

## 1. Relational Model and SQL

(a)

$$\pi_{dname}(\sigma_{age < 40}(emp) \bowtie_{works.eid=emp.eid} works \bowtie_{dept.did=works.did} dept)$$

Q1(n): -Dept(d, n, b, m), Works(x, d, p), Emp(x, y, z, s), z < 40

(b)

```
SELECT DISTINCT dname
FROM dept
WHERE dept.did IN (SELECT works.did
                   FROM works
                   WHERE works.eid IN (SELECT emp.eid
                                       FROM emp
                                       WHERE emp.age < 40))
```

(c)

```
SELECT DISTINCT ename
FROM emp, dept
WHERE emp.salary > dept.budget
```

(d)

```
SELECT dname, COUNT(emp.eid)
FROM emp, dept, works
WHERE emp.eid = works.eid AND
      works.did = dept.did
GROUP BY dept.did
HAVING (SUM(emp.salary)/COUNT(emp.eid)) < 64000
```

## 2. Schema Normalization

(a) The Key of R is ACD, BCD, CDE:

For ACD: A → B

AC → BC → E

ACD → BCD → ED

For BCD: BC → E

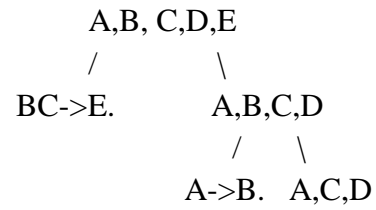
BCD → ED → A

For CDE: ED → A → B

CED → CA → BC

(b) It is not BCNF, The condition of BCNF is For each non-trivial FD  $X \rightarrow Y$ ,  $X$  is a super-key of  $R$ .

$R = (A, B, C, D, E)$



$R_1 = (B, C, E)$  is BCNF

$R_2 = (A, B, C, D)$  is not BCNF, because the  $A$  can get  $B$

$R_3 = (A, B)$  is BCNF

$R_4 = (A, C, D)$  is BCNF

(c) It is 3NF. because  $A, B, E$  all element in the key