# Department of Computer Science and Engineering
## National Sun Yat-sen University
## First Semester of 2025 PhD Qualifying Exam

Subject：  Algorithms

1.  Please explain P, NP-hard, NP-complete problems as well as reduction. Then, prove that the vertex-cover problem is NP-complete. (20%)
2.  Please use the master method to obtain the asymptotic "$\theta$" bounds of the following cases (15%):
    (a) $T(n) = 4T(n/2) + n$
    (b) $T(n) = 9T(4\,n/6) + 1$
    (c) $T(n) = 4T(n/5) + n lgn$
3.  Please design an algorithm to find the minimum and maximum values in a set of $n$ elements using $3\lfloor n/2 \rfloor$ comparisons in total. (5%)
4.  Please use the dynamic programming method to solve the matrix-chain multiplication and provide a simple example to illustrate how it works. (20%)
5.  Please explain how the Bellman-Ford algorithm solves the single-source shortest-paths problem in the general case where edge weights may be "negative" and provide a simple example to illustrate it. (10%)
6.  Please explain why any comparison sort algorithm requires $\Omega(n lgn)$ comparisons in the worst case. (10%)
7.  Please explain the minimum spanning tree (MST) and how to solve it using the Kruskal's and Prim's algorithms. (20%)