

Object Oriented Programming & Design - Monsoon 2023

Final Examination Questions (4-Credit)

Name of the Student:

Roll Number:

Stream:

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 15 short conceptual questions each carrying 3 points.
2. The 2nd section consists of 6 longer questions each carrying 5 points.

1 Short Conceptual Questions (3x10=30 points)

- A1 Consider the case of a program that returns a total of n random numbers, but none of them should be divisible by 10. A programmer writes the following code fragment to implement the above logic. Is this a good way of writing this code? If so, explain why the code is correct. If not so, explain why this is not a good strategy.

```
do {
    int i = 0;
    try {
        int x = random();
        if ((x % 10) == 0)
            throw x;
        i++;
    } catch (x) {
    }
} while (i < n);
```

- (a) No, not a good strategy – 1 mark
 - (b) Using exception handling for ordinary logic slows down execution OR because i is recreated, would lead to infinite loop – 2 marks
- A2 Consider a case where a user has entered a wrong input, but the program's logic has enough intelligence to work in spite of getting a wrong input. Which technique of C++ is the best to handle such a case?
- (a) Exception handling – 2 marks
 - (b) The catch block can suitably fix the input – 1 mark
- A3 Consider a template class that is used to create objects of some data structure. The objects initialized need not have the same type (as allowed by templates). Is it possible to still store them in a data structure like a Binary Search Tree, which requires comparisons across objects? If so, how is it possible? If not so, why is it not possible?

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- (a) Yes, possible. – 1 mark
- (b) By using a comparator function / by using operator overloading – 2 marks
- A4 Consider the case of a static variable x declared outside any functions. Functions $f1$ and $f2$ are defined in files $F1$ and $F2$ respectively. The functions $f1$ and $f2$ both manipulate x in different threads. Is there a possibility of a race condition? Justify.
- (a) No race condition will occur – 1 mark
- (b) The two variables are distinct, since they are both static / a variable from one file cannot be accessed in another file – 2 marks
- A5 Suppose we create a new process using the fork system call, but do not write to any variables in the new process. In this case, is the overhead of creating a new process higher than that of creating a thread, in the Linux OS? Justify.
- (a) Yes, overhead is higher – 1 mark
- (b) Address space / system / environment variables need to be copied – 2 marks
- A6 Consider a program that requires both gcc-7 and python 3.6. A user decides to install a virtual machine (VM) first, and then install the program within the VM. Is this a good decision, and why or why not?
- (a) No, it is a wrong decision – 1 mark
- (b) It consumes too much disk space, and introduces overhead of execution – 2 marks
- A7 Consider two disks with the same filesystem on the same machine, with the home directories of users divided among them. A user finds his own disk full, and decides to utilize the installation of Matlab by another user on the other disk by using a hard link. Is this a good strategy? Justify.
- (a) No, it is a wrong strategy – 1 mark
- (b) Hard links do not work across filesystems – 2 marks
- A8 Suppose you find that your program has a bug in it. You fix the code, save the file and then re-compile the program. Is it possible that you again encounter the same bug in the executable file? If so, why and how can it be prevented?
- (a) Yes, it is possible – 1 mark
- (b) The changes might be stored on the disk cache and not be actually written – 1 mark
- (c) Prevention – Use synchronized write / sync command – 1 mark
- A9 Consider a program $p.out$ which generates too much amount of text, but only a limited amount of it is useful. The useful lines are always marked with a “INFO: ” tag. What is the best way to store only these lines into a file while ignoring the other lines of output? You must mention the exact command.
- `./p.out — grep "INFO:" > output`
- (a) 1 mark for pipe and redirection
- (b) 1 mark for using grep
- (c) 1 mark for executing $p.out$ and writing output filename
- A10 Consider the case of a filesystem where a large file was being written. The inodes were allocated, but before the allocated inodes could be registered in the filesystem, power went off. Would it be possible to recover the data that was written on restarting the machine? If so, how? You may assume that no other records about the existence of the inodes exist anywhere on the filesystem.
- (a) Yes, it is possible – 1 mark
- (b) By running a disk check / using fsck command – 2 marks

A11 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

A12 Suppose you utilize a vector of vectors to store a 2-dimensional matrix. Now, we decide to fill up the rows by using the append function. Is this a good idea? Justify.

- (a) No, not a good idea – 1 mark
- (b) Repeated allocations of memory lead to poor performance – 2 marks

A13 Suppose a public function of a derived class overrides one (defined as virtual) 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

A14 Suppose you utilize gprof to profile the C++ code. Since C++ code is compiled into object files and linked into executable file, is it still possible for gprof to know which line of (C++) source code consumes how much time? If so, how? If not so, what does gprof actually show?

- (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

A15 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

- 1. Correct output – 1 mark
- 2. The setValue only changes its own local variable, not the object's variable – 2 marks

2 Long Questions (5 x 6 = 30 points)

- B1 The Indian Railways runs 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 {
    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 (a) Consider a program in which there are two vectors A and B on which Fast Fourier Transform needs to be performed. The operation on A takes some t_1^p time and on B takes some t_2^p time, in Python. However, the programmer decides to create threads so that they can be run concurrently. What is the approximate running time of this program, ignoring other overheads of creating the threads?
- i. The sum of the two times – 1 mark
 - ii. Python does not allow running of parallel threads – 1 mark
- (b) Assume that there are two threads that run concurrently which increases the value of a global variable x . If x was initialized to 0, what is the final value of x , if the program is written in (i) C++, and in (ii) Python?
- i. In C++, value is not deterministic – 1 or 2 – 1 mark for saying either of them
 - ii. In Python, the value will be 2 – 1 mark
 - iii. C++ allows running parallel threads, but Python does not – 1 mark
- B3 You want to create an abstract data structure that has a key and object. Search and sort operations always happen only by referring to the key, but the object contains other essential information. Explain and justify the best solution in the following cases:
- (a) The data type of the key can vary depending on the use case.
 - (b) The data type of the object can vary depending on the use case.

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- (a) Using a template is best, with operator overloading, because the comparison operation is a must – 1 + 1 + 1
- (b) Either templates or void pointer (Any one) – 2 marks
- B4 Consider two programs P1 and P2 both of which implement sorting of arrays of ints and floats. P1 uses templates to do the sorting, whereas P2 uses function overloading to write the two functions. Which among P1 and P2 have higher compilation time, and specify that who among P1's int_sort, P1's float_sort, P2's int_sort and P2's float_sort are the fastest and slowest respectively? You need to justify the reason.
- (a) P1 has higher compilation time, because templates make compilation slower – 1 + 1
- (b) P1's float sort and P2's float sort both are equally slow (and similarly P1's int sort and P2's int sort both are equally fast) – 3 marks (No marks for saying only one among P1's float or P2's float)
- B5 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 {
};
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
- B6 In the above question, the application is considered critical, as a decision has major impact on the security. This requires unit testing of various classes that deal with issuing of visas. How would you go about testing each of such classes? You need to show the structure of any extra code that might be needed.
- (a) Utilization of mock classes is essential – 2 marks
- (b) extending the Visa class (or its derived classes) with a MockClass in code – 3 marks