МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ МОСКОВСКИЙ АВИАЦИОННЫЙ ИНСТИТУТ
(НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ)

ЛАБОРАТОРНАЯ РАБОТА №8 по курсу

объектно-ориентированное программирование I семестр, 2021/22 уч. год

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Цель работы:

Целью лабораторной работы является:

Закрепление навыков по работе с памятью в C++;
Создание аллокаторов памяти для динамических структур данных.

Задание:

Используя структуру данных, разработанную для лабораторной работы №5, спроектировать и разработать аллокатор памяти для динамической структуры данных.
Цель построения аллокатора – минимизация вызова операции malloc. Аллокатор должен

выделять большие блоки памяти для хранения фигур и при создании новых фигур-объектов выделять место под объекты в этой памяти. Аллокатор должен хранить списки использованных/свободных блоков. Для хранения списка свободных блоков нужно применять динамическую структуру данных (контейнер 2-го уровня, согласно варианту задания). Для вызова аллокатора должны быть переопределены оператор new и delete у классов-фигур.

Нельзя использовать:

Стандартные контейнеры std.

Программа должна позволять:

Вводить произвольное количество фигур и добавлять их в контейнер;
Распечатывать содержимое контейнера;
Удалять фигуры из контейнера.

Дневник отладки

Во время выполнения лабораторной были некие трудности с реализацией аллокатора, позже они были полностью ликвидирован.

Недочёты

Недочётов не было обнаружено.

Выводы

Лабораторная работа №8 позволила мне реализовать свой класс аллокаторов, полностью прочувствовать процесс выделения памяти на низкоуровневых языках программирования. Лабораторная прошла успешно.

Исходный код

figure.h

```
#ifndef FIGURE_H
#define FIGURE_H

#include "point.h"

class Figure {
public:
    virtual double Area() = 0;
    virtual void Print(std::ostream &os) = 0;
    virtual size_t VertexesNumber() = 0;
    virtual ~Figure() {};
};

#endif
```

main.cpp

```
#include <iostream>
#include "pentagon.h"
#include "TBinaryTree.h"
```

```
#include "TBinaryTreeItem.h"
int main () {
    //lab1
    Pentagon a (std::cin);
    std:: cout << "The area of your figure is : " << a.Area() << std:: endl;

    Pentagon b (std::cin);
    std:: cout << "The area of your figure is : " << b.Area() << std:: endl;

    Pentagon c (std::cin);
    std:: cout << "The area of your figure is : " << c.Area() << std:: endl;

    Pentagon d (std::cin);
    std:: cout << "The area of your figure is : " << d.Area() << std:: endl;

    Pentagon e (std::cin);
    std:: cout << "The area of your figure is : " << e.Area() << std:: endl;

    //lab2
    TBinaryTree<Pentagon> tree;
    std:: cout << "Is tree empty? " << tree.Empty() << std:: endl;
    tree.Push(a);
    std:: cout << "And now, is tree empty? " << tree.Empty() << std:: endl;
    tree.Push(b);
    tree.Push(c);
    tree.Push(d);
    tree.Push(e);
    std:: cout << "The number of figures with area in [minArea, maxArea] is: " << tree.Count(0,
100000) << std:: endl;
    std:: cout << "The result of searching the same-figure-counter is: " << tree.root-
>ReturnCounter() << std:: endl;
    std:: cout << "The result of function named GetItemNotLess is: " << tree.GetItemNotLess(0,
tree.root) << std:: endl;

    //lab5
    TIterator<TBinaryTreeItem<Pentagon>, Pentagon> iter(tree.root);
    std:: cout << "The figure that you have put in root is: " << *iter << std:: endl;
    iter.GoToLeft();
    std:: cout << "The first result of Left-Iter function is: " << *iter << std:: endl;
    iter.GoToRight();
    std:: cout << "The first result of Right-Iter function is: " << *iter << std:: endl;
    TIterator<TBinaryTreeItem<Pentagon>, Pentagon> first(tree.root->GetLeft());
    TIterator<TBinaryTreeItem<Pentagon>, Pentagon> second(tree.root->GetLeft());
    if (first == second) {
        std:: cout << "YES, YOUR ITERATORS ARE EQUALS" << std::endl;
    }
    TIterator<TBinaryTreeItem<Pentagon>, Pentagon> third(tree.root->GetRight());
    TIterator<TBinaryTreeItem<Pentagon>, Pentagon> fourth(tree.root->GetLeft());
    if (third != fourth) {
        std:: cout << "NO, YOUR ITERATORS ARE NOT EQUALS" << std::endl;
    }
    return 0;
}
```

pentagon.cpp

```
#include "pentagon.h"
#include <cmath>

    Pentagon::Pentagon() {}

    Pentagon::Pentagon(std::istream &InputStream)
  {
      InputStream >> a;
      InputStream >> b;
      InputStream >> c;
      InputStream >> d;
      InputStream >> e;
      std:: cout << "Pentagon that you wanted to create has been created" << std::
endl;
  }

  void Pentagon::Print(std::ostream &OutputStream) {
      OutputStream << "Pentagon: ";
      OutputStream << a << " " << b << " " << c << " " << d << " " << e << std:: endl;

  }

   size_t Pentagon::VertexesNumber() {
       size_t number = 5;
       return number;
   }

   double Pentagon::Area() {
   double q = abs(a.X() * b.Y() + b.X() * c.Y() + c.X() * d.Y() + d.X() * e.Y() + e.X() *
a.Y() - b.X() * a.Y() - c.X() * b.Y() - d.X() * c.Y() - e.X() * d.Y() - a.X() * e.Y());
   double s = q / 2;
   this->area = s;
   return s;
   }

   double Pentagon:: GetArea() {
       return area;
   }
```

```
Pentagon::~Pentagon() {
      std:: cout << "My friend, your pentagon has been deleted" << std:: endl;
  }

bool operator == (Pentagon& p1, Pentagon& p2){
   if(p1.a == p2.a && p1.b == p2.b && p1.c == p2.c && p1.d == p2.d && p1.e ==
p2.e) {
      return true;
   }
   return false;
}

std::ostream& operator << (std::ostream& os, Pentagon& p){
os << "Pentagon: ";
os << p.a << p.b << p.c << p.d << p.e;
os << std::endl;
return os;
}
```

Pentagon.h

```
#ifndef PENTAGON_H
#define PENTAGON_H

#include "figure.h"
#include <iostream>


class Pentagon : public Figure {
  public:
  Pentagon(std::istream &InputStream);
  Pentagon();
  double GetArea();
  size_t VertexesNumber();
  double Area();
  void Print(std::ostream &OutputStream);
  friend bool operator == (Pentagon& p1, Pentagon& p2);
  friend std::ostream& operator << (std::ostream& os, Pentagon& p);
  virtual ~Pentagon();
  double area;

  private:
  Point a;
  Point b;
  Point c;
  Point d;
```

```
    Point e;
};
#endif
```

Point.cpp

```
#include "point.h"

#include <cmath>

Point::Point() : x(0.0), y(0.0) {}

Point::Point(double x, double y) : x(x), y(y) {}

Point::Point(std::istream &is) {
  is >> x >> y;
}


double Point::X() {
  return x;
};
double Point::Y() {
  return y;
};

std::istream& operator>>(std::istream& is, Point& p) {
  is >> p.x >> p.y;
  return is;
}

std::ostream& operator<<(std::ostream& os, Point& p) {
  os << "(" << p.x << ", " << p.y << ")";
  return os;
}

bool operator == (Point &p1, Point& p2) {
  return (p1.x == p2.x && p1.y == p2.y);
}
```

Point.h

```
#ifndef POINT_H
#define POINT_H

#include <iostream>
```

```
class Point {
public:
  Point();
  Point(std::istream &is);
  Point(double x, double y);
  friend bool operator == (Point& p1, Point& p2);
  friend class Pentagon;
  double X();
  double Y();
  friend std::istream& operator>>(std::istream& is, Point& p);
  friend std::ostream& operator<<(std::ostream& os, Point& p);

private:
  double x;
  double y;
};

#endif
```

TBinaryTree.cpp

```
#include "TBinaryTree.h"

template <class T>
TBinaryTree<T>::TBinaryTree () {
    root = NULL;
}

template <class T>
std::shared_ptr<TBinaryTreeItem<T>> copy (std::shared_ptr<TBinaryTreeItem<T>> root) {
    if (!root) {
        return NULL;
    }
    std::shared_ptr<TBinaryTreeItem<T>> root_copy(new TBinaryTreeItem<T>(root-
>GetPentagon()));
    root_copy->SetLeft(copy(root->GetLeft()));
    root_copy->SetRight(copy(root->GetRight()));
    return root_copy;
}

template <class T>
TBinaryTree<T>::TBinaryTree (const TBinaryTree<T> &other) {
    root = copy(other.root);
}
```

```
template <class T>
void Print (std::ostream& os, std::shared_ptr<TBinaryTreeItem<T>> node){
    if (!node){
        return;
    }
    if(node->GetLeft()){
        os << node->GetPentagon().GetArea() << ": [";
        Print (os, node->GetLeft());
        if (node->GetRight()){
            if (node->GetRight()){
                os << ", ";
                Print (os, node->GetRight());
            }
        }
        os << "]";
    } else if (node->GetRight()) {
       os << node->GetPentagon().GetArea() << ": [";
        Print (os, node->GetRight());
        if (node->GetLeft()){
            if (node->GetLeft()){
                os << ", ";
                Print (os, node->GetLeft());
            }
        }
        os << "]";
    }
    else {
        os << node->GetPentagon().GetArea();
    }
}

template <class T>
std::ostream& operator<< (std::ostream& os, TBinaryTree<T>& tree){
    Print(os, tree.root);
    os << "\n";
    return os;
}

template <class T>
void TBinaryTree<T>::Push (T &pentagon) {
    if (root == NULL) {
    std::shared_ptr<TBinaryTreeItem<T>> help(new TBinaryTreeItem<T>(pentagon));
    root = help;
    }
    else if (root->GetPentagon() == pentagon) {
        root->IncreaseCounter();
    }
    else {
        std::shared_ptr <TBinaryTreeItem<T>> parent = root;
```

```
        std::shared_ptr <TBinaryTreeItem<T>> current;
        bool childInLeft = true;
        if (pentagon.GetArea() < parent->GetPentagon().GetArea()) {
            current = root->GetLeft();
        }
        else if (pentagon.GetArea() > parent->GetPentagon().GetArea()) {
            current = root->GetRight();
            childInLeft = false;
        }
        while (current != NULL) {
            if (current->GetPentagon() == pentagon) {
                current->IncreaseCounter();
            }
            else {
            if (pentagon.GetArea() < current->GetPentagon().GetArea()) {
                parent = current;
                current = parent->GetLeft();
                childInLeft = true;
                }
            else if (pentagon.GetArea() > current->GetPentagon().GetArea()) {
                parent = current;
                current = parent->GetRight();
                childInLeft = false;
            }
        }
    }
        std::shared_ptr <TBinaryTreeItem<T>> item (new TBinaryTreeItem<T>(pentagon));
        current = item;
        if (childInLeft == true) {
            parent->SetLeft(current);
        }
        else {
            parent->SetRight(current);
        }
    }
}

template <class T>
std::shared_ptr <TBinaryTreeItem<T>> FMRST(std::shared_ptr <TBinaryTreeItem<T>> root)
{
    if (root->GetLeft() == NULL) {
        return root;
    }
    return FMRST(root->GetLeft());
}

template <class T>
std::shared_ptr <TBinaryTreeItem<T>> TBinaryTree<T>:: Pop(std::shared_ptr
<TBinaryTreeItem<T>> root, T &pentagon) {
```

```
    if (root == NULL) {
        return root;
    }
    else if (pentagon.GetArea() < root->GetPentagon().GetArea()) {
        root->SetLeft(Pop(root->GetLeft(), pentagon));
    }
    else if (pentagon.GetArea() > root->GetPentagon().GetArea()) {
        root->SetRight(Pop(root->GetRight(), pentagon));
    }
    else {
        //first case of deleting - we are deleting a list
        if (root->GetLeft() == NULL && root->GetRight() == NULL) {
            root = NULL;
            return root;
        }
        //second case of deleting - we are deleting a verex with only one child
        else if (root->GetLeft() == NULL && root->GetRight() != NULL) {
            std::shared_ptr <TBinaryTreeItem<T>> pointer = root;
            root = root->GetRight();
            return root;
        }
        else if (root->GetRight() == NULL && root->GetLeft() != NULL) {
            std::shared_ptr <TBinaryTreeItem<T>> pointer = root;
            root = root->GetLeft();
            return root;
        }
        //third case of deleting
        else {
            std::shared_ptr <TBinaryTreeItem<T>> pointer = FMRST(root->GetRight());
            root->GetPentagon().area = pointer->GetPentagon().GetArea();
            root->SetRight(Pop(root->GetRight(), pointer->GetPentagon()));
        }
    }
    return root;
}

template <class T>
void RecursiveCount(double minArea, double maxArea,
std::shared_ptr<TBinaryTreeItem<T>> current, int& ans) {
    if (current != NULL) {
        RecursiveCount(minArea, maxArea, current->GetLeft(), ans);
        RecursiveCount(minArea, maxArea, current->GetRight(), ans);
        if (minArea <= current->GetPentagon().GetArea() && current->GetPentagon().GetArea()
< maxArea) {
            ans += current->ReturnCounter();
        }
    }
}
```

```
template <class T>
int TBinaryTree<T>::Count(double minArea, double maxArea) {
    int ans = 0;
    RecursiveCount(minArea, maxArea, root, ans);
    return ans;
}

template <class T>
T& TBinaryTree<T>::GetItemNotLess(double area, std::shared_ptr <TBinaryTreeItem<T>>
root) {
    if (root->GetPentagon().GetArea() >= area) {
        return root->GetPentagon();
    }
    else {
        return GetItemNotLess(area, root->GetRight());
    }
}

template <class T>
void RecursiveClear(std::shared_ptr <TBinaryTreeItem<T>> current){
    if (current!= NULL){
        RecursiveClear(current->GetLeft());
        RecursiveClear(current->GetRight());
            current = NULL;
    }
}

template <class T>
void TBinaryTree<T>::Clear(){
    RecursiveClear(root);
    root = NULL;
}

template <class T>
bool TBinaryTree<T>::Empty() {
     if (root == NULL) {
         return true;
     }
     return false;
}

template <class T>
TBinaryTree<T>::~TBinaryTree() {
    Clear();
    std:: cout << "Your tree has been deleted" << std:: endl;
}

#include "pentagon.h"
template class TBinaryTree<Pentagon>;
```

```
template std::ostream& operator<<(std::ostream& os, TBinaryTree<Pentagon>& stack);
```

TBinaryTree.h

```
#ifndef TBINARYTREE_H
#define TBINARYTREE_H
#include "TBinaryTreeItem.h"

template <class T>

class TBinaryTree {
public:
TBinaryTree();
TBinaryTree(const TBinaryTree<T> &other);
void Push(T &pentagon);
std::shared_ptr<TBinaryTreeItem<T>> Pop(std::shared_ptr<TBinaryTreeItem<T>> root, T
&pentagon);
T& GetItemNotLess(double area, std::shared_ptr<TBinaryTreeItem<T>> root);
void Clear();
bool Empty();
int Count(double minArea, double maxArea);
template <class A>
friend std::ostream& operator<<(std::ostream& os, TBinaryTree<A>& tree);
virtual ~TBinaryTree();
std::shared_ptr <TBinaryTreeItem<T>> root;
};
#endif
```

TBinaryTreeItem.cpp

```
#include "TBinaryTreeItem.h"

template <class T>
TBinaryTreeItem<T>::TBinaryTreeItem(const T &pentagon) {
    this->pentagon = pentagon;
    this->left = this->right = NULL;
    this->counter = 1;
}
```

```
template <class T>
TBinaryTreeItem<T>::TBinaryTreeItem(const TBinaryTreeItem<T> &other) {
    this->pentagon = other.pentagon;
    this->left = other.left;
    this->right = other.right;
    this->counter = other.counter;
}

template <class T>
T& TBinaryTreeItem<T>::GetPentagon() {
    return this->pentagon;
}

template <class T>
void TBinaryTreeItem<T>::SetPentagon(const T& pentagon){
    this->pentagon = pentagon;
}

template <class T>
std::shared_ptr<TBinaryTreeItem<T>> TBinaryTreeItem<T>::GetLeft(){
    return this->left;
}

template <class T>
std::shared_ptr<TBinaryTreeItem<T>> TBinaryTreeItem<T>::GetRight(){
    return this->right;
}

template <class T>
void TBinaryTreeItem<T>::SetLeft(std::shared_ptr<TBinaryTreeItem<T>> item) {
    if (this != NULL){
        this->left = item;
    }
}

template <class T>
void TBinaryTreeItem<T>::SetRight(std::shared_ptr<TBinaryTreeItem<T>> item) {
    if (this != NULL){
        this->right = item;
    }
}

template <class T>
void TBinaryTreeItem<T>::IncreaseCounter() {
    if (this != NULL){
        counter++;
    }
}
```

```
template <class T>
void TBinaryTreeItem<T>::DecreaseCounter() {
    if (this != NULL){
        counter--;
    }
}

template <class T>
int TBinaryTreeItem<T>::ReturnCounter() {
    return this->counter;
}

template <class T>
TBinaryTreeItem<T>::~TBinaryTreeItem() {
    std::cout << "Destructor TBinaryTreeItem was called\n";
}

template <class T>
std::ostream &operator<<(std::ostream &os, TBinaryTreeItem<T> &obj)
{
    os << "Item: " << obj.GetPentagon() << std::endl;
    return os;
}

#include "pentagon.h"
template class TBinaryTreeItem<Pentagon>;
template std::ostream& operator<<(std::ostream& os, TBinaryTreeItem<Pentagon> &obj);
```

TIterator.h

```
#ifndef TITERATOR_H
#define TITERATOR_H
#include <iostream>
#include <memory>

template <class T, class A>
class TIterator {
public:
TIterator(std::shared_ptr<T> iter) {
    node_ptr = iter;
}
A& operator*() {
    return node_ptr->GetPentagon();
}

void GoToLeft() { //переход к левому поддереву, если существует
    if (node_ptr == NULL) {
```

```
        std:: cout << "Root does not exist" << std:: endl;
    }
    else {
        node_ptr = node_ptr->GetLeft();
    }
}
void GoToRight() { //переход к правому поддереву, если существует
    if (node_ptr == NULL) {
        std:: cout << "Root does not exist" << std:: endl;
    }
    else {
        node_ptr = node_ptr->GetRight();
    }
}
bool operator == (TIterator &iterator) {
    return node_ptr == iterator.node_ptr;
}
bool operator != (TIterator &iterator) {
    return !(*this == iterator);
}

private:
    std::shared_ptr<T> node_ptr;
};
#endif
```

TBinaryTreeItem.h

```
#ifndef TBINARYTREE_ITEM_H
#define TBINARYTREE_ITEM_H
#include "pentagon.h"

template <class T>
class TBinaryTreeItem {
public:
TBinaryTreeItem(const T& pentagon);
TBinaryTreeItem(const TBinaryTreeItem<T>& other);
T& GetPentagon();
void SetPentagon(T& pentagon);
std::shared_ptr<TBinaryTreeItem<T>> GetLeft();
std::shared_ptr<TBinaryTreeItem<T>> GetRight();
void SetLeft(std::shared_ptr<TBinaryTreeItem<T>> item);
void SetRight(std::shared_ptr<TBinaryTreeItem<T>> item);
```

```
void SetPentagon(const T& pentagon);
void IncreaseCounter();
void DecreaseCounter();
int ReturnCounter();
virtual ~TBinaryTreeItem();

template<class A>
friend std::ostream &operator<<(std::ostream &os, const TBinaryTreeItem<A> &obj);

private:
T pentagon;
std::shared_ptr<TBinaryTreeItem<T>> left;
std::shared_ptr<TBinaryTreeItem<T>> right;
int counter;
};
#endif
```

TAllocatorBlock.h

```
#ifndef TALLOCATORBLOCK_H
#define TALLOCATORBLOCK_H

#include "TLinkedList.h"
#include <memory>

class TAllocatorBlock {
   public:
      TAllocatorBlock(const size_t& size, const size_t count){
         this->size = size;
         for(int i = 0; i < count; ++i){
            unused_blocks.Insert(malloc(size));
         }
      }
      void* Allocate(const size_t& size){
         if(size != this->size){
            std::cout << "Error during allocation\n";
         }
         if(unused_blocks.Length()){
            for(int i = 0; i < 5; ++i){
               unused_blocks.Insert(malloc(size));
            }
         }
         void* tmp = unused_blocks.GetItem(1);
         used_blocks.Insert(unused_blocks.GetItem(1));
         unused_blocks.Remove(0);
         return tmp;
      }
      void Deallocate(void* ptr){
         unused_blocks.Insert(ptr);
      }
   ~TAllocatorBlock(){
```

```
        while(used_blocks.size()){
            try{
                free(used_blocks.GetItem(1);)
                used_blocks.Remove(0);
            } catch(...){
                used_blocks.Remove(0);
            }
        }
        while(unused_blocks.size()){
            try{
                free(unused_blocks.GetItem(1);
                unused_blocks.Remove(0);
            } catch(...){
                unused_blocks.Remove(0);
            }
        }
    }

    private:
        size_t size;
        TLinkedList <void*> used_blocks;
        TLinkedList <void*> unused_blocks;
};

#endif
```

HListItem.cpp

```
#include <iostream>
#include "HListItem.h"

template <class T> HListItem<T>::HListItem(const std::shared_ptr<Pentagon> &pentagon) {
  this->pentagon = pentagon;
  this->next = nullptr;
}
template <class A> std::ostream& operator<<(std::ostream& os,HListItem<A> &obj) {
  os << "[" << obj.pentagon << "]" << std::endl;
  return os;
}
template <class T> HListItem<T>::~HListItem() {
}
```

HListItem.h

```
#ifndef HLISTITEM_H
#define HLISTITEM_H
#include <iostream>
#include "pentagon.h"
#include <memory>
```

```
template <class T> class HListItem {
public:
  HListItem(const std::shared_ptr<Pentagon> &pentagon);
  template <class A> friend std::ostream& operator<<(std::ostream& os, HListItem<A>
&obj);
  ~HListItem();
  std::shared_ptr<T> pentagon;
  std::shared_ptr<HListItem<T>> next;
};
#include "HListItem.cpp"
#endif
```

TLinkedList.cpp

```
#include <iostream>
#include "TLinkedList.h"

template <class T> TLinkedList<T>::TLinkedList() {
  size_of_list = 0;
  std::shared_ptr<HListItem<T>> front;
  std::shared_ptr<HListItem<T>> back;
  std::cout << "Pentagon List created" << std::endl;
}
template <class T> TLinkedList<T>::TLinkedList(const std::shared_ptr<TLinkedList>
&other){
  front = other->front;
  back = other->back;
}
template <class T> size_t TLinkedList<T>::Length() {
  return size_of_list;
}
template <class T> bool TLinkedList<T>::Empty() {
  return size_of_list;
}
template <class T> std::shared_ptr<Pentagon>& TLinkedList<T>::GetItem(size_t idx){
  int k = 0;
  std::shared_ptr<HListItem<T>> obj = front;
  while (k != idx){
    k++;
    obj = obj->next;
  }
  return obj->pentagon;
}
template <class T> std::shared_ptr<Pentagon>& TLinkedList<T>::First() {
```

```
  return front->pentagon;
}
template <class T> std::shared_ptr<Pentagon>& TLinkedList<T>::Last() {
  return back->pentagon;
}
template <class T> void TLinkedList<T>::InsertLast(const std::shared_ptr<Pentagon>
&&pentagon) {
  std::shared_ptr<HListItem<T>> obj (new HListItem<T>(pentagon));
  if(size_of_list == 0) {
    front = obj;
    back = obj;
    size_of_list++;
    return;
  }
  back->next = obj;
  back = obj;
  obj->next = nullptr;
  size_of_list++;
}
template <class T> void TLinkedList<T>::RemoveLast() {
  if (size_of_list == 0) {
    std::cout << "Pentagon does not pop_back, because the Pentagon List is empty"
<< std:: endl;
  } else {
    if (front == back) {
      RemoveFirst();
      size_of_list--;
      return;
    }
    std::shared_ptr<HListItem<T>> prev_del = front;
    while (prev_del->next != back) {
      prev_del = prev_del->next;
    }
    prev_del->next = nullptr;
    back = prev_del;
    size_of_list--;
    }
}
template <class T> void TLinkedList<T>::InsertFirst(const std::shared_ptr<Pentagon>
&&pentagon) {
    std::shared_ptr<HListItem<T>> obj (new HListItem<T>(pentagon));
    if(size_of_list == 0) {
      front = obj;
      back = obj;
    } else {
```

```
      obj->next = front;
      front = obj;
    }
    size_of_list++;
}
template <class T> void TLinkedList<T>::RemoveFirst() {
    if (size_of_list == 0) {
      std::cout << "Pentagon does not pop_front, because the Pentagon List is empty"
<< std:: endl;
    } else {
    std::shared_ptr<HListItem<T>> del = front;
    front = del->next;
    size_of_list--;
    }
}
template <class T> void TLinkedList<T>::Insert(const std::shared_ptr<Pentagon>
&&pentagon, size_t position) {
  if (position <0) {
    std::cout << "Position < zero" << std::endl;
  } else if (position > size_of_list) {
    std::cout << " Position > size_of_list" << std::endl;
  } else {
    std::shared_ptr<HListItem<T>> obj (new HListItem<T>(pentagon));
    if (position == 0) {
      front = obj;
      back = obj;
    } else {
      int k = 0;
      std::shared_ptr<HListItem<T>> prev_insert = front;
      std::shared_ptr<HListItem<T>> next_insert;
      while(k+1 != position) {
        k++;
        prev_insert = prev_insert->next;
      }
      next_insert = prev_insert->next;
      prev_insert->next = obj;
      obj->next = next_insert;
    }
    size_of_list++;
  }
}
template <class T> void TLinkedList<T>::Remove(size_t position) {
  if (position > size_of_list ) {
    std:: cout << "Position " << position << " > " << "size " << size_of_list << " Not
correct erase" << std::endl;
```

```
  } else if (position < 0) {
    std::cout << "Position < 0" << std::endl;
  } else {
    if (position == 0) {
      RemoveFirst();
    } else {
      int k = 0;
      std::shared_ptr<HListItem<T>> prev_erase = front;
      std::shared_ptr<HListItem<T>> next_erase;
      std::shared_ptr<HListItem<T>> del;F
      while( k+1 != position) {
        k++;
        prev_erase = prev_erase->next;
      }
      next_erase = prev_erase->next;
      del = prev_erase->next;
      next_erase = del->next;
      prev_erase->next = next_erase;
    }
    size_of_list--;
  }
}
template <class T> void TLinkedList<T>::Clear() {
  std::shared_ptr<HListItem<T>> del = front;
  std::shared_ptr<HListItem<T>> prev_del;
  if(size_of_list !=0 ) {
    while(del->next != nullptr) {
      prev_del = del;
      del = del->next;
    }
    size_of_list = 0;
    //   std::cout << "HListItem deleted" << std::endl;
  }
  size_of_list = 0;
  std::shared_ptr<HListItem<T>> front;
  std::shared_ptr<HListItem<T>> back;
}
template <class T> std::ostream& operator<<(std::ostream& os, TLinkedList<T>& hl) {
  if (hl.size_of_list == 0) {
    os << "The pentagon list is empty, so there is nothing to output" << std::endl;
  } else {
    os << "Print Pentagon List" << std::endl;
    std::shared_ptr<HListItem<T>> obj = hl.front;
    while(obj != nullptr) {
      if (obj->next != nullptr) {
```

```
        os << obj->pentagon << " " << "," << " ";
        obj = obj->next;
      } else {
        os << obj->pentagon;
        obj = obj->next;
      }
    }
    os << std::endl;
  }
  return os;
}
template <class T> TLinkedList<T>::~TLinkedList() {
  std::shared_ptr<HListItem<T>> del = front;
  std::shared_ptr<HListItem<T>> prev_del;
  if(size_of_list !=0 ) {
    while(del->next != nullptr) {
      prev_del = del;
      del = del->next;
    }
    size_of_list = 0;
    std::cout << "Pentagon List deleted" << std::endl;
  }
}
```

TLinkedList.h

```
#ifndef HLIST_H
#define HLIST_H
#include <iostream>
#include "HListItem.h"
#include "pentagon.h"
#include <memory>

template <class T> class TLinkedList {
public:
  TLinkedList();
  int size_of_list;
  size_t Length();
  std::shared_ptr<Pentagon>& First();
  std::shared_ptr<Pentagon>& Last();
  std::shared_ptr<Pentagon>& GetItem(size_t idx);
  bool Empty();
  TLinkedList(const std::shared_ptr<TLinkedList> &other);
  void InsertFirst(const std::shared_ptr<Pentagon> &&pentagon);
  void InsertLast(const std::shared_ptr<Pentagon> &&pentagon);
```

```
  void RemoveLast();
  void RemoveFirst();
  void Insert(const std::shared_ptr<Pentagon> &&pentagon, size_t position);
  void Remove(size_t position);
  void Clear();
  template <class A> friend std::ostream& operator<<(std::ostream& os, TLinkedList<A>&
list);
  ~TLinkedList();
private:
  std::shared_ptr<HListItem<T>> front;
  std::shared_ptr<HListItem<T>> back;
};
#include "TLinkedList.cpp"
#endif
```