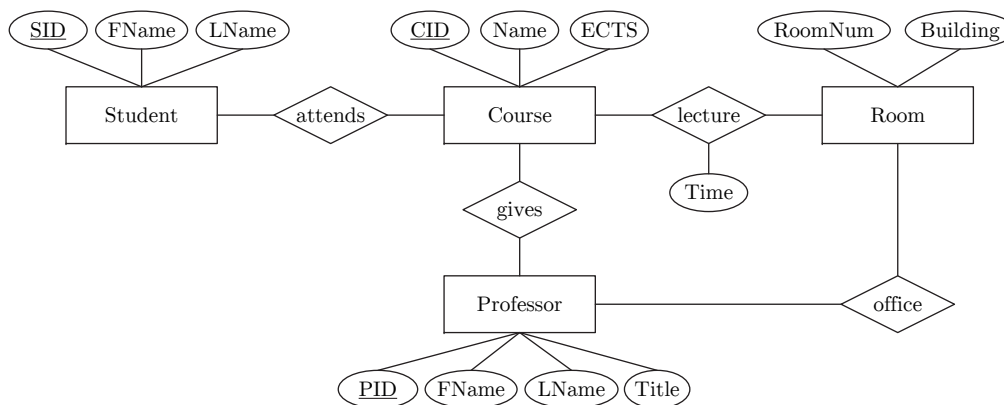


Exam 706.004 Databases 1 (Summer 2019, V3b)

Important notes: The working time is 90min, and lecture materials or any kind of mobile devices are not allowed. Please make sure to put your name and matriculation number on the top right of each piece of paper. You may give the answers in English or German, as well as directly write into the task description.

Task 1 Data Modeling (25 points)



- (a) Given the above Entity-Relationship diagram, specify the cardinalities in Modified Chen notation based on the following information (if some aspect is unspecified, please model the more general case). (8 points)
- A student attends zero or many courses and a course is attended by at least 3 students.
 - A course is given by exactly one professor and a professor might give between 1 and 7 courses.
 - A course takes place in exactly one room, but many courses might be taught in the same room (at different times).
 - Every professor has an office room, and professors never share offices.

(b) Map the given Entity-Relationship diagram into a relational schema, including data types, primary keys, and foreign keys. **(10 points)**

(c) Assume an additional multi-valued attribute Professor.Phone (lists of phone numbers). Bring your schema in third normal form, describe the schema modifications (delta) or the full schema, and explain why it is in third normal form. **(7 points)**

Task 2 Structured Query Language (30 points)

Employees

<u>EID</u>	FName	LName	Age	PID
4	Isabella	Brown	30	2
2	Olivia	Johnson	30	1
1	Emma	Smith	35	3
3	Ava	Williams	20	1
5	Sophie	Jones	35	2
6	Taylor	Miller	55	4
7	Charlotte	Davis	40	2

Projects

<u>PID</u>	Name	Customer
1	UX Design	B
2	App Backend	B
3	Data Storage	A
4	ML Pipeline	C
5	UX Design	C

- (a) Given the Employees and Projects tables above, and compute the results for the following three queries: **(15 points)**

```
Q1: SELECT DISTINCT P.Customer, P.Name
     FROM Employees E, Projects P
     WHERE E.PID = P.PID
           AND E.FName IN('Ava', 'Emma', 'Sophie')
```

```
Q2: SELECT Age, count(*) FROM Employees
     GROUP BY Age
     ORDER BY count(*) DESC, Age ASC
```

```
Q3: SELECT P.Name, round(avg(E.Age)) --avg=sum/count
     FROM Employees E, Projects P
     WHERE E.PID = P.PID
     GROUP BY P.Name
```

- (b) Given the Employees and Projects table schemas above, write SQL queries to answer the following questions: **(15 points)**

- Q4: Which employees work on projects for customer B (the SQL query should return the first names and last names)?

- Q5: Which customers have more than one project (the SQL query should return the distinct customer names)?

- Q6: What is the age range of employees per project other than UX Design (the SQL query should return the age range in years for each project)?

Task 3 Query Processing (20 points)

- (a) Assume tables $R(a,b)$, and $S(c,d,e)$, draw a logical query tree in relational algebra for the following query: **(5 points)**

```
Q7: SELECT R.a, S.d FROM R, S
      WHERE R.b = S.c AND S.e > 3
INTERSECT
SELECT R.a, S.d FROM R, S
      WHERE R.b = S.c AND S.e < 7
```

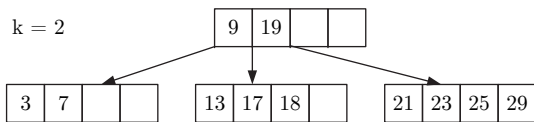
- (b) Draw an optimized logical query tree for the above query in relational algebra by eliminating the intersect operation. **(3 points)**

(c) Define the derived relational operators (1) join and (2) set intersection via basic relational operators (cartesian product, union, difference, projection, selection). (4 points)

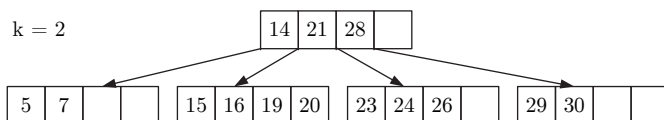
(d) Describe the conceptual idea of a hash join operator, including the resulting time and space complexity and how this operator fits into the Volcano iterator model. (8 points)

Task 4 Physical Design (15 points)

(a) Given the B-tree below, insert the key 20 and draw the resulting B-tree. (6 points)



(b) Given the B-tree below, delete the key 14 and draw the resulting B-tree. (4 points)



- (c) Briefly discuss the concept of horizontal table partitioning. Recall table Employees R from Task 2, and provide relational algebra expressions for (1) horizontally partition R into R_1 and R_2 , and (2) reconstruct R from R_1 and R_2 . (**5 points**)

Task 5 Transaction Processing (10 points)

- (a) Explain the concept of a database transaction and its ACID properties Atomicity, Consistency, Isolation, and Durability. (**4 points**)

- (b) Explain the transaction isolation level **SERIALIZABLE** by means of anomalies its prevents and describe a technique for implementing this isolation level in a system. (**6 points**)