

一、 True/False (10 points)

1. When using a linked implementation, a bag can never become full.
2. For large values of  $n$ , the growth rate of  $n^2$  is smaller than  $n \log n$ .
3. The bottom item in a stack was the last item added.
4. You should always trace a recursive method to ensure it is correct.
5. The quick sort algorithm always divides an array in half.
6. The item most recently added to a queue is at the back of the queue.
7. A binary search is usually slower than a sequential search on sorted array of data.
8. Separate chaining is an efficient way to resolve collisions.
9. Completely balanced binary trees are not necessarily full.
10. All graphs are trees but not all trees are graphs.

二、 Multiple choice(20 points)

1. When implementing the bag ADT, which scenario could result in a security problem?  
A. a client attempts to create a bag whose capacity exceeds a given limit  
B. set the head node's next reference to NULL in initial method  
C. call the clear method in delete method  
D. the *delete* method is implemented before the *add* method
2. What is an advantage of using a chain for a Bag ADT?  
A. It avoids moving data when adding or removing bag entries.  
B. It has a fixed size which is easier to manage.  
C. It can be resized to provide as much space as needed.  
D. All of the above.
3. To measure the time requirement of an algorithm, we must  
A. find an appropriate growth rate function  
B. run the algorithm for different problem sizes  
C. code the algorithm in several different languages and compare the run times  
D. all of the above
4. What is the entry returned by the peek method after the following stack operations. push(A), push(R), pop(), push(D), pop(), push(L), pop(), push(J), push(S), pop(), pop()  
A. A  
B. S  
C. L  
D. D
5. What is the output of the following program when the method is called with 4?  

```
void unknown(int n){  
    if (n > 0) {  
        printf("?");  
        unknown(n-1);  
    }  
}
```

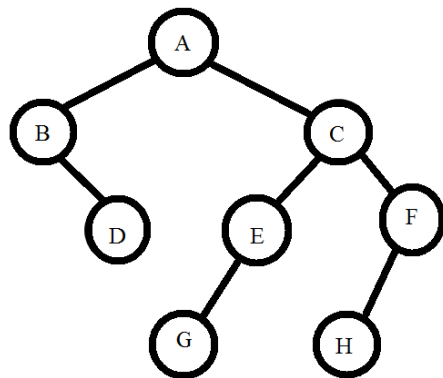
  
A. ????

- B. ????
  - C. ???
  - D. none of the above
6. Shell sort works by
- A. using insertion sort on subarrays of equally spaced entries
  - B. using insertion sort on subarrays of equal size consecutive entries
  - C. iteratively searching for the smallest entry in subarrays of equally spaced entries
  - D. iteratively searching for the smallest entry in subarrays of equal size consecutive entries
7. Which sort does not use comparisons?
- A. radix sort
  - B. quick sort
  - C. merge sort
  - D. shell sort
8. What type of behavior defines a queue?
- A. last-in first-out
  - B. first-in last-out
  - C. first-in first-out
  - D. none of the above
9. A good hash function should
- A. minimize collisions
  - B. be fast to compute
  - C. distribute entries uniformly throughout the table
  - D. all of the above
10. If a directed graph has  $n$  vertices, how many edges can it have?
- A.  $n * (n+1) / 2$
  - B.  $n * (n-1) / 2$
  - C.  $n * (n+1)$
  - D.  $n * (n-1)$

### 三、Short Answer(24 points)

1. Given the following array of 9 elements, trace one iteration of the quick sort algorithm. Use the middle value in the array as the pivot. Assume the array is to be sorted in ascending order.  
81 16 4 6 34 11 23 67 52
2. Given the following array, show the comparisons to an array entry that are performed to search for the number 23 if you use the binary search algorithm?  
2 3 5 7 11 13 17 19 23 29 31 37
3. Given a table size of 19 the hash function  $h(k) = k \% \text{table size}$  and the entries 19, 38, 20, 39 and 21 show the hash table after the five entries are inserted into the table using open addressing with linear probing.

4. Give the postorder traversal of the following binary tree.



#### 四、Application (36 points)

1. A communication system uses eight characters to transmit messages. Before information transmission, it needs to be converted into binary code, and the frequency of each character is shown in Table 1.

Table 1 character frequency distribution table

a	b	c	d	e	f	g	h
0.11	0.03	0.23	0.04	0.08	0.25	0.21	0.05

According to the basic principles and algorithms you have learned, complete the following tasks:

- Using the optimal binary tree can construct variable length prefix code and shorten the message length. What is the optimal binary tree? (2 points)
  - Please give the algorithm principle, coding process and results of constructing variable length prefix coding with optimal binary tree (when constructing optimal binary tree, keep the weight of left child less than the right child). (10 points)
2. For the convenience of transporting goods, the road in the scenic area need to be repaired so that any two scenic spots can be connected by cement road (which can be reached through other scenic spots, as long as there is cement road connection). After the investigation of the existing road conditions, some statistical data are obtained. The cost of maintenance of the existing roads in the scenic area is listed in Table 2.

Table 2 scenic spots and repairing costs

scenic spot ID	scenic spot ID	repairing costs	scenic spot ID	scenic spot ID	repairing costs
1	2	3	2	5	3
1	3	2	3	4	4
2	4	2	3	6	3
4	6	3	5	6	1

Please complete the following tasks based on the basic principles of data structure and algorithm.

- Please design a suitable data structure for the above problems, and give

- the corresponding logical structure and visual representation. (3 points)
  - ii. Design two kinds of data storage schemes, and give the corresponding virtual storage structure definition and storage structure diagram, at the end compare the advantages and disadvantages of the two storage schemes from the perspective of storage density. (4 points)
  - iii. What is the minimum cost and route to maintain the roads between scenic spots in order to realize the purpose of connecting scenic spots? Give the basic principle, analysis process and results of the analysis method you used. (7 points)
3. English is very important to computer engineers. Electronic dictionary is an important auxiliary tool for learning English. A student hopes to design an electronic dictionary to meet the following functions. (a) It can insert a word into the dictionary when it fails to find it; (b) when the searching is successful, record the number of times the word has been searched, which can be used to count the error prone words. Please complete the following tasks based on the basic principles of data structure and algorithm.
- i. To solve the problem (a), should we use static search algorithm or dynamic search algorithm? Please give the name of the designed search algorithm. (2 points)
  - ii. If the e-dictionary is initially empty, query 10 words in turn, they are “means”, “range”, “organize”, “element”, “particle”, “program”, “include”, “project”, “industry” and “expert”. According to the algorithm designed in (i), draw the evolution process of the structure of the electronic dictionary is step by step.(4 points)
  - iii. After (ii) calculate the search length of the search word “include” and the average successful search length of the electronic dictionary (compare the words in dictionary order) (4 points)

### **五、Algorithm Design (10 points)**

Design a recursive algorithm to find the depth of the binary tree (the data storage type should be defined first).