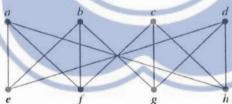1. (10%) A computer has 128 MB of memory. Each word in this computer is eight bytes. How many bits are needed to address any single word in memory?

2. (10%) For each of the following decimal integers, write down the 8-bit binary representation in sign-magnitude and twos-complement, respectively: (a) +72 (b) −8 (c) 240

3. (10%) NAND is a universal logic gate in the sense that the behavior of NOT, AND and OR gates can be implemented using only NAND. Show how this is possible using a truth table to demonstrate your solution.

4. (10%) Imagine we have written three different programs to solve the same problem. The first one has a complexity of $O(\log_{10} n)$, the second $O(n)$, and the third $O(n^2)$. Assuming 1 million inputs, how long does it take to execute each of these programs on a computer that executes one instruction in one microsecond, that is, one million instructions per second?

5. (15%) Please give asymptotic upper and lower bounds for $T(n)$ in the following recurrence. Assume that $T(n)$ is constant for sufficiently small n. Make your bounds as tight as possible, and justify your answer.

$$T(n) = 4T(\frac{n}{2}) + n^2 \sqrt{n}$$

6. (10%) Please encrypt the message DO NOT PASS GO by translating the letters into numbers, applying the given encryption function, and then translating the numbers back into letters.
   (a) $f(p) = (p + 13) \bmod 26$ (the Caesar cipher)
   (b) $f(p) = (3p + 7) \bmod 26$ (the Caesar cipher)

7. (15%) Please use Kuratowski's theorem to have a detailed justification of whether the given graph is planar.

8. (20%) Please explain the following state-of-the-art technologies.
   (a) Blockchain
   (b) Deep Learning
   (c) Edge computing
   (d) Natural Language Processing