Object Oriented Programming & Design - Monsoon 2023

Final Examination Questions (2-Credit)

Name of the Student:

Roll Number:

Question Structure and Instructions

Please write your roll number **on each page of the question paper** above the top margin. This paper consists of two sections:

1. The 1st section consists of 10 short conceptual questions each carrying 3 points.
2. The 2nd section consists of 4 longer questions each carrying 5 points.

1 Short Conceptual Questions (3x10=30 points)

A1 Consider the following code:

```
class C {
    int *array;
    int x;
    C(C& c) {
        array = c.array;
        this-> x = c.x;
    }
};
```

Is the above copy constructor performing a deep copy? Justify.

(a) No, this is not doing a deep copy. – 1 mark

(b) Because the array's content is not copied in the copy constructor – 2 marks

A2 Suppose a programmer finds that their developed program is relatively slow (even after using compiler's optimization), and decides to improve the algorithm that has the highest time complexity. Is this a good idea? If not so, what is a better approach? Mention any tool that might be useful to speed up the program.

(a) No, this is not a good idea – 1 mark

(b) Better approach is to utilize profiling – 1 mark

(c) gprof could be used – 1 mark

A3 Consider a Makefile that builds a large program containing 5 different C++ files named "A.cpp", ..., "E.cpp". Suppose the programmer now changes the file "C.cpp" and then uses the makefile to rebuild the program. Which steps of the building process will be done on giving this command?

(a) Compilation of C.cpp – 1.5 mark

(b) Linking – 1.5 marks

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A4 Is there a memory leak in the following code? How would you detect it, if it is in some other function?

```
class C {
    public:
    int *x = NULL;
    int y;
    c(int y) {
        this->y = y;
        x = malloc(sizeof(int) * y);
    }
};
int main(void) {
    C *c = NULL;
    c = new C{10};
    /*Additional arithmetic operations on data members of c */
    delete c;
    return 0;
}
```

(a) Yes, there is a memory leak – 1.5 marks

(b) Detection is possible using valgrind – 1.5 marks

A5 Consider the following program that uses dynamic memory allocation:

```
int main(void) {
    int *x = NULL;
    x = malloc(40);
    x[9] = 5;
    return 0;
}
```

What is the content of the array that was allocated when the return statement was invoked? <9 garbage values, 5>

(a) 1 mark for specifying 10 elements

(b) 1 mark for specifying 9 garbage values

(c) 1 mark for specifying "5" at the end

A6 Suppose a designer needs to model the functioning of an international organization like the United Nations (UN), which consists of a group of countries. The designer feels that since UN policies are applicable to each individual country, it is better to utilize inheritance so that the attributes and functions/methods of UN are inherited by each individual country. Is the designer's approach right, or is an alternative strategy better, and if so, which strategy? Justify.

(a) No, this is not the right strategy – 1 mark

(b) Aggregation / composition is better strategy, because the UN is made of these countries – 1 + 1 marks

A7 Suppose a public function of a derived class overrides one in the base class. Is it possible for the derived class function to utilize the function of base class?

(a) Yes, it is possible – 1 mark

(b) Need to use BaseClass::function() from within the derived class – 1 mark for specifying the scope operator + 1 mark for specifying the right syntax

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A8 Suppose you utilize gprof to profile the C++ code. Since C++ code is compiled into object files and linked into executable file, how is it possible for gprof to know which line of source code consumes how much time?

(a) Yes, it is still possible –1 mark

(b) During compilation, the "-g" symbol adds additional data about the source code during compilation – 2 marks for specifying using either "-g" symbol or adding data during compilation

A9 What will be the output of the following program?

```
class C {
    public:
    int x;
    C() { x = 0; }
    void setValue(int x) { x = 5; }
};
int main(void) {
    C c;
    c.setValue(3);
    cout << c.x;
    return 0;
}
```

0; since setValue only touches the local variable

(a) Correct output – 1 mark

(b) The setValue only changes its own local variable, not the object's variable – 2 marks

A10 Suppose I have two classes corresponding to two distinct data structures – BST and Max-Heap. Both of them inherit their methods from an abstract class called DataStructure. Adding elements to BST and Max-Heap requires me to call the function BST.insertElementToBST and MaxHeap.insertElementToMaxHeap. Which feature of object-oriented programming is NOT being used here, and how could you utilize it?

1. Polymorphism is not being used – 1.5 marks
2. By using function overriding / renaming functions to insertElement – 1.5 marks

2 Long Questions (5 x 4 = 20 points)

B1 The Indian Railways run a variety of trains, falling into a variety of categories. The highest level of category are the passenger and freight trains. The passenger trains are categorized as mail and express trains, among which a limited number are also sub-categorized as superfast trains. Superfast trains also have the attribute that they more passenger amenities than non-superfast trains. Assuming that the train signaling system requires assigning priority based on the sub-category of trains, which is kept track using a priority parameter. Design a class structure that can automatically compute the priority of trains, depending on their type. You may assume that the highest priority is given to superfast, followed by express but non-superfast, followed by mail trains, followed by freight trains.

```
class Train {
    virtual int getPriority() = 0;
};
class PassengerTrain: public Train {
    int passengerAmenities;
    virtual int getPriority() { return 2; }
};
class FreightTrain: public Train {
```


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```
    virtual int getPriority() { return 1; }
};
class ExpressTrain: public PassengerTrain {
    virtual int getPriority() { return 3; }
};
class SuperFastTrain: public ExpressTrain {
    virtual int getPriority() { return 4; }
};
```

(a) 2 marks for having 5 classes

(b) 1 mark for proper inheritance

(c) 1 mark for using getPriority values

(d) 1 mark for having getPriority as a virtual function

B2 The Indian immigration system classifies countries into trusted and distrusted categories. Citizens of trusted countries get a visa on arrival, whereas citizens of distrusted countries do not get. There are also different categories of visa, such as tourist, work, education. Note that every visa must belong to some category. Furthermore, anybody making a false claim is noted down, and further visa requests are denied to them. Design a class structure to model the visas issued by the immigration system.

```
class Citizen {
    protected:
    bool visaDenied;
};
class TrustedCountryCitizen: public Citizen {
    bool visaOnArrival() { return true; }
class DistrustedCountryCitizen: public Citizen {
    bool visaOnArrival() { return false; }
class Visa() {
    Citizen c;
    public virtual bool issueVisa() = 0;
};
class TouristVisa: public Visa {
    public virtual bool issueVisa() { /* ... */ }
};
class WorkVisa: public Visa {
    public virtual bool issueVisa() { /* ... */ }
};
class EduVisa: public Visa {
    public virtual bool issueVisa() { /* ... */ }
};
```

(a) 2 marks for having 2 distinct hierarchy of classes

(b) 1 mark for using pure virtual / virtual functions

(c) 2 marks for using issueVisa and visaOnArrival functions

B3 Consider a situation where you are using a version manager like git to manage code. A second developer wants to join in and makes some changes to the code. On trying to push the (modified) code to the common repository, this second developer finds that you have also made some changes. What are the possible ways of ensuring that both the changes are part of a single code-base?

(a) In case of changes to different files – push will succeed – 2 marks

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(b) In case of changes to same file – merging of the changes need to be done by the user, either manually or by creating a second branch – 1.5 + 1.5 marks

B4 (a) Suppose we need to sort an array of strings and then an array of integers. Which of them is likely to be faster, and why? You may assume that the arrays are of the same length.

i. Depends on the type of strings – 1 mark

ii. Because longer and similar types of strings would take longer; shorter strings would take similar time – 1.5 mark

(b) In the above case, suppose we replace the array of integers by an array of floats. Which is likely to be faster now and why?

i. Depends on the type of strings – 1 mark

ii. Same reason as above – 1.5 marks

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