**OOPDraw  
Learn the principles of OOP by writing a simple drawing program**

STUDENT WORKBOOK

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# Exercise 1: Using Turtle Graphics

In this first exercise we are going to write a program to create a simple drawing made up of squares and circles, using the *procedural programming* paradigm that you have mainly used so far.

You might well have encountered ‘Turtle Graphics’ earlier in your education - instructions are given to an imaginary Turtle to move forward/backward a specified distance, and to rotate (turn) a number of degrees (positive for clockwise, negative for anti-clockwise).

Start by downloading, unzipping, and then opening the OOPDraw project. Build the solution (**Build > Build Solution**) - this is necessary to get Visual Studio to download and install any packages (specifically *Nakov.TurtleGraphics* that it depends upon). After this the code should compile.

Find and edit the empty MyDrawings.Draw function, and then add this code into it:

namespace OOPDraw

{

public class MyDrawing

{

public static void Draw()

{

Turtle.PenColor = Color.Blue;

for (int i = 0; i < 4; i++)

{

Turtle.Forward(100);

Turtle.Rotate(90);

}

}

}

}

Run the program and copy a partial screenshot showing the resulting drawing here. Make sure you understand why this generates a square.

Experiment with different values in the Forward(100) function call.

Next we will extract the code for drawing a square into a separate function, passing the sideLength and Colour as paramaters, and also a positionX and position to specify where the square should be started (0,0 being the centre of the screen). Then we will call this function more than once to draw multiple squares.

public static void Draw()

{

DrawSquare(0,0,Color.Blue, 100);

DrawSquare(100, 0, Color.Red, 50);

}

private static void DrawSquare(float positionX, float positionY,   
 Color lineColor, float sideLength)

{

Turtle.X = positionX;

Turtle.Y = positionY;

Turtle.PenColor = lineColor;

for (int i = 0; i < 4; i++)

{

Turtle.Forward(sideLength);

Turtle.Rotate(90);

}

}

Make the changes highlighted above, run the program, and paste in a partial screenshot showing the resulting drawing.

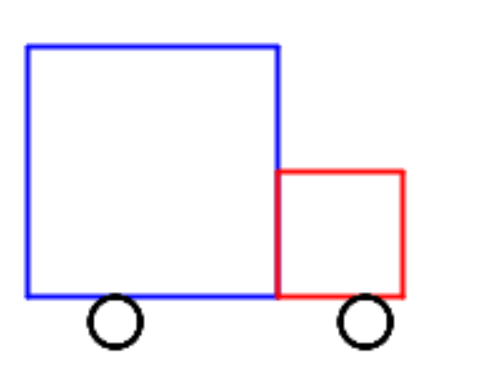
Now create a new function called DrawCircle, which takes four parameters. The first three are the same as for Square, but the last one should be a float named radius.

In Turtle graphics, the simplest way to draw a circle is to draw a polygon with 360 sides - rotating one degree each time. The length of each side can be calculated as:

(float) (2 \* Math.PI \* radius /360)

(The is needed to convert the result of the calculation from a double to a float, which is the type taken by the Forward function).

Within the Draw function, create two small circles positions such that your drawing resembles a truck:



Paste in the code for your Circle function and the Draw function that calls it.

# Exercise 2: Introducing objects as custom data types

It would be possible continue with the *procedural* approach adopted in Exercise 1 to create a sophisticated drawing, and indeed this is somewhat like the approach used by *Paint* programs - except that the functions to draw lines and shapes, to fill them with colour and so forth are triggered by the user’s mouse clicks and movements.

The limitation of this approach is that once a square has been drawn, that square exists only as a set of pixels on the screen. If we wanted to change the drawing (because, say, we weren’t happy with the size of the wheels) we would have to erase the necessary pixels and draw something afresh, copying all the parameters we need for the shape, and modifying the one(s) we want to change.

At minimum it would be nice to hold all the parameters that define one square in one holder and give it a meaningful name such as Cab, or Wheel, say. We can’t hold those parameters in an array because they are of different types: float, and color, so far.

An *object* can be thought of, in the first instance, as custom data type with multiple *properties* holding individual data items, each with a name and type. (Shortly, we will see that this is a very limited view of what an object is, but it will do for the moment). We define one of these custom types by creating a *class.* You can define a new class within the same code file as your drawing functions, but it is considered better practice to create each new class in a file of its own. Do this by right-clicking on the project icon and selecting Add > Class, giving the new class the name Square. Then edit the new file to look like this:

using System.Drawing;

namespace OOPDraw

{

public class Square

{

//Properties

public float PositionX { get; set; }

public float PositionY { get; set; }

public Color LineColor { get; set; }

public float SideLength { get; set; }

//The 'Constructor

public Square(float x, float y, Color lineColor, float sideLength)

{

LineColor = lineColor;

PositionX = x;

PositionY = y;

SideLength = sideLength;

}

}

}

When writing the four properties you can make use of the ‘prop’ *code snippet*: just type prop and then Tab twice, then edit the highlighted fields for type and name.

It is a convention to start each property name with a capital letter.

A  *class* can be thought of as a *template* that defines a type (Square) and from which you can create multiple objects (also known as *instances)* each having its own copy of the properties containing its own individual values.

The *constructor* is the function that is used to create a new instance of that type (in this case to create a new Square). Its parameters specify the values that you must provide to create an instance, and in the body of the constructor these parameters are used to set up the individual properties. (Many people comment that it looks a bit wasteful copying each parameter into a similarly-named property, but you’ll soon get used to it. Some programming languages have side-stepped this apparent repetition.)

You can use the ‘ctor’ code snippet to help write the constructor, though you will need to add all the parameters to it yourself.

Now we can change the code in our Draw function to create two instances of type Square as follows:

public static void Draw()

{

var body = new Square(0,0,Color.Blue, 100);

var cab = new Square(100, 0, Color.Red, 50);

Circle(125, -10, Color.Black, 10);

Circle(25, -10, Color.Black, 10);

}

Note the use of new to create a new instance. If you right click on the word Square and select **Go To Definition** you will be taken to the *constructor* on the Square class.

However, if you run the program now, the body and cab are no longer drawn. We’ve created holders for the properties of each (instances of Square) but we have not told the program to draw them. We need to call the DrawSquare function, but instead of passing it the individual parameters as before, we now just want to pass it an object of type Square, from which it can read the properties it needs. Make these changes:

public static void Draw()

{

var body = new Square(0,0,Color.Blue, 100);

DrawSquare(body);

var cab = new Square(100, 0, Color.Red, 50);

DrawSquare(cab);

DrawCircle(125, -10, Color.Black, 10);

DrawCircle(25, -10, Color.Black, 10);

}

private static void DrawSquare(Square sq)

{

Turtle.X = sq.PositionX;

Turtle.Y = sq.PositionY;

Turtle.PenColor = sq.LineColor;

for (int i = 0; i < 4; i++)

{

Turtle.Forward(sq.SideLength);

Turtle.Rotate(90);

}

}

Code of the form sq.PositionX may be read as ‘the PositionX property of the object sq’ and this is known as the *dot syntax.* As well as being easy to read, it has another advantage: if you type just ‘sq.’ Visual Studio will give you a pop up list showing all the properties you can access on that typefrom which you can select - or carry on typing (e.g. ‘sq.Pos’) to see matching properties. This *auto-complete* feature saves time and reduces errors and is one of the big advantages of statically-typed object-orientation languages such as Java, C# and VB - you won’t get this in a dynamically-typed language such as Python or JavaScript because the system is not able to determine the type of a variable or parameter until the program is run - so it can’t work out which properties are available.

Check that the program now draws the whole truck again.

Now add a new class named Circle, using appropriate properties for that type. Modify the DrawCircle function in a manner equivalent to DrawSquare. Then in the Draw method create two instances of Circle for the two wheels, and draw them. Paste in your completed code for the Circle class, the modified DrawCircle function, and the modified Draw function that uses both.