First Letter of your last name:_____

Your Full Name: _____

COM S 363: Exam 2

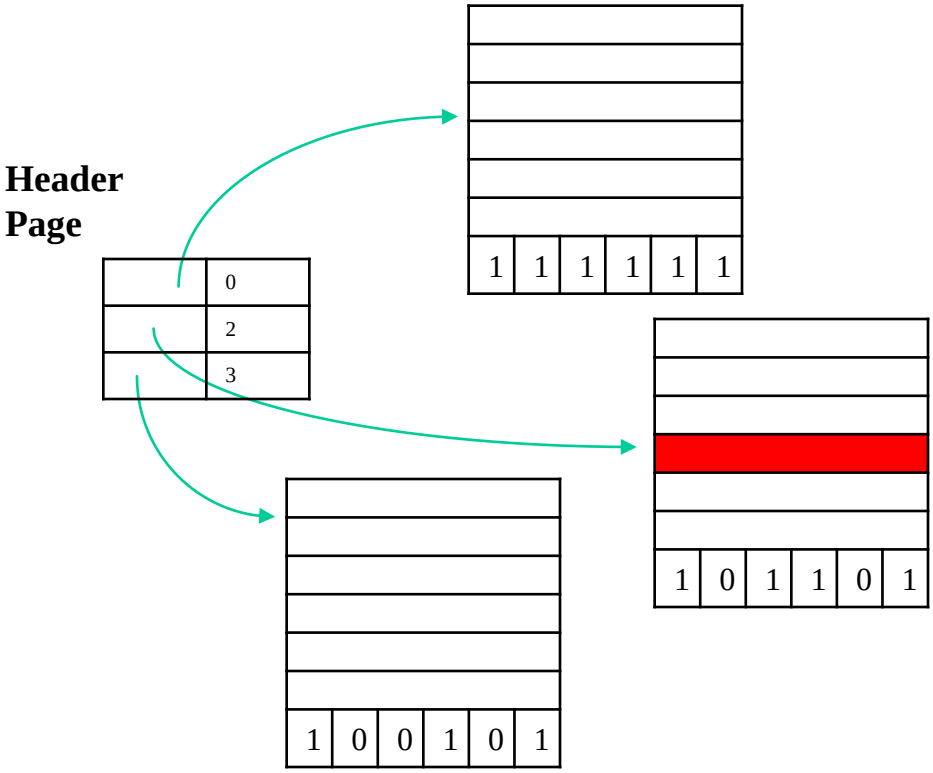
Time: 75 minutes

NOTES:

•DO NOT OPEN THIS EXAM UNTIL YOU ARE TOLD TO OPEN
•This is a closed book closed notes exam.
•Write your name and answer legibly; if the grader can't read, you receive no point.
•Attempt all problems. Write solutions on these sheets.
•Fill in your name now, but do not turn the page until the signal is given.

Problem	Max Points	Points
1	15	
2	15	
3	10	
4	10	
5	10	
6	15	
7	10	
8	15	
Total	100	

1. (15 points) Suppose a relation is stored in heap files showing below.



(1) (5 points) From the illustration, can you decide if the records are fix length or variable length, packed or unpacked?
(2) (5 points) Suppose a user inserts another record. What the result files should look like?
(3) (5 points) Suppose a user wants to delete a record. This record is located at the highlighted slot. What is the procedure?

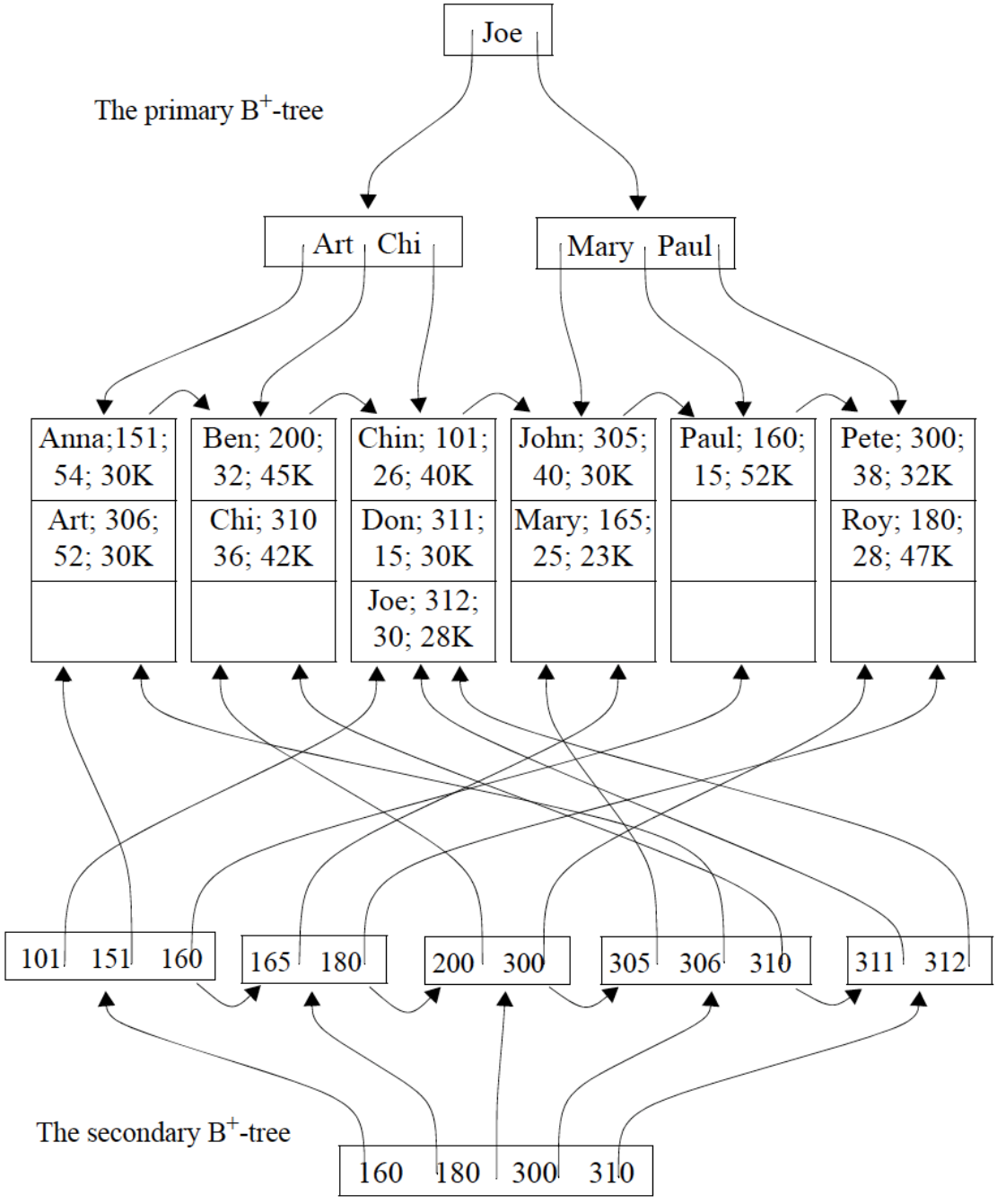
2. (15 points) Consider a relation with this schema, Employee(ename:string, eid:integer, age:integer, salary:integer). Suppose ename is indexed by a sparse B^+-tree and eid is indexed by a dense and unclustered B^+-tree, as illustrated by the figure showed in the next page.

   Suppose the relation has 1,000 pages, and each page holds 4 records. Estimate the total number of pages that need to be read from the disk in order to answer the following queries. Explain your answer. For each query, you can assume the selection factor is 0.1, i.e., out of 1,000 * 4 records, 1,000 * 4 * 0.1 = 400 records will satisfy the query condition.

   a) (5 points) Find all employees whose salary is in between 80k and 100k.

   b) (5 points) Find all employees whose name starts with a character that is in between "A" and "C".

   c) (5 points) Find all employees whose eid is in between 100 to 200.


Joe
The primary B+-tree
Art Chi
Mary Paul
Anna;151; 54; 30K
Art; 306; 52; 30K
Ben; 200; 32; 45K
Chi; 310 36; 42K
Chin; 101; 26; 40K
Don; 311; 15; 30K
Joe; 312; 30; 28K
John; 305; 40; 30K
Mary; 165; 25; 23K
Paul; 160; 15; 52K
Pete; 300; 38; 32K
Roy; 180; 28; 47K
101 151 160
165 180
200 300
305 306 310
311 312
The secondary B+-tree
160 180 300 310

3. (10 points) Derive the time cost of a block nested loops join of relations R and S given the following variables, which you may or may not use all of them. Ignore the CPU time costs. R is the outer relation and the results of the join are written back to the disk.

   |R|: Number of tuples in R
   |S|: Number of tuples in S
   M: Number of pages in R
   N: Number of pages in S
   B: Number of available memory in pages
   P: Number of pages that the join results occupy
   Cr: Time cost of reading a page from disk into memory in seconds
   Cw: Time cost of writing a page from memory into disk in seconds

4. (10 points) Grace Hash Join consists of two phases: partition and join. Explain them in detail.

5. (10 points) Explain in detail how to sort 8 pages of data (e.g., numbers) with 3 pages of main memory. Your algorithm needs to be as efficient as possible.

6. (15 points) Consider three relations Students(sid, sname, dob, addr), Courses (cid, cname), and Register (sid, cid, semester). Write a relational algebraic expression for each of the following queries.

    a) (5 points) Find the names of students who registered the course whose cid = "COMS363"

    a) (5 points) Find the names of students who reserved at least one course in semester "Spring2020"

    a) (5 points) Find the names of students who have not registered any course

7. (10 points) Draw a relational algebraic tree that represents the following SQL statement.

```
SELECT  S.sname
FROM  Reserves R, Sailors S
WHERE  R.sid=S.sid AND
   R.bid=100 AND S.rating>5
```

8. (15 points) Finding the best plan for join operations is prohibitively expensive. A practical solution is to avoid the worst plans by considering only the left-deep plans.

   a) (5 points) Explain the main benefit of left-deep plans.

   b) (10 points) Consider joining 4 relations A, B, C, and D. Suppose A ⋈ B is known to have the least disk I/Os among the joins of any two relations. Given this information, draw all possible left-deep join trees that will be considered by IBM System R.

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