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Winter Term
2018/19

Exam in

Advanced Programming Techniques

March 29, 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 associative container: _____

_____

One sequential container: _____

_____

One CV-qualifier: _____

_____

Two C++ keywords for explicit casts: _____

_____

(b) (4P) List three different kinds of smart pointers 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 pointer to a `float` and a reference to a constant `std::vector` as input and returns an `int`.
Using the `std::function` library type, define the variable `f` and initialise it with `fct`.

_____

_____

(d) (3P) List three different parts of the standard library by specifying the corresponding header file.

_____

_____

_____

_____

Problem 2: Errors and Function Matching (14 points)

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

```
#include <iostream>

template<T> T sum(T a, T b) { return a+b;}

class Complex {
  private:
    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 = sum(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 and last 2 elements of the vector independently
- use the STL for sorting
- append a sum 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};

lotto(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) Assuming `buf` is a valid pointer, what is the problem in the code below?

```
size_t sz = buf->size();
while ( --sz >= 0 )
{
/* do something */
}
```

(b) (2P) What is `i` and `j` after the code below is executed?

```
int i = 5;
int j = i++;
```

(c) (2P) Name two differences between a reference variable and a pointer variable.

(d) (2P) What is a `friend` function?

(e) (2P) When should be a “destructor” declared virtual and why?

(f) (2P) What is the difference between variable declaration and variable definition?

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