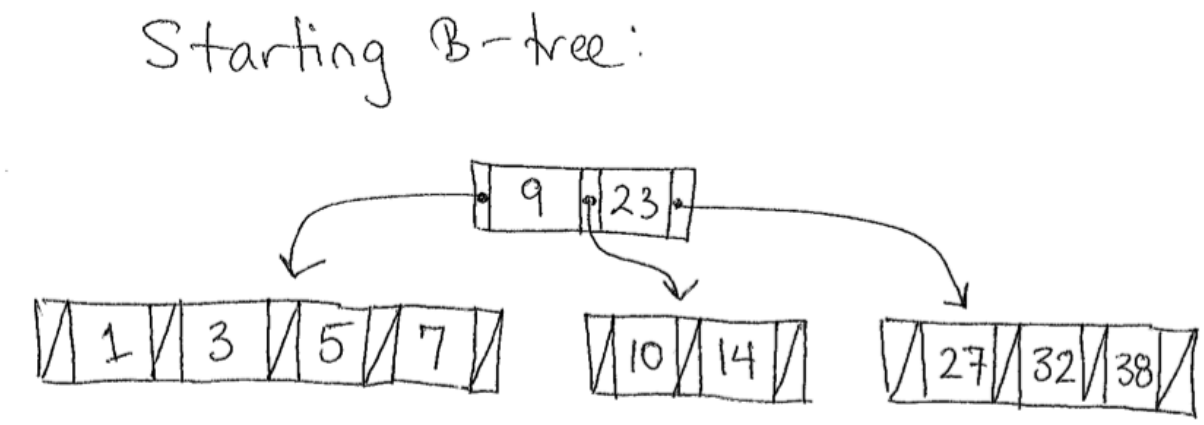
Databases – Fall 2016
Homework 6

1. Assume you have a B-tree of degree 2 (d=2) as shown in the figure below.



   You want to execute the five operations listed below (a through e). Show the B-tree at after each step is completed (you will have one tree per operation). The operations are not independent; they should be done in the order given. **Use only the insertion and deletion algorithms discussed in class**. There are handouts available on the class website for how to do insert & delete.

   a. Insert 28
   b. Insert 4
   c. Delete 38
   d. Delete 14
   e. Delete 9

2. Consider the relation R(A, B, C, D) with the following dependencies (notice the first two are functional and the last one is multivalued):

   $AB \rightarrow C$
   $C \rightarrow D$
   $D \rightarrow\rightarrow B$

   Is this relation in 4NF? If it is not in 4NF, decompose it into a set of 4NF relations. Show your work and make sure your decomposition is lossless.

3. Recall the nested loop join algorithm used to join relations R and S on some condition C:

```
(1)   For each tuple r in R do:
(2)      For each tuple s in S do:
(3)         If r and s satisfy C, then
(4)            Add new tuple (r, s) to the output relation
```

Consider the following three relations:

Students	
Rnum	**Name**
1	Alice
2	Bob
3	Carla
4	David

Courses	
Cnum	**Title**
141	CS I
142	CS II
172	Discrete
231	Comp Org
241	CS III

Enroll	
Rnum	**Cnum**
1	141
2	142
2	172
2	231
3	172
3	241

Consider the query

```
SELECT Title
FROM Students NATURAL JOIN Enroll NATURAL JOIN Courses;
```

Assume none of the relations have indexes, so we can't use anything other than the nested loop join algorithm.

a) There are two possible join orders for these three tables, assuming we keep the left-to-right sequence of tables the same as the query specifies. What are these two join orders?

b) Assume in the nested loop join algorithm, the "if" test (line 3) takes one unit of time, and the "add new tuple" command also takes one unit of time. For each of the two possible join orders, determine the total amount of time each join order would take to execute the query. Do not consider time for projection, just the joins. Is one query faster than the other?

c) Suppose we want to add a selection operation to this query:

```
SELECT Title
FROM Students NATURAL JOIN Enroll NATURAL JOIN Courses
WHERE Rnum = 1;
```

Assume a simple selection algorithm to select all tuples in R that satisfy condition C:

```
(1) For each tuple r in R do:
(2)     If r satisfies C, then
(3)         Add r to the output relation
```

Lines 2 and 3 each take one unit of time. Describe how to optimize the new query to minimize total time, and state how much total time this new query will take. In other words, give a precise ordering of the selection and join operations along with calculating the total time this ordering takes. Show your work as much as possible.

4. Consider two transactions, T1 and T2, which arrive simultaneously at the DBMS. The DBMS decides to interleave the pieces of the transactions as follows (time flows down):

Time	**T1**	**T2**
1	Read(A)	
2	Read(B)	
3		Read(A)
4		Read(B)
5		A = A - 10
6		B = B / 5
7		Write(A)
8	A = A + 10 * B	
9	Write(A)	
10		Write(B)
11	Write(B)	

   a. Suppose that before the transactions begin, A = 10 and B = 5. What are the values of A and B at the end of the transactions as scheduled above?

   b. Identify one anomaly in the interleaved schedule above. Give the offending line numbers and what type of anomaly it is (dirty read, non-repeatable read, etc).

   c. Does this interleaving schedule above conform to the I in ACID? (In other words, are the ending values of A and B in the schedule above possible if each transaction operated in complete isolation from the other?) If not, give one set of possible values of A and B that might be obtained by a DBMS with ACID transactions.