Московский Авиационный Институт

(Национальный Исследовательский Университет)

Кафедра 806 «Вычислительная информатика и программирование»

Факультет: «Информационные технологии и прикладная математика»

Лабораторная работа

Дисциплина: «Объектно-ориентированное программирование»

I I I семестр

Задание 4: «Основы метапрограммирования»

|  |  |
| --- | --- |
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| Оценка: |  |
| Дата: | 09.01.2020 |

Москва, 2019

1. **Тема**: Основы метапрограммирования
2. **Цель работы**: Изучение основ работы с шаблонами в C++
3. **Задание** (*вариант № 19* ):

Разработать шаблоны классов согласно варианту задания. Параметром шаблона должен являться скалярный тип данных, задающий тип данных для оси координат. Классы должны иметь публичные поля. Фигуры являются фигурами вращения.

Созздать набор шаблонов, реализующий функции:

* Вычисление геометрического центра фигуры
* Вывод в стандартный поток std::cout координат вершин фигуры
* Вычисление площади фигуры

Параметром шаблона должен являться тип класса фигуры. Помимо самого класса фигуры, шаблонная функция должна уметь работать с tuple.

Фигуры (Вариант 3):

Прямоугольник,трапеция, ромб.

1. **Адрес репозитория на GitHub** <https://github.com/vitalouivi/oop_exercise_0>4
2. **Код программы на С++**

main.cpp

|  |
| --- |
| #include <iostream> |
|  | #include <tuple> |
|  | #include "point.h" |
|  | #include "trapezoid.h" |
|  | #include "rectangle.h" |
|  | #include "rhombus.h" |
|  | #include "templates.h" |
|  |  |
|  | template<class T> |
|  | void running(std::istream& is, std::ostream& os) { |
|  | if constexpr (is\_figurelike\_tuple<T>::value) { |
|  | int ang; |
|  | std::cout << "Input number of angles" << std::endl; |
|  | std::cin >> ang; |
|  | if (ang == 4) { |
|  | point<double> A, B, C, D; |
|  | is >> A >> B >> C >> D; |
|  | auto object = std::make\_tuple(A, B, C, D); |
|  | print(os, object); |
|  | os << area(object) << std::endl; |
|  | os << center(object) << std::endl; |
|  | }else if(ang == 3){ |
|  | point<double> A, B, C; |
|  | is >> A >> B >> C; |
|  | auto object = std::make\_tuple(A, B, C); |
|  | print(os, object); |
|  | os << area(object) << std::endl; |
|  | os << center(object) << std::endl; |
|  | } |
|  | }else { |
|  | T object(is); |
|  | print(os, object); |
|  | os << '\n' << area(object) << std::endl; |
|  | os << center(object) << std::endl; |
|  | } |
|  | } |
|  |  |
|  | int main() { |
|  | char obj\_type; |
|  | std::cout << "Input figure type: 1 - trapezoid, 2 - rhombus, 3 - rectangle, 4 - tuple or 'q' to quit" << std::endl; |
|  | while (std::cin >> obj\_type){ |
|  | if(obj\_type == '4') { |
|  | running<std::tuple<point<double>>> (std::cin, std::cout); |
|  | }else if(obj\_type == '1'){ |
|  | running<trapezoid<double>>(std::cin, std::cout); |
|  | }else if(obj\_type == '2'){ |
|  | running<rhombus<double>>(std::cin, std::cout); |
|  | }else if(obj\_type == '3'){ |
|  | running<rectangle<double>>(std::cin, std::cout); |
|  | }else if(obj\_type == 'q'){ |
|  | return 0; |
|  | }else{ |
|  | std::cout << "Wrong. Try 1 - trapezoid, 2 - rhombus, 3 - rectangle, 4 - tuple or 'q' to quit" << std::endl; |
|  | } |
|  | } |
|  | } |

point.h

|  |
| --- |
| #ifndef POINT\_H\_ |
|  | #define POINT\_H\_ |
|  |  |
|  | #include <iostream> |
|  |  |
|  | template<class T> |
|  | struct point { |
|  | T x; |
|  | T y; |
|  | }; |
|  |  |
|  | template<class T> |
|  | point<T> operator+(const point<T>& A, const point<T>& B) { |
|  | point<T> res; |
|  | res.x = A.x + B.x; |
|  | res.y = A.y + B.y; |
|  | return res; |
|  | } |
|  |  |
|  | template<class T> |
|  | point<T> operator/=(point<T>& A, const double B) { |
|  | A.x /= B; |
|  | A.y /= B; |
|  | return A; |
|  | } |
|  |  |
|  | template<class T> |
|  | std::istream& operator>> (std::istream& is, point<T>& p) { |
|  | is >> p.x >> p.y; |
|  | return is; |
|  | } |
|  |  |
|  | template<class T> |
|  | std::ostream& operator<< (std::ostream& os, const point<T>& p) { |
|  | os << '[' << p.x << ' ' << p.y << ']'; |
|  | return os; |
|  | } |
|  |  |
|  | #endif |

rhombus.h

|  |
| --- |
| #ifndef RHOMBUS\_H\_ |
|  | #define RHOMBUS\_H\_ |
|  | #include <iostream> |
|  | #include <cmath> |
|  | #include "point.h" |
|  |  |
|  |  |
|  | template<class T> |
|  | struct rhombus { |
|  | point<T> points[4]; |
|  | rhombus(std::istream& is); |
|  | double area() const; |
|  | point<T> center() const; |
|  | void print(std::ostream& os) const; |
|  | }; |
|  |  |
|  | template<class T> |
|  | rhombus<T>::rhombus(std::istream& is) { |
|  | for(int i = 0; i < 4; ++i){ |
|  | is >> points[i]; |
|  | } |
|  | double a, b, c, d; |
|  | a = sqrt((points[1].x - points[0].x) \* (points[1].x - points[0].x) + (points[1].y - points[0].y) \* (points[1].y - points[0].y)); |
|  | b = sqrt((points[2].x - points[1].x) \* (points[2].x - points[1].x) + (points[2].y - points[1].y) \* (points[2].y - points[1].y)); |
|  | c = sqrt((points[2].x - points[3].x) \* (points[2].x - points[3].x) + (points[2].y - points[3].y) \* (points[2].y - points[3].y)); |
|  | d = sqrt((points[3].x - points[0].x) \* (points[3].x - points[0].x) + (points[3].y - points[0].y) \* (points[3].y - points[0].y)); |
|  | if(a != b || a != c || a != d) |
|  | throw std::logic\_error("It`s not a rhombus"); |
|  | } |
|  |  |
|  | template<class T> |
|  | double rhombus<T>::area() const { |
|  | const T d1 = sqrt((points[0].x - points[2].x) \* (points[0].x - points[2].x) + (points[0].y - points[2].y) \* (points[0].y - points[2].y)); |
|  | const T d2 = sqrt((points[1].x - points[3].x) \* (points[1].x - points[3].x) + (points[1].y - points[3].y) \* (points[1].y - points[3].y)); |
|  | return d1 \* d2 / 2; |
|  | } |
|  |  |
|  | template<class T> |
|  | point<T> rhombus<T>::center() const { |
|  | point<T> res; |
|  | res.x = (points[0].x + points[1].x + points[2].x + points[3].x) / 4; |
|  | res.y = (points[0].y + points[1].y + points[2].y + points[3].y) / 4; |
|  | return res; |
|  | } |
|  |  |
|  | template<class T> |
|  | void rhombus<T>::print(std::ostream& os) const { |
|  | for(int i = 0; i < 4; ++i){ |
|  | os << points[i]; |
|  | if(i + 1 != 4){ |
|  | os << ' '; |
|  | } |
|  | } |
|  | } |
|  |  |
|  | #endif |

rectangle.h

|  |
| --- |
| #ifndef RECTANGLE\_H\_ |
|  | #define RECTANGLE\_H\_ |
|  | #include <iostream> |
|  | #include "point.h" |
|  | #include <cmath> |
|  |  |
|  | template<class T> |
|  | struct rectangle { |
|  | point<T> points[4]; |
|  | rectangle(std::istream& is); |
|  | double area() const; |
|  | point<T> center() const; |
|  | void print(std::ostream& os) const; |
|  | }; |
|  |  |
|  | template<class T> |
|  | rectangle<T>::rectangle(std::istream& is) { |
|  | for(int i = 0; i < 4; ++i){ |
|  | is >> points[i]; |
|  | } |
|  | double a, b, c, d, d1, d2, ABC, BCD, CDA, DAB; |
|  | a = sqrt((points[1].x - points[0].x) \* (points[1].x - points[0].x) + (points[1].y - points[0].y) \* (points[1].y - points[0].y)); |
|  | b = sqrt((points[2].x - points[1].x) \* (points[2].x - points[1].x) + (points[2].y - points[1].y) \* (points[2].y - points[1].y)); |
|  | c = sqrt((points[2].x - points[3].x) \* (points[2].x - points[3].x) + (points[2].y - points[3].y) \* (points[2].y - points[3].y)); |
|  | d = sqrt((points[3].x - points[0].x) \* (points[3].x - points[0].x) + (points[3].y - points[0].y) \* (points[3].y - points[0].y)); |
|  | d1 = sqrt((points[1].x - points[3].x) \* (points[1].x - points[3].x) + (points[1].y - points[3].y) \* (points[1].y - points[3].y)); |
|  | d2 = sqrt((points[2].x - points[0].x) \* (points[2].x - points[0].x) + (points[2].y - points[0].y) \* (points[2].y - points[0].y)); |
|  | ABC = (a \* a + b \* b - d2 \* d2) / 2 \* a \* b; |
|  | BCD = (b \* b + c \* c - d1 \* d1) / 2 \* b \* c; |
|  | CDA = (d \* d + c \* c - d2 \* d2) / 2 \* d \* c; |
|  | DAB = (a \* a + d \* d - d1 \* d1) / 2 \* a \* d; |
|  | if(ABC != BCD || ABC != CDA || ABC != DAB) |
|  | throw std::logic\_error("It`s not a rectangle"); |
|  | } |
|  |  |
|  | template<class T> |
|  | double rectangle<T>::area() const { |
|  | const T a = sqrt((points[1].x - points[0].x) \* (points[1].x - points[0].x) + (points[1].y - points[0].y) \* (points[1].y - points[0].y)); |
|  | const T b = sqrt((points[2].x - points[1].x) \* (points[2].x - points[1].x) + (points[2].y - points[1].y) \* (points[2].y - points[1].y)); |
|  | return a \* b; |
|  | } |
|  |  |
|  | template<class T> |
|  | point<T> rectangle<T>::center() const { |
|  | point<T> res; |
|  | res.x = (points[0].x + points[1].x + points[2].x + points[3].x) / 4; |
|  | res.y = (points[0].y + points[1].y + points[2].y + points[3].y) / 4; |
|  | return res; |
|  | } |
|  |  |
|  | template<class T> |
|  | void rectangle<T>::print(std::ostream& os) const { |
|  | for(int i = 0; i < 4; ++i){ |
|  | os << points[i]; |
|  | if(i + 1 != 4){ |
|  | os << ' '; |
|  | } |
|  | } |
|  | } |
|  |  |
|  | #endif |

trapezoid.h

|  |
| --- |
| #ifndef TRAPEZOID\_H\_ |
|  | #define TRAPEZOID\_H\_ |
|  | #include <iostream> |
|  | #include <cmath> |
|  | #include "point.h" |
|  |  |
|  |  |
|  | template<class T> |
|  | struct trapezoid { |
|  | point<T> points[4]; |
|  | trapezoid(std::istream& is); |
|  | double area() const; |
|  | point<T> center() const; |
|  | void print(std::ostream& os) const; |
|  | }; |
|  |  |
|  | template<class T> |
|  | trapezoid<T>::trapezoid(std::istream& is) { |
|  | for(int i = 0; i < 4; ++i){ |
|  | is >> points[i]; |
|  | } |
|  | if((points[2].y - points[1].y) / (points[2].x - points[1].x) != (points[3].y - points[0].y) / (points[3].x - points[0].x)) |
|  | throw std::logic\_error("It`s not a trapezoid"); |
|  | } |
|  |  |
|  | template<class T> |
|  | double trapezoid<T>::area() const { |
|  |  |
|  | return 0.5 \* std::abs( points[0].x \* points[1].y + points[1].x \* points[2].y + points[2].x \* points[3].y + points[3].x \* points[0].y - points[1].x \* points[0].y - points[2].x \* points[1].y - points[3].x \* points[2].y - points[0].x \* points[3].y); |
|  | } |
|  |  |
|  | template<class T> |
|  | point<T> trapezoid<T>::center() const { |
|  | point<T> res; |
|  | res.x = (points[0].x + points[1].x + points[2].x + points[3].x) / 4; |
|  | res.y = (points[0].y + points[1].y + points[2].y + points[3].y) / 4; |
|  | return res; |
|  |  |
|  | } |
|  |  |
|  | template<class T> |
|  | void trapezoid<T>::print(std::ostream& os) const { |
|  | for(int i = 0; i < 4; ++i){ |
|  | os << points[i]; |
|  | if(i + 1 != 4){ |
|  | os << ' '; |
|  | } |
|  | } |
|  | } |
|  |  |
|  | #endif |

templates.h

|  |
| --- |
| #ifndef TEMPLATES\_H\_ |
|  | #define TEMPLATES\_H\_ |
|  |  |
|  | #include <tuple> |
|  | #include <type\_traits> |
|  | #include "point.h" |
|  |  |
|  |  |
|  | template<class T> |
|  | struct is\_point : std::false\_type {}; |
|  |  |
|  | template<class T> |
|  | struct is\_point<point<T>> : std::true\_type {}; |
|  |  |
|  | template<class T> |
|  | struct is\_figurelike\_tuple : std::false\_type {}; |
|  |  |
|  | template<class Head, class... Tail> |
|  | struct is\_figurelike\_tuple<std::tuple<Head, Tail...>> : |
|  | std::conjunction<is\_point<Head>, std::is\_same<Head, Tail>...> {}; |
|  |  |
|  | template<class T> |
|  | inline constexpr bool is\_figurelike\_tuple\_v = is\_figurelike\_tuple<T>::value; |
|  |  |
|  |  |
|  |  |
|  | template<class T, class = void> |
|  | struct has\_method\_area : std::false\_type {}; |
|  |  |
|  | template<class T> |
|  | struct has\_method\_area<T, std::void\_t<decltype(std::declval<const T&>().area())>> : std::true\_type {}; |
|  |  |
|  | template<class T> |
|  | inline constexpr bool has\_method\_area\_v = has\_method\_area<T>::value; |
|  |  |
|  | template<class T> |
|  | std::enable\_if\_t<has\_method\_area\_v<T>, double> area(const T& object) { |
|  | return object.area(); |
|  | } |
|  |  |
|  | template<class T, class = void> |
|  | struct has\_method\_center : std::false\_type {}; |
|  |  |
|  | template<class T> |
|  | struct has\_method\_center<T, std::void\_t<decltype(std::declval<const T&>().center())>> : std::true\_type {}; |
|  |  |
|  | template<class T> |
|  | inline constexpr bool has\_method\_center\_v = has\_method\_center<T>::value; |
|  |  |
|  | template<class T> |
|  | std::enable\_if\_t<has\_method\_center\_v<T>, point<double>> center(const T& object) { |
|  | return object.center(); |
|  | } |
|  |  |
|  | template<class T, class = void> |
|  | struct has\_method\_print : std::false\_type {}; |
|  |  |
|  | template<class T> |
|  | struct has\_method\_print<T, std::void\_t<decltype(std::declval<const T&>().print(std::cout))>> : std::true\_type {}; |
|  |  |
|  | template<class T> |
|  | inline constexpr bool has\_method\_print\_v = has\_method\_print<T>::value; |
|  |  |
|  | template<class T> |
|  | std::enable\_if\_t<has\_method\_print\_v<T>, void> print(std::ostream& os, const T& object) { |
|  | object.print(os); |
|  | } |
|  |  |
|  | template<size\_t Id, class T> |
|  | double compute\_area(const T& tuple) { |
|  | if constexpr (Id >= std::tuple\_size\_v<T>){ |
|  | return 0; |
|  | }else{ |
|  | const auto x1 = std::get<Id - 0>(tuple).x - std::get<0>(tuple).x; |
|  | const auto y1 = std::get<Id - 0>(tuple).y - std::get<0>(tuple).y; |
|  | const auto x2 = std::get<Id - 1>(tuple).x - std::get<0>(tuple).x; |
|  | const auto y2 = std::get<Id - 1>(tuple).y - std::get<0>(tuple).y; |
|  | const double local\_area = std::abs(x1 \* y2 - y1 \* x2) \* 0.5; |
|  | return local\_area + compute\_area<Id + 1>(tuple); |
|  | } |
|  | } |
|  |  |
|  | template<class T> |
|  | std::enable\_if\_t<is\_figurelike\_tuple\_v<T>, double> |
|  | area(const T& object) { |
|  | if constexpr (std::tuple\_size\_v<T> < 3){ |
|  | throw std::logic\_error("It`s not a figure"); |
|  | }else{ |
|  | return compute\_area<2>(object); |
|  | } |
|  | } |
|  |  |
|  | template<size\_t Id, class T> |
|  | point<double> tuple\_center(const T& object) { |
|  | if constexpr (Id >= std::tuple\_size<T>::value) { |
|  | return point<double> {0, 0}; |
|  | } else { |
|  | point<double> res = std::get<Id>(object); |
|  | return res + tuple\_center<Id+1>(object); |
|  | } |
|  | } |
|  |  |
|  | template<class T> |
|  | point<double> compute\_center(const T &tuple) { |
|  | point<double> res{0, 0}; |
|  | res = tuple\_center<0>(tuple); |
|  | res /= std::tuple\_size\_v<T>; |
|  | return res; |
|  | } |
|  |  |
|  | template<class T> |
|  | std::enable\_if\_t<is\_figurelike\_tuple\_v<T>, point<double>> |
|  | center(const T& object) { |
|  | if constexpr (std::tuple\_size\_v<T> < 3){ |
|  | throw std::logic\_error("It`s not a figure"); |
|  | }else{ |
|  | return compute\_center(object); |
|  | } |
|  | } |
|  |  |
|  | template<size\_t Id, class T> |
|  | void step\_print(const T& object, std::ostream& os) { |
|  | if constexpr (Id >= std::tuple\_size<T>::value) { |
|  | std::cout << "\n"; |
|  | } else { |
|  | os << std::get<Id>(object) << " "; |
|  | step\_print<Id + 1>(object, os); |
|  | } |
|  | } |
|  |  |
|  | template<class T> |
|  | std::enable\_if\_t<is\_figurelike\_tuple\_v<T>, void> |
|  | print(std::ostream& os, const T& object) { |
|  | if constexpr (std::tuple\_size\_v<T> < 3){ |
|  | throw std::logic\_error("It`s not a figure"); |
|  | }else{ |
|  | step\_print<0>(object, os); |
|  | } |
|  | } |
|  |  |
|  | #endif |

CMakeLists.txt

|  |
| --- |
| cmake\_minimum\_required (VERSION 3.5) |
|  |  |
|  | project(lab4) |
|  |  |
|  | add\_executable(oop\_exercise\_04 |
|  | main.cpp |
|  | ) |
|  |  |
|  | set(CMAKE\_CXX\_FLAGS "${CMAKE\_CXX\_FLAGS} -Wall -Wextra -std=c++1z -g3") |
|  |  |
|  | set\_target\_properties(oop\_exercise\_04 PROPERTIES CXX\_STANDART 14 CXX\_STANDART\_REQUIRED ON) |

1. **Набор testcases**

test\_01.txt

|  |
| --- |
| 1 |
|  | 0 0 1 1 2 1 3 0 |
|  | 2 |
|  | 0 0 -1 2 0 4 1 2 |
|  | 3 |
|  | 0 0 0 1 4 1 4 0 |
|  | q |

test\_02.txt

|  |
| --- |
| 4 |
|  | 3 |
|  | 0 0 1 1 2 0 |
|  | 4 |
|  | 4 |
|  | 0 0 0 2 2 2 2 0 |

1. **Результаты выполнения тестов**

**Input figure type: 1 - trapezoid, 2 - rhombus, 3 - rectangle, 4 - tuple or 'q' t**

**o quit**

**1**

**0 0 1 1 2 1 3 0**

**[0 0] [1 1] [2 1] [3 0]**

**2**

**[1.5 0.5]**

**2**

**0 0 -1 2 0 4 1 2**

**[0 0] [-1 2] [0 4] [1 2]**

**4**

**[0 2]**

**3**

**0 0 0 1 4 1 4 0**

**[0 0] [0 1] [4 1] [4 0]**

**4**

**[2 0.5]**

**q**

**C:\lab4\lab4\Debug\lab4.exe (процесс 17196) завершил работу с кодом 0.**

**Input figure type: 1 - trapezoid, 2 - rhombus, 3 - rectangle, 4 - tuple or 'q' t**

**o quit**

**4**

**Input number of angles**

**3**

**0 0 1 1 2 0**

**[0 0] [1 1] [2 0]**

**1**

**[1 0.333333]**

**4**

**Input number of angles**

**4**

**0 0 0 2 2 2 2 0**

**[0 0] [0 2] [2 2] [2 0]**

**4**

**[1 1]**

**q**

**C:\lab4\lab4\Debug\lab4.exe (процесс 13468) завершил работу с кодом 0.**

1. **Объяснение результатов работы программы - вывод**

В файлах rectangle.h, trapezoid.h и rhombus.h описаны фигуры. В templates.h описаны шаблоны для работы с этими фигурами и tuple.

В ходе выполнения данной лабораторной работы были получены навыки работы с шаблонами, а также хэдером <type\_traits>, создания шаблонных классов.