1. (12%) IPv4 addresses are divided into three different classes: class A, class B and class C.
   (a) (6%) How do we identify each class (i.e., how do we know the corresponding class when receiving an IPv4 address)?
   (b) (6%) How many bits are designed for the host part in each class A, B and C?

2. (4%) Carrier Sense Multiple Access (CSMA) is a Media Access Control (MAC) protocol. It defines how network devices respond when two devices attempt to use a data channel simultaneously. There are several CSMA access modes. For example, P-persistent mode is used in CSMA/CA systems, like Wi-Fi. Explain what the P-persistent mode is?

3. (10%) Describe how the number of comparisons used in the worst case changes when the size of the list to be sorted changes from \( n \) to \( kn \), where \( k \) and \( n \) are two positive integers and the bubble sort algorithm is used.

4. (10%) Consider the following recursive, probabilistic algorithm A. It takes as input a list \( L \) of \( n \) items \( x_1, \ldots, x_n \).

```plaintext
def A(L, n):
    if n <= 1:
        return
    else:
        for i in range(1, 3):
            L_i = initialize an empty list
            for j in range(1, n):
                flip a fair coin: if it comes up "heads," append \( x_j \) to \( L_i \)
            flip a fair coin: if it comes up "heads," recursively call A on input \( L_i \)
```

What is the expected running time (expressed in Big-O notation) of this algorithm? Give a careful justification of your claim.

5. (6%) How many edges are there in a graph with 10 vertices each of degree six?

6. (8%) What is the von Neumann Model/Architecture and what is the von Neumann Bottleneck? How we solve the von Neumann Bottleneck in practice?
7. (10%) Prove or disprove that these two graphs are isomorphic.

![Graphs](image)

8. (10%) What is the output (i.e., Boolean expression) of the following circuit?

![Circuit](image)

9. (10%) Analog-to-Digital Converter (ADC) is used to convert analog data into digital data. The basic analog-to-digital conversion process can be divided into a series of three operations. Each operation performs a specific task in the conversion process. What are the three operations and explain the functionality of each of the operations.

10. (20%) A certain machine with a 10 ns (10 x 10^{-9}s) clock period can perform jumps (1 cycle), branches (3 cycles), arithmetic instructions (2 cycles), multiply instructions (5 cycles), and memory instructions (4 cycles). A certain program has 10% jumps, 10% branches, 50% arithmetic, 10% multiply, and 20% memory instructions. Answer the following questions. Show your derivation in sufficient detail.
   (a) What is the CPI (clock cycle per instruction) of this program on this machine?
   (b) If the program executes 10^9 instructions, what is its execution time?
   (c) A 5-cycle multiply-add instruction is implemented that combines an arithmetic and a multiply instruction. 50% of the multiplies can be turned into multiply-adds. What is the new CPI?
   (d) Following (c) above, if the clock period remains the same, what is the program’s new execution time?