1. (10%) Please explain the following terms:
   (a) Compulsory misses (3%)
   (b) Capacity misses (3%)
   (c) Conflict misses (4%)

2. (15%) Pipeline
   (a) Please explain how a MIPS processor can exploit the instruction-level parallelism (ILP)? (5%)
   (b) Please draw the datapath of the MIPS processor with the control unit. (10%)

3. (10%) Assume that the miss rate of an instruction cache is 3% and the miss rate of the data cache is 5%. If a processor has a CPI of 3 without any memory stalls and the miss penalty is 100 cycles for all misses. How much faster the processor can run with a perfect cache that never missed? Assume the frequency of all loads and stores is 30%.

4. (5%) Please explain branch prediction buffer and use 2-bit prediction scheme as an example.

5. (10%) Virtual Memory
   (a) Please explain TLB, cache, and page table. (5%)
   (b) How to integrate TLB, cache, and page table together. (5%)
6. (8%)
   (a) Sort the following functions based on their orders from high to low. (3%)
   \[ f_1(n) = n^2 \log n + \log n \]
   \[ f_2(n) = n/100 + 100/n^2 \]
   \[ f_3(n) = n^3 + 2n^2 + 1 \]
   \[ f_4(n) = \log n^2 \]
   \[ f_5(n) = 2^n + 3 \]
   (b) Write a recursive function to calculate \( \sum_{i=1}^{n} i^2 \). (5%)

7. (6%)
   If the height of a binary tree is \( k \), what is the maximum number of nodes in this tree? Prove it. (6%)

8. (10%)
   (a) If the postorder traversal of a binary tree is CBEGFDA and the inorder traversal of the tree is BCAEDGF, draw this binary tree. (5%)
   (b) Draw the binary expression tree for \((a+b*c)/(d-e)\). (5%)

9. (16%)
   Briefly explain the following terms:
   (a) Dequeue (4%)
   (b) Depth-first search (4%)
   (c) Spanning Tree (4%)
   (d) Hash Collision Resolution (4%)

10. (10%)
    (a) Is QuickSort stable? Explain your answer briefly. (4%)
    (b) If one n-element list is sorted by QuickSort, what is its computation complexity for the average case? What is its computation complexity for the worst case? Demonstrate one n-element list, where the worst case happens if we use QuickSort to sort. (6%)