UNIVERSITY OF GHANA

SCHOOL OF ENGINEERING SCIENCES
SECOND SEMESTER EXAMINATIONS: 2016/2017
LEVEL200: BACHELOR OF SCIENCE IN ENGINEERING
CPEN 204: DATA STRUCTURES AND ALGORITHMS [*3 CREDITS*]

TIME ALLOWED: 2 *HOURS 30 MINUTES*

INSTRUCTIONS:

Attempt ***ALL*** the questions. [100 MARKS]

Q1. A binary search tree, ***T***, has the following numbers: 83 44 19 97 69 17 92 11 49 72 40 71 28 32 99 to form a 15-node tree with a root node of 49; and the second and third nodes of 28 and 83 respectively.

a) Draw the final tree, ***T***. [3 marks]

b) Describe the tree as the following operations are applied to the original tree ***T*** in ***Q1(a)***. [10 marks]

i) node 20 is added to **T**.
ii) node 9 is added to **T**.
iii) node 27 is added to **T**.
iv) node 42 is added to **T**.
v) node 70 is added to **T**.
vi) node 18 is added to **T**.
vii) node 60 is added to **T**.
viii) node 33 is added to **T**.
ix) node 5 is added to **T**.
x) node 90 is added to **T**.

c) From the final tree, ***T***, in *Q1b(x)*, consider the nodes up to level 4, and write the:

i) *inorder* traversal expression. [1½ marks]
ii) *preorder* traversal expression. [1½ marks]
iii) *postorder* traversal expression. [1½ marks]

d) Design an ***algorithm*** to implement insertion of an element into binary search tree. [4 marks]

e) The following 2-dimensional array of M x N dimension has a base address of 100 with spaces of 4 and a word size of 64bits. Calculate the address of the $(2, 2)^{th}$ element in the array matrix using the row-major order. [3½ marks]

8	6	5	4
2	1	9	7
3	6	4	2

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Q2. a) What are the differences between a linked list and a *circular* queue? [2 marks]

b) What are the *three (3)* differences between a stack and a queue? [3 marks]

c) Why are circular queues needed? What are queue shortfalls circular queue implemented to address? [3 marks]

d) Consider the following queue of Quako Assurance Company LTD clients waiting to be attended to by the employees of the company, where the order is a circular array which is allocated six memory cells:

FRONT = 2, REAR = 4; QUEUE: = _, B, D, A, _, _

Describe the order as the following operations take place: [5 marks]

i) F is added to the queue.
ii) Two elements are deleted.
iii) K, L, and M are added to the queue.
iv) Two elements are deleted.
v) R is added to the queue.
vi) An element is deleted.
vii) S is added to the queue.
viii) Two elements are deleted.
ix) An element is deleted.
x) An element is deleted.

e) Under what condition*(s)* circular queue will have the front and rear pointers at the same cell? [2 marks]

f) Suppose the keys on the middle row of a standard keyboard (ASDFGHJKL) are inserted in succession into an initially empty binary search tree. Draw the tree after this sequence of insertions has been made. [2 marks]

g) Which data structures is most appropriate for situations in which you need to efficiently manage (key, value) pairs that are stored on disk? [1 mark]

h) Suppose that you need to maintain a collection of data whose contents are fixed— i.e., you need to search for and retrieve existing items, but never need to add or delete items. Although the collection of data may be quite large, you may assume that it can fit in the computer's memory. Which data structures is the most efficient one to use for this task? [2 marks]

f) Design an ***algorithm*** to implement addition of a name into the queue. [5 marks]

Q3. a) Figure Q3a uses 2D array to simulate linked-list *(first column stores data part and second column stores next part)* for list class.

	node	data	next
	[0]	66	-1
	[1]	25	-1
	[2]	?	?
	[3]	33	8
	[4]	?	?
First →	[5]	10	9
	[6]	7	3
	[7]	?	?
	[8]	21	0
	[9]	48	6

Figure: Q3a

Based on the figure Q3a, answer the following questions:

i) What is the data value of the first element in the list? [2 marks]

ii) What is the data value of the third element in the list? [2 marks]

iii) What is the data value of the last element in the list? [2 marks]

iv) Demonstrate a logic-view of the linked list up to the last element in the list. [4 marks]

b) The following figure Q3b is a list of six hotel customers and their room numbers to foster linked communication between them as they need to discuss ahead of conference that is taking place in the hotel conference room, where *NSTART* and *RSTART* are the left and right header pointers respectively.

	NAME	ROOM	NLINK	RLINK
1	Mills	735		
2	Jones	527		
3	Gloria	894		
4	Patience	578		
5	David	703		

NSTART RSTART

Figure: Q3b

i) Fill in values for NSTART and NLINK so that they form an alphabetical listing of the names. [2 marks]

ii) Fill in values for RSTART and RLINK so that they form an ordering of the room numbers. [6 marks]

iii) What is the logic view of *Q3b(ii)*. [3 marks]

c) Suppose that items Q, K, W, P and G are pushed, in that order, into an initially empty stack *S*. *S* is then popped four times; as each item is popped off, it is inserted into an initially empty queue. If three items are then removed from the queue, what is/are the next item(s) that will be removed from the queue? Demonstrate all the steps involved in the answer. [4 marks]

Q4 a) An array of 6 integers *(shown in figure Q4a)* is being sorted by the heapsort algorithm. Demonstrate each instance of the heap tree in the ordering for the array. [5 marks]

B[1]	B[2]	B[3]	B[4]	B[5]	B[6]
15	30	20	17	45	52

Figure: Q4a

b) Design an ***algorithm*** to implement heapsort insertion. [3 marks]

c) Suppose the following STACK is allocated N = 6 memory cells and initial STACK is empty, or, in other words TOP = 0. Find the outputs (*at steps 2 and 3*) of the following module: yu [7 marks]

1. Set A: = 4 and B: = 3
2. Call PUSH(STACK, A)
   Call PUSH(STACK, 5)
   Call PUSH(STACK, 3B+5)
   Call PUSH(STACK, A-7)
   Call PUSH(STACK, 2B-A)
3. Repeat while TOP # 0;
   Call POP (STACK, ELEMENT)
   While: ELEMENT
   [END of Loop]
4. Return

d) *i*) Applying stack algorithms, write the postfix expression for the following infix expression by demonstrating each step involved in the conversion.

$F = ((2 + 3) * 4 + 5 * (6 + 7) * 8) + 9$ [4 marks]

ii) Using the postfix evaluation algorithm, evaluate the converted postfix expression in *d(i)* by showing each step in the evaluation. [2 marks]

e) Design an ***algorithm*** to implement deleting an item from stack. [4 marks]