CSE 3318-004
Test 1
Fall 2022
Part A

_____
Your name as it appears on your UTA ID Card

Multiple Choice:

1. Write the letter or value of your answer on the line (_____) to the LEFT of each problem.
2. CIRCLED ANSWERS DO NOT COUNT.
3. 2 points each

1. The time for the following code is in which set?

```
for (i=0; i<n-5; i++)
  for (j=2; j<n; j+=5)
  {
    c[i][j] = 0;
    for (k=0; k<n; k++)
      c[i][j] += a[i][k]*b[k][j];
  }
```

_____ A. $\Theta(n)$ B. $\Theta(n^2)$ C. $\Theta(n^2 \log n)$ D. $\Theta(n^3)$

2. The number of calls to `merge()` while performing `mergesort` on n items is:

_____

3. Which of the following is true?

_____ A. $n^3 \in \Omega(n^2)$ B. $n \log n \in \Omega(n^2)$

C. $g(n) \in O(f(n)) \Leftrightarrow f(n) \in O(g(n))$ D. $3^n \in O(2^n)$

4. Which of the following is not true regarding a maxheap with 1000 elements?

_____ A. Subscript 1 will store the maximum priority.
B. The parent for the node with subscript 500 is stored at subscript 250.
C. The left child for the node with subscript 200 is stored at subscript 400.
D. The right child for the node with subscript 455 is stored at subscript 901.

5. The function $n^2 + 3n \log n$ is in which set?

_____ A. $\Omega(n^2)$ B. $\Theta(\log n)$ C. $\Theta(n)$ D. $\Theta(n \log n)$

6. The time for the following code is in which set?

```
for (i=0; i<n-5; i++)
  for (j=2; j<n; j+=j)
  {
    c[i][j] = 0;
    for (k=0; k<n; k++)
      c[i][j] += a[i][k]*b[k][j];
  }
```

_____ A. $\Theta(n)$ B. $\Theta(n^2)$ C. $\Theta(n^2 \log n)$ D. $\Theta(n^3)$

7. Heapsort may be viewed as being a faster version of which sort?

_____ A. insertion B. mergesort
C. selection D. `qsort`

8. The time to run the code below is in:

```
for (i=n-1; i>=0; i-=2)
  for (j=5; j<n; j*=3)
    sum+=i+j;
```

_____ A. $\Theta(n \log n)$ B. $\Theta(n^2)$ C. $\Theta(n^3)$ D. $\Theta(n)$

9. Suppose that you have correctly determined some c and n_o to prove that $g(n) \in \Omega(f(n))$. Which of the following is not necessarily true?

_____ A. c may be decreased B. n_o may be decreased C. n_o may be increased D. $f(n) \in O(g(n))$

10. Suppose you are using the substitution method to establish a Θ bound on a recurrence $T(n)$ and that you already know that $T(n) \in \Omega(\log n)$ and $T(n) \in O(n^2)$. Which of the following cannot be shown as an improvement?

_____ A. $T(n) \in \Omega(n^2)$ B. $T(n) \in \Omega(n^3)$ C. $T(n) \in O(\log n)$ D. $T(n) \in O(n)$

11. What is *n*, the number of elements, for the *largest* table that can be processed by binary search using no more than 10 probes?

_____

12. Suppose there is a large table with *n* integers in ascending order, possibly with repeated values. How much time is needed to determine the number of occurences of a particular value?

_____ A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n)$ D. $\Theta(n \log n)$

13. The time to run the code below is in:

```
for (i=n-1; i>=0; i--)
  for (j=15; j<n; j+=2)
    sum+=i+j;
```

_____ A. $\Theta(n \log n)$ B. $\Theta(n^2)$ C. $\Theta(n^3)$ D. $\Theta(n)$

14. Which of the following facts cannot be proven using one of the limit theorems?

_____ A. $n^2 \in O(n^3)$ B. $n^2 \in \Omega(n \log n)$ C. $g(n) \in \Theta(f(n)) \Leftrightarrow f(n) \in \Theta(g(n))$ D. $3^n \in \Omega(2^n)$

15. Which of the following is solved heuristically by a greedy method?

_____ A. Fractional knapsack B. This semester's second lab assignment
C. Unweighted interval scheduling D. 0/1 knapsack

16. What is the value of $\sum_{k=0}^{\infty} \left(\frac{1}{3}\right)^k$?

_____

17. Suppose there is a large unordered table with *n* integers, possibly with repeated values. How much time is needed to determine the number of occurences of a particular value?

_____ A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n)$ D. $\Theta(n \log n)$

18. A sort is said to be stable when:

_____ A. Items with the same key will appear in the same order in the output as in the input.
B. It removes duplicate copies of any key in the final output.
C. It runs in $O(n \log n)$ time.
D. The expected time and the worst-case time are the same.

19. Suppose a Huffman code tree is constructed for an alphabet with five symbols where each symbol has a probability of 0.2 of occuring. What is the expected bits per symbol?

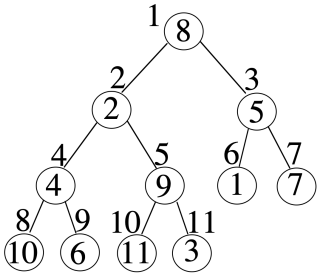
_____

20. The number of calls to `heapExtractMin` to build a Huffman code tree for *n* symbols is:

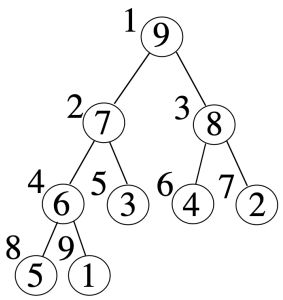
_____ A. $\Theta(\log n)$ B. *n* - 1 C. *n* D. 2*n* - 2

Long Answer

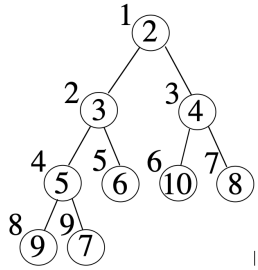
1. Use the efficient construction from Notes 05 to convert into a maxheap. 10 points



2. a. Show the maxheap after performing `heapExtractMax`. 5 points



b. Show the minheap after changing the priority at subscript 6 to 1. 5 points



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Test 1
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Part B

_____
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1. Give the greedy algorithm for the activity scheduling problem from Notes 06. 5 points
2. Give a Huffman code tree for the following symbols and probabilities. Besides the tree, be sure to compute the expected bits per symbol. 15 points

A	0.04
B	0.3
C	0.01
D	0.15
E	0.23
F	0.27

3. Use the recursion-tree method to show that $T(n) = 2T\left(\frac{n}{4}\right) + \sqrt{n}$ is in $\Theta\left(\sqrt{n}\log n\right)$. 10 points
4. Use the substitution method to show that $T(n) = 2T\left(\frac{n}{4}\right) + \sqrt{n}$ is in $\mathrm{O}\left(\sqrt{n}\log n\right)$. (You do not need to show that $T(n)$ is in $\Omega\left(\sqrt{n}\log n\right)$.) 10 points

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Test 2
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Part A

Name _____
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Multiple Choice:

1. Write the letter or value of your answer on the line (_____) to the LEFT of each problem.
2. CIRCLED ANSWERS DO NOT COUNT.
3. 2 points each

1. In a binary search tree, which element does not have a successor?

_____ A. the root B. any one of the leaves C. the maximum D. the minimum

2. The most accurate description of the time to perform a deletion in an unbalanced binary search tree with n keys and height h is:

_____ A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n)$ D. $\Theta(h)$

3. The time to fill in the dynamic programming matrix when computing the LCS for sequences of lengths m and n is:

_____ A. $\Theta(n)$ B. $\Theta(m + n)$ C. $\Theta(n \log n)$ D. $\Theta(mn)$

4. The purpose of the binary searches used when solving the longest (monotone) increasing subsequence (LIS) problem is:

_____ A. to assure that the final solution is free of duplicate values
B. to determine the longest possible increasing subsequence terminated by a particular input value
C. to search a table that will contain only the LIS elements at termination
D. to sort the original input

5. Given a pointer to a node, the worst-case time to delete the node from a doubly-linked list with n nodes in ascending order is:

_____ A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n \log n)$ D. $\Theta(n)$

6. Suppose that only numbers in 1 . . . 1000 appear as keys in a binary search tree. While searching for 500, which of the following sequences of keys could not be examined?

_____ A. 300, 400, 900, 800, 500
B. 700, 200, 600, 550, 500
C. 200, 700, 600, 300, 400, 500
D. 100, 1000, 200, 800, 300, 900, 500

7. For which of the following sorts does the decision tree model not apply?

_____ A. Insertion B. LSD Radix Sort C. MERGE-SORT D. QUICKSORT

8. In the example of recycling the elements of a list in O(1) time, which element becomes the first element of the garbage list?

_____ A. The second element of the original garbage list
B. The first element of the circular list
C. The second element of the circular list
D. The last element of the circular list

9. Recently, we considered an abstraction supporting the operations *allocate*, *allocateAny*, and *freeup* in constant time. How does the *allocateAny* operation detect that all items have already been allocated?

_____ A. the header points at `(-1)` B. the header points at itself
C. `next[n]!=0` D. the recycling list is empty

10. Suppose a binary search tree includes each subtree's size at the subtree's root. How should the rank for the key stored at the tree's root be computed?

_____ A. Subtract 1 from the subtree size for the subtree to the right of the root.
B. Add 1 to the subtree size stored at the root.
C. Add 1 to the subtree size for the subtree to the left of the root.
D. Count nodes while doing an inorder traversal.

11. Which of the following may be performed in $\Theta(1)$ worst-case time?

_____ A. SEARCH(L, k) on a sorted, singly linked list
B. SEARCH(L, k) on an unsorted, singly linked list
C. LOGICALPREDECESSOR(L, x) on a sorted, singly linked list
D. LOGICALPREDECESSOR(L, x) on a sorted, doubly linked list

12. If POP is implemented as return stack[--SP], then the test for an empty stack is implemented as:

_____ A. return stack[SP++] B. return SP==(-1) C. return SP==0 D. stack[SP++] = X

13. The worst-case number of comparisons for finding the kth largest of n keys using PARTITION is in which asymptotic set?

_____ A. $\Theta(\log n)$ B. $\Theta(n)$ C. $\Theta(n \log n)$ D. $\Theta(n^2)$

14. Suppose a node x in an unbalanced binary search tree has two children, each storing one key. What is the first step to delete x?

_____ A. Find the successor of x B. Inorder traversal
C. Rotate x so it becomes a leaf D. Splice the parent of x to either child of x

15. Given a pointer to a node, the worst-case time to insert the node into an unsorted, doubly-linked list with n nodes is:

_____ A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n \log n)$ D. $\Theta(n)$

16. Suppose a (singly) linked list is used to implement a queue. Which of the following is true?

_____ A. The head points to the first element and the tail points to the last element.
B. The tail points to the first element and the head points to the last element.
C. Like a circular queue, the maximum number of items is determined at initialization.
D. One node is always wasted.

17. Which binary tree traversal corresponds to the following recursive code?

```
void traverse(noderef x)
{
if (x==null)
  return;
// process x here
traverse(x.left);
traverse(x.right);
}
```

_____ A. inorder B. postorder C. preorder D. search for key `x`

18. What is the worst-case time to perform MINIMUM(L) for a sorted, doubly-linked list with n nodes?

_____ A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n)$ D. $\Theta(n \log n)$

19. Which of the following is a longest common subsequence for 2 0 1 0 1 2 and 1 1 0 0 2 2?
_____ A. 0 0 2 B. 1 1 0 C. 1 1 2 2 D. 1 0 1 2
20. The asymptotic number of nodes in the decision tree for any key-comparison sorting algorithm for an input sequence with *n* unique values is:

_____

Long Answer

1. Give the unbalanced binary search tree that results when the keys 40, 60, 30, 80, 20, 50, 10, 90 are inserted, ***in the given order***, into an initially empty tree. (5 points)
2. Two billion integers in the range 0 . . . 999,999 are to be sorted by LSD radix sort. How much faster will this be done if radix 0 . . . 999 is used rather than radix 0 . . . 99? Show your work. (5 points)
3. Describe the four phases of counting sort and give the asymptotic complexity for each phase. (5 points)

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Part B

4. Show the result of the backtrace to achieve 14 for the subset sum problem. (5 points)

i	S
0	0
1	2
2	3
3	5
4	7
5	11

i	C
0	0
1	6
2	1
3	2
4	6
5	2
6	6
7	3
8	3
9	4
10	3
11	5
12	4
13	5
14	4

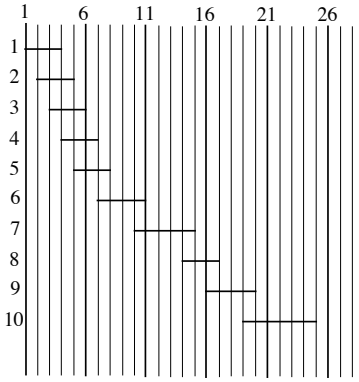
5. Complete the following instance of the optimal matrix multiplication ordering problem, including the tree showing the optimal ordering. SHOW YOUR WORK. 10 points

	p[0]=5		p[1]=4		p[2]=6		p[3]=2		p[4]=5	p[5]=6
	1		2		3		4		5	
1	0	0	120	1	88	1	138	3	**???**	**?**
2	-------		0	0	48	2	88	3	156	3
3	-------		-------		0	0	60	3	132	3
4	-------		-------		-------		0	0	60	4
5	-------		-------		-------		-------		0	0

6. Show the result after PARTITION (Version 1) manipulates the following subarray. Recall that both pointers start at the left end of the subarray. (10 points)

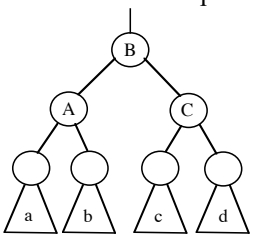
2	7	9	4	3	8	6	1	0	5

7. Use dynamic programming to solve the following instance of weighted interval scheduling. Be sure to indicate the intervals in your solution and the sum achieved. 10 points

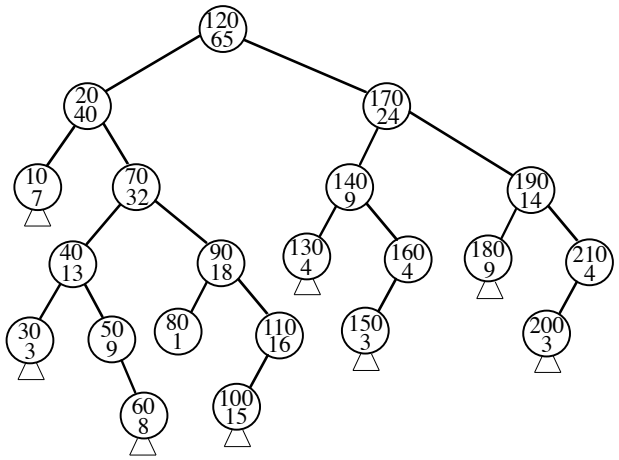


	v	*p*	*m*
1	1	0	
2	2	0	
3	3	0	
4	4	1	
5	1	2	
6	2	4	
7	3	5	
8	4	6	
9	1	7	
10	2	8	

8. Give the result of performing a left rotation at node B. (5 points)



9. The given binary search tree also includes subtree sizes. Notice that a few subtrees (like the one with key 100) are given with just the root of the tree. What is the key for rank 50? Also, circle the nodes that must be accessed to determine the key. (5 points)



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Name _____
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Part A
Multiple Choice:

1. Write the letter or value of your answer on the line (_____) to the LEFT of each problem.
2. CIRCLED ANSWERS DO NOT COUNT.
3. 2 points each

1. Which of the following cannot occur when additional edges are included in a directed graph?

_____ A. The number of strong components may remain the same.
B. The number of strong components may increase.
C. The number of strong components may decrease.
D. The graph acquires a cycle.

2. For a double hash table with $\alpha = 0.75$ (without deletions), the upper bound on the expected number of probes for unsuccessful search is:

_____

3. Which disjoint subset implementation implements the `find` operation in worst-case linear time?

_____ A. Implementation 1 B. Implementation 2
C. Implementation 3 D. All three implementations

4. Suppose a depth-first search on a directed graph yields a path of tree edges from vertex X to vertex Y and a path of tree edges from vertex X to Z. If there is also an edge from Z to X, then its type will be:

_____ A. Back B. Cross C. Forward D. Tree

5. The cycle property for minimum spanning trees may be used to find an MST by:

_____ A. Growing the MST by repeatedly including a minimum weight edge from some vertex in the tree to some vertex that has not yet been placed in the tree.
B. Remove the maximum weight in any cycle until only a tree of edges remains.
C. Remove the minimum weight in any cycle until only a tree of edges remains.
D. Growing the MST by repeatedly including a maximum weight edge from some vertex in the tree to some vertex that has not yet been placed in the tree.

6. Using the values *never-used* (-1) and *recycled* (-2) are part of which data structure?

_____ A. hashing with chaining B. open addressing
C. ordered linked list D. compressed adjacency lists

7. Suppose a directed graph has a path from vertex X to vertex Y, but no path from vertex Y to vertex X. The relationship between the finish times for depth-first search is:

_____ A. finish(X) > finish(Y) B. finish(X) < finish(Y)
C. finish(X) = finish(Y) D. could be either A. or B.

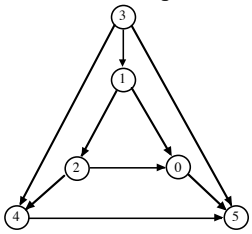
8. During a breadth-first search, the status of a gray vertex is:

_____ A. It has been completely processed. B. It is in the priority queue.
C. It is in the FIFO queue. D. It is undiscovered.

9. What is required when calling `union(i,j)` for maintaining disjoint subsets?

_____ A. `i` and `j` are leaders for the same subset B. `i` and `j` are in the same subset
C. `i` and `j` are leaders for different subsets D. `i` is the ancestor of `j` in one of the trees

10. What is the number of strongly connected components in this graph?



_____

11. When using two breadth-first searches to find the diameter of a tree, the purpose of the first search is to find:

_____ A. all vertices that could be an end of a diameter. B. both ends of a diameter.
C. one end of a diameter. D. the number of edges in the diameter.

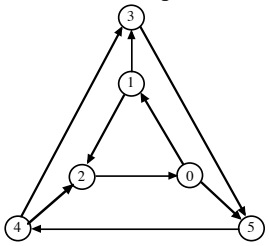
12. A topological ordering of a directed graph may be computed by:

_____ A. Ordering the vertices by ascending finish time after DFS
B. Ordering the vertices by descending discovery time after DFS
C. Ordering the vertices by descending finish time after DFS
D. Ordering the vertices by ascending discovery time after DFS

13. Dijkstra's algorithm may be viewed as being a generalization of which technique?

_____ A. DFS B. BFS C. Warshall D. Strong Components

14. What is the number of strongly connected components in this graph?



_____

15. The number of potential probe sequences when using linear probing with a table with *m* entries (*m* is prime) is:

_____

16. Which algorithm maintains multiple subtrees?

_____ A. Dijkstra's B. Kruskal's C. Prim's D. Warshall's

17. The worst-case time for Dijkstra's algorithm implemented with a minheap is:

_____ A. $\theta(V + E)$ B. $\theta(E \log V)$ C. $\theta(V \log V)$ D. $\theta(V \log E)$

18. In Dijkstra's algorithm, the final shortest path distance from the source s to a vertex x is known when:

_____ A. x is placed on the heap.
B. x has its entry extracted from the heap.
C. x is read from the input file.
D. some vertex y moves from T to S and there is an edge from y to x.

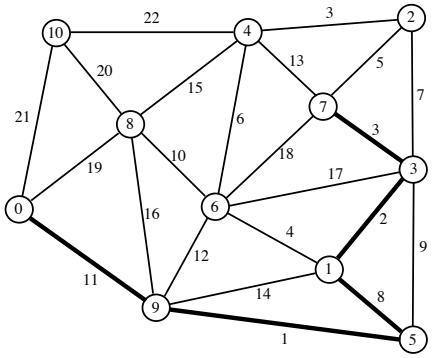
19. The number of potential probe sequences when using double hashing with a table with *m* entries (*m* is prime) is:

_____

20. When finding the strongly connected components, the number of components is indicated by:

_____ A. The number of cross edges found during the second depth-first search.
B. The number of back edges found during the first depth-first search.
C. The number of restarts for the first depth-first search.
D. The number of restarts for the second depth-first search.

1. What are the entries in the T-table (for Prim's algorithm) before and after moving the next vertex and edge into the minimum spanning tree? DO NOT COMPLETE THE ENTIRE MST!!! Edges already in the MST are the thick ones. Edges currently not in the MST are the narrow ones. 10 points.



2. Consider the following hash table whose keys were stored by double hashing using $h_1(key) = key \% 17$ and $h_2(key) = 1 + (key \% 16)$.

```
 0  442
 1  222
 2  -1
 3  776
 4  -1
 5  200
 6  -1
 7  -1
 8  -1
 9  -1
10  333
11  555
12  -1
13  999
14  660
15  882
16  220
```

a. Suppose 2005 is to be inserted (using double hashing). Which slot will be used? Show your work. (5 points)
b. Suppose 2006 is to be inserted (using double hashing) *after* 2005 has been stored. Which slot will be used? Show your work. (5 points)

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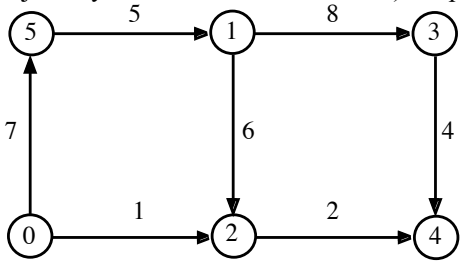
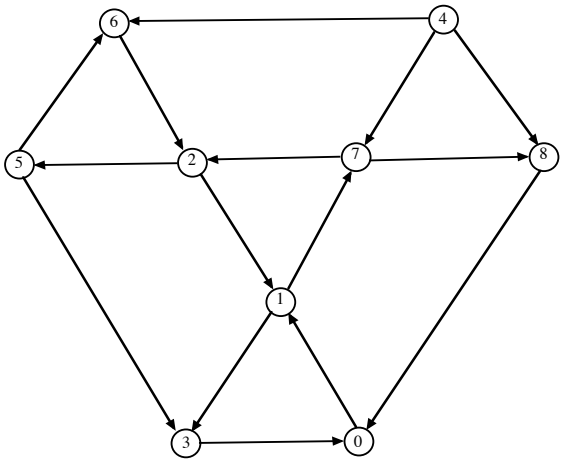
3. Show the ***compressed*** adjacency list representation for this weighted, directed graph. (Answers using conventional adjacency lists will receive no credit.) 10 points.



4. The matrix below shows an instance of the Floyd-Warshall algorithm with successors. All processing for columns 0, 1, and 2 has been completed. Give the final matrix after processing column 3. 15 points.

```
     0      1      2      3

0    6 2    3 1    1 2    2 2

1   oo     oo     oo     4 3

2    5 0    2 1    6 0    1 3

3    1 0    4 0    2 0    3 0
```

5. Perform depth-first search on the following graph, including start/finish times and edge types (T=tree, B=back, C=cross, F=forward.) Assume that the adjacency lists are **ordered**. Write your answer in the tables below. 15 points



Vertex	Start	Finish	Edge	Type	Edge	Type
0	1	____	0 1	____	5 3	____
1	____	____	1 3	____	5 6	____
2	____	____	1 7	____	6 2	____
3	____	____	2 1	____	7 2	____
4	____	____	2 5	____	7 8	____
5	____	____	3 0	____	8 0	____
6	____	____	4 6	____		
7	____	____	4 7	____		
8	____	____	4 8	____		