CHAPTER 12

Abstract Data Types

(Solutions to Review Questions and Problems)

Review Questions

Q12-1. An abstract data type (ADT) is a data declaration packaged together with the operations that are meaningful for the data type. In an ADT, the operations used to access the data are known, but the implementation of the operations are hidden.

Q12-3. A queue is a linear list in which data can only be inserted at one end, called the rear, and deleted from the other end, called the front. These restrictions ensure that the data are processed through the queue in the order in which they are received. In other words, a queue is a first in, first out (FIFO) structure. Four basic queue operations defined in this chapter are *queue*, *enqueue*, *dequeue*, and *empty*.

Q12-5. A tree consists of a finite set of elements, called nodes (or vertices), and a finite set of directed lines, called arcs, that connect pairs of the nodes. If the tree is not empty, one of the nodes, called the root, has no incoming arcs. The other nodes in a tree can be reached from the root following a unique path, which is a sequence of consecutive arcs. A binary tree is a tree in which no node can have more than two subtrees. A binary search tree (BST) is a binary tree with one extra property: the key value of each node is greater than the key values of all nodes in each left subtree and smaller than the value of all nodes in each right subtree.

Q12-7. A graph is an ADT made of a set of nodes, called vertices, and set of lines connecting the vertices, called edges or arcs. Graphs may be either directed or undirected. In a directed graph, or digraph, each edge, which connects two vertices, has a direction (arrowhead) from one vertex to the other. In an undirected graph, there is no direction.

Q12-9. General linear lists are used in situations where the elements are accessed randomly or sequentially. For example, in a college, a linear list can be used to store information about the students who are enrolled in each semester.

Problems

P12-1. The following shows the algorithm segment.

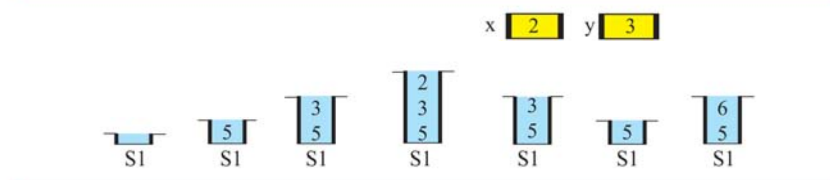
```
while (NOT empty (S2))
{
    pop (S2, x)                    // x will be discarded
}
```

P12-3. The following shows the algorithm segment.

```
stack(Temp)
while (not empty (S1))
{
    pop (S1, x)
    push (Temp, x)      // Temp is a temporary stack
}
while (not empty (Temp))
{
    pop (Temp, x)
    push (S1, x)
    push (S2, x)
}
```

P12-5. Figure P12-5 shows the contents of the stack and the value of the variables.

Figure P12-5 *Solution to problem P12-5*



P12-7. Algorithm P12-7 shows the pseudocode.

Algorithm P12-7 *Checking the equality of two stacks*

```
Purpose: Check if two stacks are the same
Pre: Given: S1 and S2
Post:
Return: true (S1 = S2) or false (S1 ≠ S2)
{
    flag ← true
    Stack (Temp1)
    Stack (Temp2)
    while (NOT empty (S1) and NOT empty (S2))
    {
        pop (S1, x)
        push (Temp1, x)
        pop (S2, y)
        push (Temp2, y)
        if (x ≠ y)
            flag ← false
    }
    if (NOT empty (S1) or NOT empty (S2))
        flag ← false
    while (NOT empty (Temp1) and NOT empty (Temp2))
    {
        pop (Temp1, x)
        push (S1, x)
        pop (Temp2, y)
        push (S2, y)
    }
    return flag
}
```

P12-9. The following shows the algorithm segment.

```
while (NOT empty (Q1))
{
    dequeue (Q1, x)
    enqueue (Q2, x)
}
```

P12-11. The following shows the algorithm segment.

```
while (NOT empty (Q2))
{
    dequeue (Q2, x)
    enqueue (Q1, x)
}
```

P12-13.

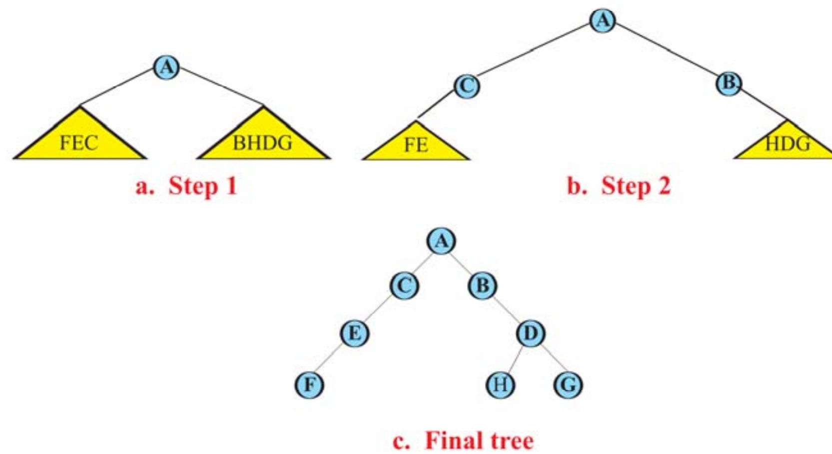
a. Since traversal is postorder, the root comes at the end: G

b. Since the traversal is preorder, the root comes at the beginning: I

c. Since traversal is postorder, the root comes at the end: E

P12-15. The postorder traversal FECHGDBA tells us that node A is the root. The Inorder traversal FECABHDG implies that nodes FEC in the left of A are in the left subtree and nodes BHDG in the right of A are in the right subtree. Following the same logic for each subtree we build the binary tree as shown Figure P12-15

Figure P12-15 *Finding the tree for problem P12-15*



P12-17. Algorithm P12-17 shows the pseudocode.

Algorithm P12-17 *Array implementation of Stack ADT*

```
Algorithm: StackADTArrayImplementation
Purpose: Implementing stack operations with an array
Allocation: Allocate an array of size n

stack (Stack S)     // Stack operation
{
     allocate record S of two fields
     S.top ← 0
     S.count ← 0
}

push (Stack S, DataRecord x)     // Push operation
{
     S.top ← S.top +1
     S.count ← S.count + 1
     A[S.top] ← x
}

pop (Stack S, DataRecord x)     // Pop operation
{
     x ← A[S.top]
     S.top ← S.top − 1
     S.count ← S.count − 1
}

empty (Stack S)     // Empty operation
{
     if (S.count = 0)
          return true
     else
          return false
}
```

P12-19. Algorithm P12-19 shows the pseudocode.

Algorithm P12-19 *Array implementation of Queue ADT*

```
Algorithm: QueueADTArrayImplementation
Purpose: Implementing queue operations with an array
Allocation: An array of size n is allocated

queue (Queue Q)          // Queue operation
{
    allocate record Q of three fields
    Q.count ← 0
    Q.rear ← 0
    Q.front ← 0
}

enqueue (Queue Q, DataRecord x)      // Enqueue operation
{
    if (Q.front = 0)
        Q.front ← 1
    Q.count ← Q.count +1
    Q.rear ← Q.rear + 1
    A [Q.rear] ← x
}

dequeue (Queue Q, DataRecord x)      // Dequeue operation
{
    x ← A [Q.front]
    Q.front ← Q.front + 1
    Q.count ← Q.count − 1
}

empty (Queue Q)      // Empty operation
{
    if (Q.count = 0)
        return true
    else
        return false
}
```

P12-21. Algorithm P12-21 shows the pseudocode.

Algorithm P12-21 *Array implementation of Linear List*

```
Algorithm: ListADTArrayImplementation
Purpose: Implementing list operations with an array
Allocation: An array of size n is allocated
Include: BinarySearchArray algorithm from chapter 11
Include: ShiftDown algorithm from chapter 11

list (List L)    // List operation
{
    allocate record L of two fields
    L.count ← 0
    L.first ← 0
}

insert (List L, DataRecord x)      // Insert operation
{
    BinarySearchArray (A, n, x.key, flag, i)
    ShiftDown (A, n, i)
    A [i] ← x
    if (empty (L))
        L.first ← 1
    L.count ← L.count + 1
}

delete (List L, DataRecord x)          // Delete operation
{
    BinarySearchArray (A, n, x.key, flag, i)
    x ← A [i]
    ShiftUp (A, n, i)
```

Algorithm P12-21 *Array implementation of Linear List (continued)*

```
    L.count ← L.count − 1
    if (empty (L))
        L.first ← 0
}

retrieve (List L, DataRecord x)    // Retrieve operation
{
    BinarySearchArray (A, n, x.key, flag, i)
    x ← A [i]
}

traverse (List L, Process)    // Traverse operation
{
    walker ← 1
    while (walker ≤ L.count)
    {
        Process (A [walker]
        walker ← walker + 1
    }
}

empty (L)    // Empty operation
{
    if (L.count = 0)
        return true
    else
        return false
}
```