

Midterm Test

1 October 2020

Time allowed: 1 hour

-
1. The assessment paper contains **THREE (3) questions** and comprises **SIX (6) pages** including this cover page.
 2. Weightage of questions is given in square brackets. The maximum attainable score is **30**.
 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. **Marks may be deducted** for excessively long code. A general guide would be not more than twice the length of our model answers.

(This portion is for the examiner's use only)

Question	Marks	Remarks
Q1	/ 8	
Q2	/ 20	
Q3	/ 2	
Total	/ 30	

Question 1: C/C++ Expressions [8 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.

```
int g(int &x) {
    printf("g: %d\n", x);
    int y = x;
    x += 3;
    return y;
}

int f(int &x, int y) {
    printf("f: %d, %d\n", x, y);
    x += g(y);
    printf("f: %d, %d\n", x, y);
    return y;
}

void main() {
    int x = 1;
    int y = 2;
    int z = f(y, x);
    printf("m: %d, %d, %d\n", x, y, z);
}
```

[4 marks]

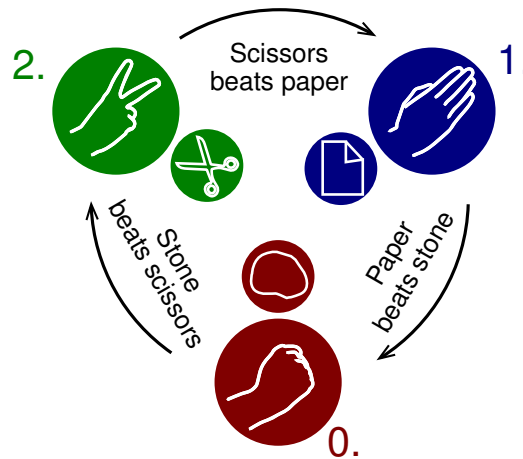
B. `void main() {`
 `int i = 0;`
 `int j = 2;`
 `for (int i = 10; i > j; i--) {`
 `printf("%d, %d\n", i, j);`
 `if (i % 3) {`
 `j += 1;`
 `continue;`
 `}`
 `if (i % 2) {`
 `j -= 1;`
 `}`
 `i = 2 * j;`
 `}`
 `printf("%d, %d\n", i, j);`
 `}`

[4 marks]

Question 2: Scissors, Paper, Stone! [20 marks]

[INSTRUCTIONS] Use of any C++ STL functions is not allowed unless otherwise stated. Functions defined in other parts should be used whenever appropriate.

Scissors, Paper, Stone is a hand game usually played between two people, in which each player simultaneously forms one of three shapes with an outstretched hand, depicting scissors, paper or stone. The rules of the game is depicted in the following diagram:



Source: Wikipedia

We can represent each shape with an integer: Scissors = 2, Paper = 1, Stone = 0.

A. The function `int fight(int p1, int p2)` takes the shapes (represented as integers) made by two players, $p1$ and $p2$, in a one round match. It returns the integer

-1 if $p1$ is beaten by $p2$,
 1 if $p1$ beats $p2$, and
 0 if it is a draw.

Provide an implementation of the function `fight`.

[6 marks]

B. Players usually play a few rounds of Scissors, Paper, Stone, with the winner of each round scoring 1 point, and 0 points for a draw. The player with the higher total score wins the match.

We can use an integer to represent the rounds played by a player. Each digit represents the shape made for the round. For example, if the player plays a sequence of two scissors, two paper and one rock in a five round match, it is represented as the integer 22110.

The function `int best_of_n(int p1, int p2)` takes the shapes played by two players $p1$ and $p2$ over a match of several rounds, represented as integers. It returns the score difference between $p1$ and $p2$, i.e., positive if $p1$ wins, negative if $p1$ loses.

Provide an implementation for the function `best_of_n`, using any previously implemented function where possible. Note that the number of rounds played should be inferred from the inputs.

[6 marks]

C. The problem with using digits of an integer to represent each round is that the integer grows quite large for as the number of rounds in a match increases. Say for a match of 10 rounds, the largest value needed to be represented is 2,222,222,222, which requires 32 bits to represent in memory ($2^{32} = 4,294,967,296$). This is quite wasteful as there are many values that do not represent a valid round, e.g. numbers containing digits other than 0, 1 or 2.

1) Propose an alternate scheme to represent a match using integers that requires the minimum number of bits, and 2) state the biggest integer value needed to represent a 10-round match. You may leave the answer in formula form, i.e., no need to calculate the value. [2 marks]

D. Alice P. Hacker wants to cheat in Scissors, Paper, Stone by hacking the `fight` function such that it will **always cause $p1$ to win**. She also needs to cover her tracks by making sure the value of the variable shows the winning shape.

For example, the following code segment:

```
int p1 = 0; // Alice plays stone
int p2 = 1; // Opponent plays paper

int win = fight(p1, p2);
printf("Alice: %d, Opponent: %d, Score: %d", p1, p2, win);
```

will display `Alice: 2, Opponent: 1, Score: 1` in the output. Alice's hand had changed into Scissors and she won the round!

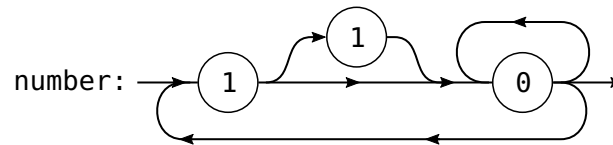
Provide a new implementation for `int fight(int p1, int p2)` that helps Alice cheat by ensuring that $p1$ will always win $p2$ in the round.

[6 marks]

Question 3: All About Computers [2 marks]

Marks for each part are distributed equally among the sub-parts.

A. Consider the following context-free grammar:



Briefly describe the numbers that are generated by this grammar.

[1 mark]

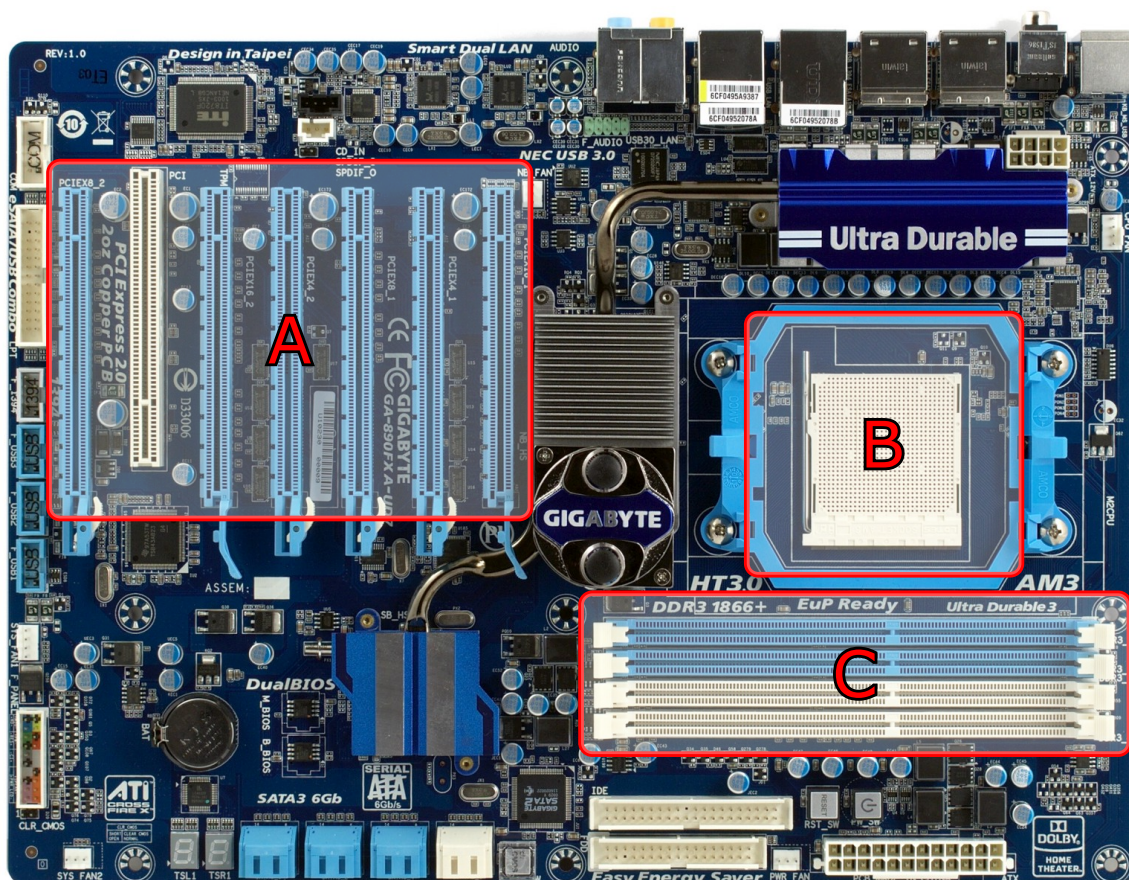
B. The Von Neumann Architecture describes three main components of a computer:

- A central processing unit (CPU)
- Memory that stores data and instructions
- Input and output (I/O) mechanisms

In a modern computer system, memory can take the form of DDR RAM, and I/O devices are typically connected via PCI-E or USB connections.

Given the following image of a modern motherboard, identify the highlighted components in terms of the Von Neumann Architecture.

[1 mark]



— END OF PAPER —

Question 1A

[4 marks]

```
f: 2, 1
g: 1
f: 3, 4
m: 1, 3, 4
```

Question 1B

[4 marks]

```
10, 2
9, 3
3, 2
0, 1
```

Question 2A

[6 marks]

```
int fight(int p1, int p2) {
    int result = p1 - p2;
    if (result == -2)
        return 1;
    else if (result == 2)
        return -1;
    return result;
}
```

Question 2B

[6 marks]

```
int best_of_n(int p1, int p2) {
    int score = 0;
    while (p1 or p2) {
        score += fight(p1 % 10, p2 % 10);
        p1 /= 10;
        p2 /= 10;
    }
    return score;
}
```

Question 2C

[2 marks]

- 1) We only require the digits 0, 1 and 2 to represent each round. So using base-3, each digit can represent a round.
- 2) The largest integer value needed is $2,222,222,222_3$ or $3^{10} - 1$.

Question 2D

[6 marks]

```
int cheat(int& p1, int p2) {  
    p1 = (p2 + 1) % 3;  
    return 1;  
}
```

Question 3A

[1 marks]

A binary number, i.e., number containing only digits 0 and 1, starting with digit 1, ending with 0, and no more than two consecutive digit 1s.

Question 3B

[1 marks]

- A) Input/Output
- B) CPU
- C) Memory