※ 注意：請用 2B 鉛筆作答於答案卡，並先詳閱答案卡上之「畫記說明」。

(一) 單選題 (每題 5 分; 答錯不倒扣)

1. The following program generates all the permutations of a string (char* a) whose length is n. What is the runtime complexity of this program?

```
void permuteAll(char* a, int n)
{
   permuteGen(a, 0, n);
}
void permuteGen(char* a, int k, int n)
{
   if (k == n - 1) {
     for (int i = 0; i < n; i++)
       // print out the character a[i]; assume O(1)
       cout << a[i] << “ “;
     cout << endl;
   }
   else {
     for (int i = k + 1; i < n; i++) {
       swap(a[k], a[i]);
       permuteGen(a, k + 1, n);
       swap(a[k], a[i]);
     }
   }
}
```

(A) $O(n^2)$

(B) O(n log n)

(C) $O(n^n)$

(D) $O(n * 2^n)$

(E) O(n * (n!))

2. Let h be the height of an arbitrary binary tree, and n be its number of nodes. The time complexity to insert a new node to this tree is:

(A) O(h)

(B) O(log n)

(C) O(h log n)

(D) O(n log h)

(E) O(n log n)

3. We know that the runtime complexity of a program depends on the program input combinations --- Suppose the probability of the program with runtime complexity O(n) is p, where p << 1, and in other cases (i.e. for the (1 - p) possible cases), the runtime complexity is O(log n). If we are running the program with K different input combinations, where K is a very large number, we can say that the amortized runtime complexity of this program is:

(A) O(log n)

(B) O(p * n)

(C) O(K * log n)

(D) O(K * p)

(E) O(K * pn)

4. Evaluate the following postfix expression. What is the actual numeric value of the expression?

```
8  3  4  +  *  10  7  2  -  *  -
```

(A) -130

(B) 6

(C) 38

(D) 124

(E) None of the above

5. Given a hash with 7 buckets, we are inserting the following set of strings into this hash. Which of the following hash functions can lead to the least number of collisions? (Note: let a[i] return the ASCII code of the i^{th} character in the string, where $0 \le i <$ string.length()).

Set of strings to be inserted: { "which", "following", "function", "can", "lead", "least", "number", "collisions" }.

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(Note: the ASCII codes for characters ‘a’ to ‘z’ are as follows)

a(97)	b(98)	c(99)	d(100)	e(101)	f(102)	g(103)
h(104)	i(105)	j(106)	k(107)	l(108)	m(109)	n(110)
o(111)	p(112)	q(113)	r(114)	s(115)	t(116)	u(117)
v(118)	w(119)	x(120)	y(121)	z(122)		

(A) a[0] % 7

(B) a[1] % 7

(C) (a[0] + (a[1] << 2)) % 7　　// Note: “<<” is the shift-left operator

(D) (a[0] + (a[1] % 5)) % 7

(E) (a[0] - 97) * (a[1] - 97) % 7

6. For the set of strings in the above problem, if we insert them into a “trie” data structure, in which each “branch node (i.e. internal node)” has 26 children nodes and each “element node (i.e. external node)” contains a Boolean (i.e. 0/1) variable. The 26 children nodes of a branch node are corresponding to the alphabets ‘a’ to ‘z’, and the Boolean variable of the element node denotes whether it is a valid trie search and returns the corresponding string. The strings are inserted to the trie from the leftist characters.

How many branch nodes (i.e. internal nodes) will be created for this trie?

(A) 5

(B) 8

(C) 45

(D) 50

(E) None of the above

(二) 複選題 (每題答對 7 分, 答錯 0 分; 答錯不倒扣)

7. Which of the following is(are) correct?

(A) The time complexity of a recursive program must be exponential.

(B) The longer a computer program, the higher its runtime complexity.

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(C) Let p(n) be a polynomial function and c be a constant whose value is greater than 1. Then $p(n) = O(c^n)$.

(D) Let p(n) be a polynomial function with degree d. Then $p(n) = \Theta(n^d) = O(n^d) = \Omega(n^d)$

(E) $\log^k n = O(n)$ for any power k.

8. Which of the following is(are) correct?

(A) Given the position (e.g. pointer) of a node in a singly linked list, inserting a data right after this node takes O(n) time.

(B) The reason why we cannot implement a O(log n) time "Binary Search" algorithm on a singly linked list is because it takes linear time (i.e. O(n)) to access an arbitrary element (i.e. the i^{th} element) in the list.

(C) Give a singly linked list of n elements, the "Max Subsequence Problem" is to find a continuous chunk of subsequence whose sum is maximum. Without using other data structure (i.e. other abstract data type) to store data, we can implement a linear time (i.e. O(n)) algorithm to compute the maximum sum.

(D) Given a doubly linked list of n elements, we can implement a "Merge Sort" algorithm with runtime complexity O(n log n).

(E) The reason why a heap can be implemented in an "array" data structure is because it always keeps the smallest (or the biggest) element on the root node (i.e. as the first element of the array).

9. Which of the following is(are) true about the "tree" data structure?

(A) If the number of edges is equal to the number of nodes minus 1, the tree must be a binary tree.

(B) If the number of leaf nodes (i.e. the external nodes) is equal to the number of internal nodes plus 1, the tree must be a binary tree.

(C) If the height of the tree is smaller than n/2, where n is the number of nodes, the tree must be a binary tree.

(D) The number of paths from the root node to the leaf nodes is exponential to the number of nodes (i.e. $O(2^n)$).

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(E) Each node in the tree can be a root node of a subtree.

10. Which of the following is(are) true about the "tree" data structure?

(A) The number of rotations per insert/delete operation in a Red-Black tree is O(log n).

(B) Given the same set of data, the height of the Red-Black tree must be smaller than or equal to the height of an AVL tree.

(C) 2-3-4 tree is a special case of a B-tree.

(D) B-tree of order 2 is full binary tree.

(E) Let m be the order of a B-tree. The search time of an element in the B-tree is in general decreasing as the value of m increases, with the price of higher memory usage.

11. Which of the following statement(s) is (are) true?

(A) Every subtree of a binary tree is also a binary tree.

(B) The right subtree of any node in a complete binary tree is complete.

(C) Given a tree, if there is a path from a node X to a node Y, and a path from node X to node Z, then there must be a path from node Y to node Z.

(D) Given a undirected graph, if there is a path from a node X to a node Y, and a path from node X to node Z, then there must be a path from node Y to node Z.

(E) If *R* is a subtree of *S*, and *S* is a subtree of *T*, then *R* is a subtree of *T*.

12. Which of the following is(are) true about "Abstract Data Type (ADT)"?

(A) The implementation of ADTs is dependent on the algorithms and programs that use them.

(B) The "insert" and "delete" operations of ADTs are required to have complexity O(log n).

(C) The "find" operation of ADTs are required to have complexity O(log n).

(D) Usually "what the interface functions of an ADT can be used" are abstracted away (i.e. hid from the users).

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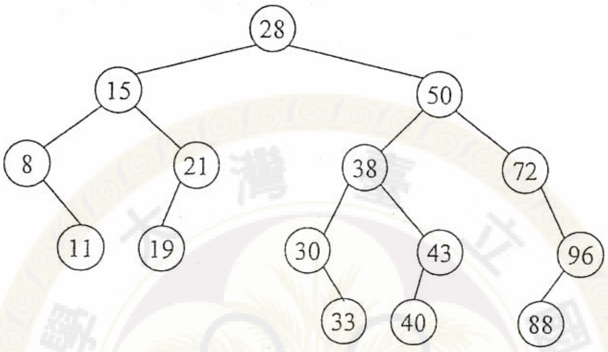
(E) Usually "how the internal data members of an ADT are implemented" are abstracted away (i.e. hid from the users).

13. Given the AVL tree below, which of the following insertion(s) will cause "double rotations"?



(A) 17

(B) 29

(C) 36

(D) 39

(E) 90

14. Which of the following is(are) true about the heap data structure? (n is the number of nodes)

(A) Heap data structure is particularly useful when we need to identify the task/event with the highest priority in a group of tasks/events.

(B) Deleting the minimum element in a min-heap takes O(log n) time.

(C) Inserting a node into a Fibonacci heap takes O(1) time

(D) Figure 14-1 is a legal deap.

(E) Figure 14-2 is a legal binominal heap

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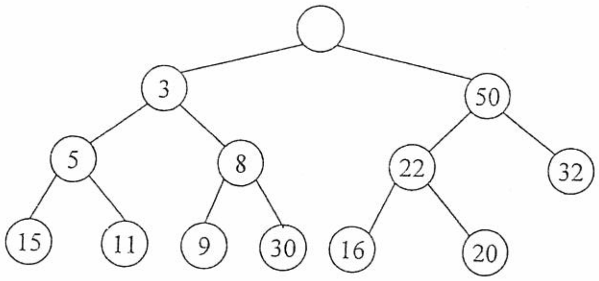


Figure 14-1

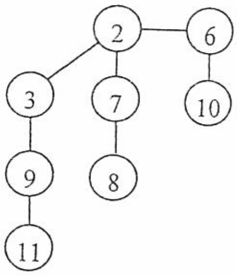
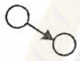
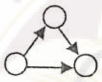
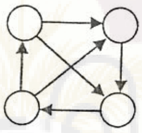


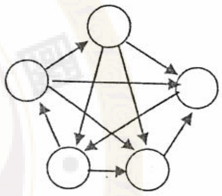
Figure 14-2

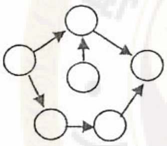
15. Which of the following directed graph(s) is(are) acyclic?

(A)


(B)


(C)


(D)


(E)


16. Which of the following is(are) correct?

(A) The max clique of Figure xx has number of nodes equal to 4.

(B) The complement graph of Figure 16-1 is as in Figure 16-2.

(C) Figure 16-3 can be covered by at least 3 cliques.

(D) Figure 16-3 is a bi-partite graph.

(E) Figure 16-1 and Figure 16-2 are isomorphic.

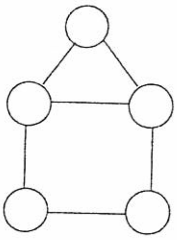


Figure 16-1

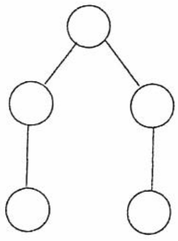


Figure 16-2

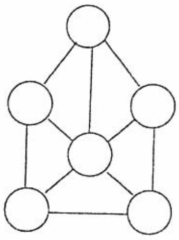


Figure 16-3

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