

(iii) $R1 :=$

$Accounts \bowtie_{Accounts.number=Acc.num \text{ AND } Accounts.balance>Acc.bal} \rho_{Acc(num,bal)}(Accounts)$

$R2 := \Pi_{balance} \sigma_{order<100} (\gamma_{balance, COUNT(bal) \rightarrow order} R1)$

$R3 := \Pi_{number} (R2 \bowtie Accounts)$

2. (a)

C and E do not appear on the RHS of the FDs; thus, they must be included in the keys

$\{CE\}^+ = \{BCDE\}$, $\{ACE\}^+ = \{ABCDEF\}$, $\{BCE\}^+ = \{BCDE\}$,
 $\{CDE\}^+ = \{BCDE\}$, $\{CEF\}^+ = \{ABCDEF\}$, $\{BCDE\}^+ = \{BCDE\}$

So, keys of R: ACE, CEF

FD $C \rightarrow D$ violates BCNF definition. $\{C\}^+ = \{BCD\}$

Decomposition of R: $R1(B, C, D)$; $R2(A, C, E, F)$

Keys of $R1$: C. $R1$ is in BCNF

Keys of $R2$: ACE, CEF. There is a hidden FD $AC \rightarrow F$.

FD $AC \rightarrow F$ violates BCNF definition. $\{AC\}^+ = \{ACF\}$

Decomposition of $R2$: $R3(A, C, F)$; $R4(A, C, E)$

Keys of $R3$: AC, E. $R3$ is in BCNF.

Keys of $R4$: ACE, $R4$ is in BCNF.

Conclusion: the decomposition of R is $R1(B, C, D)$; $R3(A, C, F)$; $R4(A, C, E)$.

Not all the FDs are reserved; e.g FD $AD \rightarrow F$ is not reserved.

(b)

FD $C \rightarrow D$ violates 3NF definition.

Let $S = \{C \rightarrow D, DF \rightarrow A, AD \rightarrow F, CD \rightarrow B, BCF \rightarrow A\}$.

We will determine the minimal basis of S.

After the first step, S remains the same.

After step 2, S becomes $\{C \rightarrow D, DF \rightarrow A, AD \rightarrow F, CD \rightarrow B\}$.

After step 3, $S = \{C \rightarrow D, DF \rightarrow A, AD \rightarrow F, C \rightarrow B\}$

Hence we ended up with the set $S = \{C \rightarrow BD, DF \rightarrow A, AD \rightarrow F\}$, which gives the 3NF decomposition of R as $R1(B, C, D)$; $R2(A, D, F)$; $R3(A, C, E)$.

3. (a)

```
SELECT temperature, heartRate
FROM Tests, Patients
WHERE Tests.pid = Patients.pid AND Patients.year < 1971
```

(b)

```
CREATE ASSERTION Q3b CHECK (
NOT EXISTS (
  SELECT *
  FROM Wards INNER JOIN PatientInWard ON Wards.number = PatientInWard.wardNumber
  GROUP BY number
  HAVING COUNT(pid) > numBeds ) );
```

(c)

```
CREATE VIEW FreeBeds AS
SELECT number AS ward, COUNT(pid) – numBeds AS numBeds
FROM Wards INNER JOIN PatientInWard ON Wards.number = PatientInWard.wardNumber
GROUP BY number
```

(d)

```
CREATE TRIGGER Q3d
BEFORE INSERT ON PatientInWard
REFERENCING NEW ROW AS n
FOR EACH ROW
WHEN NOT EXISTS ( SELECT * FROM FreeBeds
                  WHERE ward = n.wardNumber AND numBeds > 0 )
INSERT INTO PatientInWard VALUES (n.pid, SELECT MIN(numBeds) FROM FreeBeds);
```

4. (a)

(i)

```
SELECT empid, name, salary
FROM Employees
ORDER BY name;
```

(ii)

```
CREATE PROCEDURE Merge (
    IN city1 CHAR(32),
    IN dept1 CHAR(32),
    IN city2 CHAR(32),
    IN dept2 CHAR(32),
    DECLARE dept1Size INTEGER,
    DECLARE dept2Size INTEGER,
    DECLARE dept1Head CHAR(32)
)
BEGIN
    UPDATE Employees SET dept = dept2, city = city2
        WHERE dept = dept1 AND city = city1;
    SET dept1Size = ( SELECT COUNT(*) FROM Employees WHERE dept = dept1 );
    SET dept2Size = ( SELECT COUNT(*) FROM Employees WHERE dept = dept2 );
    SET dept1Head = ( SELECT departmentHead
                     FROM Departments WHERE dname = dept1 );
    IF dept1Size > dept2Size THEN
        UPDATE Departments SET departmentHead = dept1Head;
        DELETE FROM Departments WHERE dname = dept1;
    END;
```

(b)

- (i) 1. The DTD states <!ELEMENT A (B)> but there are multiple sections of B under A.
2. The DTD states that attribute b2 of B is required but it is absent in the second section of B
- (ii) <!ELEMENT A (B)> needs to be changed to <!ELEMENT A (B+)>
<!ATTLIST B b1 CDATA #REQUIRED b2 CDATA #REQUIRED> needs to be changed to
<!ATTLIST B b1 CDATA #REQUIRED b2 CDATA #IMPLIED>

(c)

- (i) There is no visible result, as the target B has no text to show (actually none of the B has any text)
- (ii) Third
Fourth