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Summer Term
2019

Exam in

Advanced Programming Techniques

August 6, 2019

Name: _____

Date of birth: _____

Matriculation number: _____

Course of studies: _____

Please do not fill out anything below this line!

Total number of points: _____ of 60

Grade: _____

Passed: ☐ Yes / ☐ No

Problem 1: Definitions and Terms (15 points)

(a) (5P) List the following:

One object from the stream library: _____

_____

One sequential container: _____

_____

Three C++ keywords for built-in data types: _____

_____

(b) (4P) List three different classes implemented in the C++ standard library and in which header file they can be found.

_____

_____

_____

_____

_____

(c) (3P) Given is the function `fct` which takes a constant reference to a `string` and a reference to a constant `std::list` as input and returns an `float`.
Using the `std::function` library type, define a variable `f` and initialise it with `fct`.

_____

_____

(d) (3P) Define a random number using the standard library.

_____

_____

_____

_____

Problem 2: Errors and Function Matching (14 points)

Given is the following incorrect C++ program that should print the difference of two complex numbers: *1+ i*0*

```
#include <iostream>


template<class T> T diff(T a, T b) { return a-b;}


class Complex {

  private:

    const int x,y;

    Complex(int _x, int _y) : x(_x), y(_y) { }


    Complex& operator-(Complex& c) { Complex * ctemp(x+c->x,y+c->y); return ctemp; }

    void print() { std::cout << x << " + i*" << y << std::endl;}

};


int main() {


  Complex c1, c2(1,0);

  const Complex res = diff(c1,c2);

  res.print();

}
```

List all errors in the code and state how one can change the program such that the correct output is printed.

Problem 3: Programming with the Standard Library (9 points)

Please note: The questions assume that all necessary header files from the Standard Library are included and an implicit `using namespace std;`*. Likewise, you can safely assume the same for your code!*

(a) (7P) implement the function

```
template<typename T>
void lottery(vector<T> & v)
```

- sort first 5 elements of the vector ascending and last 2 elements of the vector descending independently
- use the STL for sorting
- append an average of the vector
- assume that instances of T support all necessary arithmetic and comparison operators

Example usage:

```
vector<int> v = {44, 20, 24, 15, 49, 9, 7};

lottery(v);

for(const auto & e : v )
    cout << e << " ";
```

Expected output of above snippet:

```
15 20 24 44 49 7 9 168
```

(b) (2P) What are the necessary arithmetic and comparison operators that a class `T` needs to provide, in order to work with the function `lottery`?

Problem 4: Instance Counter (10 points)

Please note: The questions assume that all necessary header files from the Standard Library are included and an implicit `using namespace std;`*. Likewise, you can safely assume the same for your code!*

Implement the class template `InstanceCounter` which "knows" how many instances of it currently exist. You must use copy control to facilitate the necessary book-keeping and also implement the static function member

```
static unsigned countInstances();
```

which returns the number currently in existence.

Then implement the class `A` which derives from `InstanceCounter< A >`. `A` shall print in its destructor to `std::cerr` how many instances of `A` are left afterwards, using the functionality of its base class.

```
template< typename T >
class InstanceCounter {
```

Problem 5: Short Questions (12 points)

(a) (2P) What is the output of the following program?

```
#include<iostream>
using namespace std;
int x = 5;

int &f() {
  return x;
}
int main() {
  f() = 10;
  cout<<x;
}
```

- ☐ 5
- ☐ address of 'x'
- ☐ 10
- ☐ compile error

(b) (2P) Does an abstract class in C++ need to consist only of pure virtual functions?

(c) (2P) What is a copy constructor?

(d) (2P) Do we have a String primitive data type in C++? If not, what is String?

(e) (2P) What is the purpose of ‘delete’ operator?

(f) (2P) If the ’new’ operator is to be avoided. What is a reasonable solution?

Problem 6: Project (20 bonus points)

Please make sure that you submit your project code with the exam paper such that we are able to check it! In case two groups submit the same code none of them will obtain any points for it.

(a) Which race did you implement in your group?

(b) What is your group's name?

(c) Did you pass the forward simulation task?

☐ Yes / ☐ No

(d) Did you pass the optimisation task?

☐ Yes / ☐ No

(e) Did you pass the push challenge?

☐ Yes / ☐ No

(f) Did you pass the rush challenge?

☐ Yes / ☐ No