

National University of Singapore

TIC1001—Introduction to Computing and Programming I

Semester 1, 2020/2021

Time allowed: 1 hour 30 mins

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1. The assessment paper contains **FIVE (5) questions** and comprises **SEVEN (7) pages** including this cover page.
 2. Weightage of questions is given in square brackets. The maximum attainable score is 45.
 3. This is a **OPEN** book assessment. Use of physical electronic calculators are not allowed. You may use the on-screen calculator in Exemplify.
 4. Enter all your answers in the correct space provided on Exemplify within the time provided. All current answers will automatically be saved and submitted the moment the time is up.
 5. With the exception of `string` and `vector` libraries, no other libraries are allowed to be used unless otherwise stated in the question.
 6. **Marks may be deducted** for excessively long code. A general guide would be not more than twice the length of our model answers.

Question 1: C/C++ Expressions [16 marks]

There are several parts to this question which are to be answered independently and separately. Each part consists of a fragment of C/C++ code. Write the exact output produced by the code in **the answer box**. If an error occurs, or it enters an infinite loop, state and explain why. You may assume that `main`, if present, is called as the entry point without inputs or output.

Assume that all appropriate preprocessor directives e.g., `#include <iostream>`, etc. have already been defined.

A.

```
string s = "corona";
string t = "virus";
for (int i = 0; i < s.size(); i++) {
    s[i] = t[i];
    string u = s;
    s = t;
    t = u;
}
cout << s + t << endl;
```

[4 marks]

B.

```
int i = 0;
do {
    cout << i << " ";
    if (i < 3) {
        i += 2;
    }
    if (i % 3 == 0) {
        i /= 2;
    }
    if (i % 2) {
        i = -i;
        continue;
    }
    i += 1;
} while (i > 0);
cout << "done " << i;
```

[4 marks]

C.

```
void p(int x, int y) {
    cout << x << ":" << y << endl;
}

double f(int &x, int &y) {
    p(x, y);
    y /= x;
    x += y;
    p(x, y);
    return x;
}

void g(int x, int y) {
    x /= y;
    y = f(x, y);
    p(x, y);
}

int main() {
    double x = 42;
    double y = 10;
    g(x, y);
    p(x, y);

    return 0;
}
```

[4 marks]

D.

```
vector<int> v = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9};
vector<int> w;
for (int i = 0; i < v.size(); i++) {
    vector<int> x = w;
    cout << v[i] << endl;
    x.push_back(v[i]);
    v.pop_back();
}

for (int i = 0; i < w.size(); i++) {
    cout << w[i] << endl;
}
```

[4 marks]

Question 2: Autobiographical Numbers [24 marks]

An autobiographical number is a number n such that the first digit (most significant digit) of n counts how many zeroes are in n , the second digit counts how many ones are in n and so on.

For example, the smallest autobiographical number 1210 has 1 zero, 2 ones, 1 two and 0 threes. 2020 is another autobiographical number, having 2 zeroes, 0 ones, 2 twos and 0 threes.

The objective for this question is to implement a function to determine if a number is an autobiographical number. This will be accomplished over several tasks.

A. An autobiographical number counts its own number of digits. Implement the function `int count(int n, int d)` that takes in two non-negative integers n and d , and returns the number of digit d found in the integer n . You may obviously assume that n is in base-10, and $0 \leq d \leq 9$. [6 marks]

B. The frequency distribution all ten digits of a number n can be represented in a ten-element vector, where the element e_i at index i is the number of occurrence of digit i in n .

For example, the vector `{1, 2, 3, 0, 0, 0, 1, 0, 0, 0}` represents the frequency distribution of the number 6210212, as it contains 1 zero, 2 ones, 3 twos, and 1 six.

Implement the function `vector<int> freq(int n)` which takes in a non-negative integer n , and returns the frequency distribution of the number as described above. [6 marks]

C. It would be more convenient to have the number represented as a vector of digits. The function `vector<int> int_to_vec(int n)` takes in a non-negative integer, and returns a vector where the elements are the digits of the number in sequence, starting with the most significant digit in index 0.

For example, the number 6210212 can be represented as a vector `{6, 2, 1, 0, 2, 1, 2}`.

Provide an implementation of the function `int_to_vec`. [6 marks]

D. Finally, using the functions defined in previous parts, implement the function `bool is_auto(int n)` which takes in a number n , and returns `true` if it is an autobiographical number, and `false` otherwise. [6 marks]

Question 3: Computer Organisation [2 marks]

A. Fill in the blanks with the appropriate noun:

- i) is a controlled mechanism to make **slow** main memory work **faster**.
- ii) is a controlled mechanism to make **small** main memory appear **larger**.

[1 mark]

B. A fully associative cache while flexible in block replacement, requires expensive hardware to locate a block. On the other hand, a direct-mapped cache requires simple hardware to locate a block, but is inflexible in block replacement.

Consider a set-associative cache, with **two** cache sets containing **two** cache blocks each. Memory blocks in the form $2n + k$ are mapped to cache set k , and the **least recently used** block within the set is replaced.

Given the following memory block accesses:

0, 1, 2, 1, 2, 3, 2, 3, 4, 3, 4, 5, 4, 3, 2, 1, 0, 2, 3, 4, 5

State the **number of cache hit and misses** with the given cache configuration. [1 mark]

Question 4: Database [2 marks]

Consider the contents of the **MODULES** table in an SQL database:

Sem	Module	Coordinator	Exam Date	Exam Time
2010	CS2100	Soo Yuen Jien	27/11/2020	09:00
1920	CS2100	Tan Tuch Choy	30/04/2020	13:00
1910	CS2100	Soo Yuen Jien	28/11/2019	09:00
2010	CS2103	Damith Rajapakse	02/12/2020	09:00
1920	CS2103	Akshay Narayan	25/04/2020	13:00
1910	CS2103	Damith Rajapakse	29/11/2020	09:00
2010	TIC1001	Leong Wai Kay	01/12/2020	17:00
1910	TIC1001	Leong Wai Kay	03/12/2019	17:00
1920	TIC1002	Soo Yuen Jien	28/04/2020	17:00
2010	TIC1101	Oh Lih Bin	24/12/2020	13:00
1910	TIC1101	Oh Lih Bin	28/11/2019	13:00
2010	TIC2001	Ho Lun Cheng	01/12/2020	09:00
1930	TIC2001	Ho Lun Cheng	NULL	NULL
2010	TIC2002	Damith Rajapakse	01/12/2020	13:00
1910	TIC2002	Damith Rajapakse	04/12/2019	13:00

A. A candidate key is a minimal set of columns that can uniquely identify each row in the table. Suggest a suitable candidate key for the **MODULES** table above. [1 mark]

B. Give the simplest SQL query that returns the following result:

CS2100	Soo Yuen Jien
CS2103	Damith Rajapakse
TIC2001	Ho Lun Cheng

[1 mark]

Question 5: 42 and the Meaning of Life [1 marks]

Either: (a) explain how you think some of what you have learnt in TIC1001 will be helpful for you for the rest of your life and/or studies at NUS; (b) tell us an interesting story about your experience with TIC1001 this semester; or (c) share how the COVID-19 situation has positively influenced/impacted your learning in TIC1001. [1 mark]

— END OF PAPER —

Question 1A

[4 marks]

vorosvorosa

Question 1B

[4 marks]

0 3 done -1

Question 1C

[4 marks]

4:10
6:2
6:6
42:10

Question 1D

[4 marks]

0
1
2
3
4

Question 2A

[6 marks]

```
int count(int digit, int num) {  
    int c;  
    for (c = 0; num > 0; num /= 10) {  
        if (num % 10 == digit) {  
            c += 1;  
        }  
    }  
    return c;  
}
```

Question 2B

[6 marks]

```
vector<int> freq(int n) {  
    vector<int> v;  
    for (int i = 0; i < 10; i++) {  
        v.push_back(count(i, n));  
    }  
    return v;  
}
```


Question 2C

[6 marks]

```
vector<int> int_to_vec(int n) {
    vector<int> v;
    while (n) {
        v.insert(v.begin(), n % 10);
        n /= 10;
    }
    return v;
}
```

Question 2D

[6 marks]

```
bool is_auto(int n) {
    vector<int> n = int_to_vec(num);
    vector<int> f = freq(num);
    for (int i = 0; i < n.size(); i++) {
        if (n[i] != f[i]) {
            return false;
        }
    }
    return true;
}
```

Question 3A

[1 marks]

- i) **Cache** is a **hardware** controlled mechanism to make **slow** main memory work **faster**.
- ii) **Virtual Memory** is a **Operating System** controlled mechanism to make **small** main memory appear **larger**.

Question 3B

[1 marks]

Access:	0	1	2	1	2	3	2	3	4	3	4	5	4	3	2	1	0	2	3	4	5
Cache:	M	M	M	H	H	M	H	H	M	H	H	M	H	H	H	M	M	H	H	M	M

11 hits, 10 misses.

Question 4A

[1 marks]

The only candidate key is (Sem, Module). No other combination pairs will give unique rows.

Question 4B

[1 marks]

```
SELECT Module, Coordinator FROM MODULES WHERE
    SEM = "2010" AND "Exam Time" = 09:00
```

The exact syntax like quotes does not matter.

Question 5

[1 marks]

The student will be awarded points as long as he/she is coherent and does not say something obviously wrong.