

1. (a) Show how to implement a queue using 2 stacks. (10 points)
(b) Analyze the running time of enqueue and dequeue operations in terms of the number of items in a queue for the above problem. (5 points)
(c) Given a queue, as in problem 1(a), initially with less than or equal to n items in the queue, there are a sequence of n queue operations, either enqueue or dequeue. Analyze the total number of stack operations used in the sequence of n queue operations. (10 points)
2. (a) Explain programming errors caused by using pointers. (10 points)
(b) Explain the side effect of a procedure call and why it is bad. (10 points)
3. (a) Design a Pascal recursive procedure to output all the permutations of the 20 letters a, b, ..., t in alphabetical order; output 20 letters consecutively without space as a word, and separate 2 words by a space. (10 points)
(b) Estimate how long it may take to finish the job, if there were a printer that can print 21 letters (including the space) in 1 micro second. (5 points)
4. Let a binary tree be a tree and each internal node has exactly 2 children. Given a binary tree with n nodes, find the relationship between the total internal path length of the binary tree and the total external path length. Also prove it. (20 points)
5. Find the output of the following Pascal program. (20 points)

```
program exam(input, output);
var x, y, z : integer;
procedure P(var i:integer; j:integer);
var x : integer;
function Q(i:integer):integer;
begin
  i := i + 1;
  y := y + 1;
  writeln('In Q ', i, j, x, y, z);
  Q := i * y
end;
begin
  x := 0;
  x := Q(i);
  z := j * x;
  writeln('In P ', i, j, x, y, z);
  i := i + 1
end;
begin
  x := 1;
  y := 2;
  z := 3;
  p(z, y);
  writeln('In exam ', x, y, z)
end.
```