CS 101 (Spring 2023) — 24 April 2024
End-semester Examination

(Instructor: Shivaram Kalyanakrishnan)

Roll Number	`Solutions`
Division and Group	NO partial marks unless specified
Name	

Q. No.	Marks	Graded By	Verified By	Student's Cribs
1 (3)				
2 (2)				
3 (3)				
4 (3)				
5 (2)				
6 (4)				
7 (2)				
8 (3)				
9 (4)				
10 (4)				
TOTAL				

Please read the following instructions carefully before you start.

- Write your roll number, name, and group number in the space provided. A paper without a roll number and name will NOT be graded.
- Write your answers neatly with a blue/black pen on this question paper itself in the space provided for each question. At the end, you must submit this paper to the invigilator.
- Rough pages will NOT be provided. Use the empty space in the margins.
- Please note that your answers should NOT include any programming concept that hasn't been covered in the class so far. If such answers are found, they shall NOT be graded.
- No clarifications will be provided on any questions. When in doubt, make suitable assumptions, state them clearly, and proceed to solve the problem. If your answer depends on any assumption you have made, the assumption must be explicitly stated in your paper.
- In some questions, you are provided code snippets. Assume that the code snippet is enclosed suitably within the main, correct header files are included, etc., and therefore, the code compiles.
- All the best!

Translation

- शुरू करने से पहले कृपया निम्नलिखित निर्देशों को ध्यान से पढ़ें।
- दिए गए स्थान पर अपना रोल नंबर, नाम और ग्रुप नंबर लिखें। बिना रोल नंबर और नाम के पेपर को grade नहीं दिया जाएगा।
- इस प्रश्नपत्र पर ही प्रत्येक प्रश्न के लिए दिए गए स्थान पर अपने उत्तर नीले/काले पेन से साफ-सुथरा लिखें। अंत में आपको यह पेपर निरीक्षक के पास जमा करना होगा।
- रफ पेज उपलब्ध नहीं कराए जाएंगे. margin में दिए खाली जगह का उपयोग करें.
- कृपया ध्यान दें कि आपके उत्तरों में कोई भी प्रोग्रामिंग अवधारणा शामिल नहीं होनी चाहिए जिसे अब तक कक्षा में शामिल नहीं किया गया है। यदि ऐसे उत्तर पाए जाते हैं, तो उन्हें grade नहीं किया जाएगा।
- किसी भी प्रश्न पर कोई स्पष्टीकरण नहीं दिया जाएगा. जब संदेह हो, तो उपयुक्त धारणाएँ बनाएं, उन्हें स्पष्ट रूप से बताएं और समस्या को हल करने के लिए आगे बढ़ें। यदि आपका उत्तर आपके द्वारा की गई किसी धारणा पर निर्भर करता है, तो धारणा को आपके paper में स्पष्ट रूप से बताया जाना चाहिए
- कुछ प्रश्नों में आपको code snippet दिए गए हैं। मान लें कि code snippet main program के अंदर लिखा है, सही header files include की गयी हैं, आदि, और इसलिए, code compile होता है।
- शुभकामनाएं!

Question 1

```
////////////////////////////////////
#include <simplecpp>

#define LENGTH 40
#define WIDTH 30
#define M 100

void f1a(){
  double area = LENGTH * WIDTH;
  cout << "f1a: " << area << "\n";
}

float g1b(float a[M], float b[M],
  int n){
  if(n == 0){
    return 0;
  }
  float x = (a[n - 1] * b[n - 1]);
  x += g1b(a, b, n - 1);
  return x;
}

void f1b(){
  float a[] = {0, 2.1, -1, 3};
  float b[] = {3.8, 1, 0, 2.2};
  cout << "f1b: " << g1b(a, b, 4)
       << "\n";
}

void f1c(int n){
  int product = 1;
  for(int i = n; i >= 0; i--){
    product *= i;
  }
  cout << "f1c: " << product
       << "\n";
}

main_program{
  f1a();//1 mark
  f1b();//1 mark
  f1c(6);//1 mark
}
////////////////////////////////////
```

Consider the program given in the column on the left. In the box given below, write down its output. [3 marks]

बाईं ओर के column में दिए गए program पर विचार करें। नीचे दिए गए box में इसका output लिखें। [3 marks]

(1 mark each)

f1a: 1200

f1b: 8.7

f1c: 0

Rough work ↓

Question 2

```
////////////////////////////////////
#include <simplecpp>
#define LETTERS 26

void g2a(char word[100]){

  int letters[LETTERS];
  for(int i = 0; i < LETTERS; i++){
    letters[i] = 0;
  }
  int w = 0;
  while(word[w] != '\0'){
    if(word[w] >= 'a' &&
       word[w] <= 'z'){
      letters[word[w] - 'a'] += 1;
    }
    else if(word[w] >= 'A' &&
    word[w] <= 'Z'){
      letters[word[w] - 'A'] += 1;
    }
    w++;
  }
  for(int i = 0; i < LETTERS; i++){
    if(letters[i] > 0){
      char c = i + 'a';
      cout << c << ":"
           << letters[i] << " ";
    }
  }
  cout << "\n";
}

void f2a(){
  char word[] = "Chandrayaan-3";
  g2a(word);
}

main_program{
  f2a();//2 marks
}
////////////////////////////////////
```

Consider the program given in the column on the left. In the box given below, write down its output. [2 marks]

बाईं ओर के column में दिए गए program पर विचार करें। नीचे दिए गए box में इसका output लिखें। [2 marks]

```
a:4 c:1 d:1 h:1 n:2 r:1 y:1

2 marks: if the letters and
their frequencies are exactly
the same and are in the same
order

1 mark: (a) if there are four
or more pairs whose letters and
frequencies are correct, but
not all. (b) if there are any
additional letters or missing
letters.

0 marks: if less than four such
pairs
```

Rough work ↓

Question 3

3a. When you compile a program, the compiler can generate both "errors" and "warnings". What is the main difference between an error and a warning? Write your answer in the box below. [1 mark]

3a. जब आप किसी program को compile करते हैं, तो compiler "errors" और "warnings" दोनों generate कर सकता है। Errors और warnings के बीच मुख्य अंतर क्या है? अपना उत्तर नीचे दिये गये box में लिखें। [1 mark]

Errors (0.5 marks): it denotes that the program has syntax errors and the compilation is unsuccessful. Thus, the executable file is not generated
warning (0.5 marks): this means that the compiler has identified some problems but may not be major issues. The executable file gets generated. For example, declaring a variable but not using it will lead to a warning.

3b. Match each entry (numbers) in the left column (Column 1) with the most related entry (letters) in the right column (Column 2). E.g. (1)B, (2)A, and so on. [1 mark]

बाएं column (column 1) में प्रत्येक entry (numbers) को दाएं column (column 2) में सबसे संबंधित entry (letters) के साथ मिलाएं। जैसे (1)B, (2)A, इत्यादि। [1 mark]

Column 1	Column 2
(1) Compiler	(A) `#define`
(2) File	(B) `cout`
(3) Output	(C) `std`
(4) Macro	(D) `fstream`
(5) Name space	(E) `g++`

Fill in the letter below.
0.2 marks/blank
(1) E (2) D (3) B (4) A (5) C

3c. Suppose files `p1.cpp` and `p2.cpp` both contain valid `c++` programs. Also, the file `p1.cpp` is larger in size (in terms of number of bytes) than `p2.cpp`. Now, suppose upon compilation, `p1.cpp` gives executable file `a.out.1`, whereas upon compilation, `p2.cpp` gives executable file `a.out.2`.

Is it necessary that `a.out.1` is larger in size (in terms of number of bytes) than `a.out.2`? Provide your answer ("Yes" or "No"), along with 1–2 lines of supporting justification, in the box below. [1 mark]

3c. मान लीजिए की files `p1.cpp` और `p2.cpp` दोनों वैध `c++` programs contain करते है। साथ ही, file `p1.cpp` size में बड़ा है (number of bytes के मुताबिक) `p2.cpp` से। अब, मान लीजिए compilation पर, `p1.cpp`, `a.out.1` executable file देता है, जबकि `p2.cpp` compilation पर, `a.out.2` executable file देता है।

क्या यह आवश्यक है कि `a.out.1` size में (bytes की संख्या के संदर्भ में) `a.out.2` से बड़ा हो? अपना उत्तर ("Yes" या "No") नीचे दिए गए box में, justification 1-2 पंक्तियों के साथ प्रदान करें। [1 mark]

(1 mark) (0.5 marks each)

No

The size of the executable depends on the code written and not the size of the file. For example, comments in the source code (any number, any size) will not increase the size of the executable.

Rough work ↓

Question 4

```
//////////////////////////////////////
#include <simplecpp>

void f4a(int n){
  for(int i = 2; i <= n; i++){
    if(n % i == 0){
      bool prime = true;
      for(int j = 2;
          j <= i && prime; j++){
        if(i % j == 0) prime = false;
      }
      if(prime) cout << i << " ";
    }
  }
}

void f4b(int n){
  for(int i = 2; i * i <= n; i++){
    if(n % i == 0){
      bool prime = false;
      for(int j = 2;
          j * j <= i && !prime; j++){
        if(i % j != 0) prime = true;
      }
      if(prime) cout << i << " ";
    }
  }
}

void f4c(int n){
  for(int i = 2; i * i <= n; i++){
    if(n % i == 0){
      bool prime = true;
      for(int j = 2;
          j * j <= i && prime; j++){
        if(i % j == 0) prime = false;
      }
      if(prime) cout << i << " ";
    }
  }
}
//////////////////////////////////////
```

Given in the column on the left are three different implementations of a function that is meant to print out all the prime factors of a given positive integer n, but excluding n. For example, if the input is $n = 84$, the output must be the following (recall that 1 is *not* prime).

2 3 7

If n is prime, there must be no output. Go through the three implementations, and for each, assess if (1) the function compiles without error, and if it does (2) the function produces the expected output for all valid inputs. Then fill out the 6 blank cells below with "Yes" or "No". [3 marks]

बाईं ओर के column में एक function के तीन अलग-अलग implementations दिए गए हैं, जिसका उद्देश्य किसी दिए गए positive integer n के सभी prime factors को print करना है, लेकिन यदि यह स्वयं prime है तो n को छोड़कर। उदाहरण के लिए, यदि input $n = 84$ है, तो output निम्नलिखित होना चाहिए। याद रखें कि 1 prime नहीं है

2 3 7

यदि n prime है, तो कोई output नहीं होना चाहिए। तीन implementations को देखें, और प्रत्येक के लिए, आकलन करें कि क्या (1) function, error के बिना compile होता है, और यदि (2) function सभी वैध input के लिए अपेक्षित output उत्पन्न करता है। फिर नीचे 6 blank cells "Yes" या "No" से भरें। [3 marks]

	f4a	f4b	f4c
Compiles with **no errors**	Yes	Yes	Yes
Produces expected output	No	No	No

0.5 marks each

Blank space for rough work ↓

Blank space for rough work ↓

Question 5

```
//////////////////////////////////////
#include <simplecpp>
struct S5a{
  char a;
  int b;
  S5a(){
    a = 'a'; b = 0;
  }
  S5a(char w, int x){
    a = w; b = x;
  }
  void setChar(char w){
    a = w;
  }
  void setInt(int x){
    b = x;
  }
};

void f5a(){
  S5a s('c', 3);
  s.setInt(-1);
  cout << "f5a: " << s.a
       << " " << s.b << "\n";
}

double g5b(float a, int b){

  return (a + b / 2 + (a * b) / 2);
}

void f5b(){
  cout << "f5b: "
       << g5b(15.0, 7) << "\n";
}

main_program{
  f5a();//1 mark
  f5b();//1 mark
}
//////////////////////////////////////
```

Consider the program given in the column on the left. In the box given below, write down its output. [2 marks]

बाईं ओर के column में दिए गए program पर विचार करें। नीचे दिए गए box में इसका output लिखें। [2 marks]

```
(0.5 marks each)
f5a:  c -1

(1 mark)
f5b:  70.5
```

Rough work ↓

Question 6

```
////////////////////////////////////
#include <simplecpp>

double g6a(double x, int n){
  if(n == 1){
    return x;
  }
  return (x * g6a(x, n - 1));
}

double h6a(double x, int n){
  if(n == 1){
    return x;
  }
  return g6a(x, h6a(x, n - 1));
}

void f6a(){
  cout << "f6a: "
       << h6a(2.0, 4) << "\n";
}

int g6b(int m, int n){
  if(m == 0 && n == 0){
    return 1;
  }
  if(m == 0){
    return (3 * g6b(m, n - 1));
  }
  return (2 * g6b(m - 1,n));
}

void f6b(){
  cout << "f6b: "
       << g6b(7, 5) << "\n";
}

main_program{
  f6a();//2 marks
  f6b();//2 marks
}
////////////////////////////////////
```

Consider the program given in the column on the left. In the box given below, write down its output. [4 marks]

बाईं ओर के column में दिए गए program पर विचार करें। नीचे दिए गए box में इसका output लिखें। [4 marks]

```
2 marks each

f6a: 65536

f6b: 31104
```

Rough work ↓

Question 7

7a. Consider the sequence T:

$$4, 1, 16, 9, 36, 25, 64, 49, \ldots.$$

We number the terms starting from index 0; hence T[0] = 4, T[1] = 1, T[2] = 16, and so on. The pattern is: for each non-negative even integer i, T[i] = $(i+2)^2$, and for each non-negative odd integer i, T[i] = i^2.

Express T[i] as a `c++` expression that only uses symbols from the list below.

$$i \quad 1 \quad 2 \quad + \quad - \quad * \quad / \quad \%$$

In particular, you cannot use conditional constructs such as `if` and the `?:` ("ternary") operator. Nor can you use additional variables for intermediate storage. The challenge is to obtain a formula that works both for even and for odd i. Write your answer in the box at the top of the right column. [1 mark]

7a. Sequence को consider करें T:

$$4, 1, 16, 9, 36, 25, 64, 49, \ldots.$$

हम terms को index 0 से शुरू करते हैं। इस तरह T[0] = 4, T[1] = 1, T[2] = 16, ... Pattern है: प्रत्येक non-negative even integer i के लिए, T[i] = $(i+2)^2$, और प्रत्येक non-negative odd integer i के लिए, T[i] = i^2.

T[i] को एक `c++` expression के रूप में व्यक्त करें जो केवल नीचे दी गई symbols का उपयोग करती है।

$$i \quad 1 \quad 2 \quad + \quad - \quad * \quad / \quad \%$$

विशेष रूप से, आप conditional constructs जैसे कि `if` और `?:` ("ternary") operator का उपयोग नहीं कर सकते। न ही आप additional variables या तो intermediate storage का उपयोग कर सकते हैं। चुनौती एक ऐसा formula प्राप्त करना है जो even और odd i दोनों के लिए काम करे। अपना उत्तर दाएँ column के शीर्ष पर स्थित box में लिखें। [1 mark]

T[i] = `(((i+1)%2) + (i/2)*2 + 1) * (((i+1)%2) + (i/2)*2 + 1)`

`If the student has written a different expression, check and see if it works. However, only i 1 2 + - * / % or parentheses should be used by the student in the answer`

Rough work ↓

7b. Let A be an $n \times n$ matrix represented in a program as a 2-dimensional array. Hence, for $i \in \{0, 1, \ldots, n-1\}$ and $j \in \{0, 1, \ldots, n-1\}$, A[$i$][$j$] is the entry of A in its i-th row and j-th column.

Now suppose that the contents of A are read into a single-dimensional array B of size n^2, using the following code snippet.

```
int k = 0;
for(int i = 0; i < n; i++){
  for(int j = 0; j < n; j++){
    B[k] = A[i][j];
    k++;
  }
}
```

For which value of k is the entry A[i][j] assigned to B[k]? In other words, express k in terms of i and j such that B[k] is equal to A[i][j]. Write your answer in the box at the top of the right column. [1 mark]

7b. मान लीजिए A एक $n \times n$ matrix है जिसे program में 2-dimensional array के रूप में दर्शाया गया है। इसलिए, $i \in \{0, 1, \ldots, n-1\}$ और $j \in \{0, 1, \ldots, n-1\}$ के लिए, A[i][j] इसकी i-वीं row और j-वें column में A की entry है।

अब मान लीजिए कि A की contents को निम्नलिखित code snippet का उपयोग करके n^2 size के single-dimensional array B में read किया जाता है।

```
int k = 0;
for(int i = 0; i < n; i++){
  for(int j = 0; j < n; j++){
    B[k] = A[i][j];
    k++;
  }
}
```

k के किस value के लिए entry A[i][j] को B[k] को सौंपा गया है? दूसरे शब्दों में, k को i और j के रूप में इस प्रकार व्यक्त करें कि B[k] और A[i][j] के बराबर हो। अपना उत्तर दाएँ column के शीर्ष पर स्थित box में लिखें। [1 mark]

k = `i * n + j`
OR
A mathematical expression like
k = `in + j`

If the student has written a different expression, check and see if it works. However, only i, j, and n should be used by the student in the answer

Rough work ↓

Question 8

```
////////////////////////////////////
#include <simplecpp>

void f8a(){
  cout << "f8a: ";
  int i = 0;
  while(i < 8){
    cout << "x";
    int j = 0;
    while(j * j < i){
      cout << j;
      j++;
    }
    i++;
  }
  cout << "\n";
}

double g8b(double a1, double a2,
           double b1, double b2,
           double &c1, double &c2){
  c1 = (a1 + b1) / 2;
  c2 = (a2 + b2) / 2;
  return ((a1 + a2 + b1 + b2) / 4);
}

void f8b(){
  double a1 = 0;
  double a2 = 1;
  double b1 = 8.5;
  double b2 = -7;
  double c1 = 0;
  double c2 = 0;
  double z = g8b(a1, a2,
                 b1, b2, c1, c2);
  cout << "f8b: " << z << " "
       << c1 << " " << c2 << "\n";
}

main_program{
  f8a();//2 marks
  f8b();//1 mark
}
////////////////////////////////////
```

Consider the program given in the column on the left. In the box given below, write down its output. [3 marks]

बाईं ओर के column में दिए गए program पर विचार करें। नीचे दिए गए box में इसका output लिखें। [3 marks]

(2 marks)
f8a: xx0x01x01x01x012x012x012
2 marks: if the entire sequence is exactly the same i.e. the blue part and the red part

1 mark: (a) if the sequence in blue is exactly the same. Ignore the sequence in the red or (b) if the sequence in red is exactly the same. Ignore the sequence in blue.

0 marks: if both the sequences i.e. red and blue, both have some mismatches

(1 mark)
f8b: 0.625 4.25 -3

Rough work ↓

Question 9

```
//////////////////////////////////////
#include <simplecpp>

double g = 9.81;

class C9a{
  double x;
public:
  C9a(){
    x = 0;
    cout << "C9a: g = " << g << "\n";
    g = -g;
  }
  double getX(){ return x;}
};

class C9b{
  C9a y;
public:
  C9b(){
    cout << "C9b: y.x = "
         << y.getX() << "\n";
  }
};

void f9c(){
  g = 2.0 * g;
  C9b z;
  cout << "f9c: g = " << g << "\n";
}

void f9d(){
  cout << "f9d: ";
  for(int n = 0; n <= 7; n++){
    int right = n % 2;
    int mid = ((n - right) / 2) % 2;
    int left =
      ((n - (2 * mid) - right) / 4) % 2;
    cout << (right + mid + left) << " ";
  }
  cout << "\n";
}

main_program{
  f9c();//2 marks
  f9d();//2 marks
}
//////////////////////////////////////
```

Consider the program given in the column on the left. In the box given below, write down its output. [4 marks]

बाईं ओर के column में दिए गए program पर विचार करें। नीचे दिए गए box में इसका output लिखें। [4 marks]

```
(1 mark each)
(No partial marks for f9d.
The entire sequence should be
correct)

C9a: g = 19.62

C9b: y.x = 0

f9c: g = -19.62

f9d: 0 1 1 2 1 2 2 3
```

Rough work ↓

Question 10

Carefully go through the program shown below and answer the following questions.

नीचे दिखाए गए program को ध्यानपूर्वक पढ़ें और निम्नलिखित प्रश्नों के उत्तर दें।

```
////////////////////////////////////////
#include <simplecpp>
#include <fstream>

main_program{

  ifstream ifile("in.txt");
  ofstream ofile1("out1.txt");
  ofstream ofile2("out2.txt");
  int a[1000];
  int ctr = 0;
  while(ifile >> a[ctr]){
    ctr++;
  }
  srand(time(NULL));
  for(int i = 0; i < ctr; i++){
    if(randuv(0, 1) < 0.5){
      ofile1 << a[i] << "\n";
    }
    else{
      ofile2 << a[i] << "\n";
    }
  }
}
////////////////////////////////////////
```

10a. What is the source of the program's input? What is the expected input format? [1 mark]

10a. Program के input का source क्या है? अपेक्षित input format क्या है? [1 mark]

(a) The source is a file "in.txt". (b) The expected input format is a sequence of integers separated by whitespace or newline characters.

10b. Where is the program's output stored? What is its relation with the input? If necessary explain using an example. [2 marks]

10b. Program का output कहाँ store किया जाता है? इसका input से क्या संबंध है? यदि आवश्यक हो तो उदाहरण देकर समझाएँ। [2 marks]

(a) The program's output is stored in two files, "out1.txt" and "out2.txt". (b) Based on the random number selected, i.e. if it is less than 0.5, the program stores one of the input number in either out1.txt, else in out2.txt. That is, each number in in.txt is written with probability half into out1.txt, and with probability half into out2.txt. Example: if input sequence is [1, 2, 3, 4, 5] random numbers generated are: [0.2, 0.6, 0.1, 0.5, 0.3] then 1, 3, and 5 are stored in out1.txt while 2 and 4 in out2.txt

10c. If the statement `srand(time(NULL))` is replaced by `srand(0)`, what would be the effect on the execution of the program? [1 mark]

10c. यदि statement `srand(time(NULL))` को `srand(0)` से बदल दिया जाए, तो program के execution पर क्या प्रभाव पड़ेगा? [1 mark]

It would seed random number with a fixed value 0 instead of current time. i.e. every time the program is executed, the same random numbers will be generated and we can predict the behavior of the program. So, the same output files will get generated each time.

Rough work ↓