Computer Systems (SS 2016)
Exercise 3: May 10, 2016

Wolfgang Schreiner
Research Institute for Symbolic Computation (RISC)
Wolfgang.Schreiner@risc.jku.at

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The exercise is to be submitted by the denoted deadline via the submission interface of the Moodle course as a single file in zip (`.zip`) or tarred gzip (`.tgz`) format which contains the following files:

- A PDF file `ExerciseNumber-MatNr.pdf` (where *Number* is the number of the exercise and *MatNr* is your "Matrikelnummer") which consists of the following parts:

  1. A decent cover page with the title of the course, the number of the exercise, and the author of the solution (identified by name, Matrikelnummer and email address).

  2. For every source file, a listing in a *fixed width font*, e.g. `Courier`, (such that indentations are appropriately preserved) and an appropriate *font size* such that source code lines do not break.

  3. A description of all tests performed (copies of program inputs and program outputs) explicitly highlighting, if some test produces an unexpected result.

  4. Any additional explanation you would like to give. In particular, if your solution has unwanted problems or bugs, please document these explicitly (you will get more credit for such solutions).

- Each source file of your solution (no object files or executables).

Please obey the coding style recommendations posted on the course site.

Exercise 3: Polygons

1. Write a class `Polygon` with the following public interface:

```cpp
class Polygon
{
public:
  // create polygon in denoted color (default black)
  Polygon(unsigned int color = 0);
  virtual ~Polygon();

  // add point with relative coordinates (x,y) to polygon
  void add(double x, double y);

  // draws the polygon at absolute coordinates (x0,y0) scaled by factor f;
  // thus every point (x,y) is drawn at position (x0+x*f, y0+y*f)
  virtual void draw(double x0, double y0, double f);
};
```

The class internally holds in a linked list the points of the polygon; for drawing the polygon, this list is to be traversed only *once*.

2. Derive from `Polygon` a class

```cpp
class RegularPolygon: public Polygon
{
public:
  RegularPolygon(double x, double y, double r, int n, double a,
    unsigned int c = 0);
}
```

The constructor creates a convex regular polygon[1] with color c and n points $0,\ldots,n-1$ where each point i is connected to point $i+1$ mod n. All points lie on the circle with center $\langle x,y \rangle$ and radius r; the line from the center to point 0 has angle a to the positive half of the horizontal axis. The class shall make use of the data representation of `Polygon`, i.e. the constructor of `RegularPolygon` must compute the coordinates of the individual points of the polygon and call `add()` to add them to the polygon.

The function `draw()` is to be overwritten to draw the polygon (using `Polygon::draw()`) but in addition also the center point of the polygon (as a small bullet).

3. Derive from `RegularPolygon` a class with public interface

```cpp
class Square: public RegularPolygon
{
public:
  Square(double x, double y, double r, unsigned int c = 0);
}
```

---

[1] http://en.wikipedia.org/wiki/Regular_polygon

The constructor creates (by calling the constructor of `RegularPolygon`) a square with color *c* and horizontal/vertical sides whose bounding circle has center *x*, *y* and radius *r*.

4. Correspondingly derive from `RegularPolygon` a class with public interface

```
class Hexagon: public RegularPolygon
{
public:
  Hexagon(double x, double y, double r, double a,
    unsigned int c = 0);
}
```
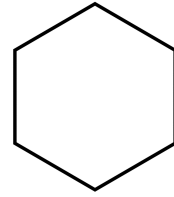
The constructor creates (by calling the constructor of `RegularPolygon`) a hexagon with color *c* whose bounding circle has center *x*, *y* and radius *r* such that the first point has angle *a* to the positive half of the horizontal axis.

5. Finally write a class

```
class Picture
{
public:
  Picture(double x, double y, double w, double h, double f = 1.0);
  virtual ~Picture();

  void add(Polygon *p);
  void draw();
}
```

A `Picture` object represents a rectangular picture which the constructor initializes with left upper point *x*, *y*, width *w* and height *h* such that its sides are horizontal/vertical. The picture consists of a boundary (a plain rectangle) and a set of polygons; the set is implemented by an linked list of (pointers to) `Polygon` objects.

The function `draw()` draws the picture (boundary and contents); all polygons are scaled by the factor *f* used in the construction of the picture and shifted by the position *x*, *y* of the left upper corner of the picture.

Write a program that tests these classes, by creating a picture, populating it with irregular polygons, squares, and hexagons and drawing the picture. Please note that all regular polygons must be shown with their center point (this indicates that you have correctly overwritten `Polygon::draw()`).