Computer Science Foundation Exam

December 14, 2000

Section I A

No Calculators!

Name: _______________________________

SSN: ________________________________

In this section of the exam, there are three (3) problems.

You must do all of them.

The weight of each problem in this section is indicated with the problem.

The algorithms in this exam are written in a combination of pseudocode, and
programming language notation.

Partial credit can not be given unless all work is shown.

As always, be complete, yet concise, and above all be neat,
credit can not be given when your results are unreadable.
Given the following array of integers and algorithm, answer the questions below. Assume that the global array $X[1..n]$ is correctly declared and contains the values shown. Assume that the procedure was called with $P1(1, 6, 5)$.

<table>
<thead>
<tr>
<th>Array X</th>
<th>8</th>
<th>6</th>
<th>2</th>
<th>7</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>position</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

procedure $P1(i, j, k : integer)$
  
  a, b, c, d : integer
  
  a $\leftarrow$ 0
  b $\leftarrow$ 0
  c $\leftarrow$ 0
  d $\leftarrow$ 0

  loop
    if $(X[i] > X[j])$ then
      a $\leftarrow$ a + $(X[i] - X[j])$
      X[i] $\leftarrow$ X[i] - k
      c $\leftarrow$ c + X[i]
      i $\leftarrow$ i + 1
    else if $(X[j] > X[i])$ then
      b $\leftarrow$ b + $(X[j] - X[i])$
      X[j] $\leftarrow$ X[j] + k
      d $\leftarrow$ d + X[j]
      j $\leftarrow$ j - 1
    else
      c $\leftarrow$ c + k
      d $\leftarrow$ d - k
      i $\leftarrow$ i + 1
      j $\leftarrow$ j - 1
    endif
  exitif $(i > 5) \; \text{OR} \; (j = 1)$
  endloop
endprocedure

a) Show the array $X$ after the procedure has completed execution?

<table>
<thead>
<tr>
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<th>8</th>
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</tr>
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</table>

b) What value will the following variables contain after the $\text{loop}$ is finished?

| a | b | c | d |
(2, 14%) In the following Postfix expressions all values are single decimal digits and the operations are addition "+", subtraction "-", multiplication "*" and division "/". In each box below the Postfix expression in part a), show ONLY the contents of the stack at the indicated point in the Postfix string (point A, B or C). Put the final answer in the blank. If the Postfix string is invalid, carry the operations as far as possible and write "invalid" as the answer.

a) \[ 4 \ 4 \ 4 \ 4 A + - \ * \ 2 \ 4 B + + 5 / C * = \] _________________

b) given the following stack and queue operations, taken in top to bottom order, show the output produced by the print statements:

push(5)
enqueue(4)
enqueue(2)
push(7)
enqueue(pop)
push(dequeue)
push(3)
print(dequeue)
print(pop)
push(8)
enqueue(6)
enqueue(pop)
push(dequeue)
push(pop)
push(dequeue)

output from print statements:

<table>
<thead>
<tr>
<th>first output</th>
<th>second output</th>
<th>third output</th>
<th>fourth output</th>
</tr>
</thead>
</table>

(3, 20%) Answer each of the following "timing" questions concerning an algorithm of a particular order and a data set of a particular size. Assume that the run time is affected only by the size of the data set and not its composition.

a) For an \( O(n^2) \) algorithm, one data set with \( n = 7 \) takes 98 seconds.
   How long will it take for a data set with \( n = 5 \)? ____________________

b) For an \( O(2^n) \) algorithm, one data set with \( n = 4 \) takes 15 seconds.
   If you used a different-sized data set and it took 60 seconds, how large must that data set be? ____________________

c) For an \( O(\log n) \) algorithm, a friend tells you that it took 12 seconds to run on her data set. You run the same program, on the same machine, and your data set with \( n = 32 \) takes 20 seconds.
   What size was her data set? ____________________

Given the following pseudocode segment, answer the questions below for an arbitrary \( n \):

\[
\begin{align*}
x & \leftarrow 0 \\
& \text{for } i \leftarrow 1 \text{ to } (2*n) \text{ do} \\
& \quad \text{for } j \leftarrow 1 \text{ to } n \text{ do} \\
& \quad \quad \text{if } (j = i) \text{ then} \\
& \quad \quad \quad x \leftarrow x + j
\end{align*}
\]

d) What is the Order of this pseudocode segment? ____________________

e) What will be the value of \( x \) when the for loops end? ____________________
Computer Science Foundation Exam

December 14, 2000

Section I B

No Calculators!

Name: ________________________________

SSN: ________________________________

In this section of the exam, there are three (3) problems.

You must do all of them.

The weight of each problem in this section is indicated with the problem.

The algorithms in this exam are written in a combination of pseudocode, and
programming language notation. Any algorithms that you are asked to
produce should use a syntax that is clear and unambiguous.

Partial credit can not be given unless all work is shown.

As always, be complete, yet concise, and above all be neat,
credit can not be given when your results are unreadable.
(4, 10%) Assume that a global array of characters, called X, exists and includes locations that range from 1 to n. In the space below, write a recursive procedure, called Reverse, that exactly reverses the order of the characters in the array.
You may assume that the array is already populated with alphabetic characters before the procedure is initially called and you should only write the code contained in Reverse. You may also assume that the procedure will initially be called as follows:
   Reverse(1, n). You may use pseudocode or C or Pascal syntax but points will be taken off if your meaning is not clear.

procedure Reverse(i, j : integer)
Find the closed form or exact value for the following:
(n is an arbitrary positive integer):

a) \[ \sum_{i=0}^{60} (5i - 3) = \] ________________ 

b) \[ \sum_{i=1}^{2k+1} (4i + 1) = \] ________________ 

c) \[ \sum_{i=40}^{90} (3i - 2) = \] ________________
Given the following Binary Tree, answer the questions below:

a) Is this a valid Binary Search Tree? (circle one)  
   Yes  No

b) List the nodes of this tree in the order that they are visited in a **preorder** traversal:

   ____    _____    ______    _______   ______    ______   _______   ______

19
13  7  11
27 16 22 25

19  13  7 11  16 22 27 25

c) Perform the following procedure on the tree above, listing the output in the spaces below and leaving any unused spaces blank. Assume that the procedure is initially called with

**P6(root)** and that the tree nodes and pointers are defined as:

```plaintext
tree_node defines a record
  data isoftype Num
  left, right isoftype ptr toa tree_node
endrecord
tree_ptr isoftype ptr toa tree_node
```

```plaintext
procedure P6(node_ptr isoftype in tree_ptr)
  if (node_ptr <> NULL) then
    P6(node_ptr^.right)
    print(node_ptr^.data)
    P6(node_ptr^.left)
  endif
endif
endprocedure
```

   ____    _____    ______    _______   ______    ______   _______   ______

19
13  7  11
27 16 22 25

19  13  7 11  16 22 27 25