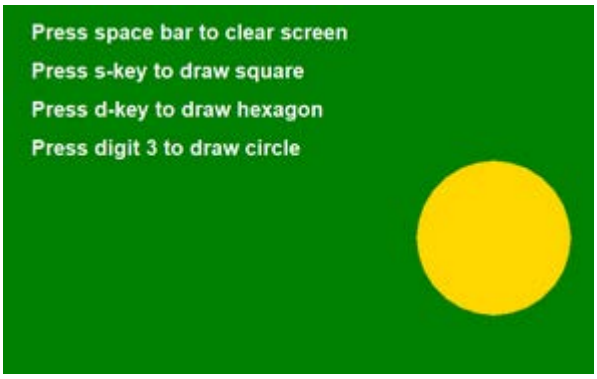
Example 16-3 shows how to draw different simple geometries with Python keyboard control.

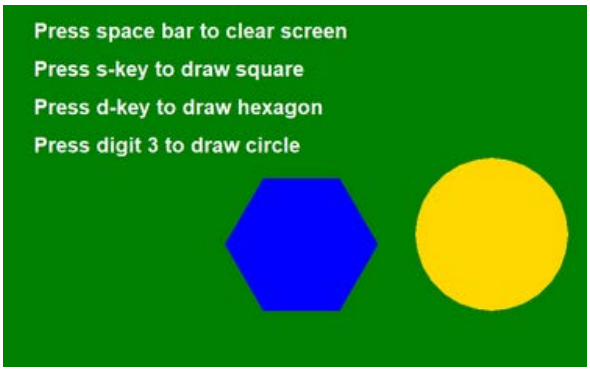
Example 16-3

```
import turtle
wn=turtle.Screen()
wn.bgcolor('green')
t1=turtle.Turtle()
t1.color('red')
t1.hideturtle()

t2=turtle.Turtle()
t2.color('blue')
t2.hideturtle()

t3=turtle.Turtle()
t3.color('blue')
t3.color('gold')
t3.hideturtle()
turtle.tracer(3)

t4=turtle.Turtle()
t4.up()
t4.color('white')
```



```
t4.hideturtle()
t4.goto(-300,300)
t4.write('Press s-key to draw \
square',
font=("Arial",20,'bold'))
t4.goto(-300,250)
t4.write('Press d-key to draw \
hexagon',
font=("Arial",20,'bold'))
t4.goto(-300,200)
t4.write('Press digit 3 to draw \
circle',
font=("Arial",20,'bold'))
t4.goto(-300,350)
t4.write('Press space bar to
clear \
screen',
font=("Arial",20,'bold'))

# This function draw a square.
def square():
    t1.up()
    t1.goto(-300,0)
    t1.down()
    t1.begin_fill()
    for i in range (4):
        t1.fd(100)
        t1.rt(90)
    t1.end_fill()

# This function draw a hexagon.
def hexagon():
    t2.goto(0,0)
    t2.down()
    t2.begin_fill()
    for i in range (6):
        t2.fd(100)
        t2.lt(60)
    t2.end_fill()

# This function draw a circle.
def circle():
    t3.up()
    t3.goto(300,0)
```



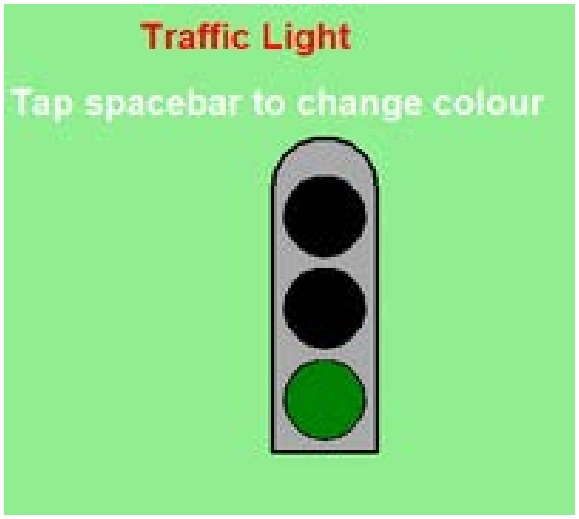


```
    t3.down()
    t3.begin_fill()
    t3.circle(100)
    t3.end_fill()

def start_over():
    t1.clear()
    t2.clear()
    t3.clear()

wn.listen()

# The functions below draws a
shape when certain keys are
pressed.
wn.onkey(square, "s")
wn.onkey(hexagon, "d")
wn.onkey(circle,3)
wn.onkey(start_over,'space')
```

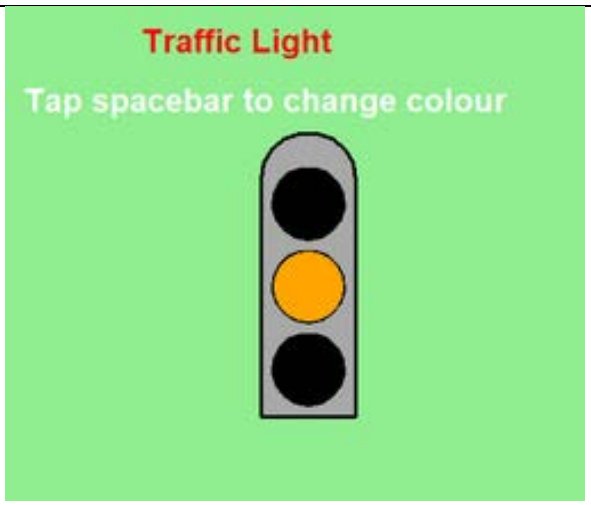
Next example: traffic light control

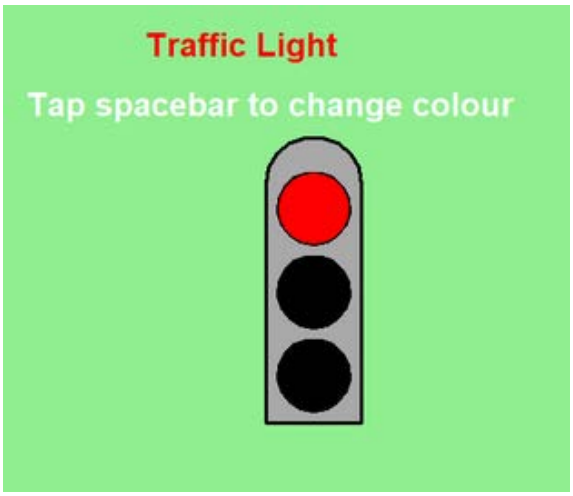
#Example 16-4

```
import turtle
turtle.setup(800,800)
wn = turtle.Screen()
wn.title("Tess becomes a traffic
light!")
wn.bgcolor("lightgreen")
t = turtle.Turtle()
t1=turtle.Turtle()
t1.up()
t1.hideturtle()
t1.color('red')
t1.goto(-100,300)
t1.write('Traffic Light',
font=("Arial",20,'bold'))
t1.goto(-200,250)
t1.color('white')
t1.write('Tap spacebar to change
colour',
font=("Arial",20,'bold'))
```



```
def light_frame():
    t.pensize(3)
    t.color("black","darkgrey")
    t.begin_fill()
    t.forward(80)
    t.left(90)
    t.forward(200)
    t.circle(40, 180)
    t.forward(200)
    t.left(90)
    t.end_fill()
    t.up()
    t.goto(40,80)
    t.down()
    t.color('black','black')
    t.begin_fill()
    t.circle(30)
    t.end_fill()
    #t.stamp()
    t.up()
    t.goto(40,10)
    t.down()
    t.begin_fill()
    t.circle(30)
    t.end_fill()
    t.up()
    t.goto(40,150)
    t.down()
    t.begin_fill()
    t.circle(30)
    t.end_fill()
    t.up()
    t.goto(0,0)

light_frame()

t.penup()
t.forward(40)
t.left(90)
t.forward(40)
t.shape("circle")
t.shapesize(3)
t.fillcolor("green")
```

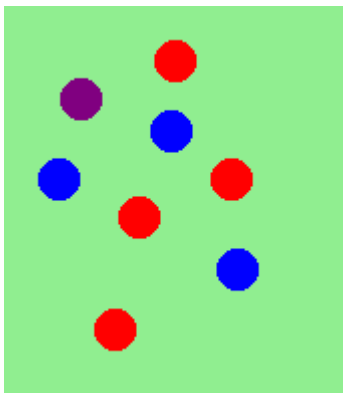




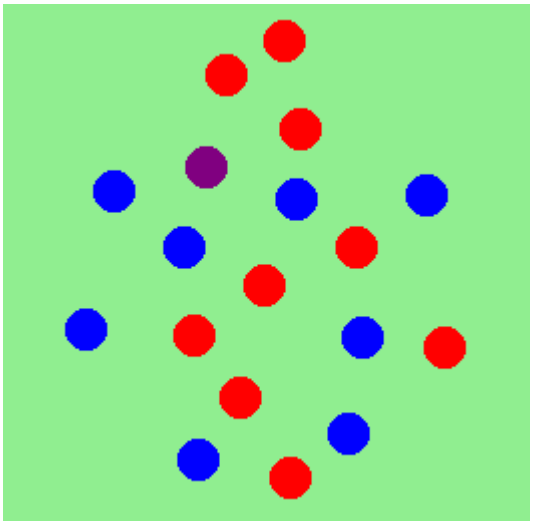
```
state=0
def next_state():
    global state
    if state == 0:
        t.forward(70)
        t.fillcolor("orange")
        state= 1
    elif state== 1:
        t.forward(70)
        t.fillcolor("red")
        state = 2
    else:
        t.back(140)
        t.fillcolor("green")
        state= 0

wn.onkey(next_state, 'space')
wn.listen()
```

Combine two Events: onkey() and onclick()

```
#Example 16-5(a)
import turtle
t = turtle.Turtle('circle')
wn = turtle.Screen()
wn.title("How to handle mouse
clicks on the window!")
wn.bgcolor("lightgreen")
t.color("purple")
t.pensize(30)
t.up()
q=0
def h(x, y):
    global q
    t.stamp()
    t.penup()
    t.goto(x, y)
    if q%2==0:
        t.color('red')
```



```
    else:
        t.color('blue')
    q=q+1
def h1():
    t.setheading(0)
    t.fd(50)
def h2():
    t.setheading(180)
    t.fd(50)
def h3():
    t.setheading(90)
    t.fd(50)
def h4():
    t.setheading(-90)
    t.fd(50)
wn.onclick(h)
wn.onkey(h1,'Right')
wn.onkey(h2,'Left')
wn.onkey(h3,'Up')
wn.onkey(h4,'Down')
wn.listen()
```



In this example you can move circle using arrow keys of the keyboard or jump circle from one screen position to the other one using mouse button click

Example 16-5(b)

```
import turtle
t = turtle.Turtle('circle')
wn = turtle.Screen()
wn.title("How to handle mouse
clicks on the window!")
wn.bgcolor("lightgreen")
t.color("purple")
t.pensize(30)
t.up()
def h(x, y):
    t.down()
    t.goto(x, y)
def h1():
    t.up()
    t.setheading(0)
    t.fd(50)
def h2():
    t.up()
    t.setheading(180)
```

```
    t.fd(50)
def h3():
    t.up()
    t.setheading(90)
    t.fd(50)
def h4():
    t.up()
    t.setheading(-90)
    t.fd(50)
wn.onclick(h)
wn.onkey(h1,'Right')
wn.onkey(h2,'Left')
wn.onkey(h3,'Up')
wn.onkey(h4,'Down')
wn.listen()
```

Lesson 17: Mouse Keyboard Control (Function ondrag))

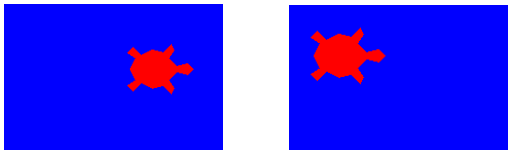
Let's continue investigate event-driven programs. Now we experiment with ondrag() function. Turtle graphics allows you to respond to mouse drag events with the ondrag function. Like the onscreenclick function, the ondrag function expects another function as an argument. This function is triggered repeatedly, while the user drags the mouse from one position to another in the turtle graphics window. Initially, you must position the mouse on the turtle's shape for the first drag event to be detected. As before, the event-handling function's two arguments will be the current mouse coordinates.

Turtle moves according ondrag function

#Example 17-1(a)

```
import turtle
wn=turtle.Screen()
wn.bgcolor('blue')
t=turtle.Turtle('turtle')
t.up()
t.color('red')
t.shapesize(3)
def dragging(x,y):
    t1.ondrag(None)
    t.goto(x,y)
    t.ondrag(dragging)
t.ondrag(dragging)
```

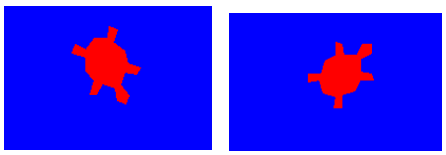
Turtle moves, direction is horizontal



Example 17-1(b)

```
import turtle
wn=turtle.Screen()
wn.bgcolor('blue')
t1= turtle.Turtle('turtle')
t1.penup()
t1.color('red')
t1.shapesize(3)
#t1.speed('fastest')

def dragging(x, y):
    t1.ondrag(None)
```

Turtle moves and specifies (can change) the angle direction

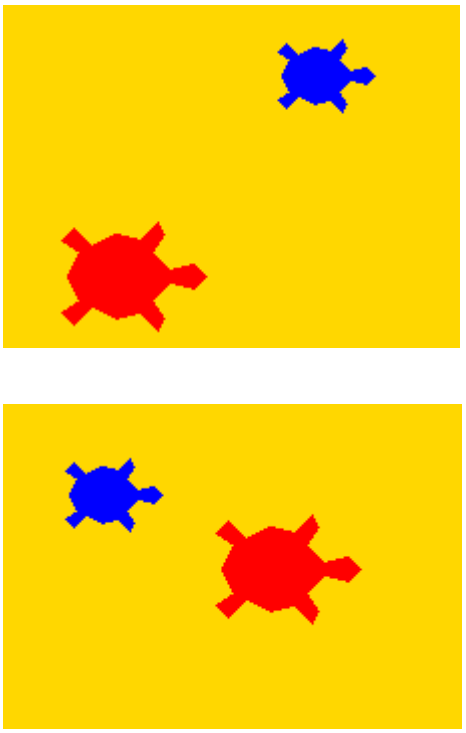


```
    angle=t1.towards(x, y)
    t1.setheading(angle)
    t1.goto(x, y)
    t1.ondrag(dragging)
    print(t1.position())
t1.ondrag(dragging)
```

Drag two turtles

#Example 17-2

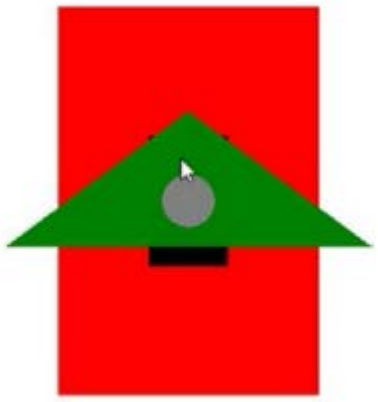
```
import turtle
wn=turtle.Screen()
wn.bgcolor('gold')
t1= turtle.Turtle('turtle')
t1.penup()
t1.color('red')
t1.shapesize(3)
t2= turtle.Turtle('turtle')
t2.color('blue')
t2.shapesize(2)
t2.up()
t2.goto(100,100)

def dragging(x, y):
    t1.ondrag(None)
    t1.goto(x, y)
    t1.ondrag(dragging)
t1.ondrag(dragging)

def dragging2(x, y):
    t2.ondrag(None)
    t2.goto(x, y)
    t2.ondrag(dragging2)
t2.ondrag(dragging2)
```



Build a house

#Example 17-3

```
import turtle
wn=turtle.Screen()
t1= turtle.Turtle('square')
t1.shapesize(15,10)
t1.penup()
t1.color('red')
t1.speed('fastest')

t2= turtle.Turtle('square')
t2.shapesize(5,3)
t2.penup()
t2.color('black')
t2.speed('fastest')

t3= turtle.Turtle('triangle')
t3.shapesize(14,6)
t3.left(90)
t3.penup()
t3.color('green')
t3.speed('fastest')

t4= turtle.Turtle('circle')
t4.shapesize(2)
t4.left(90)
t4.penup()
t4.color('grey')
t4.speed('fastest')

def dragging1(x, y):
    t1.goto(x, y)
def dragging2(x, y):
    t2.goto(x, y)
def dragging3(x, y):
    t3.goto(x, y)
def dragging4(x, y):
    t4.goto(x, y)

t1.ondrag(dragging1)
t2.ondrag(dragging2)
t3.ondrag(dragging3)
```



`t4.ondrag(dragging4)`	

Video code result

https://youtu.be/pFRGnwrFAyQ

Build a house (short version)

```
#Example 17-3(b)
import turtle
t=[]
sh=['square','square','triangle','circle']
clr=['red','black','green','grey']
for n in range (4):
     t.append(turtle.Turtle())
     t[n].shape(sh[n])
     t[n].up()
     t[n].color(clr[n])
     t[n].speed('fastest')

t[0].shapesize(15,10)
t[1].shapesize(5,3)
t[2].shapesize(14,6)
t[2].left(90)
t[3].shapesize(2)


def dragging0(x, y):
    t[0].goto(x, y)

def dragging1(x, y):
    t[1].goto(x, y)

def dragging2(x, y):
    t[2].goto(x, y)

def dragging3(x, y):
    t[3].goto(x, y)
t[0].ondrag(dragging0)
t[1].ondrag(dragging1)
t[2].ondrag(dragging2)
t[3].ondrag(dragging3)
```

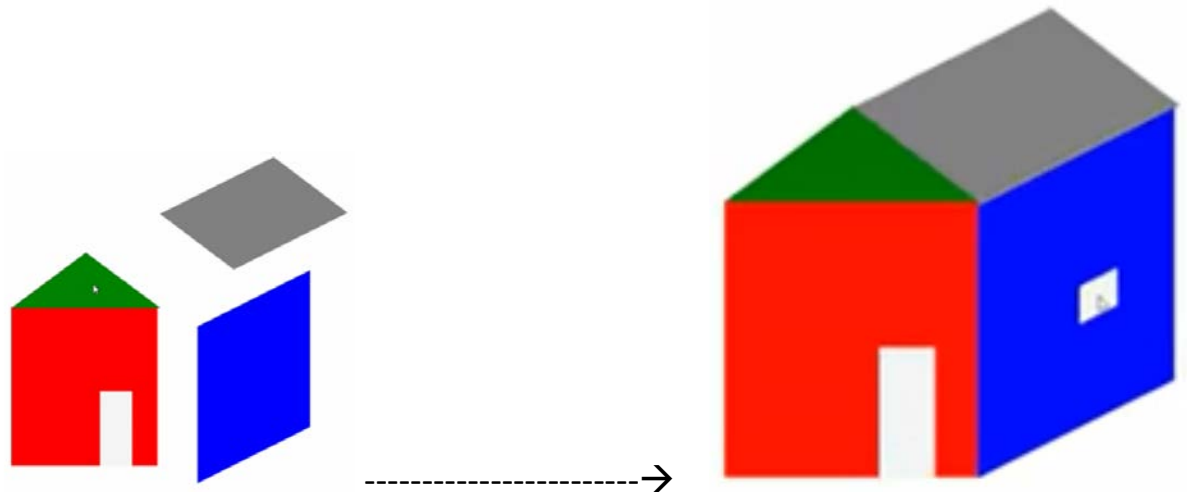
Images to build a house can be download at:
https://github.com/victenna/My-House

Build 3D house

```
#Example 17-4
import turtle
wn=turtle.Screen()
wn.setup(1000,1000)
turtle.tracer(2)
TEXT_FONT=('Arial', 20,'bold')
capture=turtle.Turtle()
capture.hideturtle()
capture.up()
capture.setposition(-400,-300)
capture.write('Build a House dragging parts with a mouse',
font=TEXT_FONT)
t=[]
sh=['square','square','triangle','square','square','square']
clr=['red','whitesmoke','green','whitesmoke','blue','gray']
for n in range (6):
     t.append(turtle.Turtle())
     t[n].shape(sh[n])
     t[n].up()
     t[n].color(clr[n])
     t[n].speed('fastest')
t[0].shapesize(15,13.8)
t[0].goto(-300,200)
t[1].shapesize(7,3)
t[1].goto(-300,-100)
t[2].shapesize(14,6)
t[2].goto(300,200)
t[2].left(90)
t[3].shapesize(2)
t[3].shearfactor(-0.5)
t[3].goto(300,-100)
t[4].shapesize(12,7.8)
t[4].right(-116.5)
t[4].shearfactor(-0.5)
t[4].goto(0,300)
t[5].shapesize(14.8,10.6)
t[5].right(0)
t[5].shearfactor(-0.5)
t[5].goto(0,-10)
def dragging0(x, y):
    t[0].goto(x, y)
def dragging1(x, y):
```

```
    t[1].goto(x, y)
def dragging2(x, y):
    t[2].goto(x, y)
def dragging3(x, y):
    t[3].goto(x, y)
def dragging4(x, y):
    t[4].goto(x, y)
def dragging5(x, y):
    t[5].goto(x, y)

my_dragg=[dragging0,dragging1,dragging2,dragging3,dragging4,dragging5]

for m in range (6):
    t[m].ondrag(my_dragg[m])
```

Static result:



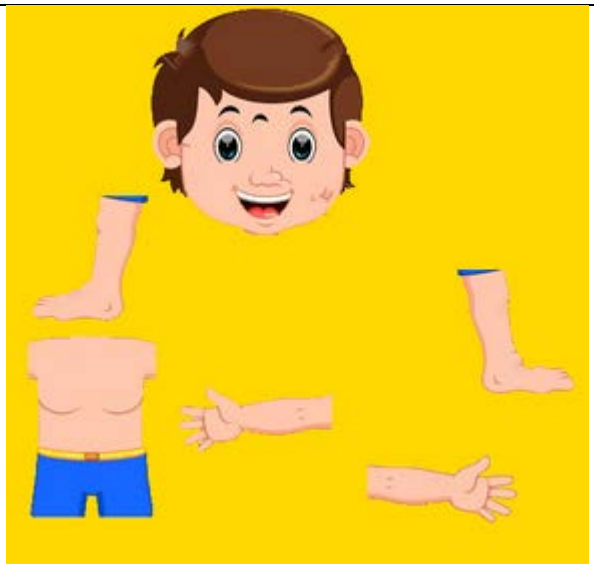
Video Result:

https://www.youtube.com/watch?v=tDgwecF0kP8

Boy assemble

#Example 17-5 `import turtle`	

```
wn=turtle.Screen()
wn.setup(800,800)
wn.bgcolor('gold')

t1=turtle.Turtle()
t2=turtle.Turtle()
t3=turtle.Turtle()
t4=turtle.Turtle()
t5=turtle.Turtle()
t6=turtle.Turtle()

image1='head_.gif'
image2='body_.gif'
image3='left_leg_.gif'
image4='right_leg_.gif'
image5='left_hand_.gif'
image6='right_hand_.gif'

wn.addshape(image1)
t1.shape(image1)
t1.up()
t1.goto(0,200)

wn.addshape(image2)
t2.shape(image2)
t2.up()
t2.goto(-300,300)

wn.addshape(image3)
t3.shape(image3)
t3.up()
t3.goto(100,100)

wn.addshape(image4)
t4.shape(image4)
t4.up()
t4.goto(-200,150)

wn.addshape(image5)
t5.shape(image5)
t5.up()
t5.goto(170,-250)

wn.addshape(image6)
```



```
t6.shape(image6)
t6.up()
t6.goto(210,-200)

def dragging2(x, y):
    t2.ondrag(None)
    t2.goto(x, y)
    t2.ondrag(dragging2)
t2.ondrag(dragging2)

def dragging3(x, y):
    t3.ondrag(None)
    t3.goto(x, y)
    t3.ondrag(dragging3)
t3.ondrag(dragging3)

def dragging4(x, y):
    t4.ondrag(None)
    t4.goto(x, y)
    t4.ondrag(dragging4)
t4.ondrag(dragging4)

def dragging5(x, y):
    t5.ondrag(None)
    t5.goto(x, y)
    t5.ondrag(dragging5)
t5.ondrag(dragging5)

def dragging6(x, y):
    t6.ondrag(None)
    t6.goto(x, y)
    t6.ondrag(dragging6)
t6.ondrag(dragging6)
```

Images for Boy assembly code:

https://github.com/victenna/Boy-Assembly

Lesson 18: Geometry with Polygons (with begin_poly)

Turtle graphics has a few simple geometry shapes (triangle, square, rectangle, circle, oval) described in Lesson 5. You can load these shapes into the program and use them to create simple animation scenario. As you write more sophisticated animations, you want to create some shapes of your own under program control. To do so, Turtle graphics use the functions begin_poly, end_poly, and get_poly to create a polygon. These functions are shown below:

begin_poly()	Start recording the vertices of a polygon. Current turtle position is first vertex of polygon.
end_poly()	Stop recording the vertices of a polygon. Current turtle position is last vertex of polygon. This will be connected with the first vertex.
get_poly()	Returns the last recorded polygon.

The first two functions "record" the turtle's movements in a set of vertices, which you can obtain after ending the recording. After calling begin_poly, you run some code that draws a polygon, with the pen up. Then you can call get_poly to retrieve the set of the vertices. The next examples show these functions in action:

Rectangle

#Example 18-1

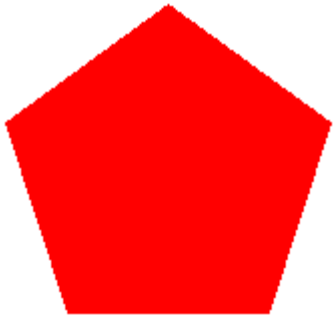
```
import turtle
t=turtle.Turtle()
wn= turtle.Screen()

t.penup()
t.begin_poly()
for count in range(2):
    t.fd(100)
    t.left(90)
```

```
    t.fd(50)
    t.left(90)
t.end_poly()
m= t.get_poly()
t.tilt(90)                    #1
wn.addshape('rectangle',m)

t.shape('rectangle')
t.shapesize(outline=5)
t.color("red", "blue")
```

Line #1 correct polygon orientation problem when drawing polygon.

Pentagon

```
#Example 18-2
import turtle
t=turtle.Turtle()
wn=turtle.Screen()
t.up()

t.begin_poly()
for count in range(5):
    t.forward(20)
    t.left(360 / 5)
t.end_poly()
t.get_poly()
m=t.get_poly()
wn.addshape('pentagon',m)
t.shape('pentagon')
t.tilt(90)
t.shapesize(5)
t.color('red')
```

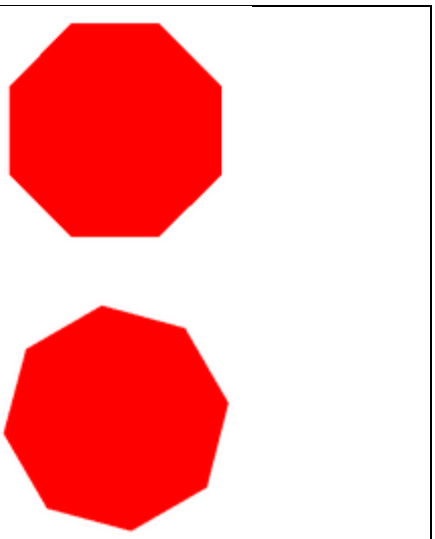


Having created a geometric figure, we can use it as a component of the Turtle module and apply all the commands of this library to element.

Created shape- rectangle

```
#Example 18-3
import turtle,time
t=turtle.Turtle()
```

```
wn=turtle.Screen()
t.up()

t.begin_poly()
for count in range(8):
    t.forward(20)
    t.left(360 / 8)
t.end_poly()
t.get_poly()
m=t.get_poly()
wn.addshape('pentagon',m)
t.shape('pentagon')
t.tilt(90)
t.shapesize(5)
t.color('red')
for i in range (2):
    t.left(30)
    time.sleep(1)
```



In example 18-3 created component octagon moves and rotates along the screen. Top image corresponds parameter i=0, bottom to i=1.

Now consider geometry of more sophisticated non regular polygon. Specify the vertex of this polygon and create it using Turtle module commands. Python's Shape class allows you to create compound shape. To use compound turtle shape, which typically consist of several polygons of different color, you must:

Create an empty Shape object of type "compound".
Add as many components to this object as desired, using the addcomponent() method. Create on irregular polygon using such method

Irregular polygon

```
#Example 18-4
import turtle
wn=turtle.Screen()
import time
s=turtle.Shape('compound') #1
turtle.hideturtle()
turtle.up()

poly1=[(60,-20),(20,40),\   #2
       (-40,60),(-40,-20),\ #3
       (-20,-80),(40,-80),\ #4
       (60,-20)]            #5
s.addcomponent(poly1,'blue') #6
wn.addshape('POLY',s)
```

```
t= turtle.Turtle(shape = 'POLY')

t.showturtle()
t.tilt(90)
```

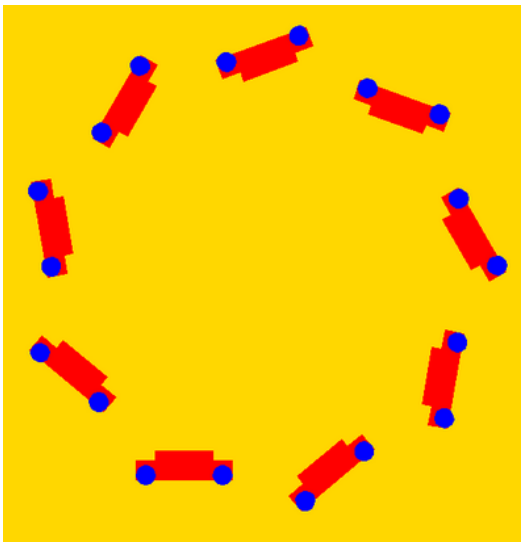
In Example 18-4 Line #1 declear polygon component, lines #2-#5 determine vertix of polygon.

Moving car create with a number of polygons

#Example 18-5

```
import turtle
wn=turtle.Screen()
wn.bgcolor('gold')
import time
turtle.penup()
turtle.hideturtle()
s=turtle.Shape('compound')
pos1=-50,0
pos2=50,0
pos3=50,20
pos4=30,20
pos5=30,30
pos6=-30,30
pos7=-30,20
pos8=-50,20
poly1=(pos1,pos2,pos3,pos4,\
       pos5,pos6,pos7,pos8)
s.addcomponent(poly1,'red')
turtle.goto(40,-5)
turtle.begin_poly()
turtle.circle(10)
turtle.end_poly()
m1=turtle.get_poly()
s.addcomponent(m1,'blue')
turtle.goto(-40,-5)
turtle.begin_poly()
turtle.circle(10)
turtle.end_poly()
m2=turtle.get_poly()
s.addcomponent(m2,'blue')
wn.addshape('car',s)
t=turtle.Turtle(shape='car')
t.penup()
t.tilt(90)
for i in range(9):
    t.fd(160)
    t.left(40)
    t.stamp()
```

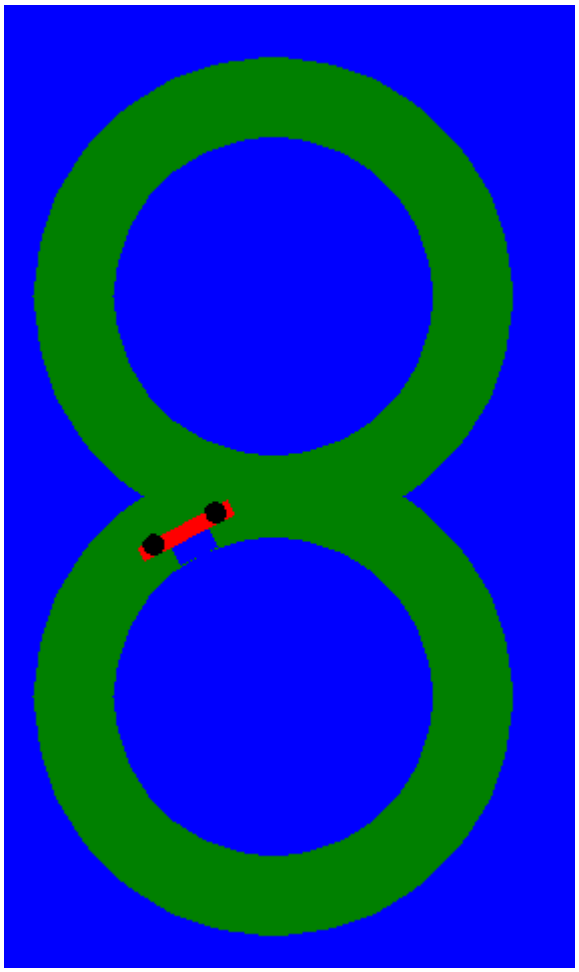
Result:



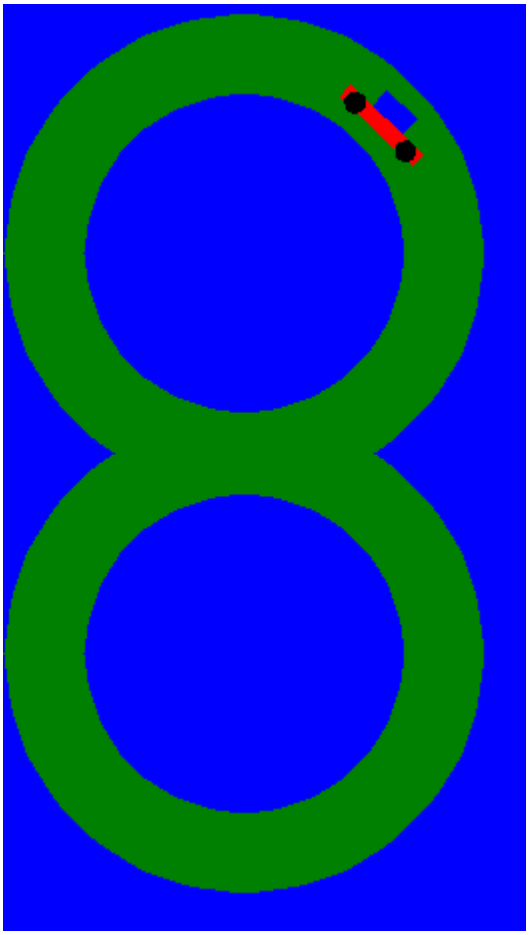
Car Race

#Example 18-6

```
# CAR TRACK, digit eight route
import turtle
import time
wn=turtle.Screen()
wn.bgcolor('blue')

s=turtle.Shape("compound")
turtle.tracer(2)

t1=turtle.Turtle()
t1.setheading(0)
t1.shapesize(1)
t1.pensize(40)
t1.color('green')
t1.hideturtle()
t1.up()
R=100
t2=turtle.Turtle()
t2.setheading(0)
t2.shapesize(1)
t2.pensize(40)
t2.color('green')
t2.hideturtle()
t2.up()

def road1():
    t1.setheading(0)
    t1.circle(R)
t1.down()
road1()

def road2():
    t1.setheading(0)
    t1.circle(-R)
t2.down()
road2()
#Head
head=turtle.Turtle()
head.hideturtle()
head.penup()
head.goto(-20,30)
head.begin_poly()
for i in range (2):
    head.fd(40)
    head.right(90)
    head.fd(20)
    head.right(90)
head.end_poly()
m1=head.get_poly()
s.addcomponent(m1,'blue')
```



```
#Body
body=turtle.Turtle()
body.hideturtle()
body.penup()
body.goto(-50,10)
body.begin_poly()
for j in range (2):
    body.fd(100)
    body.right(90)
    body.fd(15)
    body.right(90)
body.end_poly()
m2=body.get_poly()
s.addcomponent(m2,'red')

#Leg1
leg1=turtle.Turtle()
leg1.hideturtle()
leg1.penup()
leg1.goto(-35,-10)
leg1.begin_poly()
leg1.circle(10)
leg1.end_poly()
m3=leg1.get_poly()
s.addcomponent(m3,'black')

#Leg2
leg2=turtle.Turtle()
leg2.hideturtle()
leg2.penup()
leg2.goto(35,-10)
leg2.begin_poly()
leg2.circle(10)
leg2.end_poly()
m4=leg2.get_poly()
s.addcomponent(m4,'black')

wn.addshape('man',s)
a=turtle.Turtle(shape='man')
a.up()
a.tilt(90)
a.goto(0,-2*R)
a.showturtle()
#a.circle(R)
a.shapesize(0.5)

#----------------------
def car(q,angle):

    for i in range (angle):
        a.fd(1.7)
        a.left(q)
```



```
        time.sleep(0.008)

for j in range(50):
        car(1,180)
        car(-1,360)
        car(1,180)
```

Canadian Flag

```
#Example 18-7
import turtle
t=turtle.Turtle()
wn=turtle.Screen()
turtle.tracer(3)
s = turtle.Shape("compound")
t.hideturtle()
t.up()
t.color('red')
poly1=((0,0),(-25,-45),(-50,-38),(-40,-110),(-75,-80),(-85,-98),(-
125,-90),\
       (-112,-135),(-130,-142),(-62,-185),(-68,-220),(0,-210),\
       (68,-220),(62,-185),(130,-142),(112,-135),(125,-90),(85,-
98),(75,-80),\
       (40,-110),(50,-38),(25,-45))
s.addcomponent(poly1,'red')
wn.register_shape('flag',s)
can_flag=turtle.Turtle(shape='flag')
can_flag.tilt(90)
can_flag.shapesize(0.6)
t2=turtle.Turtle()
t2.up()
t2.color('red','red')
def rectangle(X,Y,width,length):
    t2.goto(X,Y)
    t2.begin_fill()
    t2.down()
    for i in range (2):
        t2.fd(length)
        t2.right(90)
        t2.fd(width)
        t2.right(90)
    t2.end_fill()
rectangle(-190,50,230,90)
t2.up()
rectangle(100,50,230,90)
t2.hideturtle()
t2.up()
rectangle(-5,-100,80,10)
```

Result:

Motion of Rocketship around the Earth

```
#Example 18-8
import turtle,time
wn=turtle.Screen()
wn.bgcolor('navy')
wn.setup(900,900)
#t.hideturtle()
#t.up()
image1='Earth.gif'
wn.addshape(image1)
earth=turtle.Turtle()
earth.shape(image1)
earth.goto(0,0)

turtle.tracer(2)
s1=turtle.Shape("compound")


poly1=((0,0),(25,0),(25,10),(0,10))
poly2=((25,0),(35,5),(25,10))
poly3=((0,10),(-5,19),(10,10))
poly4=((0,0),(-5,-10),(10,0))
poly5=((5,7),(15,7),(15,10),(5,10))
poly6=((0,3),(-10,-4),(-10,14),(0,8))
clr=['red','light
blue','gold','yellow']
s1.addcomponent(poly1,clr[0],'black')
s1.addcomponent(poly2,clr[1],'black')
s1.addcomponent(poly3,clr[2],'black')
s1.addcomponent(poly4,clr[3],'black')
s1.addcomponent(poly5,'blue','black')
s1.addcomponent(poly6,'yellow','black')
```

```
wn.addshape('geometry',s1)

Roket=turtle.Turtle(shape='geometry')
Roket.shapesize(2)
Roket.tilt(90)
Roket.showturtle()
Roket.up()
Roket.goto(0,-400)
Roket.rt(0)
turtle.tracer(2)
while True:
    Roket.circle(400,1)
    time.sleep(0.01)
```

Satellite and Rockets around the spinning Earth (with animation)

```
#Example 18-9
import turtle,time
wn=turtle.Screen()
wn.bgpic('sky.gif')
wn.setup(900,900)
t=turtle.Turtle()
t.up()
turtle.tracer(2)
s1=turtle.Shape("compound")
s2=turtle.Shape("compound")
s3=turtle.Shape("compound")

#Earth file images
image=[]
for i in range(45):
    i1=str(i)
    image.append(i1+'.gif')
wn.addshape(image[0])
turtle.shape(image[0])
#====================================
#Rocket polygons
poly1=((0,0),(25,0),(25,10),(0,10))
poly2=((25,0),(35,5),(25,10))
poly3=((0,10),(-5,19),(10,10))
poly4=((0,0),(-5,-10),(10,0))
poly5=((5,7),(15,7),(15,10),(5,10))
poly6=((0,3),(-10,-4),(-10,14),(0,8))

#Rocket1 geometry
s1.addcomponent(poly1,'red','black')
s1.addcomponent(poly2,'light blue','black')
s1.addcomponent(poly3,'gold','black')
s1.addcomponent(poly4,'yellow','black')
s1.addcomponent(poly5,'blue','black')
s1.addcomponent(poly6,'yellow','black')
wn.addshape('geometry1',s1)
```

```
Rocket1=turtle.Turtle(shape='geometry1')
Rocket1.hideturtle()
Rocket1.shapesize(2)
Rocket1.tilt(90)
Rocket1.up()
Rocket1.goto(0,-400)
Rocket1.showturtle()
#================================================
#Rocket2 geometry
s2.addcomponent(poly1,'light blue','black')
s2.addcomponent(poly2,'red','black')
s2.addcomponent(poly3,'gold','black')
s2.addcomponent(poly4,'brown','black')
s2.addcomponent(poly5,'blue','black')
s2.addcomponent(poly6,'yellow','black')
wn.addshape('geometry2',s2)

Rocket2=turtle.Turtle(shape='geometry2')
Rocket2.hideturtle()
Rocket2.shapesize(1.4)
Rocket2.tilt(90)
Rocket2.up()
Rocket2.goto(-220,0)
Rocket2.lt(270)
Rocket2.showturtle()
#================================================
#Sattelite polygons
poly1=((0,0),(30,0),(30,10),(0,10))   #red
poly2=((20,5),(40,-5),(40,15))
poly3=((0,3),(-10,-4),(-10,14),(0,8))
poly4=((10,0),(20,0),(20,-30),(10,-30))  #gold
poly5=((5,7),(15,7),(15,10),(5,10))
poly6=((10,10),(20,10),(20,40),(10,40))
clr=['red','gold','gainsboro','light blue']

s3.addcomponent(poly1,'red','black')  #red
s3.addcomponent(poly3,'gold','black')
s3.addcomponent(poly4,'gainsboro','black')   #gold
s3.addcomponent(poly6,'light blue','black')
wn.addshape('geometry3',s3)
Sat1=turtle.Turtle(shape='geometry3')
Sat1.hideturtle()
Sat1.shapesize(2)
Sat1.tilt(0)
Sat1.up()
Sat1.goto(300,0)
Sat1.lt(90)
Sat1.showturtle()
#================================================
#Earth motion anime files

turtle.tracer(3)
```

```
k=0
while True:
    k=k+1
    k0=k%44
    k1=k%44
    if k0<22:
        wn.bgpic('sky.gif')
    if k0>22:
        wn.bgpic('sky1.gif')
    wn.addshape(image[k1])
    t.shape(image[k1])
    Rocket1.circle(400,1)
    Rocket2.circle(220,3)
    Sat1.fd(10)
    angle=Sat1.heading()
    Sat1.setheading(angle+2)
    time.sleep(0.01)
```

Static code results

Images for project #18-9 are availabe at:

https://github.com/victenna/Rockets-around-Earth

You can watch video at:

https://youtu.be/s2Ksfeeo1Dc

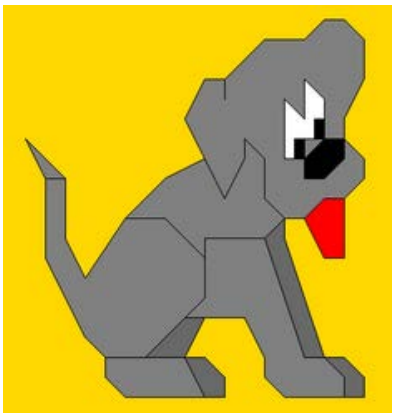
Animated Gog

```
#Example 18-10
import turtle,time
wn=turtle.Screen()
wn.setup(1200,900)
turtle.tracer(3)
wn.bgcolor('gold')
t=turtle.Turtle('turtle')
```

```
t.penup()
t.hideturtle()
B=150
s=turtle.Shape('compound')
s1=turtle.Shape('compound')
s2=turtle.Shape('compound')

t.begin_poly()

poly1=((10,-20),(30,0),(20,-20))
poly1_=((10,-20),(0,0),(20,-20))
poly2=((40,-110),(80,-110),(90,-120),(90,-130),(50,-130),(40,-120))
poly3=((60,-110),(80,-90),(90,-90),(80,-110))
poly4=((80,-110),(90,-110),(100,-120),(100,-130),(90,-130))
poly5=((50,-40),(70,-20),(90,-10),(100,-30),(110,-10),(110,0),(120,-
10),(120,-30),(130,-40),(120,-50),(90,-50),(90,-60),(70,-40))
poly6=((80,10),(90,30),(100,30),(100,20),(100,30),(120,50),(140,50),(
150,60),(160,60),(170,50),(170,30),(160,10),\
      (160,0),(170,-10),(170,-20),(160,-30),(150,-30),(140,-40),\
      (130,-40),(120,-30),(120,-10),(110,0),(110,-10),(100,-30))
poly7=((140,-40),(150,-30),(160,-30),(160,-60),(150,-60))# язык
poly8=((135,0),(140,0),(140,-10),(135,-10))
poly9=((145,10),(150,10),(150,0),(145,0))
poly10=((130,-
10),(130,20),(140,10),(140,30),(150,20),(150,0),(140,0),(140,-10))
poly11=((140,-10),(150,0),(160,0),(160,-10),(150,-20),(140,-20))
poly12=((80,-90),(90,-90),(110,-90),(120,-110),(120,-120),(130,-
130),(160,-130),(160,-120),(150,-110),(140,-110),(120,-50),(90,-
50),(90,-80))
poly13=((150,-110),(160,-110),(170,-120),(170,-130),(160,-130),(160,-
120))
poly14=((130,-40),(130,-50),(150,-110),(140,-110),(120,-50))
poly15=((20,-20),(20,-50),(30,-70),(50,-40),(70,-40),(90,-60),(90,-
80),(60,-110),(40,-110),(30,-100),(10,-60),(10,-20))
s.addcomponent(poly1,'gray','black')
s.addcomponent(poly2,'gray','black')
s.addcomponent(poly3,'dim gray','black')
s.addcomponent(poly4,'dim gray','black')
s.addcomponent(poly5,'gray','black')
s.addcomponent(poly6,'gray','black')
s.addcomponent(poly10,'white','black')
s.addcomponent(poly8,'black','black')
s.addcomponent(poly9,'black','black')
s.addcomponent(poly11,'black','black')
s.addcomponent(poly12,'gray','black')
s.addcomponent(poly13,'dim gray','black')
s.addcomponent(poly14,'dim gray','black')
s.addcomponent(poly15,'gray','black')

wn.addshape('dog',s)
q=turtle.Turtle(shape='dog')
q.tilt(90)
q.up()
```

```
q.shapesize(2)
q.hideturtle()
q.goto(-400,0)
q.showturtle()

s1.addcomponent(poly7,'red','black')
wn.addshape('dog1',s1)
q1=turtle.Turtle(shape='dog1')
q1.tilt(90)
q1.up()
q1.shapesize(2)
q1.hideturtle()
q1.goto(-400,0)
q1.setheading(0)

s2.addcomponent(poly1,'gold','gold')
s2.addcomponent(poly1_,'gray','black')
wn.addshape('dog2',s2)
q2=turtle.Turtle(shape='dog2')
q2.tilt(90)
q2.up()
q2.shapesize(2)
q2.hideturtle()
q2.goto(-400,0)
q2.setheading(0)
turtle.tracer(5)
while True:
    q1.showturtle()
    q2.hideturtle()
    time.sleep(0.3)
    q1.hideturtle()
    q2.showturtle()

    time.sleep(0.1)
```

The display resulting from this program:



Scottich Terrier

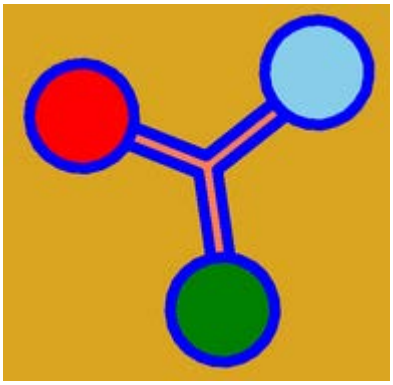
```
#Example 18-11
import turtle,time
wn=turtle.Screen()
wn.bgcolor('gold')
t=turtle.Turtle()
t.penup()
t.hideturtle()
s=turtle.Shape('compound')

poly1=((2,1),(2,9),(1,12),(4,9),(9,9),(11,18),(12,16),(13,18),\
       (14,16),(16,15),(15,14),(17,12),(17,11),(18,11),

(18,8),(14,6),(14,7),(11,9),(13,1),(10,1),(10,1),(9,4),(5,6),(5,1))
s.addcomponent(poly1,'gray','black')

turtle.tracer(5)
t.goto(12.5,13)
t.begin_poly()
t.circle(0.5)
t.end_poly()
m1=t.get_poly()
s.addcomponent(m1,'black')

t.goto(14.3,13.5)
t.begin_poly()
t.circle(0.5)
t.end_poly()
m1=t.get_poly()
s.addcomponent(m1,'black')

t.goto(14,12.5)
t.begin_poly()
t.circle(-12/15)
t.end_poly()
m1=t.get_poly()
s.addcomponent(m1,'black')

t.goto(16.3,11)
t.pensize(5)
t.begin_poly()
t.setheading(270)
t.circle(-12/6,120)
t.end_poly()
m1=t.get_poly()
s.addcomponent(m1,'black')

wn.addshape('dog',s)
q=turtle.Turtle(shape='dog')
```

```
q.tilt(90)
q.up()
q.hideturtle
q.shapesize(0.0001)
def motion():
    q.hideturtle()
    q.goto(-400,0)
    q.showturtle()
    for i in range (150):
        q.shapesize(0.1*(i+1))
        q.fd(2)
        time.sleep(0.05)
turtle.tracer(3)
while True:
    time.sleep(0.1)
    motion()
```

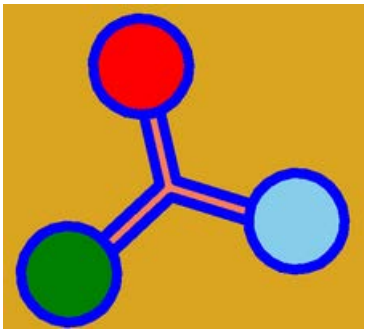
The display resulting from this program:

Spinner

```
#Example 18-12
import turtle,time
turtle.bgcolor('goldenrod')
t0=turtle.Turtle('turtle')
t0.hideturtle()
t0.up()
t0.setheading(-90)
t0.goto(0,-25)
wn=turtle.Screen()
turtle.tracer(2)
s=turtle.Shape('compound')
def support(angle):
    t0.fd(200)
    t0.left(90)
    t0.fd(25)
    t0.left(90)
    t0.fd(200)
    t0.setheading(angle)
t0.begin_poly()
t0.left(60)
support(90)
```



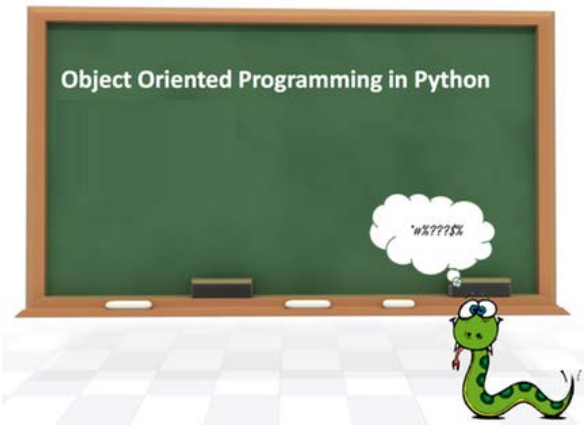
```
support(210)
support(90)
t0.end_poly()
m0=t0.get_poly()
s.addcomponent(m0,'coral','blue')
t1=turtle.Turtle()
t2=turtle.Turtle()
t3=turtle.Turtle()
def spinner(turtle,X,Y,m,clr1,clr2):
    turtle.hideturtle()
    turtle.up()
    turtle.goto(X,Y)
    turtle.begin_poly()
    turtle.setheading(0)
    turtle.circle(70)
    turtle.end_poly()

s.addcomponent(turtle.get_poly(),clr1,clr2)

spinner(t1,170,-170,t1.get_poly(),'sky
blue','blue')
spinner(t2,-170,-
170,t2.get_poly(),'green','blue')
spinner(t3,0,100,t3.get_poly(),'red','blue')

wn.addshape('spin',s)
q=turtle.Turtle(shape='spin')
q.shapesize(outline=15)
q.tilt(90)
a=0
def animate():
    global a
    if a > 0:
        a -= 1
    if a < 0:
        a += 1
    ang=a/10
    q.right(ang)
    turtle.ontimer(animate, 20)
animate()
def flick1():
    global a
    a += 10
def flick2():
    global a
    a -= 10
turtle.onkey(flick1, 'Right')
turtle.onkey(flick2, 'Left')
turtle.listen()
```



Lesson 19: Classes and Objects

Object-oriented programming

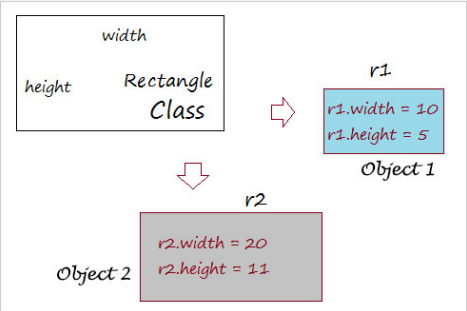
Python is an object-oriented programming language, which means that it provides features that support object oriented programming (OOP). In object-oriented programming the focus is on the creation of objects which contain both data and functionality together. We've already seen Turtle classes and worked with them in lesson #12.



Below it is shown code that calculates rectangle perimeter and rectangle area using class method (with Python).

Figure below shows visually class Rectangle and two objects: object 1 and object 2 that are components of created class. Our goal: to calculate perimeter and area of two objects r1 and r2. First object is a rectangle named as r1 with a width=10 and a height=5, second object r2 has a width=20 and a height=11.

Fig. 19-1



Code for calculation is shown below

Rectangle perimeter and Area

```
#Example 19-1
#This is Rectangle class
class Rectangle():                                          #2
    # Method to create object (Constructor)
    def __init__(self, width, height):                     #3
        self.length = width
        self.width  = height

    # Method to calculate Perimeter
    def rectangle_perimeter(self):
        return 2*self.length+2*self.width                   #4


    # Method to calculate Area
    def rectangle_area(self):
        return self.length*self.width

r1 = Rectangle(10, 5)   #Object #1
r2 = Rectangle(20,11)   #Object #2
#r3 = Rectangle(52,7)   #Object #3                          #5

print('Rectangle1 Perimeter=',r1.rectangle_perimeter())
print('Rectangle1 Area=',r1.rectangle_area())

print('Rectangle2 Perimeter=',r2.rectangle_perimeter())
print('Rectangle2 Area=',r2.rectangle_area())

#print('Rectangle3 Perimeter=',r3.rectangle_perimeter())    #6
#print('Rectangle3 Area=',r3.rectangle_area())              #7
```

Let's explain basic structure of the code, that uses classes and objects concept.

You need to start with the **`class`** keyword to indicate that you are creating a

class, then you add the name of the class (in our case **Rectangle**) and colon (:) [line #2]. Remember: the class is just for defining the **Rectangle**, not actually creating *instances* of individual rectangles with specific width and height; we'll get to that shortly.

In the class body [all lines between #4 and #4 including lines #3 and #4], you declare parameters (attributes), methods (method of calculation in our case), and constructors.

Attribute:

The attribute is a member of the class. Our rectangle code has two attributes (parameters): width and height. All classes create objects, and all objects contain characteristics called attributes (In our case **class**-Rectangle and **objects**-r1, r2, which is shown in Fig 19-1)

Method:

The method of class is similar to a normal function but it is a function of class, in order to use it, you need to call through object. The first parameter of the method is always **self** (a keyword that refers to the class itself).

Constructor:

Constructor is used to create an object. Constructor assigns values of the parameter to the properties of the object that will be created. You can only define a constructor in class. The task of constructors is to initialize (assign values) to the data members of the class when an object of class is created. In Python the __init__() method is called the constructor and is always called when an object is created. The first parameter of the constructor is always **self** (a keyword refers to the class itself). If the class is not defined by the constructor, **Python** assumes that it inherits constructor of parent class.

NOTE: You will never have to call the `__init__()` method; it gets called automatically when you create a new 'Rectangle' instance.

Result of the code, which calculates rectangle parameters is shown below

```
 RESTART: C:/Users/Victor/Google
ample 19-1.py
Rectangle1 Perimeter= 30
Rectangle1 Area= 50
Rectangle2 Perimeter= 62
Rectangle2 Area= 220
>>>
```

Similar we can add to our code an object r3 with the following parameters width=52, height =7 (you have to remove symbol #from left side of lines #5,#6, and #7. Code and result of calculation looks like:

Circle Calculation with classes concept

Example 19-2

```
import math
class Circle():
    def __init__(self,radius):
        self.radius=radius
    def curcumference(self):
        return 2*math.pi*self.radius
    def area(self):
        return math.pi*self.radius**2
c1=Circle(5)
c2=Circle(10)
c3=Circle(15)

print('Radius=5,curcumference=',round(c1.curcumference(),1))
print('Radius=5,area',round(c1.area(),1))
print('Radius=10,curcumference=',round(c2.curcumference(),1))
print('Radius=10,area',round(c2.area(),1))
print('Radius=15,curcumference=',round(c3.curcumference(),1))
print('Radius=15,area',round(c3.area(),1))
```

Result of the code, which calculates circle parameters is shown below:

```
 RESTART: C:/Users/Victor/Google
ample 19-2.py
Radius=5,curcumference= 31.4
Radius=5,area 78.5
Radius=10,curcumference= 62.8
Radius=10,area 314.2
Radius=15,curcumference= 94.2
Radius=15,area 706.9
>>>
```

Isosceles Triangle Area Calculation (interactive with input parameters)

Example 19-3

```
class Triangle():
    def __init__(self, base, height):
        self.base = base
        self.height  =height
    def area(self):
        A=self.base*self.height/2
        return A
a=float(input('Enter triangle base length:\n'))
b=float(input('Enter triangle height length:\n'))
t = Triangle(a,b)
print('triangle area=',t.area())
print('_____________________________')
```

Output:

```
Enter triangle base length:
25
Enter triangle height length:
10
triangle area= 125.0
```

Program Explanation

1. User must enter the value of base and height.
   a. A class called Triangle is created and the __init__() method is used to initialize values of that class.
   b. A method called as A returns self.base*self.height/2 which is the area of the class.
   3. An object **t=Triangle(a,b)** for the class is created.
   6. Using the object, the method area() is called.
   7. The area and perimeter of the circle is printed.

Below it is shown an example that allows to combine turtle GUI (graphic user interface) with class concept. We create code to draw circle with some certain parameters

```
#Example 19-4

import turtle                                          #1
wn=turtle.Screen()                                     #2
wn.setup(800,800)                                      #3
wn.bgcolor('red')                                      #4

class Circle(turtle.Turtle):                           #5
    def __init__(self,X,Y,radius,color):               #6

        self.X=X                                       #7
        self.Y=Y                                       #8
        self.radius=radius                             #9
        turtle.Turtle.__init__(self)                   #10
        #super().__init__()                            #11
        self.up()                                      #12
        self.setposition(X,Y)                          #13
        self.down()                                    #14
        self.pensize(5)                                #15
        self.color(color)                              #16
        self.shape('circle')                           #17
        self.circle(radius)                            #18

circle1=Circle(100,100,30,'gold')                      #19
circle1=Circle(100,-100,80,'blue')                     #20
circle1=Circle(-100,-100,60,'green')                   #21
circle1=Circle(-100,100,100,'yellow')                  #22
```

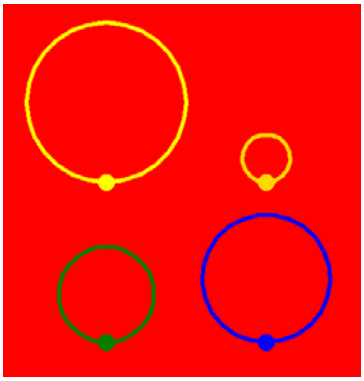
Program Explanation

1. First four lines common for turtle module come with Python soft Line #5 creates Circle subclass with turtle.
2. X and Y position of the circle on the plane are the parameters of the class Circle. Also, parameters of the Circle class are radius and color.
3. Line #10 allows to communicate turtle commands with class Circle declared with line #6.

4. Lines #16-22 determine main turtle commands, which are known from the previous lessons.
5. Lines #19-#22 specify object circles with certain parameters.

We can add any numbers of circle objects to the end of this code, for example,

Output of Example 19-4:

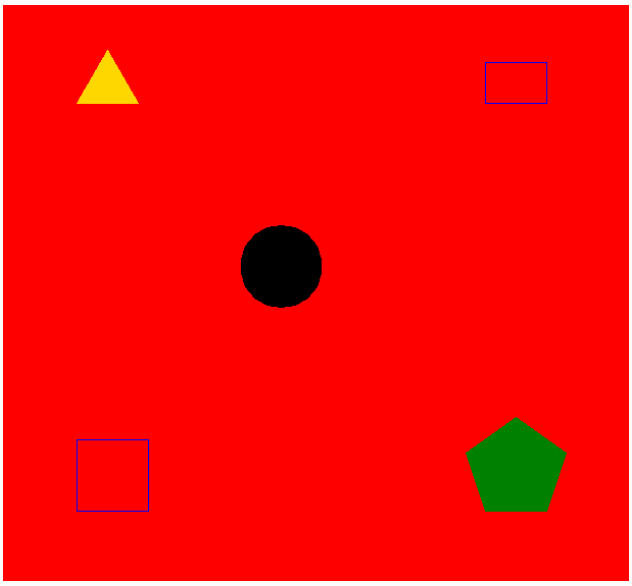


Rectangle, Circle, Pentagon, and Square using Class concept

```
#Example 19-5
import turtle
wn=turtle.Screen()
wn.setup(800,800)
wn.bgcolor('red')
wn.tracer(5)
class Polygons(turtle.Turtle):

    def __init__(self):
        super().__init__()
        self.hideturtle()

    def draw_circle(self,R,color):
        self.down()
        self.shape('circle')
        self.color(color)
        self.begin_fill()
        self.circle(R)
        self.end_fill()
        self.hideturtle()

    def draw_rectangle(self,X,Y,width,length,color):
        self.shape('turtle')
        self.up()
        self.goto(X,Y)
```

```
        self.down()
        self.color(color)
        for i in range(2):
            self.fd(width)
            self.left(90)
            self.fd(length)
            self.left(90)
        self.hideturtle()

    def draw_triangle(self,X,Y,side,color):
        self.shape('turtle')
        self.up()
        self.goto(X,Y)
        self.down()
        self.color(color)
        self.begin_fill()
        for i in range(3):
            self.fd(side)
            self.left(120)
        self.end_fill()
        self.hideturtle()

    def draw_pentagon(self,X,Y,side,color):
        self.shape('turtle')
        self.up()
        self.goto(X,Y)
        self.down()
        self.color(color)
        self.begin_fill()
        for i in range(5):
            self.fd(side)
            self.left(72)
        self.end_fill()
        self.hideturtle()

tcircle=Polygons()
tcircle.draw_circle(40,'black')
trectangle=Polygons()
trectangle.draw_rectangle(200,200,60,40,'blue')
trectangle.draw_rectangle(-200,-200,70,70,'blue')
ttriangle=Polygons()
trectangle.draw_triangle(-200,200,60,'gold')
trectangle.draw_pentagon(200,-200,60,'green')
```

Output result:

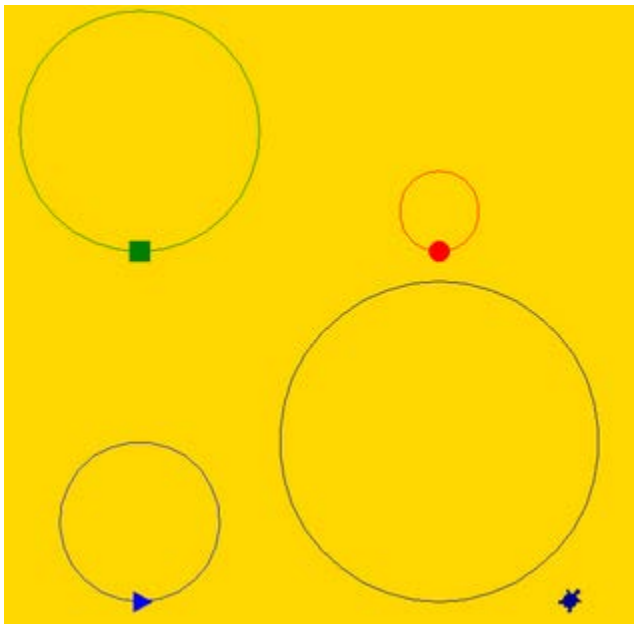


A few turtle shapes

```
#Example 19-6
import turtle
wn=turtle.Screen()
wn.setup(800,800)
wn.bgcolor('gold')


class Object(turtle.Turtle):
    def __init__(self,shape,X,Y,color):
        super().__init__()

        self.up()
        self.shape(shape)
        self.setposition(X,Y)
        self.down()
        self.color(color)

    def goo(self,distance,angle):
        self.fd(distance)
        self.left(angle)



object1=Object('circle',150,150,'red')
object2=Object('triangle',-150,-200,'blue')
object3=Object('square',-150,150,'green')
object4=Object('turtle',150,-200,'dark blue')
```

```
object1.circle(40)
object2.circle(80)
object3.circle(120)
object4.circle(160)
object4.up()
object4.goo(130,50)
```

Output:



Class function together with ondrag function

#Example 19-7

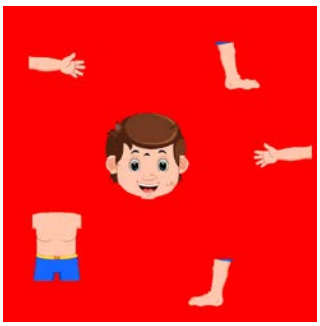
```
import turtle
wn=turtle.Screen()
wn.setup(800,800)
wn.bgcolor('red')
turtle.tracer(2)

class Boy(turtle.Turtle):

    def __init__(self,X,Y,image):
        super().__init__()
        wn.addshape(image)
        self.shape(image)
        self.up()
        self.goto(X,Y)
        self.down()

t=[0,0,0,0,0,0]
t[0]=Boy(0,0,'head_.gif')
t[1]=Boy(-200,-200,'body_.gif')
t[2]=Boy(200,200,'left_leg_.gif')
t[3]=Boy(140,-280,'right_leg_.gif')
t[4]=Boy(-200,200,'left_hand_.gif')
t[5]=Boy(300,0,'right_hand_.gif')

for m in range(1,6):
    t[m].up()
    t[m].ondrag(t[m].goto)
```

#Example 19-8

```
import turtle
wn=turtle.Screen()
wn.setup(800,800)
wn.bgcolor('red')

class Boy(turtle.Turtle):

    def __init__(self,X,Y,image):
        super().__init__()
        wn.addshape(image)
        self.shape(image)
        self.up()
        self.goto(X,Y)
        self.down()
```

```
t1=Boy(0,0,'head_.gif')
t2=Boy(-200,-200,'body_.gif')
t3=Boy(200,200,'left_leg_.gif')
t4=Boy(140,-280,'right_leg_.gif')
t5=Boy(-200,200,'left_hand_.gif')
t6=Boy(300,0,'right_hand_.gif')


def dragg(turtle, x, y):
    turtle.up()
    turtle.ondrag(None)  # disable ondrag event inside
drag_handler
    turtle.goto(x, y)
    turtle.ondrag(lambda x, y, turtle=turtle: dragg(turtle, x,
y))

t2.ondrag(lambda x, y: dragg(t2, x, y))
t3.ondrag(lambda x, y: dragg(t3, x, y))
t4.ondrag(lambda x, y: dragg(t4, x, y))
t5.ondrag(lambda x, y: dragg(t5, x, y))
t6.ondrag(lambda x, y: dragg(t6, x, y))
```

Result (Examples 19-7 and 19-8):



Games with Turtle Graphics

Apple Catcher (with onclick function)

```
import turtle
import random
import winsound # Import sound library

wn=turtle.Screen()
wn.setup(700,700)
wn.tracer(5)  #to make this process faster
wn.bgpic('Apple_Tree.gif')

turtle.hideturtle()
turtle.penup()

# Create apple Image
apple=turtle.Turtle()
image1='apple.gif'
wn.addshape(image1)
apple.shape(image1)

# Create bowl Image
bowl=turtle.Turtle()
image2='b.gif'
wn.addshape(image2)
bowl.shape(image2)
bowl.hideturtle()
bowl.penup()
bowl.goto(0,-300)
bowl.showturtle()

s=0
while True:
    apple.penup()
    a=random.randrange(-300,300)
    apple.goto(a,300)
    apple.showturtle()
    for i in range(240):
        apple.setheading(-90)
        apple.fd(2.5)
        position1=apple.position()
        position2=bowl.position()
        delta=abs(position1-position2)

        if delta <70:
            s=s+1
            apple.hideturtle()
            frequency=1000 #Sound
```

```
            duration=100  # Sound
            winsound.Beep(frequency,duration) # Sound

 # Score on the Screen with position (x=150, y=250)
 # Score number position x=230, y=250

            turtle.goto(150,250)
            turtle.clear()
            turtle.write ('Score=', font = ('Times New Roman',\
                                            20, 'bold'))

            turtle.goto(230,250)
            turtle.write (s, font = ('Times New Roman', 20, 'bold'))
            apple.goto(a,300)

        wn.onclick(bowl.goto)# Control of the bowl position
```

Apples (two) Catcher with onkey function

```
import turtle,random,time
import winsound # Import sound library

# Create Screen
wn=turtle.Screen()
wn.setup(700,700)
wn.tracer(5)  # make this process faster
wn.bgpic('Apple_Tree.gif')

score=turtle.Turtle()
score.hideturtle()
score.up()
score.color('blue')

def scr():
    score.goto(150,250)
    score.clear()
    score.write ('Score=', font = ('Times New Roman',\
                                    20, 'bold'))
    score.goto(230,250)
    score.write (s, font = ('Times New Roman', 20, 'bold'))

#_____________________________________________
# Create apple1 Image
apple1=turtle.Turtle()
image1='apple.gif'
wn.addshape(image1)
apple1.shape(image1)
```

```
# Create apple2 Image
apple2=turtle.Turtle()
image2='apple.gif'
wn.addshape(image2)
apple2.shape(image2)
apple2.up()

# Create bowl Image
bowl=turtle.Turtle()
image2='bowl.gif'
wn.addshape(image2)
bowl.shape(image2)
bowl.hideturtle()
bowl.penup()
bowl.goto(0,-300)
bowl.showturtle()

def left():
    bowl.fd(-50)
def right():
    bowl.fd(50)

turtle.onkey(left,"Left")
turtle.onkey(right, "Right")
turtle.listen()

s=0
def apple(turtle,rand):
    turtle.hideturtle()
    turtle.penup()
    turtle.setheading(-90)
    rand=random.randrange(-300,300)
    turtle.goto(rand,300)

delta1=1000
delta2=1000

def condition(turtle,delta):
    global s
    turtle.showturtle()
    turtle.fd(1)

    if turtle.ycor()<-300:
        turtle.hideturtle()
        turtle.goto(random.randrange(-300,300),300)
        turtle.showturtle()
    if delta <70:
        s=s+1
        turtle.hideturtle()
        frequency=1000 #Sound
        duration=100  # Sound
```

```
        winsound.Beep(frequency,duration) # Sound
        turtle.goto(random.randrange(-300,300),300)
        scr()
apple(apple1,random.randrange(-300,300))
apple(apple2,random.randrange(-300,300))

while True:
    delta1=abs(apple1.position()-bowl.position())
    delta2=abs(apple2.position()-bowl.position())
    condition(apple1,delta1)
    condition(apple2,delta2)
```

Gif images used in the game Apples Catcher can be download to a computer from the site:

https://github.com/victenna/Apple-Game

TIC-TAC-TOE

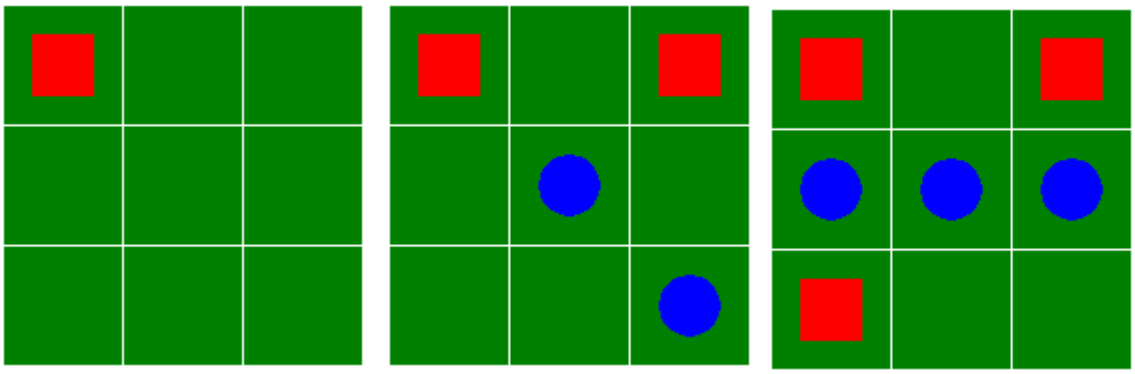
```
import turtle
import time
t1=turtle.Turtle('square')
wn=turtle.Screen()
wn.setup(500,500)

t1.shapesize(2.9)
t1.color('green')
t1.penup()
t1.hideturtle()
t1.goto(0,0)
t1.showturtle()
t1.goto(-100,100)

t1.speed(10)
def grid():
    for m in range(3):
```

```
        for n in range (3):
                t1.goto(-100+60*n,100-60*m)
                t1.stamp()
grid()
reference=[(-100,100),(-40,100),(20,100),(-100,40),(-40,40),(20,40)\
          ,(-100,-20),(-40,-20),(20,-20)]
delta=[100,100,100,100,100,100,100,100,100]

q=-1
t=turtle.Turtle('square')
t.shapesize(1.5)
t.hideturtle()
t.speed(10)

crs=[0,0,0,0,0,0,0,0,0]
circ=[0,0,0,0,0,0,0,0,0]
z=[0,0,0,0,0,0,0,0,0]


def loopp():
    for u in range(9):
        crs[u]=0
        circ[u]=0
        z[u]=0


def h(x, y):
    sum=0
    global q
    #global zz

    t.penup()
    t.goto(x, y)
    q=q+1
    #print('q=',q)

    for s in range(9):
            if q%2==0:
                t.shape('square')
                t.shapesize(1.5)
                t.color('red')
            else:
                t.shape('circle')
                t.shapesize(1.5)
                t.color('blue')

            delta[s]= t.distance(reference[s])
            print(z[s])
            X0,Y0=t.position()
            if X0<-130 or X0>50 or Y0>130 or Y0<-50:
                exit()
```

```
            if delta[s]>40:
                t.hideturtle()
            if delta[s]<40 and z[s]==0:
                t.hideturtle()

                t.setposition(reference[s])
                t.showturtle()
                z[s]=1
                print('s=',s)
                #print('z[s]=',z[s])
                q1=q
                t.stamp()
                X,Y=t.position()

                for w in range(3):
                    if Y==(100-w*60):
                        if q%2==0:
                            crs[w]=crs[w]+X
                            if crs[w]==-120:
                                print('cross win')
                                time.sleep(2)
                                q=-1
                                grid()
                                loopp()
                        else:
                            circ[w]=circ[w]+X
                            if circ[w]==-120:
                                print('circle win')

                                time.sleep(2)
                                q=-1
                                grid()
                                loopp()

                for w1 in range(3):
                    if X==-(100-w1*60):
                        if q%2==0:
                            crs[3+w1]=crs[3+w1]+Y
                            if crs[3+w1]==120:
                                print('cross win')
                                time.sleep(2)
                                q=-1
                                grid()
                                loopp()
                        else:
                            circ[3+w1]=circ[3+w1]+Y
                            if circ[3+w1]==120:
                                print('circle win')
                                time.sleep(2)
                                q=-1
```

```
                                grid()
                                loopp()

                if (X==-100 and Y==100) or (X==-40 and Y==40) or
(X==20 and Y==-20):
                    if q%2==0:
                        crs[6]=crs[6]+Y
                        if crs[6]==120:
                            print('cross win')
                            time.sleep(2)
                            q=-1
                            grid()
                            loopp()
                    else:
                        circ[6]=circ[6]+Y
                        if circ[6]==120:
                            print('circle win')
                            time.sleep(2)
                            q=-1
                            grid()
                            loopp()

                if (X==-100 and Y==-20) or (X==-40 and Y==40) or
(X==20 and Y==100):
                    if q%2==0:
                        crs[7]=crs[7]+Y
                        if crs[7]==120:
                            print('cross win')
                            time.sleep(2)
                            q=-1
                            grid()
                            loopp()
                    else:
                        circ[7]=circ[7]+Y
                        if circ[7]==120:
                            print('circle win')
                            time.sleep(2)
                            q=-1
                            grid()
                            loopp()

    for s in range (9):
        sum=sum+z[s]
    print('sum=',sum)
    if sum==9:

        print('q=',q)
        print('Draw')
        time.sleep(2)
        q=-1
        grid()
```

```
        loopp()
wn.onclick(h)
```

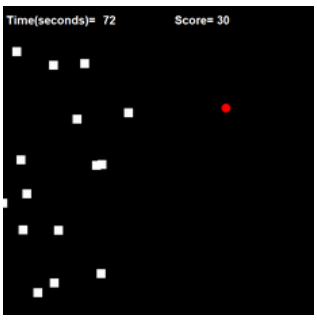


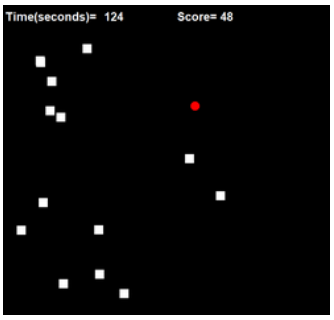
Ball eats squares

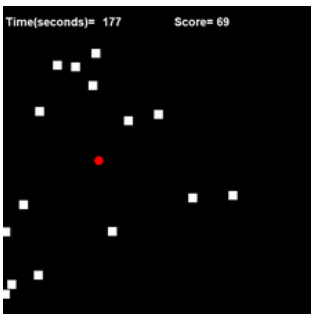
```
import turtle
import time
import random
TEXT_FONT = ('Arial', 50, 'bold')
SCORE_FONT = ('Arial', 20, 'bold')
TIME_FONT = ('Arial', 20, 'bold')
wn=turtle.Screen()
wn.setup(800,800)
wn.tracer(33)
wn.update()
wn.bgcolor('yellow')
text_turtle = turtle.Turtle()
text_turtle.write('Press SPACE to start', align='center',
font=TEXT_FONT)
time.sleep(5)
wn.clear()
wn.bgcolor('black')
wn.tracer(3)
t0=turtle.Turtle('circle')
t0.shapesize(1)
t0.up()
t0.color('red')
q=[]
q1=[]
q.append(t0)
q[0].goto(-350,-40)
q1.append(0)
q1[0]=q[0].position()

for n in range(1,20):
    t1=turtle.Turtle('square')
```

```
    t1.shapesize(1)
    t1.color('white')
    t1.penup()
    t1.speed(2)
    #print(n)
    q.append(t1)
    q[n].penup()
    q[n].goto(random.randint(-300,300),random.randint(-300,300))
    q1.append(0)
    q1[n]=q[n].position()
    q[n].showturtle()

def jump_up():
        q[0].speed(1)
        y=q[0].ycor()
        y =y+20
        q[0].sety(y)
def jump_down():
        q[0].speed(1)
        y =q[0].ycor()
        y =y-20
        q[0].sety(y)
def jump_right():
        q[0].speed(1)
        x=q[0].xcor()
        x =x+20
        q[0].setx(x)
def jump_left():
        q[0].speed(1)
        x =q[0].xcor()
        x =x-20
        q[0].setx(x)
def score_number():
    score_turtle.clear()
    score_turtle.hideturtle()
    score_turtle.up()
    score_turtle.setposition(10,330)
    score_turtle.write('Score=', font=SCORE_FONT)
    score_turtle.setposition(110,330)
    score_turtle.write(score, font=SCORE_FONT)
def time_number():
    time_turtle.clear()
    time_turtle.hideturtle()
    time_turtle.up()
    time_turtle.setposition(-390,330)
    time_turtle.write('Time(seconds)=', font=TIME_FONT)
    time_turtle.setposition(-160,330)
    time_turtle.write((delta_t), font=TIME_FONT)
def start_game():
    wn.onkey(None, 'space')  # can't restart currently
    text_turtle.clear()
```

```
    score = 0
    score_number()
    delta_t=0
    time_number()
score_turtle=turtle.Turtle()
score_turtle.color('white')
score_turtle.hideturtle()
time_turtle=turtle.Turtle()
time_turtle.color('white')
time_turtle.hideturtle()
text_turtle = turtle.Turtle()
text_turtle.write('Press SPACE to start', align='center',
font=TEXT_FONT)
turtle.listen()
wn.onkey(start_game, 'space')
turtle.onkey(jump_up, "Up")
turtle.onkey(jump_down, "Down")
turtle.onkey(jump_left, "Left")
turtle.onkey(jump_right, "Right")
score=0
delta_t=0
then = round(time.time()) #Time before the operations start
while True:
    for s in range(1,20):
            q[s].fd(-3)
            if q[s].xcor()<-400:
                q[s].hideturtle()
                q[s].goto(q1[s])
                q[s].showturtle()
            dist=t0.distance(q[s].xcor(),q[s].ycor())
            if dist<25:
                q[s].hideturtle()
                q[s].goto(random.randint(-300,300),random.randint(-
300,300))
                score=score+1
                score_number()
                now =round( time.time()) #Time after it finished
                delta_t=now-then
                time_number()
    if score==150:
        print("It took: ", now-then, " seconds")
```



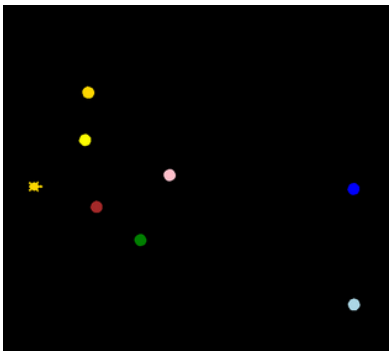
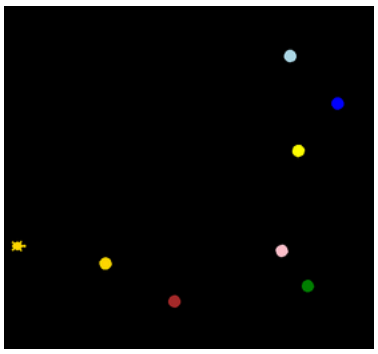
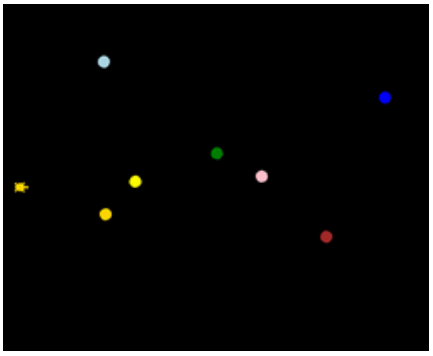




Turtle and Balls

```
import turtle
import random
import time
t1=turtle.Turtle('turtle')
t1.hideturtle()
t1.up()
t1.goto(-400,25)
t1.color('gold')
t1.showturtle()

wn=turtle.Screen()
wn.setup(1000,1000)
wn.bgcolor('black')

turtle.tracer(40)
p=[]


def left():
    global tX
    global tY
    t1.speed(10)
    t1.setheading(180)
    t1.forward(10)
    tX=t1.xcor()
    tY=t1.ycor()

def right():
    global tX
    global tY
    t1.speed(10)
    t1.setheading(0)
    t1.forward(10)
    tX=t1.xcor()
    tY=t1.ycor()

def up():
    global tX
    global tY
```

```
    t1.speed(10)
    t1.setheading(90)
    t1.forward(10)
    tX=t1.xcor()
    tY=t1.ycor()

def down():
    global tX
    global tY
    t1.speed(10)
    t1.setheading(-90)
    t1.forward(10)
    tX=t1.xcor()
    tY=t1.ycor()

wn.listen()

wn.onkey(left, 'Left')
wn.onkey(right, 'Right')
wn.onkey(up, 'Up')
wn.onkey(down, 'Down')

clr=['red','pink','green','brown','yellow','gold','blue','light
blue']
for n in range(8):
    p.append(turtle.Turtle('circle'))
    p[n].hideturtle()
    p[n].up()
    p[n].shapesize(1)
    p[n].color(clr[n])
    if n==0:
        p[n].color('black')
    p[n].goto(0,-50*n)
    p[n].showturtle()

while True:
    for m in range (8):
        p[m].circle(50*m,random.randint(1,10))
        p1=turtle.distance(p[m])
        pX=p[m].xcor()
        pY=p[m].ycor()
        dist=abs(t1.distance(pX,pY))
        if dist<25:
            t1.goto(-400,25)
            t1.setheading(0)

        time.sleep(0.005)
#wn.exitonclick()
```

Turtle is eating balls

```
import turtle
import time
import random
wn=turtle.Screen()
wn.bgcolor('lightblue')
turtle.tracer(3)
t1=turtle.Turtle('turtle')
t1.shapesize(2)
t1.color('red')
t1.speed(2)
t1.penup()
t1.goto(-300,0)
q=[]
q1=[0,0,0,0,0]

for i in range (5):
        c=random.randint(50,200)
        c1=random.randint(1,5)
        t=turtle.Turtle('circle')
        t.shapesize(2)
        t.speed(0)
        q.append(t)
        q[i].penup()
        q[i].goto(100*(i-1),c)
        q1[i]=q[i].position()
        q[i].setheading(-90)
        q[i].color('black')
        q[i].showturtle()

k1=0
def motion(ang):
    global k1
    t1.goto(-300,0)
    t1.setheading(ang)

    for j in range(601):
        k1=k1+1
        #print(k1)
```

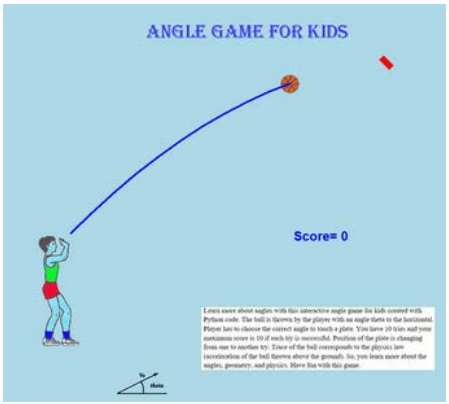
```
        if k1<601:
            t1.fd(1)
            a1=t1.position()
            for m in range(5):
                if j==0:
                    q1[m]=q[m].position()
                q[m].fd(0.4)#+0.04*m)
                a2=q[m].position()
                dist=abs(a1-a2)
                if dist<40:
                    q[m].hideturtle()
        if k1==599:
            t1.goto(-300,0)
            a1=t1.position()
            for m in range(5):
                print(q1[m])
                q[m].goto(q1[m])
                #print(q1[5])
                k1=0
for k in range (10):
    t1.penup()
    t1.goto(-300,0)
    a1=input ('Please,input turtle angle?')
    b1=int(a1)
    t1.setheading(b1)
    motion(b1)
```

Basketball shots

```
import turtle
import time
import math,random
#turtle.tracer(2)
t1=turtle.Turtle()
wn=turtle.Screen()
wn.setup(1000,900)
wn.bgcolor('light blue')

# box around a player
t5=turtle.Turtle()
t5.up()
t5.pensize(15)
t5.goto(-450,-318)
t5.down()
#t5.color('blue')
t5.goto(200,-318)

#player image
image1='player.gif'
wn.addshape(image1)
t1.shape(image1)
```

```
t1.up()
t1.goto(-350,-200)

#ball image
t2=turtle.Turtle()
image2='ball.gif'
wn.addshape(image2)
t2.shape(image2)
t2.up()
t2.pencolor('blue')
t2.goto(-325,-77)
#t2.showturtle()

#basket image
t3=turtle.Turtle()
image3='basket.gif'
wn.addshape(image3)
t3.shape(image3)
t3.up()
t3.goto(320,220)

#vector image
t6=turtle.Turtle()
image6='vector.gif'
wn.addshape(image6)
t6.shape(image6)
t6.up()
t6.goto(-160,-400)

# reflecting plate psition
t4=turtle.Turtle('square')
t4.shapesize(0.3,6.5)
t4.color('red')
t4.up()
t4.goto(355,305)
t4.setheading(-65)

t1.speed(0)
t2.speed(0)

pi=math.pi
g=9.81
delta=0.15

for q in range (20):
    time.sleep(0.01)
    t2.showturtle()
    t=0
    eps=0
    #eps=50*q
    t1.goto(-350+eps,-200)
```

```
    t2.goto(-325+eps,-77)

    Vo=float(wn.textinput('Basketball Shooting Drills','Enter initial
velocity Vo'))
    theta=float(wn.textinput('Basketball Shooting Drills','Enter
angle theta'))

    Vox=Vo*math.cos(pi*theta/180)
    Voy=Vo*math.sin(pi*theta/180)
    t2.setheading(theta)
    D=400
    for i in range (150):

        if D>50:
            i1=i
            X=Vox*t
            Y=Voy*t-g*t*t/2
            time.sleep(0.01)
            t=t+delta
            DX=t2.xcor()-t3.xcor()
            DY=t2.ycor()-(t3.ycor()+90)
            D=int(math.sqrt(DX*DX+DY*DY))
            t2.setposition(X-325+eps,Y-77)

        if D<=50:
            time.sleep(0.01)
            t=t+5*delta
            t2.setheading(-90)
            t2.fd(t)
```



Gif images used in the program **Basketball shots** can be download to a computer from the site:

https://github.com/victenna/Basketball-drills

Math and Physics Applications with Turtle Graphics

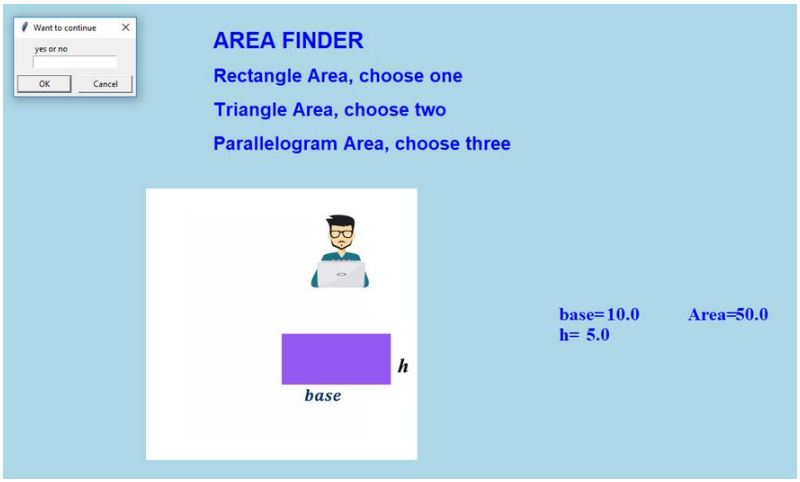
Area finder: Rectangle, Triangle, Parallelogram

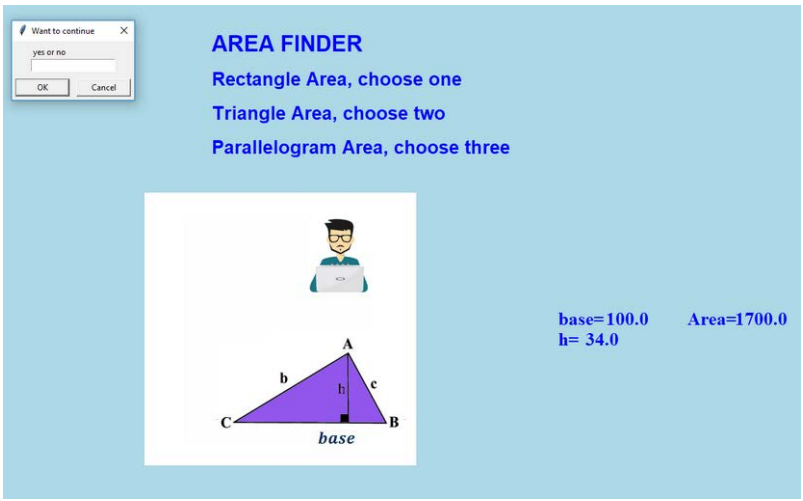
```
import turtle,time
turtle.hideturtle()
t1=turtle.Turtle()
t1.hideturtle()
t2=turtle.Turtle()
t2.hideturtle()
wn=turtle.Screen()
wn.setup(1300,1000)
turtle.bgcolor('light blue')
text=turtle.Turtle()
text.color('blue')
text.hideturtle()
text.up()
text.goto(-300,400)
TEXT_FONT=('Arial',25,'bold')
text.write('AREA FINDER', font=TEXT_FONT)
TEXT_FONT=('Arial',20,'bold')
text.goto(-300,350)
text.write('Rectangle Area, choose one', font=TEXT_FONT)
text.goto(-300,300)
text.write('Triangle Area, choose two', font=TEXT_FONT)
text.goto(-300,250)
text.write('Parallelogram Area, choose three', font=TEXT_FONT)


image1=('rectangle.gif')
image2=('triangle.gif')
image3=('para_gram.gif') #down load image parallelogram from internet
to your computer (the same directory, where youe execute file)

def img(image):

    wn.addshape(image)
    t1.shape(image)

t1.up()
t1.goto(-200,0)
t1.showturtle()

def triangle():
    global base
    global h
    global Area
    base=float(wn.textinput('Triangle Area','Base='))
    h = float(wn.textinput('Triangle Area','Height='))
```

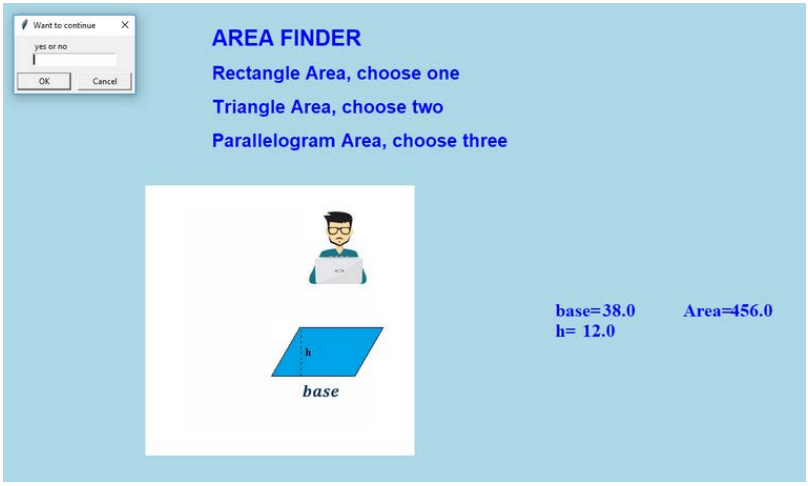
```
    Area=base*h/2
    print(Area)
    turtle.clear()

def rectangle():
    global base
    global h
    global Area
    base = float(wn.textinput('Rectangle Area','Base='))
    h = float(wn.textinput('Rectangle Area','Height='))
    Area=base*h
    print(Area)
    turtle.clear()


def parall_m():

    global base
    global h
    global Area
    base = float(wn.textinput('Parallelogram Area','Base='))
    h = float(wn.textinput('Parallelogram Area','Height='))
    Area=base*h
    print(Area)
    turtle.clear()

def spec(X1,Y1, X2,Y2, Z,str_name):

    turtle.up()
    turtle.color('blue')
    turtle.goto(X1,Y1)
    turtle.down()
    turtle.write(str_name,font=('Times New Roman',20,'bold'))
    turtle.up()
    turtle.goto(X2,Y2)
    turtle.write(Z, font=('Times New Roman',20,'bold'))

answer=wn.textinput('Choose Area number','one or two or three')
if answer=='one':
    t1.clear()
    img(image1)
    rectangle()
if answer=='two':
    t1.clear()
    img(image2)
    triangle()
if answer=='three':
    t1.clear()
    img(image3)
    parall_m()
```

```
spec(210,0,280,0,base,'base=')

spec(210,-30,250,-30,h,'h=')
spec(400,0,470,0,Area,'Area=')

while True:

    answer=wn.textinput('Want to continue','yes or no')


    if answer=='yes':
        turtle.clear()

        answer=wn.textinput('Choose Area number','one or two or
three')
        if answer=='one':
            t1.clear()
            img(image1)
            rectangle()
        if answer=='two':
            t1.clear()
            img(image2)
            triangle()
        if answer=='three':
            t1.clear()
            img(image3)
            parall_m()
        turtle.clear()

        spec(210,0,280,0,base,'base=')
        spec(210,-30,250,-30,h,'h=')
        spec(400,0,470,0,Area,'Area=')

    if answer=='no':
         turtle.clear()
         t1.hideturtle()
         t2.clear()

         print("CALCULATION OVER")
         turtle.color('red')
         turtle.hideturtle()
         turtle.goto(-200,0)
         turtle.write('THE END', font=('Times New Roman',105,'bold'))
         time.sleep(5)
         break
```

Result:







Images for this code can be download to a computer from the site:

https://github.com/victenna/Math

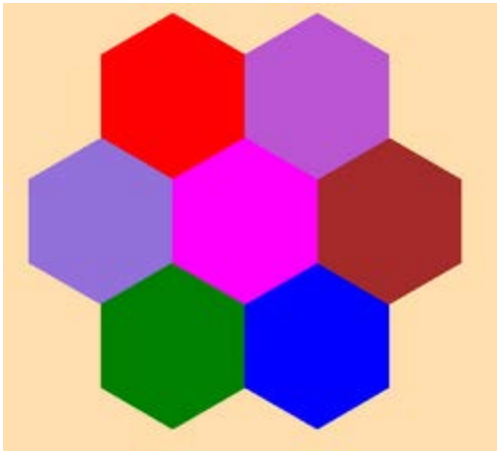
Tiles drawing: hexagons and pentagons

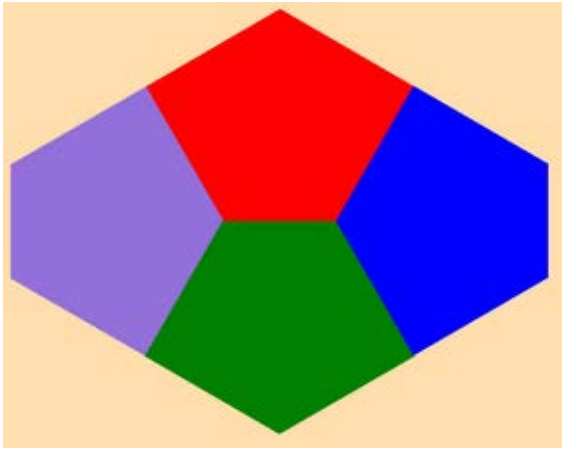
```
#Hexagon Tiles
import turtle
turtle.tracer(2)
turtle.bgcolor('navajo white')
t=turtle.Turtle('turtle')
t.hideturtle()
t.pensize(1)
length=100

t.up()
t.goto(0,0)
t.down()

clr=['red','medium purple','green','blue','brown','medium
orchid','magenta']

for m in range(7):
    t.color(clr[m])
    t.setheading(150+m*60)
    if m==6:
        t.setheading(150)
    t.up()
    t.goto(0,0)
    t.fd(length)
    if m==6:
        t.goto(0,-length)
    t.down()
    t.begin_fill()
    for i in range(6):
        t.fd(length)
        t.right(60)
    t.end_fill()
```

```
#Pentagon Tiles
import turtle,time
#turtle.tracer(5)
turtle.bgcolor('navajo white')
t=turtle.Turtle('turtle')
t.hideturtle()
t.pensize(1)
length=200
a=1-0.27
t.up()
t.goto(100,200)
t.down()
```

```
clr=['red','medium purple','green','blue','brown','medium
orchid','magenta']

def
tile(length1,length2,length3,length4,length5,ang1,ang2,ang3,ang4,colo
r):
        t.color(color)
        t.begin_fill()
        t.fd(length1)
        t.lt(ang1)
        t.fd(length2)
        t.lt(ang2)
        t.fd(length3)
        t.lt(ang3)
        t.fd(length4)
        t.lt(ang4)
        t.fd(length5)
        t.end_fill()

t.setheading(0)
tile((length*a),length,length,length,length,60,90,60,90,clr[0])

t.left(180)
tile(length,length,length*a,length,length,90,60,60,90,clr[1])

t.setheading(0)
tile(length*a,length,length,length,length,-60,-90,-60,-90,clr[2])

t.rt(60)
t.fd(length*a)
t.lt(60)
tile(length,length,length*a,length,length,-90,-60,-60,-90,clr[3])
```

The display resulting from these programs(hexagon and pentagon tiles) is:

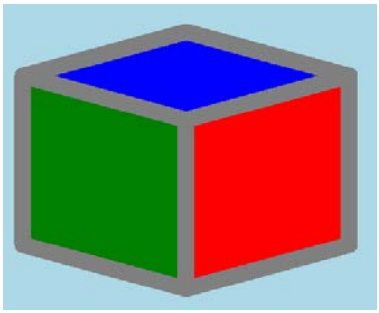




Cube

```
import turtle

turtle.bgcolor('light blue')
t=turtle.Turtle('turtle')

t.pensize(20)
length=200
height=100

t.setheading(15)
t.color('gray','blue')
t.begin_fill()
for i in range(2):
    t.fd(length)
    t.right(30)
    t.fd(length)
    t.rt(150)
t.end_fill()

t.setheading(-90)
t.color('gray','green')
t.begin_fill()
t.fd(length)
t.lt(75)
t.fd(length)
t.lt(105)
t.fd(length)

t.lt(75)
t.fd(length)
t.end_fill()
t.back(length)
t.rt(150)

t.color('gray','red')
t.begin_fill()

t.fd(length)
t.rt(105)
t.fd(length)
t.rt(75)
t.fd(length)
t.rt(105)
t.fd(length)
t.end_fill()

t.hideturtle()
```

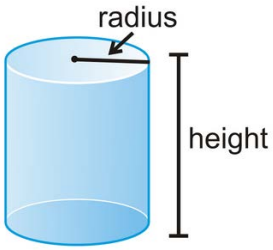
The display resulting from this program is:



Cylinder: Volume and Surface Area

```
import turtle,time
import math
t=turtle.Turtle()
wn=turtle.Screen()
image='cylinder.gif'
wn.addshape(image)
t.shape(image)
t1=turtle.Turtle()
t1.up()
t1.hideturtle()
Text_font=('Arial',20,'bold')
pi=math.pi
for s in range (10):
    height=float(wn.textinput('Cube volume','Height of cylinder: '))
    radius=float(wn.textinput('Cube volume','Radius of cylinder: '))
    volume = height*pi * radius**2
    sur_area = 2*pi*radius * height + 2*pi*radius**2
    t1.goto(-300,-350)
    t1.color('blue')
    t1.write('Volume=',font=Text_font)
    t1.goto(-150,-350)
    t1.write(round(volume,1),font=Text_font)
    t1.goto(0,-350)
    t1.write('Surface Area=',font=Text_font)
    t1.goto(200,-350)
    t1.write(round(sur_area,1),font=Text_font)
    time.sleep(3)
    t1.clear()
wn.bye()
```

Result:



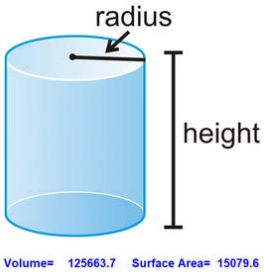


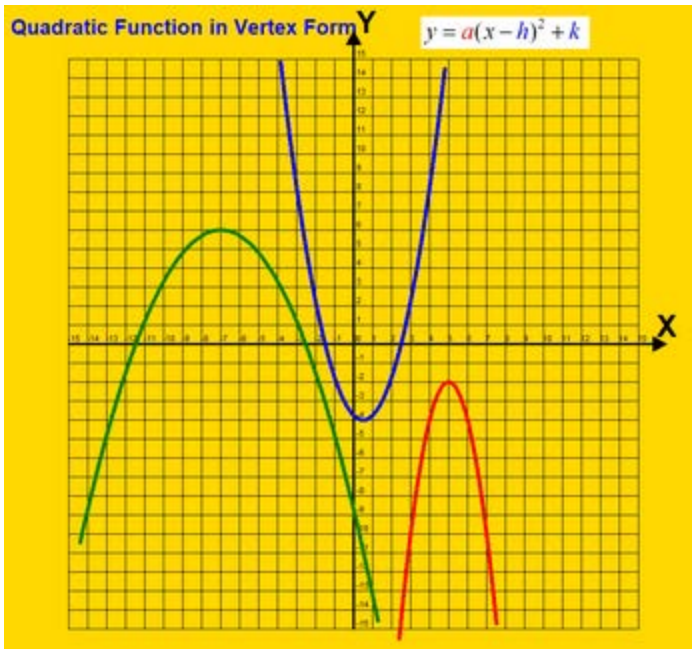
Image for this code can be download to a computer from the site:

https://github.com/victenna/Math

Quadratic Function in Vertex Form

```
import turtle,time
import grid_module1      #Grid_module1 is shown below
#from grid_module1 import GRIDS
wn=turtle.Screen()
wn.setup(950,900)
wn.tracer(10)
t1=turtle.Turtle()
t1.setheading(0)
t1.pensize(5)
t1.hideturtle()
t1.up()
r=-1
clr=['blue','red','green']
while True:
    def shift(a,h,k):
        #global X,Y
        #A=40/Q
        X1=-400
        Y1=a*(X1-h)*(X1-h)+k
        t1.up()
        t1.setposition(X1,Y1)
        deltax=2

        for q in range(0,400):
```

```
            X=(X1+q*deltax)
            Y=a/25*(X-25*h)*(X-25*h)+25*k
            if abs(Y)<370 and abs(X)<360:

                #print(Y)
                t1.down()
            else:
                t1.up()
            t1.setposition(X,Y)
    r=r+1
    r1=r%3
    a1=float(wn.textinput('Quadratic Function','Enter value a'))
    h1=float(wn.textinput('Quadratic Function','Enter value h'))
    k1=float(wn.textinput('Quadratic Function','Enter value k'))
    print(k1)
    t1.color(clr[r1])
    shift(a1,h1,k1)
    if r1==2:
        time.sleep(4)
        t1.clear()
```



Images for this code can be download to a computer from the site:

https://github.com/victenna/Quadratic-function

Grid _module1 file for code (**Quadratic Function in Vertex Form**):

```
import turtle
wn=turtle.Screen()
wn.setup(900,900)
wn.bgcolor('gold')
turtle.tracer(2)
t2=turtle.Turtle()
t2.hideturtle()
t2.up()
Text_font=('Arial',20,'bold')
Text_font1=('Arial',10,'bold')
t2.goto(-450,400)
t2.color('blue')
t2.write('Quadratic Function in Vertex Form', font=Text_font)
t2.up()
image='function.gif'
wn.addshape(image)
t2.shape(image)
t2.goto(200,410)
t2.showturtle()
def GRIDS():
    tgrid=turtle.Turtle('triangle')
    tgrid.up()
    tgrid.hideturtle()
    tgrid.speed(0)
    tgrid.pensize(1)
    box=25
    A=15
    B=16
    def grid(dir,a,b,c,d):

         for j in range (-A,B):
              tgrid.setheading(dir)
              tgrid.penup()
              tgrid.goto(a*box*j-A*box*b,-box*A*c+box*j*d)
              tgrid.pendown()
              if j==0:
                   tgrid.pensize(3)
                   tgrid.fd(2*box*(A+0.5))
                   tgrid.stamp()
                   tgrid.fd(-2*box*(A+0.5))
              tgrid.pensize(1)
              tgrid.fd(2*box*A)
    grid(90,1,0,1,0)
    grid(0,0,1,0,1)

    txy=turtle.Turtle()
    txy.hideturtle()
    txy.goto(-A*box,0)
```

```
    def numbers(axis):
        for i in range (-A,B):
            txy.write(i)
            txy.fd(box)
            if i==A:
                txy.write(axis,font=('Arial',30,'bold'))
    numbers('X')
    txy.penup()
    txy.goto(5,-A*box)
    txy.setheading(90)
    numbers('Y')
GRIDS()
```

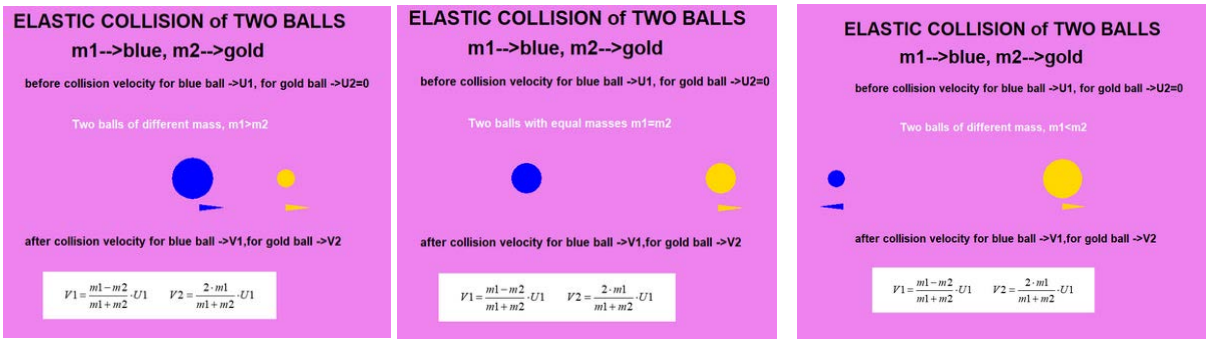
Ellasic Collision of two Balls

```
import turtle,time
wn=turtle.Screen()
wn.bgcolor('violet')
#turtle.tracer(3)
turtle.tracer(2)

t1=turtle.Turtle('circle')
t1.color('blue')
t1.hideturtle()
t1.up()

t2=turtle.Turtle('circle')
t2.color('gold')
t2.hideturtle()
t2.up()


t3=turtle.Turtle('arrow')
t3.hideturtle()
t3.up()
t3.color('blue')
t3.shapesize(0.5,4)

t4=turtle.Turtle('arrow')
t4.hideturtle()
t4.up()
t4.color('gold')
t4.shapesize(0.5,4)

t5=turtle.Turtle()
t5.hideturtle()
t5.up()
t5.goto(0,-200)
image='Equation.gif'
wn.addshape(image)
```

```
t5.shape(image)
t5.showturtle()

#-----------------------------------------------

#TEXT

TEXT_FONT=('Arial',15,'bold')
text_main=turtle.Turtle()
text_main.color('black')
text_main.hideturtle()
text_main.up()
text_main.setposition(-250,250)
text_main.write('ELASTIC COLLISION of TWO BALLS',
font=('Arial',25,'bold'))
text_main.up()
text_main.setposition(-150,200)
text_main.write('m1-->blue, m2-->gold', font=('Arial',25,'bold'))

text_main.up()
text_main.setposition(-230,150)
text_main.write('before collision velocity for blue ball ->U1, \
for gold ball ->U2=0', font=('Arial',15,'bold'))

text_main.up()
text_main.setposition(-230,-120)
text_main.write('after collision velocity for blue ball ->V1,\
for gold ball ->V2', font=('Arial',15,'bold'))

#-----------------------------------------------
def collision(size1,size2,angle1,angle2,speed1,speed2,speed3):
    text1=turtle.Turtle()
    text1.hideturtle()
    text1.color('ghostwhite')
    text1.up()
    text1.clear()
    text1.setposition(-150,80)
    if speed1==0:
        text1.write('Two balls with equal masses m1=m2',\
                    font=('Arial',15,'bold'))
    if speed1==-3:
        text1.write('Two balls of different mass, m1<m2',\
                    font=('Arial',15,'bold'))

    if speed2==2:
        text1.write('Two balls of different mass, m1>m2',\
                    font=('Arial',15,'bold'))

    t1.goto(-300,0)
    t1.shapesize(size1)
    t1.showturtle()
```

```
    t2.goto(0,0)
    t2.shapesize(size2)
    t2.showturtle()

    t3.setheading(angle1)
    t3.goto(-300,-50)
    t3.showturtle()
    time.sleep(0.5)

    for i in range(62):
        t1.fd(4)
        t3.fd(4)
        time.sleep(0.01)
    t3.hideturtle()
    t3.setheading(angle2)
    t3.goto(-40,-50)
    t3.showturtle()

    t4.goto(0,-50)
    t4.showturtle()

    for i in range(280):
        t1.fd(speed1)
        t3.fd(speed2)
        if speed1==0:
            t3.hideturtle()
        t2.fd(speed3)
        t4.fd(speed3)
        time.sleep(0.01)

    time.sleep(0.5)
    t1.hideturtle()
    t2.hideturtle()
    t3.hideturtle()
    t4.hideturtle()
    text1.clear()

#-----------------------------------------------------------

while True:
    collision(2.5,2.5,0,0,0,0,4)
    collision(1.5,3.5,0,180,-3,3,2)
    collision(3.5,1.5,0,0,2,2,4)
```

Result:



Images for this code can be download to a computer from the site:

https://github.com/victenna/Physics/tree/master/Elastic%20Collision

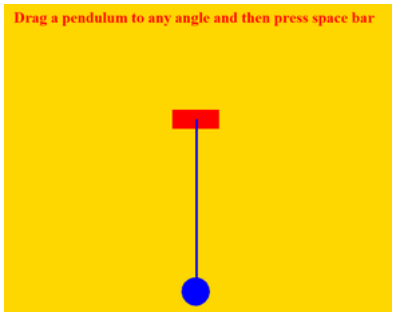
Pendulum Waves

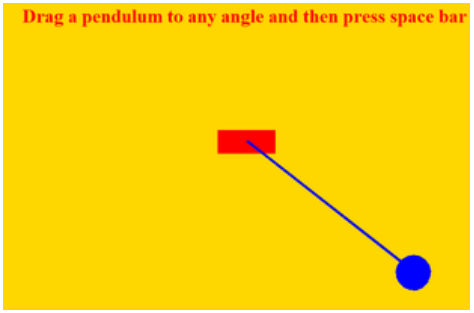
```
import turtle
import time
t1=turtle.Turtle()
wn=turtle.Screen()
wn.setup(1200,900)
wn.bgcolor('gold')
t1.hideturtle()
turtle.tracer(2)

t2=turtle.Turtle('turtle')
t2.hideturtle()
t2.color('blue')

t4=turtle.Turtle('square')
t4.shapesize(2,5)
t4.color('red')

t5=turtle.Turtle()
t5.up()
t5.hideturtle()
t5.goto(-390,200)
#t5.showturtle()
t5.color('red')
t5.write('Drag a pendulum to any angle and then press space bar',\
         font=('Times New Roman',25,'bold'))

t2.penup()
t2.hideturtle()
t2.goto(0,0)
t2.begin_poly()
```

```
t2.fd(400)
t2.left(90)
t2.circle(30.358)

t2.fd(4)
t2.left(90)
t2.fd(400)
t2.end_poly()

wn.register_shape('pend',t2.get_poly())

t3=turtle.Turtle(shape='pend')
t3.up()
t3.color('blue')
t3.showturtle()

def motion():
    global teta
    i=-1
    q=-1
    t3.setheading(teta)
    #time.sleep(3)
    while True:
        if teta>0 and teta<90:
        #print(teta)
            i=i+1
            i1=i%(2*teta+1)
            if i1==2*teta:
                q=-1*q
            #print(t3.heading())
            t3.left(q)
            time.sleep(0.02)

        if teta>300:
            teta1=360-teta
            print(teta1)
            i=i+1
            i1=i%(2*teta1+1)
            if i1==2*teta1:
                q=-1*q
            t3.right(q)
            time.sleep(0.02)


teta=0
def drag(x,y):
    #t3.ondrag(None)
    t3.setheading(0.2*x)
    global teta
    teta=t3.heading()
    teta=round(teta)
```

```
    #t3.ondrag(drag)
t3.ondrag(drag)

wn.onkey(motion,'space')
#print(q.heading())
wn.listen()
print(teta)
```

Result:





River Boat problem

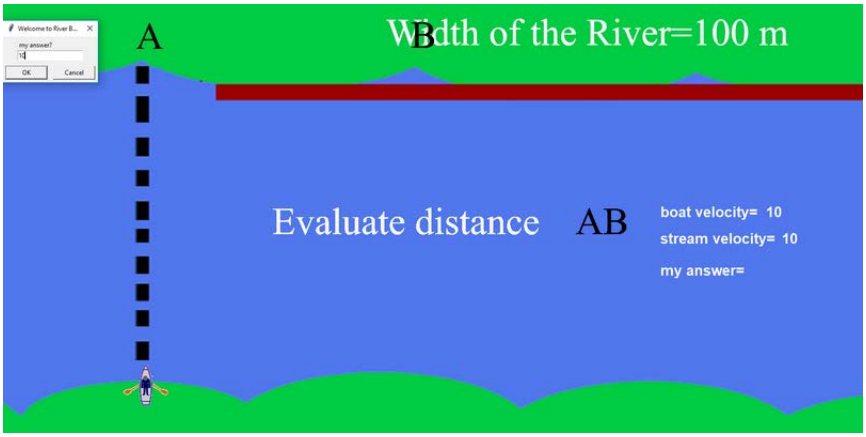
```
import turtle
import time
import math
wn=turtle.Screen()
wn.setup(1800,850)
wn.bgpic('riv1.gif')
turtle.tracer(2)

# Images for boat
image1='boat_1.gif'
image2='boat_2.gif'
image3='boat_3.gif'

#Turtle for boat image1
t1=turtle.Turtle('turtle')
t1.penup()
t1.hideturtle()
wn.addshape(image1)
t1.shape(image1)
t1.setposition(-580,-310)
t1.showturtle()
```

```
# Upper shore line position
t2X=-450
t2Y=250
t2=turtle.Turtle('turtle')
t2.hideturtle()
t2.pensize(5)
t2.penup()
t2.goto(-t2X,t2Y)
t2.goto(t2X,t2Y)

# Turtle of letter B and position of letter B
t4=turtle.Turtle('turtle')
image4='B.gif'
wn.addshape(image4)
t4.shape(image4)
t4.hideturtle()
t4.penup()

#Turtle of sentence AB, positition (0,0)
t5=turtle.Turtle('turtle')
image5='AB.gif'
wn.addshape(image5)
t5.shape(image5)
t5.hideturtle()
t5.penup()
TEXT_FONT=('Arial', 20,'bold')

#Velocity (boat and stream) and position of the text
velocity=turtle.Turtle()
velocity.color('white')
velocity.hideturtle()
velocity.up()

#Text answer and position of the text
answer=turtle.Turtle()
answer.color('white')
answer.hideturtle()
answer.up()
image=[image1,image2,image3]
q=-1

# Function for main boat motion
def motion():
    X=-580
    Y=-310
    q=-1
    running=True
    while running:
        q=q+1
        q1=q%3
        X=X+deltaX
```

```
        Y=Y+deltaY
        wn.addshape(image[q1])
        t1.shape(image[q1])
        time.sleep(0.1)
        t1.setposition(X,Y)
        Xcor=t1.xcor()
        Ycor=t1.ycor()
        dist=abs(Ycor-t2Y)
        if dist<40:
            t1.hideturtle()
            t1.goto(-580,-310)
            t1.showturtle()
            t4.setposition(Xcor,Ycor+130)
            t4.showturtle()
            t5.showturtle()
            time1=100/deltaY
            AB_distance=time1*deltaX
            answer.setposition(400,-110)
            answer.write('my answer=',font=TEXT_FONT)
            answer.setposition(580,-110)
            #my_answer=input('answer=')
            my_answer=wn.textinput("Welcome to River Boat Problem!",
\
                                   "my answer?")
            answer.write(my_answer,font=TEXT_FONT)
            answer.setposition(400,-160)
            answer.write('real answer=',font=TEXT_FONT)
            answer.setposition(580,-160)
            answer.write(round(AB_distance),font=TEXT_FONT)
            time.sleep(3)
            print(AB_distance)
            running=False

while True:
    activation = wn.textinput("Welcome to River Boat Problem!", \
                              "Are you ready?")
    if activation=='no':
        print("Goodbye!")
        #wn.clear()
        wn.bye()
    else:
        deltaY= wn.textinput('Welcome to River Boat Problem!', \
                             'Boat velocity')
        deltaY=int(deltaY)
        velocity.setposition(400,0)
        velocity.write('boat velocity=',font=TEXT_FONT)
        velocity.setposition(600,0)
        velocity.write(deltaY,font=TEXT_FONT)

        deltaX= wn.textinput('Welcome to River Boat Problem!', \
                             'Stream velocity')
```

```
        deltaX=int(deltaX)
        velocity.setposition(400,-50)
        velocity.write('stream velocity=',font=TEXT_FONT)
        velocity.setposition(630,-50)
        velocity.write(deltaX,font=TEXT_FONT)
        motion()
        running=True
    velocity.clear()
    answer.clear()
```

Static Fragment of the Result



Images for this code can be download to a computer from the site:

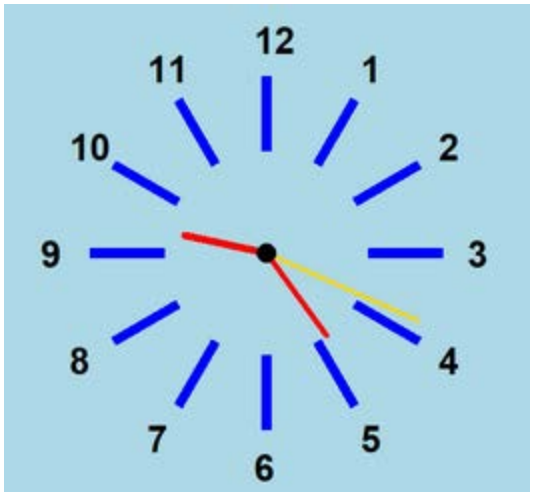
https://github.com/victenna/Physics/tree/master/River_Boat

Wall Clock

```
import turtle
wn=turtle.Screen()
wn.bgcolor("lightblue")
import time
turtle.tracer(2)

# Clock Face
```

```
TEXT_FONT=('Arial',30,'bold')
digit=turtle.Turtle()
digit.up()
digit.hideturtle()
digit.color('black')
digit.goto(-12,205)
#digit.write(12,font=TEXT_FONT)
for q in range (12):
    digit.circle(-230,30)
    digit.write(1+q,font=TEXT_FONT)
    #t0.stamp()


t0 = turtle.Turtle('square')
t0.up()
t0.color('blue')
t0.shapesize(4,0.5)
t0.goto(0,150)
t0.stamp()

for i in range (11):
    t0.circle(-150,30)
    t0.stamp()

#--------------------------------------
# Hour Hand
t1=turtle.Turtle('triangle')

t1.goto(0,0)
t1.color('red')
t1.pensize(8)
t1.hideturtle()
#--------------------------
# Minute Hand
t2=turtle.Turtle('triangle')
t2.goto(0,0)
t2.color('red')
t2.pensize(6)
t2.hideturtle()

#-------------------------
#Second Hand
t3=turtle.Turtle('square')
t3.color('gold')
t3.pensize(4)
t3.hideturtle()

def sec_angle(angle):
    t3.setheading(angle+90)
    t3.fd(180)
    t3.fd(-180)
```

```
    time.sleep(1)
    t3.clear()
#--------------------------------
#Point (0,0)
t4=turtle.Turtle('circle')

#----------------------------
while True:

    #Time
    time_hour=time.strftime("%H")
    time_min=time.strftime("%M")
    time_sec=time.strftime("%S")
    t_s=int(time_sec)
    t_h=int(time_hour)
    tt1=t_h%12 #round every 12 hourss
    angle_hour=tt1*30 #hour in degrees

    t_m=int(time_min)
    angle_minute=t_m*6 # minutes in degrees
    print('angle_minute=', angle_minute/6)
    print(t_h,t_m)
    angle_hour=angle_hour+angle_minute/12
    print('angle_hour=', angle_hour)

    #Hour arrow
    t1.setheading(-angle_hour+90)
    t1.fd(90)
    t1.fd(-90)
    #---------------------------------------
    #Minute Arrow
    t2.setheading(-angle_minute+90)
    t2.fd(110)
    t2.fd(-110)

    #--------------------
    m=0
    #Second Arrow
    for m in range (60):
        sec_angle(-6*m)
        if m==59:
            t1.clear()
            t2.clear()

    #Central point
    t4.goto(0,0)
```



Flight to the Moon

```
import turtle,time
import winsound
wn=turtle.Screen()
t=turtle.Turtle()
t.hideturtle()
t.up()
turtle.tracer(2)
wn.setup(900,900)

#Moon Sky
wn.bgpic('moon3.gif')
turtle.bgcolor('black')

#Astronaut1
image1=['ast11.gif','ast12.gif','ast11_m.gif','ast12_m.gif']
ast1=turtle.Turtle()
ast1.up()
ast1.goto(-250,-240)
wn.addshape('ast11.gif')
wn.addshape('ast12.gif')
wn.addshape('ast11_m.gif')
wn.addshape('ast12_m.gif')
ast1.shape('ast11.gif')

#_____________________Atronaut2 is standing
ast2=turtle.Turtle()
```

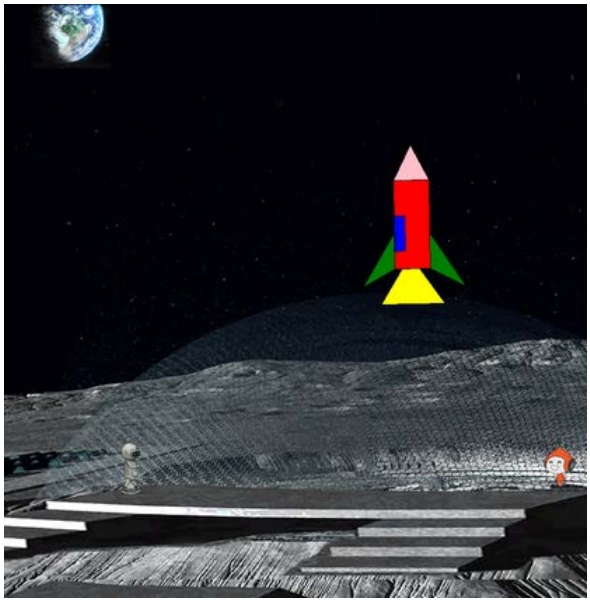
```
ast2.up()
ast2.goto(390,-240)
wn.addshape('ast2.gif')
ast2.shape('ast2.gif')
#_____________________________________

#____________Astronaut3 Comes out of the Shuttle
image3=['ast31.gif','ast32.gif','ast33.gif','ast34.gif','ast35.gif']
ast3=turtle.Turtle()
ast3.hideturtle()
for i in range (4):
    wn.addshape(image3[i])


s = turtle.Shape("compound")

#Space Shuttle
poly1=((0,0),(25,0),(25,10),(0,10))
poly2=((25,0),(35,5),(25,10))
poly3=((0,10),(-5,19),(10,10))
poly4=((0,0),(-5,-10),(10,0))
#poly5=((5,2),(15,2),(15,5),(5,5))
poly5=((5,7),(15,7),(15,10),(5,10))
poly6=((0,3),(-10,-4),(-10,14),(0,8))

s.addcomponent(poly1,'red','black')
s.addcomponent(poly2,'pink','black')
s.addcomponent(poly3,'green','black')
s.addcomponent(poly4,'green','black')
s.addcomponent(poly5,'blue','black')

wn.addshape('roket',s)

Roket=turtle.Turtle(shape='roket')
Roket.penup()
Roket.hideturtle()
Roket.tilt(90)

Roket.setheading(90)
Roket.hideturtle()


s.addcomponent(poly6,'yellow','black')

wn.addshape('roket1',s)
Roket1=turtle.Turtle(shape='roket1')
Roket1.hideturtle()
Roket1.up()
Roket1.shapesize(0.1)
Roket1.tilt(90)
Roket1.hideturtle()
```

```
Roket1.goto(400,400)
Roket1.setheading(230)
Roket1.showturtle()
a1=2/100
a2=4/100
length=0.5

#Roket arrives to the Moon
winsound.PlaySound('to_moon.wav', winsound.SND_ASYNC)


for m in range(160):
    Roket1.fd(2)
    Roket1.shapesize(length)

    length=length+0.03
    time.sleep(0.01)
time.sleep(0.1)
print('length=',length)

Roket1.rt(139)

for i in range(82):
    Roket1.fd(-4.5)
    time.sleep(0.1)#  0.01?????????????
time.sleep(0.5)
Roket1.fd(-65)
X,Y=Roket1.position()

#Roket.hideturtle()
Roket.goto(X,Y)
Roket.showturtle()
Roket1.hideturtle()
Roket.shapesize(5)

#_____Astronaut1 moves to the Shuttle
for m in range(21):
    for n in range(2):
        ast1.shape(image1[0])
        ast1.fd(5)
        time.sleep(0.2)
        ast1.shape(image1[1])
        ast1.fd(5)
        time.sleep(0.2)
ast1.hideturtle()
X1,Y1=ast1.position()
#_____________________________

#Astronaut2 comes out!!!!!!!
delta=5
ast3.hideturtle()
```

```
ast3.up()
ast3.goto(X1,Y1)
ast3.showturtle()
for m in range(50):
    m1=m%4
    wn.addshape(image3[m1])
    ast3.shape(image3[m1])
    ast3.goto(X1,Y1)
    X1=ast3.xcor()
    X1=X1-delta
    time.sleep(0.2)
wn.addshape(image3[4])
ast3.shape('ast35.gif')
ast3.showturtle()
time.sleep(1)

winsound.PlaySound('come.wav', winsound.SND_ASYNC)

# Shuttle starts from the moon
length=5
Roket.shapesize(0.01)
for i in range(130):
    Roket1.showturtle()
    Roket1.rt(0.35)
    Roket1.shapesize(length)
    length=length-0.04
    time.sleep(0.01)

    Roket1.fd(5)
time.sleep(0.2)


wn.setup(900,900)
Roket1.hideturtle()
Roket1.shapesize(2)

#_________________Shuttle in free space
ast1.hideturtle()
ast2.hideturtle()
ast3.hideturtle()
sky=['sk1.gif','sk2.gif']
winsound.PlaySound('kosmos.wav', winsound.SND_ASYNC)
for m in range(2):
    Roket1.goto(-400,-400)
    Roket1.setheading(45)
    Roket1.showturtle()
    k=0
    for i in range(430):
        k=k+1
        k1=k%15
        if k1==0:
```

```
            wn.bgpic(sky[0])
        if k1==7:
            wn.bgpic(sky[1])


        Roket1.fd(3)
        time.sleep(0.01)
turtle.tracer(1)
# Shuttle arrives to the Earth
wn.bgpic('Spaceport2.gif') #   Earth Image


winsound.PlaySound('to_earth.wav', winsound.SND_ASYNC)

#_________________________________Guest3 and Guest4 meet the roket
imageg3=['guest11.gif','guest12.gif']#,'guest13.gif']
imageg4=['guest21.gif','guest22.gif']#,'guest23.gif','guest24.gif','g
uest25.gif']
guest3=turtle.Turtle()
guest3.hideturtle()
guest3.up()
guest3.goto(350,-350)

guest4=turtle.Turtle()
guest4.hideturtle()
guest4.up()
guest4.goto(-200,-120)

for i in range(2):
    wn.addshape(imageg3[i])

for i in range(2):
    wn.addshape(imageg4[i])

guest3.shape(imageg3[0])
guest4.shape(imageg4[0])

Roket1.hideturtle()
Roket1.goto(400,400)
Roket1.setheading(-135)
a1=2/100
a2=4/100
length=0.3
Roket1.shapesize(length)
Roket1.showturtle()

guest3.showturtle()
guest4.showturtle()
#_________________________________

#_____________________________Rocket arrives to the Earth
```

```
for m in range(180):
    Roket1.fd(2)
    Roket1.shapesize(length)

    length=length+0.025
    time.sleep(0.01)

Roket1.setheading(90)

for i in range(95):
    Roket1.fd(-4.5)
    time.sleep(0.02)

X,Y=Roket1.position()
time.sleep(0.5)

Roket.goto(X,Y)
Roket.showturtle()
Roket1.hideturtle()
Roket.shapesize(5)
#_____________________________________________________

ast1.goto(100,-240)
ast1.showturtle()

winsound.PlaySound('clap.wav', winsound.SND_ASYNC)
#turtle.tracer(2)
for i in range(70):
    i1=i%2
    #i2=i%5

    if i<10:
        for n in range(4):
            n1=n%2
            ast1.shape(image1[2])
            ast1.fd(-5)
            time.sleep(0.04)
            ast1.shape(image1[3])
            ast1.fd(-5)
            time.sleep(0.04)
            guest3.shape(imageg3[n1])
            guest4.shape(imageg4[n1])
    if i>=10:
        guest3.shape(imageg3[i1])
        guest4.shape(imageg4[i1])
        time.sleep(0.08)
        ast1.shape(image1[0])
```



Images for this code can be download to a computer at:

https://github.com/victenna/Flight-to-the-Moon

Video Watch:

https://youtu.be/1J7xIzgvj3w

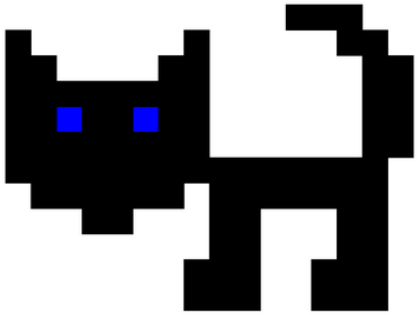
Pixel Art with Python Turtle Module

Cat Image with Pixels

```
import turtle

t= turtle.Turtle()
wn=turtle.Screen()

wn.tracer(0)
t.speed(0)
#Pen.color("#000000")
t.color("black")

# This function draws a box by drawing each side of the square and
using the fill function
def box(size,color):
    t.fillcolor(color)
    t.begin_fill()
    # 0 deg.
    t.forward(size)
    t.left(90)
    # 90 deg.
    t.forward(size)
    t.left(90)
    # 180 deg.
    t.forward(size)
    t.left(90)
    # 270 deg.
    t.forward(size)
    t.end_fill()
    t.setheading(0)


#Position t in top left area of the screen
t.penup()
t.forward(-100)
t.setheading(90)
t.forward(100)
t.setheading(0)

##Here is an example of how to draw a box
#box(boxSize)


#Here is how your PixelArt is stored (using a "list of lists")

pixels     = [[1,1,1,1,1,1,1,1,1,1,1,2,2,2,1,1]]
pixels.append([2,1,1,1,1,1,1,2,1,1,1,1,1,2,2,1])
```

```
pixels.append([2,2,1,1,1,1,2,2,1,1,1,1,1,2,2])
pixels.append([2,2,2,2,2,2,2,2,1,1,1,1,1,2,2])
pixels.append([2,2,3,2,2,3,2,2,1,1,1,1,1,2,2])
pixels.append([2,2,2,2,2,2,2,2,1,1,1,1,1,2,2])
pixels.append([2,2,2,2,2,2,2,2,2,2,2,2,2,2,1])
pixels.append([1,2,2,2,2,2,2,1,2,2,2,2,2,2,1])
pixels.append([1,1,1,2,2,1,1,1,2,2,1,1,1,2,1])
pixels.append([1,1,1,1,1,1,1,1,2,2,1,1,1,2,1])
pixels.append([1,1,1,1,1,1,1,2,2,2,1,1,2,2,1])
pixels.append([1,1,1,1,1,1,1,2,2,2,1,1,2,2,1])

for i in range (12):
    for j in range (16):
        if pixels[i][j]==2:
            box(40,'black')
        if pixels[i][j]==3:
            box(40,'blue')

        t.penup()
        t.forward(40)
        t.pendown()
    t.setheading(270)
    t.penup()
    t.forward(40)
    t.setheading(180)
    t.forward(40*16)
    t.setheading(0)
    t.pendown()
```

The display resulting from this program is:

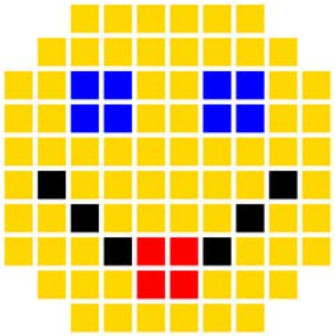


Face from Pixels

```
import turtle
t=turtle.Turtle('square')
t.shapesize(2.5)

t.hideturtle()
t.speed('fastest')
t.up()
```

```
t.goto(-240,100)

#Here is how your PixelArt is stored (using a "list of lists")

row0=[0,0,1,1,1,1,1,1,0,0]
row1=[0,1,1,1,1,1,1,1,1,0]
row2=[1,1,2,2,1,1,2,2,1,1]
row3=[1,1,2,2,1,1,2,2,1,1]
row4=[1,1,1,1,1,1,1,1,1,1]
row5=[1,3,1,1,1,1,1,1,3,1]
row6=[1,1,3,1,1,1,1,3,1,1]
row7=[1,1,1,3,4,4,3,1,1,1]
row8=[0,1,1,1,4,4,1,1,1,0]
row9=[0,0,1,1,1,1,1,1,0,0]

clm=[row0,row1,row2,row3,row4,row5,row6,row7,row8,row9]

clr=['gold','blue','black','red']

for i in range (10):
    #print(25)
    for j in range (10):

        t.fd(60)
        for k in range(4):
            if clm[i][j]==(k+1):
                t.showturtle()
                t.color(clr[k])
                t.stamp()
                t.hideturtle()

    t.setposition(-240,100-60*(i+1))
    t.setheading(0)
```

The display resulting from this program is:



Canadian Leaf

```
import turtle
t=turtle.Turtle('square')
t.shapesize(1)

t.hideturtle()
turtle.tracer(3)
#t.speed('fastest')
t.up()
t.goto(-240,100)
t.color('red')

#Here is how your PixelArt is stored (using a "list of lists")

row0=[0,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0,0,0,0,0,0,0]
row1=[0,0,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0,0,0,0,0,0]
row2=[0,0,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0,0,0,0,0,0]
row3=[0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,0,0,0,0,0,0,0,0,0]
row4=[0,0,0,0,0,0,0,0,1,1,0,1,1,1,1,0,1,1,0,0,0,0,0,0]
row5=[0,0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0]
row6=[0,0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0]
row7=[0,0,0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,0,0,0,0,0,0,0]
row8=[0,0,0,0,1,0,0,0,0,1,1,1,1,1,1,1,1,0,0,0,1,0,0,0]
row9=[1,1,1,0,1,1,0,0,1,1,1,1,1,1,1,1,1,0,0,1,1,0,1,1]
row10=[0,1,1,1,1,1,1,1,0,1,1,1,1,1,1,1,1,1,0,1,1,1,1,1,1,0]
row11=[0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0]
row12=[0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0]
row13=[0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0]
row14=[1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1]
row15=[0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0]
row16=[0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0]
row17=[0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0]
row18=[0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0]
row19=[0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0]
row20=[0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0]
row21=[0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0]
row22=[0,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0,0,0,0,0,0,0]
row23=[0,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0,0,0,0,0,0,0]
row24=[0,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0,0,0,0,0,0,0]
row25=[0,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0,0,0,0,0,0,0]

clm=[row0,row1,row2,row3,row4,row5,row6,row7,row8,row9,row10,row11,ro
w12,\
     row13,row14,row15,row16,row17,row18,row19,row20,row21,\
     row22,row23,row24,row25]

box=10
for i in range (26):
    #print(25)
    for j in range (24):
```

```
        t.fd(box)
        #print(clm[i][j])


        if clm[i][j]==1:
                t.showturtle()
                #t.color(clr[k])
                t.stamp()
                t.hideturtle()

    t.setposition(-240,100-box*(i+1))
    t.setheading(0)
```

The display resulting from this program is:

Module Files in Animation with Turtle Graphics

In Python, modules are smaller pieces of a bigger program. Each moduleis is a separate file, that has a name, statements and extension *.py*. Typically, module contains functions (you want to include in your main code) and variables of all types (arrays, dictionaries, objects etc.). Functions stored in the module are made available to the main program using the Python **import** keyword, that has to be inserted to the main code. Module file should be placed in the same directory as the program that we import it in. To use created module file in the main program we hve to make two things:

a) Insert keyword **import** with the name of module file into the main code;
b) Call each function, created in module file, in the main program.

Below it is shown a few examples of programs, that demonstrate using of module files in the main program. In the listing code (Pumkin boy crosses a street) keywords that are inserted to the main file words are in bold.

Pumkin boy crosses a street

#Main file

```
import turtle,time
from mod_pumkin import sprite
from mod_pumkin import shapes
wn=turtle.Screen()
wn.setup(1000,800)
wn.bgpic('cross1.gif')
im=[]
shapes(im)
print(im)
chipo=turtle.Turtle()
chipo.showturtle()
chipo.up()
chipo.goto(-40,-275)
sprite(chipo,0,im[0])

m=0
while True:
    m=m+1
    m1=m%10
    chipo.showturtle()
    sprite(chipo,0,im[m1])
    chipo.fd(10)
    X,Y=chipo.position()
```

#Module file (mod_pumkin.py)

```
import turtle
wn=turtle.Screen()

def shapes(im):
    for m in range(10):
        im.append('0'+str(m)+'.gif')

def sprite(turtle,angle,img):
    wn.addshape(img)
    turtle.shape(img)
    turtle.up()
    turtle.setheading(angle)
```

```
    time.sleep(0.2)
    if X>500:
        chipo.hideturtle()
        chipo.goto(-40,-275)
        chipo.showturtle()
```

Images for this code(Pumkin boy crosses a street) can be download at:

https://github.com/victenna/Animation-with-Images/tree/master/Pumkin%20boy

Soccer Shots

#Main file

```
import turtle,time,random
from mod_soccer1 import sprite
from mod_soccer1 import shapes
from mod_scr import scr
from mod_scr import tot_number
wn=turtle.Screen()
wn.setup(800,800)
wn.bgpic('grass.gif')

im=[]
shapes(im)
print(im)

player=turtle.Turtle()
player.up()
wn.addshape('00.gif')
wn.addshape('03.gif')
player.shape('00.gif')
player.showturtle()
player.goto(-100,-250)
ball=turtle.Turtle()
ball.up()
ball. hideturtle()
ball.goto(170,-400)
wn.addshape('ball.gif')
ball.shape('ball.gif')
```

#Module file (mod_soccer1.py)

```
import turtle
wn=turtle.Screen()

def shapes(im):
    for i in range(27):

im.append(str(i)+'.gif')

def
sprite(turtle,angle,img):
    wn.addshape(img)
    turtle.shape(img)
    turtle.up()
    turtle.setheading(angle)
```

```
golkip=turtle.Turtle()
golkip.up()
golkip.goto(-120,80)
sprite(golkip,0,im[0])

pos=100,100
n=-1
def right():
    global n
    n=n+1
    n1=n%27
    global pos
    sprite(golkip,0,im[n1])
    golkip.fd(15)
    pos=golkip.position()

def left():
    global n
    n=n+1
    n1=n%27
    global pos
    sprite(golkip,0,im[n1])
    golkip.fd(-15)
    pos=golkip.position()

wn.onkey(left,'Left')
wn.onkey(right,'Right')
wn.listen()

turtle.tracer(1)
delta=100
i=-1
while True:
    ball.hideturtle()

ball.setheading(random.randint(40,110))
    i=i+1
    i1=i%2
    if i1==0:
        player.shape('00.gif')
        player.showturtle()
        X,Y=player.position()
        ball.setposition(X,Y+100)
        ball.hideturtle()
        time.sleep(0.2)
    if i1==1:
        player.shape('03.gif')
        p=0
        tot_number()
        for q in range(110):
```

```
            if p==0:
                ball.showturtle()
            if p==1:
                ball.hideturtle()
            ball.fd(4)
            delta=abs(ball.position()\
                -golkip.position())
            if delta<40:
                scr()
                ball.hideturtle()
                ball.goto(100,-150)
                p=1
            if q==109:
                ball.hideturtle()
                ball.goto(-100,-150)
                player.shape('00.gif')
                i=-1
```

Second module file for Soccer Shots code is:

```
#Module file(mod_scr.py)
import turtle,time
score=turtle.Turtle()
score.hideturtle()
score.up()
score.color('blue')
s=0
FONT=('Times New Roman', 20, 'bold')
t_num='Total number of shotts='
def scr():
    global s
    s=s+1
    time.sleep(0.5)
    score.goto(150,-50)
    score.clear()
    score.write ('Score=', font =FONT)
    score.goto(230,-50)
    score.write (s,font=FONT)

total=turtle.Turtle()
total.hideturtle()
total.up()
total.color('blue')
r=0
def tot_number():
    global r
    r=r+1
```

```
    time.sleep(0.5)#!!!!!!
    total.goto(50,0)
    total.clear()
    total.write (t_num, font=FONT)
    total.goto(330,0)
    total.write (r, font=FONT)
```

Images for this code(Pumkin boy crosses a street) can be download at:

https://github.com/victenna/Animation-with-Images/tree/master/Soccer%20Sots

Shark and Muffin

#Main file

```
import turtle,random,time
from mod_muffin import muffin
from mod_scr import scr
#import module score
from mod_shark import shapes
from mod_shark import sprite

import winsound # Import sound
library
wn=turtle.Screen()
wn.setup(700,700)
wn.bgpic('Aquarium.gif')
im=[]
shapes(im)
print(im)
shark=turtle.Turtle()
sprite(shark,im[0])
shark.goto(0,-200)
muffin1=turtle.Turtle()
muffin(muffin1)

def right():
    sprite(shark,im[0])
    shark.fd(10)

def left():
    sprite(shark,im[1])
    shark.fd(-10)

wn.onkey(left,"Left")
wn.onkey(right, "Right")
wn.listen()
delta1=1000
```

#Module file(mod_shark)

```
import turtle
wn=turtle.Screen()
def shapes(im):
    for m in range(2):
im.append('shark'+str(m+1)+'.gif')
def sprite(turtle,img):
    wn.addshape(img)
    turtle.shape(img)
    turtle.up()
#--------------------------------
```

#Module file(mod_muffin)

```
import turtle
wn=turtle.Screen()
image0='muffin1.gif'

def muffin(turtle):
    wn.addshape(image0)
    turtle.shape(image0)
    turtle.hideturtle()
    turtle.penup()
    turtle.setheading(-90)
    turtle.goto(0,300)
    turtle.showturtle()
#------------------------------
```

#Module file(mod_scr)

```
import turtle
score=turtle.Turtle()
score.hideturtle()
score.up()
score.color('gold')
s=0
FONT=('Times New Roman',20,\
      'bold')
```

```
turtle.tracer(1)
while True:
    muffin1.fd(10)
    if muffin1.ycor()<-300:
        muffin1.hideturtle()

muffin1.goto(random.randrange(-
300,300),300)
        muffin1.showturtle()

    delta=abs(shark.position()-
muffin1.position())

    if delta <50:
        muffin1.hideturtle()
        frequency=1000 #Sound
        duration=100  # Sound

winsound.Beep(frequency,duration)
# Sound
        #print(delta1)

muffin1.goto(random.randrange(-
300,300),300)
        scr()
        time.sleep(0.1)
```

```
def scr():
    global s
    s=s+1
    score.goto(150,250)
    score.clear()
    score.write
('Score=',font=FONT)
    score.goto(230,250)
    score.write (s,font=FONT)
```

Images for this code(Shark and Muffin) can be download at

https://github.com/victenna/Shark-and-Muffin/tree/master

Bouncing Ball

#Main file

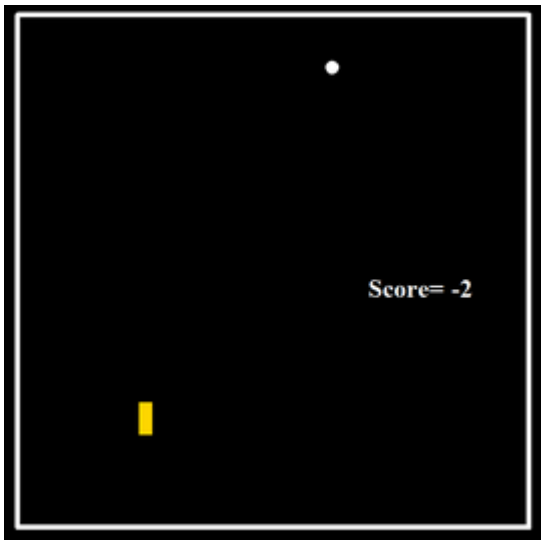
```
import turtle,time
from mod_scr import scr
turtle.tracer(2)
wn=turtle.Screen()
wn.bgcolor('black')
plate=turtle.Turtle()
plate.shape('square')
plate.color('gold')
plate.showturtle()
plate.shapesize(2.5,1)
plate.up()
plate.goto(-200,50)
```

#Module file(mod_scr)

```
import turtle,time
score=turtle.Turtle()
score.hideturtle()
score.up()
score.color('white')
FONT='Times New Roman', 30,
'bold'

s=0
def scr():
    global s
    s=s-1
    score.goto(150,-50)
```

```
ball=turtle.Turtle('circle')
ball.color('white')
ball.setheading(45)   # Initial
ball angle
ball.up()

border=turtle.Turtle()
border.hideturtle()
border.pensize(8)
border.penup()
border.goto(-400,400)
border.pendown()
border.color('white')
for m in range(4):
    border.fd(800)
    border.right(90)



def move_up():
    y=plate.ycor()
    y=y+40
    plate.sety(y)
    if y > 380:
        plate.goto(-200,380)

def move_down():
    y=plate.ycor()
    y=y-40
    plate.sety(y)
    if y <-380:
        plate.goto(-200,-380)

def move():
    wn.update()
    ball.fd(10)
    angle=ball.heading()
    X=ball.xcor()
    Y=ball.ycor()
    delta=abs(ball.position()-
plate.position())
    if delta<20:
        ball.setheading(180-
angle)
        ball.fd(10)

    if X<-380:
        scr()
        ball.setheading(180-
angle)
        ball.fd(10)
```

```
    score.clear()
    score.write('Score='\
                ,font=FONT )
    score.goto(280,-50)
    score.write (s,font=FONT)
```



```
    if X>380:
        ball.setheading(180-
angle)
        ball.fd(10)
    if Y<-380:
        ball.setheading(-angle)
        ball.fd(10)
    if Y>380:
        ball.setheading(-angle)
        ball.fd(10)

    turtle.ontimer(move,2)
move()
wn.onkey(move_up,'Up')
wn.onkey(move_down,'Down')
wn.listen()
```