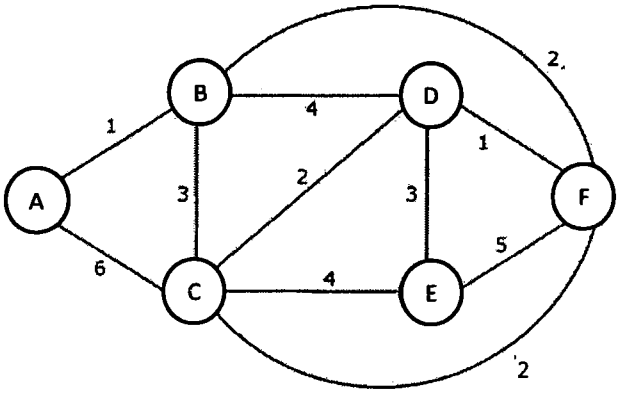
國立中央大學 113 學年度碩士班考試入學試題

所別： 資工類

科目： 資料結構與演算法

＊本科考試禁用計算器

複選題（共100分，每題 5 分，全部答對才給分，答錯倒扣一分）



1. Consider the graph above. Which of the following cannot be the edge selection sequence of Kruskal's minimum spanning tree algorithm?
   (A) (d, f) (a, b) (d, c) (b, f) (d, e)
   (B) (d, f) (a, b) (b, f) (d, e) (d, c)
   (C) (a, b) (d, f) (b, f) (f, c) (d, e)
   (D) (a, b) (d, f) (d, c) (f, c) (d, e)

2. Consider the following five sorting algorithms: Quick Sort, Heap Sort, Merge Sort, Insertion Sort and Radix Sort. Which of the following statements are true?
   (A) Insertion Sort gives best performance when applied on an array which is sorted or almost sorted (maximum 1 or two elements are misplaced).
   (B) Radix Sort is most efficient to sort string consisting of ASCII characters?
   (C) All these five sorting algorithms are comparison based sorting algorithms.
   (D) All these five sorting algorithms are stable.

3. Which of the following statements are true? Let T(n) denote the time complexity of performing insertion in an n-element Binary Search Tree.
   (A) $T(n) = 2T(n/2) + O(1)$ and $T(1) = T(0) = O(1)$ holds for best case only.
   (B) $T(n) = T(n-1) + O(1)$ and $T(1) = T(0) = O(1)$ holds for worst case only
   (C) $T(n) = T(n/2) + O(1)$ and $T(1) = T(0) = O(1)$ holds for best case.
   (D) $T(n) = T(n-2) + O(1)$ and $T(1) = T(0) = O(1)$ holds for worst case.

4. Which of the following are true for dynamic programming?
   (A) The solution has optimal substructure
   (B) Breaking a problem into smaller overlapping subproblems.
   (C) Solving problems in a sequential manner.
   (D) The time complexity of dynamic programming (with overlapping subproblems using memorization) is $O(n^2)$

5. Let LASTPOST, LASTIN and LASTPRE denote the last vertex visited in a postorder, inorder and preorder traversal, respectively. Which of the following are true?
   (A) LASTIN = LASTPOST of a complete binary tree.
   (B) LASTIN = LASTPRE of a full binary tree
   (C) LASTPRE = LASTPOST of a full binary tree
   (D) LASTIN = LASTPRE of a complete binary tree

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6. Consider a complete graph G with vertex set {0, 1, 2, 3, 4} . Let W be the matrix of edge weights of G, e.g., entry Wij in matrix W is the weight of edge {i, j}. What are the minimum possible cost of a spanning tree T of G?

$$W = \begin{bmatrix} 0 & 1 & 8 & 1 & 5 \\ 1 & 0 & 5 & 5 & 9 \\ 8 & 5 & 0 & 7 & 3 \\ 1 & 4 & 7 & 0 & 2 \\ 4 & 9 & 3 & 2 & 0 \end{bmatrix}$$

(A) 7 when vertex 0 is the root of T
(B) 8 when vertex 0 is not the root in T
(C) 9 when vertex 0 is a leaf node in T
(D) 10 when vertex 0 is a leaf node in T

7. Which of the following statements are true?
(A) AB+DE*F/-BC*+ is the postfix expression of A+B-D*E/F+B*C
(B) AB+DE*F/*BC-+ is the postfix expression of A+B-D*E/F+B*C
(C) AB*DE*F/+BC*+ is the postfix expression of A+B*D*E/F+B*C
(D) ABD*E*F/+BC*+ is the postfix expression of A+B*D*E/F+B*C

8. Consider the following function that takes reference to head of a Doubly Linked List as parameter. Assume that a node of doubly linked list has previous pointer as prev and next pointer as next.

```
void fun(struct node **head_ref)
{
    struct node *temp = NULL;
    struct node *current = *head_ref;

    while (current !=  NULL)
    {
        temp = current->prev;
        current->prev = current->next;
        current->next = temp;
        current = current->prev;
    }

    if(temp != NULL )
        *head_ref = temp->prev;
}
```

Assume that reference of head of a doubly linked list L is passed to above function. What is the resulting linked list after the function call?

(A) 2 <--> 1 <--> 4 <--> 3 <--> 6 <-->5 when L is 2 <--> 1 <--> 4 <--> 3 <--> 6 <-->5
(B) 5 <--> 4 <--> 3 <--> 2 <--> 1 <-->6 when L is 5 <-->4 <--> 3 <-->2 <--> 6<-->1
(C) 6 <--> 5 <--> 4 <--> 3 <--> 2 <--> 1 when L is 1 <--> 2 <--> 3 <--> 4 <--> 5 <-->6
(D) 6 <--> 5 <--> 4 <--> 3 <--> 1 <--> 2 when L is 1 <--> 2 <--> 3 <--> 4 <--> 5 <-->6

9. The following function reverse() is supposed to reverse a singly linked list. There is one line missing at the end of the function.

```
/* Link list node */
struct node
{
  int data;
  struct node* next;
};

/* head_ref is a double pointer which points to head (or start) pointer of linked list */
static void reverse(struct node** head_ref)
{
  struct node* prev   = NULL;
  struct node* current = *head_ref;
  struct node* next;
  while (current != NULL)
  {
    next  = current->next;
    current->next = prev;
    prev = current;
    current = next;
  }
  /*ADD A STATEMENT HERE*/
}
```

What should be added in place of "/*ADD A STATEMENT HERE*/", so that the function correctly reverses a linked list.

(A) *head_ref = prev;
(B) current =*head_ref ;
(C) next =*head_ref ;
(D) *head_ref = NULL;

10. What does the following function do for a given binary tree?

```
int f(struct node *root)
{
    if (root == NULL)
        return 0;
    if (root->left == NULL && root->right == NULL)
        return 0;
    return 1 + f(root->left) + f(root->right);
}
```

(A) Counts leaf nodes when x =1 and y=0;
(B) Counts internal nodes when x =0 and y=1.
(C) Returns height where height is defined as number of edges on the path from root to deepest node when x=0 and y=1
(D) Return diameter where diameter is number of edges on the longest path between any two nodes when x =1 and y=0

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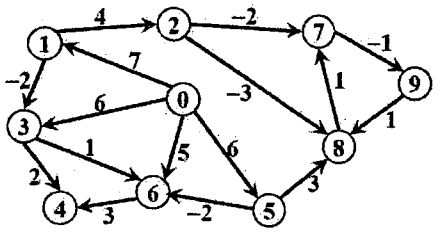
11. Consider the problem of solving single-source shortest-paths on the following weighted directed graph:



Let $d[i,j]$ denote the length of shortest path from node i to node j. For the following items, choose the correct one(s):
(A) $d[0,1] = 7$ (B) $d[0,2] = 11$ (C) $d[0,3] = 6$ (D) $d[0,4] = 8$ (E) $d[0,5] = 6$

12. Follow the previous question. Choose the correct item(s):
(A) $d[0,6] = 5$ (B) $d[0,7] = 9$ (C) $d[0,8] = 7$
(D) There are exactly two shortest paths from node 0 to node 4.
(E) There are exactly two shortest paths from node 0 to node 9.

13. Let $f(n)$ and $g(n)$ be asymptotically positive functions, and $\lg x = \log_2(x)$. Which of the following statements are correct?
(A) If $f(n) = O(g(n))$ then $\lg f(n) = O(\lg g(n))$, where $g(n) \geq 2$ and $f(n) \geq 1$ for $n \geq 1$.
(B) If $f(n) = O(n)$ then $f(n) \times f(n) = O(n^2)$.
(C) If $f(n) = O(n)$ then $2^{f(n)} = O(2^n)$.
(D) $f(n) + o(f(n)) = \theta(f(n))$.
(E) $f(n) = \theta(f(n/2))$.

14. Assume that the function value of each of the following functions is constant for $n \leq 2$.

$t(n) = n + \sum_{k=1}^{n-1}[t(k) + t(n-k)]$, $\quad f(n) = 2f(n/4) + \sqrt{n}$,

$g(n) = g(n/2) + \sqrt{n}$, $\quad h(n) = 5h(n/2) + (n \lg n)^2$,

$a(n) = a(n-1) + n^k \lg n$.

Choose the correct answers.
(A) $t(n) = \theta(2^n)$ (B) $f(n) = \theta(\sqrt{n})$ (C) $g(n) = \theta(\sqrt{n})$
(D) $h(n) = n^{\lg 5}$ (E) $a(n) = \theta(n^{k+1} \lg n)$

15. The following statements about minimum spanning tree (MST) may or may not be correct. Assume that the weighted graph $G = (V, E)$ is undirected and connected. Do not assume that edge weights are distinct unless this is specifically stated. Chose the correct items.
(A) If $|E| \geq |V|-1$, and there is a unique heaviest edge, then this edge cannot be part of any MST of G.
(B) If G has a cycle with a unique heaviest edge e, then e cannot be part of any MST of G.
(C) If the lightest edge in G is unique, then it must be part of every MST of G.
(D) If G has a cycle with a unique lightest edge e, then e must be part of some MST of G.
(E) The shortest path between two nodes is necessarily part of some MST of G.

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16. Which of the following statements about sorting algorithms are incorrect?
(A) The merge sort and quick sort are designed based on the similar algorithm design principle.
(B) If most of the numbers are in the correct order, quick sort is the best algorithm.
(C) The worst-case time complexity of quick sort, merge sort, and heap sort is $O(n\log n)$.
(D) The worst-case time complexity and the expected time complexity of both merge sort and heap sort are in the same order.
(E) No sorting algorithm has time complexity lower than $O(n\log n)$.

17. Consider a hash table of size 7, with hash function $H(k) = k \% 7$, and pseudo random $i = (i + 5) \% 7$. We want to insert the following keys one by one from left to right.
15, 11, 25, 16, 9, 8, 12
If random probing is used, which of the following statements are incorrect?
(A) key 25 is at position 4.
(B) key 16 is at position 0.
(C) key 9 is at position 0.
(D) key 8 is at position 6.
(E) Some key has no place to store in the table.

18. Given 4 matrices *Q*, *R*, *S*, and *T* with dimensions 13x12, 12x30, 30x15, and 15x18, respectively. If we would like to obtain the matrix multiplication *QRST* with the least number of scalar multiplications, which of the following statements are incorrect?
(A) This is a divide-and-conquer question.
(B) The first pair of metrices to be multiplied are *Q* and *R*.
(C) The last matrix to be multiplied is *T*.
(D) There is more than one way to achieve the minimum number of scalar multiplications.
(E) The minimum number of scalar multiplications needed is 11250.

19. Let X = {a/25, b/20, c/10, d/20, e/50} be the alphabet and its frequency distribution. Which of the following statements are correct?
(A) This is a greedy algorithm question.
(B) The code length of 'e' is 1.
(C) 'a' and 'c' have the same code length.
(D) The code length for the string "cad" is 9.
(E) There is more than one way to achieve optimum prefix code.

20. Which of the following statements describe the differences between Dynamic Programming and Divide-and-Conquer?
(A) Whether the subproblems overlap or not
(B) The division of problems
(C) The combination of subproblems
(D) The way the base case is solved
(E) The depth of recurrence

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