Московский Авиационный Институт

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Факультет «Информационные технологии и прикладная математика»

Кафедра 806 «Вычислительная математика и программрование»

Дисциплина «Объектно-ориентированное программирование»

**Лабораторная работа №3**

**Тема: Наследование, полиморфизм**

|  |  |
| --- | --- |
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**1 – Задание**

Разработать классы triangle, octagon, square которые должны наследоваться от базового класса figure. Все классы должны поддерживать набор общих методов:

1. Вычисление геометрического центра фигуры.
2. Вывод в стандартный поток вывода std::cout координат вершин фигуры.
3. Вычисление площади фигуры.

**2 - Репозиторий GitHub**

https://github.com/KolesovaMariya/oop\_exercise\_03

**3 - Описание программы**

Создан базовый абстрактный класс figure с виртуальными функциями, вычисляющие площадь, геометрический центр, а также вывод и ввод. Наследуемые классы triangle, square, octagon. В каждом классе реализованы функции center, area, print. Для удобства создан вспомогательный класс point, с помощью которого задаются точки. В классах triangle и square реализованы функции проверки того, являются ли фигуры треугольником или квадратом, так же возможен ввод точек в любом порядке, в то время вершины восьмиугольника необходимо вводить строго по порядку. Так же написано простое пользовательское меню со следующими командами:

exit - закончить работу программы;

add triangle/ square/ octagon - добавить фигуру

delete i - удаление по индексу i

areas - выводит площади всех введённых фигур

centers - выводит центры всех введенных фигур

figures - выводит все введенные фигуры

print - выводит все фигуры с их площадями и центрами

destroy – удаляет все фигуры

Все добавленные фигуры помещаются в вектор с элементами типа figure.

Как производились вычисления:

* площадь квадрата вычисляется возведением в квадрат одной из сторон
* площадь треугольника вычисляется по формуле Герона
* площадь восьмиугольника вычисляется с помощью разбиения фигуры на треугольники, и вычисление уже их площади
* геометрический центр вычисляется по формуле xc = x1 + x2 +… + xn,
* yc = y1 + y2 + … + yn, где n – кол-во вершин в фигуре.

**4 – Тесты**

**test\_00.txt**

add triangle 2 1 7 4 10 2

add triangle 4 3 7 4 6 5

add triangle 0 0 0 0 0 0

add triangle 8 8 8 8 8 8

add triangle 0.5 -0.5 0.75 4.25 2 28

add triangle 3 6 4 4.5 5 3

add triangle 0 0 1 2 2 4

print

delete 1

figures

destroy

figure

exit

**result 00**

The figure Triangle [(2,1),(7,4),(10,2)] was successfully added;

The figure Triangle [(4,3),(7,4),(6,5)] was successfully added;

The figure Triangle [(0,0),(0,0),(0,0)] was successfully added;

The figure Triangle [(8,8),(8,8),(8,8)] was successfully added;

The figure Triangle [(0.5,-0.5),(0.75,4.25),(2,28)] isn't a triangle, square or octagon;

The figure Triangle [(3,6),(4,4.5),(5,3)] isn't a triangle, square or octagon;

The figure Triangle [(0,0),(1,2),(2,4)] isn't a triangle, square or octagon;

Triangle [(2,1),(7,4),(10,2)]; Center: (6.33333,2.33333); Area: 9.5;

Triangle [(4,3),(7,4),(6,5)]; Center: (5.66667,4); Area: 2;

Triangle [(0,0),(0,0),(0,0)]; Center: (0,0); Area: 0;

Triangle [(8,8),(8,8),(8,8)]; Center: (8,8); Area: 0;

Deleted by index 1;

Figures:

Triangle [(2,1),(7,4),(10,2)]

Triangle [(0,0),(0,0),(0,0)]

Triangle [(8,8),(8,8),(8,8)]

All figures are destroyed;

Process finished with exit code 0

**test\_01.txt**

add square 0 0 0 4 4 0 4 4

add square 4 1 2 3 4 5 6 3

add square 2 4 3 2 5 3 4 5

add square 2 2 -2 2 2 -2 -2 -2

add square 0 0 0 0 0 0 0 0

add square 2 3 2 4 2 5 4 4

print

delete 1

figures

destroy

figure

exit

**result 01**

The figure Square: [(0,0)(0,4)(4,4)(4,0)] was successfully added;

The figure Square: [(2,3)(4,1)(6,3)(4,5)] was successfully added;

The figure Square: [(2,4)(3,2)(5,3)(4,5)] was successfully added;

The figure Square: [(-2,-2)(-2,2)(2,2)(2,-2)] was successfully added;

The figure Square: [(0,0)(0,0)(0,0)(0,0)] was successfully added;

The figure Square: [(2,3)(2,4)(4,4)(2,5)] isn't a triangle, square or octagon;

Square: [(0,0)(0,4)(4,4)(4,0)]; Center: (2,2); Area: 16;

Square: [(2,3)(4,1)(6,3)(4,5)]; Center: (4,3); Area: 8;

Square: [(2,4)(3,2)(5,3)(4,5)]; Center: (3.5,3.5); Area: 5;

Square: [(-2,-2)(-2,2)(2,2)(2,-2)]; Center: (0,0); Area: 16;

Square: [(0,0)(0,0)(0,0)(0,0)]; Center: (0,0); Area: 0;

Deleted by index 1;

Figures:

Square: [(0,0)(0,4)(4,4)(4,0)]

Square: [(2,4)(3,2)(5,3)(4,5)]

Square: [(-2,-2)(-2,2)(2,2)(2,-2)]

Square: [(0,0)(0,0)(0,0)(0,0)]

All figures are destroyed;

Process finished with exit code 0

**tesr\_02.txt**

add octagon 2 4 4 4 6 3 6 1 4 0 2 0 0 1 0 3

add octagon 5 6 4 5 3 5 2 6 2 7 3 8 4 8 5 7

add octagon 1 4 0 6 1 10 4 8 6 5 7 3 6 0 3 1

add octagon -4 8 -7 4 -5 0 -1 -3 3 -2 7 0 9 7 6 10

add octagon 4 6 3 7 1 4 3 4 3 2 5 3 6 5 5 7

add octagon 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

add octagon 2 2 2 2 3 3 3 3 4 4 4 4 5 5 5 5

print

delete 1

figures

destroy

figure

exit

**result 02**

The figure Octagon [(2,4), (4,4), (6,3), (6,1), (4,0), (2,0), (0,1), (0,3)] was successfully added;

The figure Octagon [(5,6), (4,5), (3,5), (2,6), (2,7), (3,8), (4,8), (5,7)] was successfully added;

The figure Octagon [(1,4), (0,6), (1,10), (4,8), (6,5), (7,3), (6,0), (3,1)] was successfully added;

The figure Octagon [(-4,8), (-7,4), (-5,0), (-1,-3), (3,-2), (7,0), (9,7), (6,10)] was successfully added;

The figure Octagon [(4,6), (3,7), (1,4), (3,4), (3,2), (5,3), (6,5), (5,7)] was successfully added;

The figure Octagon [(0,0), (0,0), (0,0), (0,0), (0,0), (0,0), (0,0), (0,0)] was successfully added;

The figure Octagon [(2,2), (2,2), (3,3), (3,3), (4,4), (4,4), (5,5), (5,5)] isn't a triangle, square or octagon;

Octagon [(2,4), (4,4), (6,3), (6,1), (4,0), (2,0), (0,1), (0,3)]; Center: (3,2); Area: 20;

Octagon [(5,6), (4,5), (3,5), (2,6), (2,7), (3,8), (4,8), (5,7)]; Center: (3.5,6.5); Area: 7;

Octagon [(1,4), (0,6), (1,10), (4,8), (6,5), (7,3), (6,0), (3,1)]; Center: (3.5,4.625); Area: 39;

Octagon [(-4,8), (-7,4), (-5,0), (-1,-3), (3,-2), (7,0), (9,7), (6,10)]; Center: (1,3); Area: 142.5;

Octagon [(4,6), (3,7), (1,4), (3,4), (3,2), (5,3), (6,5), (5,7)]; Center: (3.75,4.75); Area: 13;

Octagon [(0,0), (0,0), (0,0), (0,0), (0,0), (0,0), (0,0), (0,0)]; Center: (0,0); Area: 0;

Deleted by index 1;

Figures:

Octagon [(2,4), (4,4), (6,3), (6,1), (4,0), (2,0), (0,1), (0,3)]

Octagon [(1,4), (0,6), (1,10), (4,8), (6,5), (7,3), (6,0), (3,1)]

Octagon [(-4,8), (-7,4), (-5,0), (-1,-3), (3,-2), (7,0), (9,7), (6,10)]

Octagon [(4,6), (3,7), (1,4), (3,4), (3,2), (5,3), (6,5), (5,7)]

Octagon [(0,0), (0,0), (0,0), (0,0), (0,0), (0,0), (0,0), (0,0)]

All figures are destroyed;

Process finished with exit code 0

**6 - Код программы**

**point.h**

#ifndef LAB3\_POINT\_H  
#define LAB3\_POINT\_H  
  
#include <iostream>  
#include <cmath>  
  
  
struct point {  
 double x;  
 double y;  
};  
  
  
  
std::ostream &operator<<(std::ostream &out, point const &a);  
  
std::istream &operator>>(std::istream &in, point &a);  
bool operator==(point a, point b);  
bool operator>(point a, point b);  
void swap(point &a, point &b);  
double dist(point a, point b);  
  
  
struct vec {  
 double x;  
 double y;  
};  
vec vector(point a, point b);  
bool same\_line(point a, point b, point c);  
  
  
#endif //LAB3\_POINT\_H

**point.cpp**

#include "point.h"  
  
std::ostream &operator<< (std::ostream &out, point const &a) {  
 out << "(" << a.x << "," << a.y << ")";  
 return out;  
}  
  
std::istream &operator>>(std::istream &in, point &a) {  
 in >> a.x >> a.y;  
 return in;  
}  
bool operator>(point a, point b) {  
 if (a.x > b.x) {  
 return true;  
 } else if ( a.x == b.x) {  
 return a.y > b.y;  
 } else {  
 return false;  
 }  
}  
  
void swap(point &a, point &b) {  
 point tmp = a;  
 a = b;  
 b = tmp;  
}  
  
bool operator==(point a, point b) {  
 return((a.x == b.x) && (a.y == b.y));  
}  
  
double dist(point a, point b) {  
 return sqrt(pow((a.x - b.x),2) + pow((a.y - b.y),2));  
}  
vec vector(point a, point b) {  
 vec v{};  
 v.x = b.x - a.x;  
 v.y = b.y - a.y;  
 return v;  
}  
  
bool same\_line(point a, point b, point c) {  
 vec ab = vector(a, b);  
 vec bc = vector(b, c);  
 return ((ab.x) / (bc.x) != (ab.y) / (bc.y));  
}

**figure.h**

#ifndef LAB3\_FIGURE\_H  
#define LAB3\_FIGURE\_H  
  
#include "point.h"  
#include<iostream>  
  
class figure {  
public:  
 virtual point center() const = 0;  
 virtual double area() const = 0;  
 virtual void print(std::ostream&) const = 0;  
  
 virtual bool is\_figure() const = 0;  
 virtual ~figure() = default;  
};  
  
  
  
#endif //LAB3\_FIGURE\_H

**figure.cpp**

#include <iostream>  
#include "figure.h"  
  
std::ostream& operator<< (std::ostream& os, const figure& f) {  
 f.print(os);  
 return os;  
}

**triangle.h**

#ifndef LAB3\_TRIANGLE\_H  
#define LAB3\_TRIANGLE\_H  
  
#include"figure.h"  
  
class triangle : public figure {  
public:  
 triangle() = default;  
  
 triangle(const point &a, const point &b, const point &c);  
  
 triangle(std::istream &is);  
  
 point center() const override;  
  
 double area() const override;  
  
 void print(std::ostream &os) const override;  
 bool is\_figure() const;  
  
private:  
 point p1{};  
 point p2{};  
 point p3{};  
  
};  
#endif //LAB{}3\_TRIANGLE\_H

**triangle.cpp**

#include "triangle.h"  
#include <iostream>  
#include <cassert>  
triangle::triangle(const point& p1\_, const point& p2\_, const point& p3\_): p1(p1\_), p2(p2\_), p3(p3\_) {}  
  
triangle::triangle(std::istream &is) {  
 is >> p1 >> p2 >> p3;  
}  
  
point triangle::center() const {  
 point cen{};  
 cen.x = (p1.x + p2.x + p3.x)/3;  
 cen.y = (p1.y + p2.y + p3.y)/3;  
 return cen;  
}  
  
double triangle::area() const {  
 double p = (dist(p1, p2) + dist(p1, p3) + dist(p2, p3))/2;  
 return sqrt(p \* (p - dist(p1, p2) ) \* (p - dist(p1, p3) ) \* (p - dist(p2, p3) ));  
}  
  
void triangle::print(std::ostream &os) const {  
 os << "Triangle [" << p1 << ","<< p2 << ","<< p3 << "]";  
}  
  
bool triangle::is\_figure() const {  
 vec p1\_p2 = vector(p1, p2);  
 vec p1\_p3 = vector(p1, p3);  
 return ((p1\_p2.x) / (p1\_p3.x) != (p1\_p2.y) / (p1\_p3.y)) || (p1 == p3 ) || (p1 == p2) || (p2 == p3);  
}

**square.h**

#ifndef LAB3\_SQUARE\_H  
#define LAB3\_SQUARE\_H  
  
#include "figure.h"  
  
class square : public figure {  
public:  
 square() = default;  
 square(point p1\_, point p2\_, point p3\_, point p4\_);  
 square(std::istream &in);  
 double area() const override;  
 point center() const override;  
 void print(std::ostream&) const override ;  
 bool is\_figure() const override;  
 void sort();  
private:  
 point p1{}, p2{}, p3{}, p4{};  
};  
  
  
#endif //LAB3\_SQUARE\_H

**square.cpp**

#include "square.h"  
#include<iostream>  
#include<cmath>  
square::square(point p1\_, point p2\_, point p3\_, point p4\_): p1(p1\_), p2(p2\_), p3(p3\_), p4(p4\_) {  
 this->sort();  
}  
  
square::square(std::istream &is) {  
 is >> p1 >> p2 >> p3 >> p4;  
 this->sort();  
}  
double square::area() const {  
 return pow(dist(p1, p2), 2);  
}  
point square::center() const {  
 vec p1\_p3 = vector(p1, p3);  
 point cen = {p1.x + (p1\_p3.x)/2, p1.y + (p1\_p3.y)/2};  
 return cen;  
}  
  
void square::print(std::ostream &out) const {  
 out << "Square: [" << p1 << p2 << p3 << p4 << "]";  
}  
  
void square::sort() {  
 point a[4] = {p1, p2, p3, p4};  
 for(int i = 0 ;i < 3; i++) {  
 for(int j = 0; j < 3; j++)  
 if(a[j] > a[j+1]) {  
 swap(a[j], a[j+1]);  
 }  
 }  
 p1 = a[0];  
 p2 = a[1];  
 p3 = a[3];  
 p4 = a[2];  
}  
bool square::is\_figure() const {  
 vec p1\_p2 = vector(p1, p2);  
 vec p2\_p3 = vector(p2, p3);  
 vec p3\_p4 = vector(p3, p4);  
 vec p4\_p1 = vector(p4, p1);  
 double v\_mlt\_1 = p1\_p2.x \* p2\_p3.x + p1\_p2.y \* p2\_p3.y;  
 double v\_mlt\_2 = p2\_p3.x \* p3\_p4.x + p2\_p3.y \* p3\_p4.y;  
 double v\_mlt\_3 = p3\_p4.x \* p4\_p1.x + p3\_p4.y \* p4\_p1.y;  
 double v\_mlt\_4 = p4\_p1.x \* p1\_p2.x + p4\_p1.y \* p1\_p2.y;  
 return (v\_mlt\_1 == 0) && (v\_mlt\_2 == 0) && (v\_mlt\_3 == 0) && (v\_mlt\_4 == 0);  
}

**octagon.h**

#ifndef LAB3\_OCTAGON\_H  
#define LAB3\_OCTAGON\_H  
#include"figure.h"  
  
class octagon : public figure {  
public:  
 octagon() = default;  
  
 octagon(const point &p1\_, const point &p2\_,  
 const point &p3\_, const point &p4\_,  
 const point &p5\_, const point &p6\_,  
 const point &p7\_, const point &p8\_);  
  
 octagon(std::istream &is);  
  
 point center() const override;  
  
 double area() const override;  
  
 void print(std::ostream &os) const override;  
  
 bool is\_figure() const override;  
  
private:  
 point p1{};  
 point p2{};  
 point p3{};  
 point p4{};  
 point p5{};  
 point p6{};  
 point p7{};  
 point p8{};  
  
};  
#endif //LAB3\_OCTAGON\_H

**octagon.cpp**

#include "octagon.h"  
#include "triangle.h"  
  
octagon::octagon (const point &p1\_, const point &p2\_,  
 const point &p3\_, const point &p4\_,  
 const point &p5\_, const point &p6\_,  
 const point &p7\_, const point &p8\_):  
 p1(p1\_), p2(p2\_), p3(p3\_), p4(p4\_),  
 p5(p5\_), p6(p6\_), p7(p7\_), p8(p8\_) {}  
  
octagon::octagon(std::istream &is) {  
 is >> p1 >> p2 >> p3 >> p4 >> p5 >> p6 >> p7 >> p8;  
}  
  
point octagon::center() const {  
 point cent{};  
 cent.x = (p1.x + p2.x + p3.x + p4.x + p5.x + p6.x + p7.x + p8.x)/8;  
 cent.y = (p1.y + p2.y + p3.y + p4.y + p5.y + p6.y + p7.y + p8.y)/8;  
 return cent;  
}  
  
double octagon::area() const {  
 point cent = this->center();  
 point m[8] = {p1, p2 ,p3, p4, p5, p6, p7, p8};  
 double ar = 0;  
 for(int i = 0; i < 7; i++) {  
 triangle a{m[i], m[i+1], cent};  
 ar += a.area();  
 }  
 triangle a{p8, p1, cent};  
 ar += a.area();  
 return ar;  
}  
  
void octagon::print(std::ostream &os) const {  
 os << "Octagon [" << p1 << ", "<< p2 << ", "<< p3 << ", "<< p4 << ", "<<  
 p5 << ", "<< p6 << ", "<< p7 << ", "<< p8 << "]";  
}  
bool octagon::is\_figure() const {  
 bool flag = true;  
 point a[8] = {p1, p2, p3, p4, p5, p6, p7, p8};  
 for(int i = 0; i < 7; i++) {  
 if(a[i] == a[i+1]) {  
 flag = false;  
 break;  
 }  
 }  
 if (flag) return true;  
 for(int i = 0; i < 7; i++) {  
 if(!(a[i] == a[i+1])) {  
 return false;  
 }  
 }  
 return true;  
}

**main.cpp**

#include <iostream>  
#include <vector>  
#include <fstream>  
  
#include "triangle.h"  
#include "square.h"  
#include "octagon.h"  
  
int main() {  
 std::ifstream in(R"(C:\Users\LENOVO\CLionProjects\OOP\lab3\test\_02.txt)");  
 std::cin.rdbuf(in.rdbuf());  
 std::string command;  
 std::vector<figure\*> figures;  
 while(std::cin >> command) {  
 bool flag = true;  
 if (command == "exit") {  
 break;  
 } else if (command == "add") {  
 std::string figure\_type;  
 std::cin >> figure\_type;  
 figure \*ptr;  
 if (figure\_type == "triangle") {  
 ptr = new triangle(std::cin);  
 } else if (figure\_type == "square") {  
 ptr = new square(std::cin);  
 } else if(figure\_type == "octagon") {  
 ptr = new octagon(std::cin);  
 } else {  
 std::cout << "Invalid input" << std::endl;  
 flag = false;  
 }  
 if(flag && ptr -> is\_figure()) {  
 figures.push\_back(ptr);  
 std::cout << "The figure ";  
 ptr->print(std::cout);  
 std::cout << " was successfully added;" << std::endl;  
 }  
 if(!ptr->is\_figure()) {  
 std::cout <<"The figure ";  
 ptr->print(std::cout);  
 std::cout << " isn't a triangle, square or octagon;" << std::endl;  
 }  
  
 } else if (command == "delete") {  
 int i;  
 std::cin >> i;  
 delete figures[i];  
 figures.erase(figures.begin() + i);  
 std::cout << "Deleted by index " << i << ";" << std::endl;  
 } else if (command == "areas") {  
 std::cout << "Areas " << std::endl;  
 for(figure \*elem : figures) {  
 elem -> print(std::cout);  
 std::cout << " Area: " << elem->area() << std::endl;  
 }  
 } else if (command == "centers") {  
 std::cout << "Centers " << std::endl;  
 for (figure \*elem : figures) {  
 elem -> print(std::cout);  
 std::cout << " Center: " << elem->center() << std::endl;  
 }  
 } else if (command == "figures") {  
 std::cout << "Figures: " << std::endl;  
 for (figure \*elem : figures) {  
 elem->print(std::cout);  
 std::cout << std::endl;  
 }  
 } else if(command == "print") {  
  
 for (figure \*elem : figures) {  
 elem->print(std::cout);  
 std::cout << "; Center: " << elem->center() << "; Area: " << elem->area() << ";" << std::endl;  
 }  
 } else if (command == "destroy") {  
 while(!figures.empty()) {  
 delete figures[0];  
 figures.erase(figures.begin());  
 }  
 std::cout << "All figures are destroyed;" << std::endl;  
 } else if (command == "help") {  
 std::cout << "The program works with figures: triangle, square, octagon.\n "  
 "Available command: \n"  
 "exit - finish the program;\n"  
 "add triangle/ square/ octagon - add figure;\n"  
 "delete i - delete by index i;\n"  
 "areas - output the areas of all figures;\n"  
 "centers - output the centers of all figures;\n"  
 "figures - output all the figures;\n"  
 "print - output all the figures, their areas and centers;\n"  
 "destroy - destroy all the figures;\n";  
 }  
 }  
}

**7 – Вывод**

Я научилась работать с базовыми абстрактными классами, делать наследуемые классы, а так же делать простейшее пользовательское меню.