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

ЛАБОРАТОРНАЯ РАБОТА №6

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

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Условие

Задание: Вариант 23: N-арное дерево (Шестиугольник). Необходимо спроектировать и запрограммировать на языке C++ класс-контейнер первого уровня, содержащий одну фи гуру (колонка фигура 1), согласно вариантам задания. Классы должны удовлетворять следующим правилам:

1. Требования к классу фигуры аналогичны требованиям из лабораторной работы 1.
2. Требования к классу контейнера аналогичны требованиям из лабораторной работы 2.
3. Класс-контейнер должен содержать объекты используя template<. . . >.
4. Классы должны быть расположены в раздельных файлах: отдельно заголовки (.h), отдельно описание методов (.cpp).

Нельзя использовать:

- Стандартные контейнеры std.

Программа должна позволять:

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

Описание программы

Исходный код лежит в 13 файлах:

1. main.cpp: тестирование кода
2. figure.h: родительский класс-интерфейс для фигур
3. point.h: описание класса точки
4. point.cpp: реализация класса точки
5. hexagon.h: описание класса hexagon, наследующегося от figure
6. hexagon.cpp: реализация класса hexagon
7. TNaryTree.cpp : реализация дерева
8. TNaryTree.h : заголовочный файл для дерева
9. TNaryTree_item.h : заголовочный файл для дерева

Дневник отладки

Ошибок по ходу решения обнаружено не было

Недочёты

Недочётов не заметил.

Вывод

В данной лабораторной работе были реализованы шаблоны классов. Задание не было сложным, так как основной код уже был написан в предыдущих работах. Шаблоны классов
- классический инструмент для написания контейнеров, поэтому, было полезно изучить и понять, зачем это нужно и как использовать. Лабораторная работа оказалась интересной и полезной для практики. Я приобрёл навыки написания шаблонов классов.

Исходный код

main.cpp

```
#include "figure.h"
#include "TNaryTree.h"
#include "TNaryTree_item.h"
#include "hexagon.h"
#include <string>

int main()
{
   TNaryTree<hexagon> a(4);
   if (a.Empty()) {
      std::cout << "The tree is empty !\n";
   } else {
      std::cout << "The tree is not empty !\n";
   }
   a.Update(std::shared_ptr<hexagon>(new hexagon(Point(1, 4), Point(1, 2), Point(5, 6), Point(2, 8),
   Point(3, 1), Point(2, 6))), ""); // 1
   a.Update(std::shared_ptr<hexagon>(new hexagon(Point(2, 5), Point(1, 5), Point(16, 6), Point(3, 6),
   Point(1, 8), Point(4, 2))), "c"); // 2
   a.Update(std::shared_ptr<hexagon>(new hexagon(Point(3, 5), Point(9, 1), Point(7, 3), Point(1, 8),
   Point(5, 6), Point(4, 8))), "cb"); // 3
   a.Update(std::shared_ptr<hexagon>(new hexagon(Point(8, 5), Point(1, 5), Point(16, 6), Point(3, 6),
   Point(1, 8), Point(4, 2))), "cbc"); // 8
   std::cout << a;
   std::cout << a.Area("cb") << "\n";
   TNaryTree<hexagon> b(a);
   std::cout << b;
   std::shared_ptr<hexagon> c = a.GetItem("");
   std::cout << *c;
   a.RemoveSubTree("cbc");
   if (a.Empty()) {
      std::cout << "The tree is empty !\n";
   } else {
      std::cout << "The tree is not empty !\n";
   }
   return 0;
}
```

figure.h

```
#ifndef FIGURE_H
#define FIGURE_H

#include "point.h"

class figure
```

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

#endif
```

hexagon.h

```
#ifndef HEXAGON_H
#define HEXAGON_H

#include "point.h"
#include "figure.h"

class hexagon : figure
{
public:
    hexagon(std::istream& is);
    hexagon();
    ~hexagon();
    hexagon(Point a, Point b, Point c, Point d, Point e, Point f);

    size_t VertexesNumber();
    double Area();
    void Print(std::ostream& os);

    hexagon& operator=(const hexagon&
    other); bool operator==(hexagon& other);
    friend std::ostream& operator<<(std::ostream& os, hexagon& other);
    friend std::istream& operator>>(std::istream& is, hexagon& other);

private:
    Point a_, b_, c_, d_;
    Point e_, f_;
};

#endif
```

hexagon.cpp

```
#include "hexagon.h"
#include "point.h"

hexagon::hexagon(std::istream& is)
{
    std::cin >> a_ >> b_ >> c_ >> d_;
    std::cin >> e_ >> f_;
}

hexagon::hexagon() : a_(0,0), b_(0,0), c_(0,0), d_(0, 0), e_(0,0), f_(0,0)
{}
```

```
hexagon::hexagon(Point a, Point b, Point c, Point d, Point e, Point f)
{
    this->a_ = a; this->b_ = b;
    this->c_ = c; this->d_ = d;
    this->e_ = e; this->f_ = f;
}

size_t hexagon::VertexesNumber()
{
    return (size_t)6;
}

double hexagon::Area()
{
    return 0.5 * abs((a_.getX() * b_.getY() + b_.getX() * c_.getY() + c_.getX() * d_.getY() + d_.getX() *
    e_.getY()
+ e_.getX() * f_.getY()
    - (b_.getX() * a_.getY() + c_.getX() * b_.getY() + d_.getX() * c_.getY() + e_.getX() * d_.getY() + f_.getX() *
e_.getY())));
}

hexagon& hexagon::operator=(const hexagon& other)
{
    this->a_ = other.a_; this->b_ = other.b_;
    this->c_ = other.c_; this->d_ = other.d_;
    this->e_ = other.e_; this->f_ = other.f_;
    return *this;
}

bool hexagon::operator==(hexagon& other)
{
    return this->a_ == other.a_ && this->b_ == other.b_ &&
    this->c_ == other.c_ && this->d_ == other.d_ &&
    this->e_ == other.e_ && this->f_ == other.f_;
}

std::ostream& operator<<(std::ostream& os, hexagon& oct)
{
    os << "Octagon: " << oct.a_ << " " << oct.b_ << " ";
    os << oct.c_ << " " << oct.d_ << " " << oct.e_ << " ";
    os << oct.f_ << "\n";
    return os;
}

std::istream& operator>>(std::istream& is, hexagon& other)
{
    is >> other.a_ >> other.b_ >> other.c_ >> other.d_;
    is >> other.e_ >> other.f_;
    return is;
}
```

```
void hexagon::Print(std::ostream& os)
{
    std::cout << "Octagon: " << a_ << " " << b_ << " ";
    std::cout << c_ << " " << d_ << " " << e_ << " ";
    std::cout << f_ << "\n";
}

hexagon::~hexagon(){}
```

TNaryTree.h

```
#ifndef TNARY_TREE
#define TNARY_TREE

#include "hexagon.h"
#include "TNaryTree_item.h"
#include <memory>

template<class T>
class TNaryTree
{
public:
   TNaryTree(int n);
   TNaryTree(const TNaryTree<T>& other);
   TNaryTree();

   void Update(const std::shared_ptr<T> &&polygon, const std::string &&tree_path)
   {
      Update(&root, polygon, tree_path);
   }

   void Update(const std::shared_ptr<T> &polygon, const std::string &tree_path)
   {
      Update(&root, polygon, tree_path);
   }

   const std::shared_ptr<T>& GetItem(const std::string& tree_path)
   {
      return GetItem(&root, tree_path);
   }

   void RemoveSubTree(const std::string &&tree_path);
   void RemoveSubTree(const std::string &tree_path);
   bool Empty();
   double Area(std::string&& tree_path);
   double Area(std::string& tree_path);
   template<class A> friend std::ostream& operator<<(std::ostream& os, const TNaryTree<A>& tree);
   virtual ~TNaryTree();

private:
   int size;
   std::shared_ptr<TreeItem<T>> root;
   void Update(std::shared_ptr<TreeItem<T>>* root, std::shared_ptr<T> polygon, std::string tree_path);
   const std::shared_ptr<T>& GetItem(std::shared_ptr<TreeItem<T>>* root, const std::string tree_path);
};

#endif
```

TNaryTree.cpp

```
#include "TNaryTree.h"
#include "TNaryTree_item.h"

template<class T>
TNaryTree<T>::TNaryTree(int n)
{
   this->size = n;
   this->root = nullptr;
}

template<class T>
std::shared_ptr<TreeItem<T>>
tree_copy(std::shared_ptr<TreeItem<T>> root)
{
   if (root != nullptr) {
      std::shared_ptr<TreeItem<T>> new_root (new
TreeItem<T>);
      new_root->figure = root->figure;
      new_root->son = nullptr;
      new_root->brother = nullptr;
      if (root->son != nullptr) {
         new_root->son = tree_copy(root->son);
      }
      if (root->brother != nullptr) {
         new_root->brother = tree_copy(root->brother);
      }
      return new_root;
   }
   return nullptr;
}

template<class T>
TNaryTree<T>::TNaryTree(const TNaryTree<T>& other)
{
   this->root =
   tree_copy(other.root); this->root-
   >cur_size = 0;
   this->size = other.size;
}
```

```
template<class T>
void TNaryTree<T>::Update(std::shared_ptr<TreeItem<T>>*
root, std::shared_ptr<T> polygon, std::string tree_path)
{
   if (tree_path == "") {
      if (*root == nullptr) {
      *root = std::shared_ptr<TreeItem<T>>(new
TreeItem<T>);
      (*root)->figure = std::shared_ptr<T>(new
      T); (*root)->figure = polygon;
      (*root)->brother = nullptr;
      (*root)->son = nullptr;
      (*root)->parent = nullptr;
      } else {
         (*root)->figure = polygon;
      }
      return;
   }
   if (tree_path == "b") {
      std::cout << "Cant add brother to root\n";
      return;
   }
   std::shared_ptr<TreeItem<T>> cur = *root;
   if (cur == NULL) {
      throw std::invalid_argument("Vertex doesn't exist in
the path\n");
      return;
   }
   for (int i = 0; i < tree_path.size() - 1; i++) {
      if (tree_path[i] == 'c') {
         cur = cur->son;
      } else {
         cur = cur->brother;
      }
      if (cur == nullptr && i < tree_path.size() - 1) {
         throw std::invalid_argument("Vertex doesn't exist in
the path\n");
         return;
      }
   }
   if (tree_path[tree_path.size() - 1] == 'c' && cur->son ==
nullptr) {
```

```
        if (cur->cur_size + 1 > this->size) {
            throw std::out_of_range("Tree is overflow\n");
            return;
        }
        if (cur->son == nullptr) {
            cur->son = std::shared_ptr<TreeItem<T>>(new
TreeItem<T>);
            cur->son->figure = std::shared_ptr<T>(new
            T); cur->son->figure = polygon;
            cur->son->son = nullptr;
            cur->son->brother = nullptr;
            cur->son->parent = cur;
            cur->son->parent->cur_size++;
        } else {
            cur->son->figure = polygon;
        }
    } else if (tree_path[tree_path.size() - 1] == 'b' && cur-
>brother == nullptr) {
        if (cur->parent->cur_size + 1 > this->size) {
            throw std::out_of_range("Tree is overflow\n");
            return;
        }
        if (cur->brother == nullptr) {
            cur->brother = std::shared_ptr<TreeItem<T>>(new
TreeItem<T>);
            cur->brother->figure = std::shared_ptr<T>(new T);
            cur->brother->figure = polygon;
            cur->brother->son = nullptr;
            cur->brother->brother = nullptr;
            cur->brother->parent = cur->parent;
            cur->brother->parent->cur_size++;
        } else {
            cur->brother->figure = polygon;
        }
    }
}

template<class T>
void delete_tree(std::shared_ptr<TreeItem<T>>* root)
{
    if ((*root)->son != nullptr) {
        delete_tree(&((*root)->son));
```

```
    }
    if ((*root)->brother != nullptr) {
        delete_tree(&((*root)->brother));
    }
    *root = nullptr;
}

template<class T>
void delete_undertree(std::shared_ptr<TreeItem<T>>* root,
char c)
{
    if (*root == nullptr) {
        return;
    }
    if (c == 'b') {
        if ((*root)->brother != nullptr) {
            std::shared_ptr<TreeItem<T>> cur = (*root)-
>brother;
            if ((*root)->brother->brother != nullptr) {
                (*root)->brother = (*root)->brother->brother;
                cur->brother = nullptr;
                delete_tree(&cur);
            } else {
                delete_tree(&((*root)->brother));
            }
        }
    } else if (c == 'c') {
        std::shared_ptr<TreeItem<T>> cur = (*root)->son;
        if ((*root)->son->brother != nullptr) {
            (*root)->son = (*root)->son->brother;
            if (cur->son != nullptr) {
                delete_tree(&(cur->son));
            }
            cur = nullptr;
        } else {
            delete_tree(&((*root)->son));
        }
    }
}

template<class T>
void TNaryTree<T>::RemoveSubTree(const std::string
```

```
&&tree_path)
{
    if (tree_path == "" && this->root != nullptr) {
        std::shared_ptr<TreeItem<T>>* iter = &(this->root);
        delete_tree(iter);
        return;
    } else if (tree_path == "" && this->root == nullptr) {
        throw std::invalid_argument("Vertex doesn't exist in
the path\n");
        return;
    }
    std::shared_ptr<TreeItem<T>> cur = this->root;
    for (int i = 0; i < tree_path.size() - 1; i++) {
        if (tree_path[i] == 'c') {
            if (cur->son == nullptr) {
                throw std::invalid_argument("Vertex doesn't exist
in the path\n");
                return;
            }
            cur = cur->son;
        } else if (tree_path[i] == 'b') {
            if (cur->brother == nullptr)
            {
                throw std::invalid_argument("Vertex doesn't exist
in the path\n");
                return;
            }
            cur = cur->brother;
        }
    }
    if (tree_path[tree_path.size() - 1] == 'c') {
        if (cur->son == nullptr) {
            throw std::invalid_argument("Vertex doesn't exist in
the path\n");
            return;
        }
        delete_undertree(&cur, 'c');
    } else if (tree_path[tree_path.size() - 1] == 'b') {
        if (cur->brother == nullptr) {
            throw std::invalid_argument("Vertex doesn't exist in
the path\n");
            return;
        }
```

```
        delete_undertree(&cur, 'b');
    }
    return;
}

template<class T>
void TNaryTree<T>::RemoveSubTree(const std::string
&tree_path)
{
    if (tree_path == "" && this->root != nullptr) {
        std::shared_ptr<TreeItem<T>>* iter = &(this->root);
        delete_tree(iter);
        return;
    } else if (tree_path == "" && this->root == nullptr) {
        throw std::invalid_argument("Vertex doesn't exist in
the path\n");
        return;
    }
    std::shared_ptr<TreeItem<T>> cur = this->root;
    for (int i = 0; i < tree_path.size() - 1; i++) {
        if (tree_path[i] == 'c') {
            if (cur->son == nullptr) {
                throw std::invalid_argument("Vertex doesn't exist
in the path\n");
                return;
            }
            cur = cur->son;
        } else if (tree_path[i] == 'b') {
            if (cur->brother == nullptr) {
                throw std::invalid_argument("Vertex doesn't exist
in the path\n");
                return;
            }
            cur = cur->brother;
        }
    }
    if (tree_path[tree_path.size() - 1] == 'c') {
        if (cur->son == nullptr) {
            throw std::invalid_argument("Vertex doesn't exist in
the path\n");
            return;
        }
```

```
        delete_undertree(&cur, 'c');
    } else if (tree_path[tree_path.size() - 1] == 'b') {
        if (cur->brother == nullptr) {
            throw std::invalid_argument("Vertex doesn't exist in
the path\n");
            return;
        }
        delete_undertree(&cur, 'b');
    }
    return;
}

template<class T>
bool TNaryTree<T>::Empty()
{
    if (this->root != nullptr) {
        return false;
    } else {
        return true;
    }
}

template<class T>
double TNaryTree<T>::Area(std::string &&tree_path)
{
    if (tree_path == "") {
        if (this->root != nullptr) {
            return this->root->figure->Area();
        } else {
            throw std::invalid_argument("Vertex doesn't exist in
the path\n");
        }
    }
    std::shared_ptr<TreeItem<T>> cur = this->root;
    double square = 0;
    for (int i = 0; i < tree_path.size(); i++) {
        if (tree_path[i] == 'c') {
            if (cur->son != nullptr) {
                cur = cur->son;
            } else {
                throw std::invalid_argument("Vertex doesn't exist
in the path\n");
```

```
            }
        } else {
            if (cur->brother != nullptr) {
                cur = cur->brother;
            } else {
                throw std::invalid_argument("Vertex doesn't exist
in the path\n");
            }
        }
        square += cur->figure->Area();
    }
    return square + this->root->figure->Area();
}

template<class T>
double TNaryTree<T>::Area(std::string &tree_path)
{
    if (tree_path == "") {
        if (this->root != nullptr) {
            return this->root->figure->Area();
        } else {
            throw std::invalid_argument("Vertex doesn't exist in
the path\n");
        }
    }
    std::shared_ptr<TreeItem<T>> cur = this->root;
    double square = 0;
    for (int i = 0; i < tree_path.size(); i++) {
        if (tree_path[i] == 'c') {
            if (cur->son != nullptr) {
                cur = cur->son;
            } else {
                throw std::invalid_argument("Vertex doesn't exist
in the path\n");
            }
        } else {
            if (cur->brother != nullptr) {
                cur = cur->brother;
            } else {
                throw std::invalid_argument("Vertex doesn't exist
in the path\n");
            }
```

```
        }
        square += cur->figure->Area();
    }
    return square + this->root->figure->Area();
}

template<class T>
void Print(std::ostream& os, std::shared_ptr<TreeItem<T>>
vertex)
{
    if (vertex != nullptr) {
        os << vertex->figure->Area();
        if (vertex->son != nullptr) {
            os << ": " << "[";
            Print(os, vertex->son);
            if ((vertex->son->brother == nullptr && vertex-
>brother != nullptr) || (vertex->son->brother == nullptr
&& vertex->brother == nullptr)) {
                os << "]";
            }
        }
        if (vertex->brother != nullptr) {
            os << ", ";
            Print(os, vertex->brother);
            if (vertex->brother->brother == nullptr) {
                os << "]";
            }
        }
    } else {
        return;
    }
}

template<class A>
std::ostream& operator<<(std::ostream& os, const
TNaryTree<A>& tree)
{
    if (tree.root != nullptr) {
        Print(os, tree.root); os << "\n";
        return os;
    } else {
        os << "Tree has no vertex\n";
```

```
        return os;
    }
}

template<class T>
const std::shared_ptr<T>&
TNaryTree<T>::GetItem(std::shared_ptr<TreeItem<T>>*
root, const std::string tree_path)
{
    if (tree_path == "" && *root == nullptr) {
        throw std::invalid_argument("Vertex doesn't exist in
the path\n");
    }
    std::shared_ptr<TreeItem<T>> cur = *root;
    for (int i = 0; i < tree_path.size(); i++) {
        if (tree_path[i] == 'c') {
            if (cur->son == nullptr) {
                throw std::invalid_argument("Vertex doesn't exist
in the path\n");
            }
            cur = cur->son;
        } else if (tree_path[i] == 'b') {
            if (cur->brother == nullptr)
            {
                throw std::invalid_argument("Vertex doesn't exist
in the path\n");
            }
            cur = cur->brother;
        }
    }
    return cur->figure;
}

template<class T>
TNaryTree<T>::~TNaryTree()
{
    if (this->root != nullptr) {
        this->RemoveSubTree("");
    }
}

template class
TNaryTree<hexagon>; template
std::ostream& operator<<
```

<hexagon>(std::ostream&, TNaryTree<hexagon> const&);

```
    size_t VertexesNumber();
    double Area();
    void Print(std::ostream &os);
    friend std::istream &operator>>(std::istream &is, Rectangle &object);
    friend std::ostream &operator<<(std::ostream &os, Rectangle object);
    Rectangle &operator=(const Rectangle &object);
    bool operator==(const Rectangle &object);

};

#endif //MAI_OOP_RECTANGLE_H
```

rectangle.cpp

```
#include "rectangle.h"
Rectangle::Rectangle() : a_(0, 0), b_(0, 0), c_(0, 0), d_(0, 0) {}
Rectangle::Rectangle(const Rectangle &rectangle) {
    this->a_ = rectangle.a_;
    this->b_ = rectangle.b_;
    this->c_ = rectangle.c_;
    this->d_ = rectangle.d_;
}

Rectangle::Rectangle(std::istream &is) {
    std::cin >> a_ >> b_ >> c_ >> d_;
}

size_t Rectangle::VertexesNumber() { return
    4;
}

double Rectangle::Area() {
    double a = a_.dist(b_);
    double b = b_.dist(c_);
    return a * b;
}

void Rectangle::Print(std::ostream &os) {
    std::cout << "Rectangle " << a_ << b_ << c_ << d_ << std::endl;
}
```

```
 std::istream &operator>>(std::istream &is, Rectangle &object){ is
  >> object.a_ >> object.b_ >> object.c_ >> object.d_; return is;
}

std::ostream &operator<<(std::ostream &os, Rectangle object){ os
  << "a side = " << object.a_.dist(object.b_) << std::endl; os << "b side
  = " << object.b_.dist(object.c_) << std::endl; os << "c side = " <<
  object.c_.dist(object.d_) << std::endl; os << "d side = " <<
  object.d_.dist(object.a_) << std::endl;

  return os;
}

Rectangle &Rectangle::operator=(const Rectangle &object){ this-
  >a_ = object.a_;
  this->b_  =  object.b_;
  this->c_  =  object.c_;
  this->d_  =  object.d_;
  return *this;
}

bool Rectangle::operator==(const Rectangle &object){
  if (this->a_ == object.a_ && this->b_ == object.b_ && this->c_ == object.c_ && this->d return
    true;
  } else return false;
}
```

square.h

```
#ifndef MAI_OOP_SQUARE_H
#define MAI_OOP_SQUARE_H

#include "figure.h"

class Square : public Figure {
 private:
  Point a_, b_, c_, d_;
 public:
  Square();
  Square(const Square &square);
  Square(std::istream &is); size_t
  VertexesNumber();
```

```
    double Area();
    void Print(std::ostream &os);
    friend std::istream &operator>>(std::istream &is, Square &object); friend
    std::ostream &operator<<(std::ostream &os, Square object); Square
    &operator=(const Square &object);
    bool operator==(const Square &object);
};

#endif //MAI_OOP_SQUARE_H
```

square.cpp

```
#include "square.h"
Square::Square() : a_(0, 0), b_(0, 0), c_(0, 0), d_(0, 0) {}
Square::Square(const Square &square) {
    this->a_ = square.a_;
    this->b_ = square.b_;
    this->c_ = square.c_;
    this->d_ = square.d_;
}

Square::Square(std::istream &is) {
    std::cin >> a_ >> b_ >> c_ >> d_;
}

size_t Square::VertexesNumber() { return
    4;
}

double Square::Area() {
    double a = a_.dist(b_);
    return a * a;
}

void Square::Print(std::ostream &os) {
    std::cout << "Square " << a_ << b_ << c_ << d_ << std::endl;
}

    std::istream &operator>>(std::istream &is, Square &object){ is
    >> object.a_ >> object.b_ >> object.c_ >> object.d_; return is;
```

```
}
std::ostream &operator<<(std::ostream &os, Square object){
   os << "a side = " << object.a_.dist(object.b_) << std::endl; os << "b
   side = " << object.b_.dist(object.c_) << std::endl; os << "c side = " <<
   object.c_.dist(object.d_)  <<  std::endl;  os  <<  "d  side  =  "  <<
   object.d_.dist(object.a_) << std::endl;

   return os;
}

Square  &Square::operator=(const  Square  &object){
   this->a_ = object.a_;
   this->b_  =  object.b_;
   this->c_  =  object.c_;
   this->d_  =  object.d_;
   return *this;

}
bool Square::operator==(const Square &object){
   if (this->a_ == object.a_ && this->b_ == object.b_ && this->c_ == object.c_ && this->d return
      true;
   } else return false;

}
```