**Graduate Comprehensive Exam**
**Data Structures and Algorithms**
**Spring 1999**

Answer all questions on the exam. Total: 100 points. Good Luck.

1. (10 pts) Using the big-O notation, estimate the running time of `proc(N)` in terms of `N`. Explain your answer.

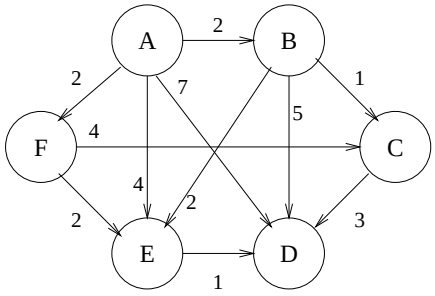
```
void proc(int x)
  {
    int i, j, k;

    for (i = 0; i < 10; i++)
      for (j = 0; j < x; j++)
        for (k = x; k > 0; k = k/2)
           /* constant-time operation */
  }
```

2. (15 pts)
   (a) What are the best-case and worst-case time complexities (in big-O) of locating an item in a hash table? Explain.
   (b) What is a collision in hashing?
   (c) Describe two collision resolution strategies and illustrate with examples.

3. (40 pts) Using C, C++, or pseudocode with sufficient details:
   (a) write a procedure that performs *selection sort* in ascending order on an array of integer elements.
   (b) use `class/struct` to represent a singly linked list of integer items and write a **recursive** function that prints a singly linked list in **reverse** order.

4. (25 pts) Given the following graph:




   (a) Perform the Dijkstra's algorithm to find the shortest path from node A to node D. Show your steps.
   (b) Assume the edges are **undirected**, peform a minimal spanning tree algorithm. Show your steps.

5. (10 pts) Given these numbers `2 8 3 1 9 4` in an array, perform Quicksort (in ascending order) and draw the array after each partitioning step.