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Факультет: «Информационные технологии и прикладная математика»
Кафедра: 806 «Вычислительная математика и программирование»

Лабораторная работа №6
по курсу «ООП»

Тема:
Основы работы с коллекциями: итераторы.

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Дата:	

Москва
2019

1. Код программы а языке C++:

rec.h

```
#pragma once

#include "point.h"
#include "stack.h"
#include <cassert>

template <class T>
struct TRectangle {
	TPoint<T> a, b, c, d;
	TRectangle();
	TRectangle(std::istream&);
	double Square() const;
	TPoint<T> Center() const;
	void Print() const;
};


template <class T>
TRectangle<T>::TRectangle() {}
template <class T>
TRectangle<T>::TRectangle(std::istream& is) {
	is >> a >> b >> c >> d;
	TPoint<T> ab, ad, cb, cd;
	ab.x = b.x - a.x;
	ab.y = b.y - a.y;
	ad.x = d.x - a.x;
	ad.y = d.y - a.y;
	cb.x = b.x - c.x;
	cb.y = b.y - c.y;
	cd.x = d.x - c.x;
	cd.y = d.y - c.y;
	if (acos((ab.x * ad.x + ab.y * ad.y) / (sqrt(ab.x * ab.x + ab.y * ab.y) * sqrt(ad.x
* ad.x + ad.y * ad.y))) / M_PI != 0.5 || acos((cb.x * cd.x + cb.y * cd.y) / (sqrt(cb.x *
cb.x + cb.y * cb.y) * sqrt(cd.x * cd.x + cd.y * cd.y))) / M_PI != 0.5) {
		throw std::logic_error("it's not rectangle\n");
	}
}

template <class T>
double TRectangle<T>::Square() const {
	double ans = (b.x - a.x) * (c.y - a.y) - (c.x - a.x) * (b.y - a.y);
```

```
	return fabs(ans);
}

template <class T>
TPoint<T> TRectangle<T>::Center() const {
	TPoint<T> p;
	T x = (a.x + b.x + c.x + d.x) /4;
	T y = (a.y + b.y + c.y + d.y) /4;
	p.x = x;
	p.y = y;

	return p;
}

template <class T>
void TRectangle<T>::Print() const {
	std::cout << a << b << c << d << "\n";
}
```

point.h:

```
#ifndef POINT_H
#define POINT_H 1

#include <iostream>
#include <algorithm>
#include <cmath>


template<class T>
struct TPoint {
	TPoint() {}
	TPoint(T a, T b) : x(a), y(b){}
	T x;
	T y;


};

template<class T>
std::ostream& operator << (std::ostream& os, const TPoint<T>& p)
{
	os << p.x << " " << p.y << " ";
	return os;
}
```

```
template <class T>
std::istream& operator >> (std::istream& is, TPoint<T>& p)
{
	is >> p.x >> p.y;
	return is;
}

template <class T>
TPoint<T> operator /= ( TPoint<T>& p, int val)
{
	p.x = p.x / val;
	p.y = p.y / val;
	return p;
}

template <class T>
TPoint<T> operator + (const TPoint<T>& p1, const TPoint<T>& p2)
{
	TPoint<T> p;
	p.x = p1.x + p2.x;
	p.y = p1.y + p2.y;
	return p;
}

template <class T>
TPoint<T> operator - (const TPoint<T> p1, const TPoint<T> p2)
{
	TPoint<T> p;
	p.x = p1.x - p2.x;
	p.y = p1.y - p2.y;
	return p;
}

#endif
```

stack.h

```
#ifndef STACK_H
#define STACK_H 1
```

```
#include <memory>
#include <iostream>
#include <iterator>



namespace containers {


template <class T, class Allocator = std::allocator<T>>
class TStack {
private:

        struct Node;

public:
        TStack() = default;

        class forward_iterator {
        public:
                using value_type = T;
       using reference = T&;
       using pointer = T*;
       using difference_type = std::ptrdiff_t;
       using iterator_category = std::forward_iterator_tag;
                forward_iterator (Node* ptr) : ptr_(ptr) {};
                T& operator* ();
                forward_iterator& operator++ ();
                forward_iterator operator++ (int);
                bool operator== (const forward_iterator& o) const;
                bool operator!= (const forward_iterator& o) const;

        private:
                Node* ptr_;
                friend TStack;
        };
        forward_iterator begin();
        forward_iterator end();
        void pop();
        T& top();
        void push(const T& value);
        void erase(const forward_iterator& it);
        void insert(forward_iterator& it, const T& val);
        void advance(forward_iterator& it, int idx);
```

```
        bool empty() {
                return head == nullptr;
        }
        void print();


private:
        using allocator_type = typename Allocator::template rebind<Node>::other;
        struct deleter {
                deleter(allocator_type* allocator) : allocator_(allocator) {}
                void operator() (Node* ptr) {
                        if (ptr != nullptr) {
            std::allocator_traits<allocator_type>::destroy(*allocator_, ptr);
            allocator_->deallocate(ptr, 1);
                        }
                }

        private:
                allocator_type* allocator_;

        };

        using unique_ptr = std::unique_ptr<Node, deleter>;

        struct Node {
                T value;
                unique_ptr following{nullptr, deleter{nullptr}};
                Node(const T& val) : value(val) {}
                forward_iterator next();

        };

        allocator_type allocator_{};
        unique_ptr head {nullptr, deleter{nullptr}};


};

template <class T, class Allocator>
typename TStack<T, Allocator>::forward_iterator TStack<T,
Allocator>::Node::next() {
        return following.get();
}

template <class T, class Allocator>
```

```
typename TStack<T, Allocator>::forward_iterator TStack<T, Allocator>::begin() {
	return head.get();
}

template <class T, class Allocator>
typename TStack<T, Allocator>::forward_iterator TStack<T, Allocator>::end() {
	return nullptr;
}

template <class T, class Allocator>
T& TStack<T, Allocator>::forward_iterator::operator* () {
	return ptr_->value;
}

template <class T, class Allocator>
typename TStack<T, Allocator>::forward_iterator& TStack<T,
Allocator>::forward_iterator::operator++ () {
	*this = ptr_->next();
	return *this;
}

template <class T, class Allocator>
typename TStack<T, Allocator>::forward_iterator TStack<T,
Allocator>::forward_iterator::operator++ (int) {
	forward_iterator prev =*this;
	++this;
	return prev;
}

template <class T, class Allocator>
bool TStack<T, Allocator>::forward_iterator::operator== (const forward_iterator& o)
const{
	return ptr_ == o.ptr_;
}

template <class T, class Allocator>
bool TStack<T, Allocator>::forward_iterator::operator!= (const forward_iterator& o)
const{
	return ptr_ != o.ptr_;
}



template <class T, class Allocator>
void TStack<T, Allocator>::push(const T& value) {
```

```
	Node* NewNode = this->allocator_.allocate(1);
	std::allocator_traits<allocator_type>::construct(this->allocator_, NewNode,
value);
	auto tmp = unique_ptr(NewNode, deleter{&this->allocator_});
	tmp->following = std::move(head);
	head = std::move(tmp);

}

template <class T, class Allocator>
void TStack<T, Allocator>::pop() {
	if (head.get() == nullptr) {
		throw std::logic_error("Stack is empty\n");
	} else {
		head = std::move(head->following);
	}
}

template <class T, class Allocator>
T& TStack<T, Allocator>::top() {
	if (head.get() == nullptr) throw std::logic_error("Stack is empty\n");
	return head->value;
}


template <class T, class Allocator>
void TStack<T, Allocator>::print() {
	Node* tmp = head.get();

	while (tmp != nullptr) {
		std::cout << tmp->value << " ";
		tmp = tmp->following.get();
	}
}


template <class T, class Allocator>
void TStack<T, Allocator>::insert(forward_iterator& it, const T& value) {

	if (it.ptr_ == head.get()) {
		this->push(value);
		return;
	}

	Node* NewNode = this->allocator_.allocate(1);
```

```
	std::allocator_traits<allocator_type>::construct(this->allocator_, NewNode,
value);
	auto tmp = unique_ptr(NewNode, deleter{&this->allocator_});
	//auto tmp = std::unique_ptr<Node>(new Node{value});
	forward_iterator i = this->begin();
	while (i.ptr_->following.get() != it.ptr_) {
		if (i.ptr_ == nullptr && i.ptr_ != it.ptr_) throw std::logic_error("Out of
range\n");
		++i;

	}
	if (i.ptr_->following == nullptr) {
		i.ptr_->following = std::move(tmp);
		return;
	}
	++i;
	tmp->following = std::move(i.ptr_->following);
	i.ptr_->following = std::move(tmp);
	return;

}

template <class T, class Allocator>
void TStack<T, Allocator>::erase(const forward_iterator& it) {
	if (it.ptr_ == head.get()) {
		this->pop();
		return;
	}
	auto i = this->begin();
	while(i.ptr_ != nullptr && i.ptr_->next() != it.ptr_) {
		++i;
	}
	if (i.ptr_ == nullptr) {
		throw std::logic_error ("Out of range\n");
	}
	i.ptr_->following = std::move(it.ptr_->following);

	return;

}



template <class T, class Allocator>
void TStack<T, Allocator>::advance(forward_iterator& it, int idx) {
```

```
        it = this->begin();
        if (it.ptr_ == nullptr && idx > 0) throw std::logic_error("Out of
range(advance)\n");
        int i = 0;
        while (i < idx) {
                if (it.ptr_->following == nullptr && i < idx - 1) {

                        throw std::logic_error("Out of range(advance)\n");
                }
                ++it;
                ++i;

        }
}

}

#endif
```

allocator.h:

```
#ifndef MY_ALLOCATOR_H
#define MY_ALLOCATOR_H 1

#include <cstdint>
#include <cstdint>

#include <exception>
#include <iostream>
#include <type_traits>
#include "queue.h"

template<class T, size_t ALLOC_SIZE>
   struct my_allocator {
      using value_type = T;
      using size_type = std::size_t;
      using difference_type = std::ptrdiff_t;
      using is_always_equal = std::false_type;

      template<class U>
      struct rebind {
         using other = my_allocator<U, ALLOC_SIZE>;
      };
```

```
    my_allocator():
        pool_begin(new char[ALLOC_SIZE]),
        pool_end(pool_begin + ALLOC_SIZE),
        pool_tail(pool_begin)
    {}

    my_allocator(const my_allocator&) = delete;
    my_allocator(my_allocator&&) = delete;

    ~my_allocator() {
        delete[] pool_begin;
    }

    T* allocate(std::size_t n);
    void deallocate(T* ptr, std::size_t n);

private:
    char* pool_begin;
    char* pool_end;
    char* pool_tail;
    containers::TQueue<char*> free_blocks;
};

template<class T, size_t ALLOC_SIZE>
T* my_allocator<T, ALLOC_SIZE>::allocate(std::size_t n) {
    if (n != 1) {
        throw std::logic_error("can`t allocate arrays");
    }
    if (size_t(pool_end - pool_tail) < sizeof(T)) {
        if (!free_blocks.empty()) {
            auto it = free_blocks.begin();
            char* ptr = *it;
            free_blocks.pop();
            return reinterpret_cast<T*>(ptr);
        }
        throw std::bad_alloc();
    }
    T* result = reinterpret_cast<T*>(pool_tail);
    pool_tail += sizeof(T);
    return result;
}

template<class T, size_t ALLOC_SIZE>
void my_allocator<T, ALLOC_SIZE>::deallocate(T *ptr, std::size_t n) {
    if (n != 1) {
```

```
            throw std::logic_error("can`t allocate arrays, thus can`t deallocate them too");
        }
        if(ptr == nullptr){
            return;
        }
        free_blocks.push(reinterpret_cast<char*>(ptr));
    }


#endif
```

main.cpp:

```
#include "stack.h"
#include "allocator.h"
#include "rec.h"
#include <algorithm>
#include <map>
#include <string>


int main() {
        containers::TStack<TRectangle<int>, my_allocator<TRectangle<int>, 500>>
s;
        std::string cmd;
        int index;
        std::cout << "push - to push figure to stack\n"
                          << "insert - to insert figure to stack\n"
                          << "pop - to pop figure from Stack\n"
                          << "erase - to delete figure from Stack\n"
                          << "top - to show first figure\n"
                          << "for_each - to print figures\n"
                          << "map - to show work allocator with map\n"
                          << "exit - to finish execution of program\n";
        while (true) {
                std::cin >> cmd;
                if (cmd == "push") {
                        std::cout << "enter coordinates\n";
                        TRectangle<int> fig;
                        try {
                                TRectangle<int> tmp(std::cin);
                                fig = tmp;
                        } catch(std::exception& err) {
                                std::cout << err.what() << std::endl;
```

```
                continue;
        }
        s.push(fig);
} else if (cmd == "insert") {
        std::cout << "enter index\n";
        std::cin >> index;
        auto p = s.begin();
        try {
                s.advance(p, index);
        } catch (std::exception& err) {
                std::cout << err.what() << std::endl;
                continue;
        }
        std::cout << "enter coordinates\n";
        TRectangle<int> fig;
        try {
                TRectangle<int> tmp(std::cin);
                fig = tmp;
        } catch(std::exception& err) {
                std::cout << err.what() << std::endl;
                continue;
        }
        s.insert(p, fig);
} else if (cmd == "pop") {
        try {
                s.pop();
        } catch(std::exception& err) {
                std::cout << err.what() << std::endl;
                continue;
        }
} else if (cmd == "erase") {
        std::cout << "enter index\n";
        std::cin >> index;
        auto p = s.begin();
        try {
                s.advance(p, index);
        } catch (std::exception& err) {
                std::cout << err.what() << std::endl;
                continue;
        }
        try {
                s.erase(p);
        } catch (std::exception& err) {
                std::cout << err.what() << std::endl;
                continue;
```

```
                }

            } else if (cmd == "top") {
                try {
                    s.top();
                } catch (std::exception& err) {
                    std::cout << err.what() << std::endl;
                    continue;
                }
                (s.top()).Print();
            } else if (cmd == "for_each") {
                std::for_each(s.begin(), s.end(), [] (TRectangle<int> tmp) {return
tmp.Print();});
            } else if (cmd == "exit") {
                break;
            } else if (cmd == "map"){
                std::map<int, int, std::less<>, my_allocator<std::pair<const int,
int>, 1000>> tree;
                for (int i = 0; i < 6; i++) {
                    tree[i] = i * i;
                }
                std::for_each(tree.begin(), tree.end(), [](std::pair<int, int> X)
{std::cout << X.first << " " << X.second << " ";});
                std::cout << std::endl;
            } else {
                std::cout << "Wrong comand\n";
                continue;
            }

        }

}
```

2. Ссылка на репозитирий Github:

https://github.com/vebcreatex7/oop_exercise_06

3. Набор тестов:

push - to push figure to stack
insert - to insert figure to stack

```
pop - to pop figure from Stack
erase - to delete figure from Stack
top - to show first figure
for_each - to print figures
map - to show work allocator with map
exit - to finish execution of program
push
enter coordinates
0 0 1 1 2 1 3 0
insert
enter index
1
enter coordinates
1 1 1 3 3 3 4 1
for_each
0 0 1 1 2 1 3 0
1 1 1 3 3 3 4 1
erase
enter index
1
for_each
0 0 1 1 2 1 3 0
top
0 0 1 1 2 1 3 0
pop
for_each
map
0 0 1 1 2 4 3 9 4 16 5 25
exit
```

4. Объяснение результатов работы программы:

Стек реализован в виде односвязного списка на итераторах. Аллокатор работает на этом же стеке. В main.cpp push добавляет элемент в начало стека, insert на позицию i, pop удаляет первый элемент, erase удаляет элемент по индексу i, for_each выводит координаты фигур на экран. Аллокатор совмести с std::map, что продемонстрировано при команде map.

5. Вывод

В ходе данной работы были получены навыки работы с аллокаторами. Аллокаторы позволяют ускорить быстродействие программ, а так же усилить контроль над менеджментом памяти.