國立中山大學 113 學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：資料結構【資管系碩士班乙組】

第 1~17 題為單選題，每題 4 分，第 18~25 題為複選題，每題 4 分（選項全對才給分）。

1. (單選) In Prim's algorithm, which of the following is applied to make the search for a minimum spanning tree more efficient?
   A. set
   B. stack
   C. priority queue
   D. binary search tree
   E. None of the above

2. (單選) Which of the following statements about heaps is TRUE?
   A. Heaps are a type of self-balancing binary search tree.
   B. In a max-heap, the key value in each node is always smaller than the key values of its children.
   C. Deletion of the maximum element from a d-ary max-heap takes $O(d \log_d n)$ time, where n is the number of nodes.
   D. Creating a heap of n elements using bottom-up heap construction takes $O(n \log n)$ time.
   E. Binary heaps are full binary trees.

3. (單選) What is the solution to the recurrence relation: $T(n) = T(n/2) + n$, with $T(1) = 1$?
   A. $T(n) = O(\log n)$
   B. $T(n) = O(n)$
   C. $T(n) = O(n \log n)$
   D. $T(n) = O(n^2)$
   E. $T(n) = O(2^n)$

4. (單選) An array contains ten integers: 7, 5, 10, 11, 3, 9, 2, 4, 8, 6. What will the resulting array be if we use the Hoare partition scheme with 7 as the pivot to partition the array?
   A. 7 5 6 4 3 2 9 11 8 10
   B. 2 5 6 4 3 7 9 11 8 10
   C. 5 3 2 4 6 7 10 11 8 9
   D. 5 3 2 4 6 7 10 11 9 8
   E. None of the above

5. (單選) Which of the following algorithms exhibits a greedy characteristic?
   A. Binary search
   B. Merge sort
   C. Quicksort
   D. Floyd-Warshall algorithm
   E. Prim's algorithm

6. (單選) Which of the following statements about binary search is TRUE?
   A. Binary search has a time complexity of $O(n)$.
   B. Binary search has a space complexity of $O(n)$.
   C. Binary search compares elements by traversing the array from left to right.
   D. Binary search requires the elements to be sorted in order.
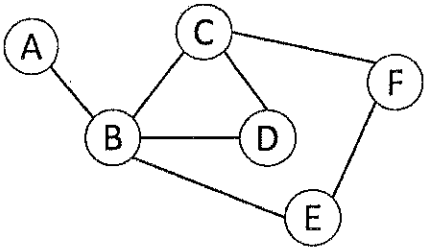   E. Binary search uses more memory compared to linear search.

7. (單選) What data structure is used when performing Breadth First Search on a graph?
    A. stack
    B. queue
    C. tree
    D. both stack and queue
    E. None of the above

8. (單選) If we sequentially insert the keys 5, 9, 2, 0, 21, 14 into a table of size 7 using the hash function h(k) = k mod 7 and linear probing, what will the final table look like?
    A.

0	21	9	2	14	5	

    B.

0	21	9	2	5	14	

    C.

0	21	9	5	2	14	

    D.

5	9	2	0	21	14	

    E.

5	9	2	0		14	21

9. (單選) Which of the following statements about complete binary trees is TRUE?
    A. The height of a complete binary tree with n nodes is $(\log n)+1$.
    B. A complete binary tree can have missing nodes on any level.
    C. All leaf nodes are at the same level.
    D. A complete binary tree is also a binary search tree.
    E. None of the above

10. (單選) Given the graph below (Figure1), which edge can be removed to turn it into a bipartite graph?

(Figure 1)

    A. C-F
    B. E-F
    C. B-C
    D. B-D
    E. None of the above.

11. (單選) Let L(X) be the number of leaves in a binary tree with root node T. Assume that Leaf(T) returns 1 if T is a leaf node. Which of the following leads to a recursive implementation?
    A.　L(T) := L(T.Left)+L(T.Right)+Leaf(T)
    B.　L(T) := L(T.Left)+L(T.Right)+Leaf(T)+1
    C.　L(T) := L(T.Left)+L(T.Right)
    D.　L(T) := L(T.Left)+L(T.Right)+1
    E.　None of the above

12. (單選) Which of the following sorting algorithms can obtain minimum time complexity in sorting a random linked list?
    A. Insertion Sort
    B. Quick Sort
    C. Heap Sort
    D. Bubble Sort
    E. Merge Sort

13. (單選) What is the best time complexity we can achieve to calculate all-pairs shortest paths in a weighted graph?
    A.　　$O(n)$
    B.　　$O(n\log n)$
    C.　　$O(n^2)$
    D.　　$O(n^3)$
    E.　　$O(n^4)$

14. (單選) Consider an undirected random graph of eight vertices. For each pair of vertices, the probability of an edge between them is 0.5. What is the expected number of unordered cycles of length three?
    A. 1/8
    B. 1/2
    C. 1
    D. 7
    E. 8

15. (單選) A priority-queue is implemented as a max-heap. Assume that a priority-queue contains five records and the level-order traversal of the heap is: 10, 8, 5, 3, 2. What is the level-order traversal of the heap, after two new records "1" and "7" are inserted into the heap in sequence?
    A. 10, 8, 7, 5, 3, 2, 1
    B. 10, 8, 7, 2, 3, 1, 5
    C. 10, 8, 7, 1, 2, 3, 5
    D. 10, 8, 5, 3, 2, 1, 7
    E. 10, 8, 7, 3, 2, 1, 5

16. (單選) What does the following procedure perform on a graph in which "edges" is the adjacency list representation of the graph?

```
void measure(vector<vector<int>>edges) {
  int count = 0;
  for (auto x: edges) {
    for (auto y: x) {
      count += 1;
    }
  }
  cout << count/2 << endl;
}
```

    A.　　Calculate the number of edges in an undirected graph.
    B.　　Calculate the number of nodes on a given graph.
    C.　　Calculate the number of connected components on a given graph.

D. Calculate the number of degrees of all nodes on a given graph.

E. None of the above

17. (單選) Consider an undirected unweighted graph G. Starting from a node r, a breadth-first traversal of G is performed. Let $d(r, u)$ and $d(r, v)$ denote the lengths of the shortest paths from r to u and v respectively. If u is visited before v during the breadth-first traversal, which of the following statements is correct?

A. $d(r, u) > d(r, v)$

B. $d(r, u) < d(r, v)$

C. $d(r, u) >= d(r, v)$

D. $d(r, u) <= d(r, v)$

E. None of the above

18. (複選) Suppose the alphabet of a text message has 5 characters: P, Q, R, S, T with frequencies of 20, 5, 13, 12, 10, respectively. We use Huffman's coding to encode these characters to binary codes. Which of the following statements are TRUE?

A. The binary codes for P and Q have the same length.

B. The binary codes for Q and S have the same length.

C. The binary codes for S and T have the same length.

D. The binary codes for P and R have the same length.

E. The binary codes for Q and T have the same length.

19. (複選) Consider an unsorted singly linked list of length n, where only the head pointer is available. Which of the following operations can be implemented in O(n) time?

A. Deleting the first node of the linked list.

B. Deleting the last node of the linked list.

C. Inserting an item at the front of the linked list.

D. Finding the minimum item in the linked list.

E. Reversing the linked list.

20. (複選) Which of the following statements about merge sort are TRUE?

A. It uses a divide-and-conquer strategy to sort the elements.

B. It has a space complexity of O(1).

C. It has a best-case time complexity of O(n) for sorting n elements.

D. It is an in-place sorting algorithm.

E. It is suitable for sorting large datasets.

21. (複選) Consider a binary tree T whose pre-order is 10 1 7 5 2 19 12 15 20 and in-order is 1 2 5 7 10 12 15 19 20. Which of the following statements are TRUE?

A. The level-order traversal is 10 1 19 7 12 20 5 15 2.

B. The post-order traversal is 2 5 7 1 15 12 20 19 10.

C. T is also a binary search tree.

D. T is also an AVL tree.

E. The height of T is 4.

22. (複選) Which of the following are TRUE?

A. Backtracking invokes recursion.

B. Divide and conquer invokes recursion.

C. Dynamic programming invokes recursion.

D. Topological sort is not solvable in linear time.

E. The most efficient algorithm for finding the number of connected components in an undirected graph on n vertices and m edges has time complexity O(mn).

23. (複選) In a connected graph with no loops or multiple edges, if this graph has v vertices and e edges, which of the following are correct?
   A. $e \leq v^2$
   B. $e \geq v - 1$
   C. $v \leq e^2 + 1$
   D. $v \geq e/2$
   E. $e \geq v^2$

24. (複選) A directed graph $G = (V, E)$ has vertex set: $V = \{v0, v1, v2, v3, v4, v5, v6\}$ and edge set: $E = \{(v0, v2), (v1, v0), (v1, v3), (v3, v0), (v3, v2), (v3, v5), (v3, v6), (v4, v1), (v4, v3), (v4, v6), (v5, v2), (v6, v5)\}$, and the weights of the above edges are 4, 2, 3, 1, 2, 8, 4, 10, 2, 7, 2, 1, respectively. Which of the following are TRUE?
   A. The shortest weighted path from v4 to v5 has weight 7.
   B. Starting from v4, then using the standard weighted shortest path algorithm, the last vertex to be reached is v1.
   C. Starting from v4, then using the acyclic weighted shortest path algorithm, the last vertex to be reached is v2.
   D. Starting from v4, then using the acyclic weighted shortest path algorithm, the last vertex to be reached is v1.
   E. If the above graph were undirected, then the cost of the minimum spanning tree is 10.

25. (複選) Assume a binary tree has five nodes and the root node is A. A has left child B and right child C. B has left child D and right child E. Which of the following are TRUE?
   A. The level order traversal of the tree is ABCDE
   B. The inorder traversal of the tree is DBEAC
   C. The inorder traversal of the tree is ABCDE
   D. The preorder traversal of the tree is ABCDE
   E. The height of the tree is 3