

- (d) Find the names of all employees whose salary exceeds the budget of all the departments that the employee works in.

Ans:

```
SELECT E.ename
FROM Emp E
WHERE E.salary > ALL (SELECT D.budget
                     FROM Dept D, Works W
                     WHERE D.did = W.did AND E.eid = W.eid)
```

- (e) Find the enames of managers who manage department with the largest budgets.

Ans:

```
SELECT E.ename
FROM Emp E
WHERE E.eid IN (SELECT D.managerid
               FROM Dept D
               WHERE D.budget = (SELECT MAX (D2.budget)
                                FROM Dept D2 ))
```

- (f) Find the enames of managers who manage only departments with budgets of at least 1 million dollars but atleast one department whose budget is less than 2 million dollars.

Ans:

```
SELECT E.ename
FROM Emp E, Dept D
WHERE E.eid = D.managerid
GROUP BY E.eid, E.ename
HAVING EVERY (D.budget >= 1000000) AND ANY (D.budget < 2000000)
```

2. Let $R(A, B, C, D)$ be a relational schema. Let $F = \{AB \rightarrow C, BC \rightarrow D, CD \rightarrow A, AD \rightarrow B\}$ be a specified set of functional dependencies. Answer the following questions.

- (a) What are the nontrivial dependencies that follow from F ? Give only those dependencies which have a single attribute on the right hand side.

From the closure, we get $AB^+ = AD^+ = BC^+ = CD^+ = \{A, B, C, D\}$. Hence we have the new dependencies $AB \rightarrow D, AD \rightarrow C, CD \rightarrow B$. $AC^+ = \{A, C\}$ and $BD^+ = \{B, D\}$ and hence they do not produce any new dependencies. In addition, we also have $ABC^+ = ABD^+ = ACD^+ = BCD^+ = \{A, B, C, D\}$ which produce the new dependencies $ABC \rightarrow D, ABD \rightarrow C, ACD \rightarrow B$ and $BCD \rightarrow A$.

- (b) What are all the keys of R ?

The keys are AB, AD, BC and CD .

- (c) What are the superkeys of R that are not keys?

Superkeys are ABC, ABD, ACD, BCD and $ABCD$

3. Let R be a relation schema with four attributes $ABCD$. Let the set of FDs that hold over R be $\{D \rightarrow B, AB \rightarrow D, AB \rightarrow C, C \rightarrow A\}$ and assume that these are the ONLY FDs that hold over R .

- (a) What are the candidate keys for R?
AB, BC, CD, AD
- (b) Which normal forms (1NF, 2NF, 3NF, BCNF) does R satisfy? Which condition of the normal form does each of the dependencies satisfy?
R is in 3NF but not in BCNF. $AB \rightarrow D$ and $AB \rightarrow C$ are valid as AB is a key. $B \rightarrow D$ and $C \rightarrow A$ are valid because D and A are both part of some key CD and AB. (FD: $C \rightarrow A$ violates the definition of BCNF as it is neither a trivial FD nor is C a superkey)
4. Let R(A, B, C, D, E) be a relation schema with 5 attributes. Let F be the following set of FDs that are given. $\{A \rightarrow B, ED \rightarrow A, BC \rightarrow E\}$.
- (a) List all the keys for R.
ACD, BCD, CDE
- (b) Is R in 3NF? Explain why or why not?
R is in 3NF. All the FDs have the right hand sides in some key for R.
- (c) Is R in BCNF? Explain why or why not?
None of A, DE or BC contain a key nor are any of the FDs trivial. So R is NOT in BCNF.