1.

```
create table Party (
    Name    Char(20),
    Leaders Char(20),
    Platform Char(20),
    Primary key (Name, Leaders)); %% can't use foreign key here
                                  %% use Assertion, see below

create table Voter (
    Id   Integer,
    Name Char(20),
    Primary key (Id)); %% can't use foreign key here, see below

create table Voting (
    VoterId   Integer,
    PartyName Char(20),
    Time      Time,
    Primary key (VoterId), %% single Role key.
    Foreign key VoterId references Voter(Id),
    Foreign key PartyName references Party(Name));
```

```
create Assertion PatryinVoting %% Participation Constraint
    check (Not Exists (
        Select * from Party P
        Where Not Exists (
            Select * from Voting V
            Where P.Name = V.PartyName)))
```

This Schema is NOT in 3NF.

Explain: Name → Platform,

Name is not a superkey and

Platform is not a part of a key.

2.

$$\pi_{RName, PName}(VOTER[RId, RName] \bowtie_{RId=VoterId} \sigma_{Time='10:10:10'}(VOTING) \bowtie_{PartyId=PName} PARTY[PName, Leaders, Platform])$$

3.

```
%% Students who took courses
(Select S.StudId, AVG(T.Grade)
 from Student S, Transcript T
 Where S.StudId = T.StudId AND
       T.Semester = 'S2002'
 GroupBy S.StudId)

UNION
%% Students who did not take anything in S2002.
( Select S.StudId, NULL
  from Student S
  Where S.StudId NOT IN
     ( Select T.StudId
       From Transcript T
       Where T.Semester = 'S2002'))
```

4.

Step 1: Split right-hand sides:

$ZY \to X$

$ZY \to W$

$YX \to V$

$YX \to U$

$Z \to U$

$U \to Y$

$X \to U$

Step 2: Minimize the left-hand sides:

$Z \to U$, $U \to Y$ $\Rightarrow Z \to Y \Rightarrow$ $ZY \to X$, $ZY \to W$ $\Rightarrow$ $Z \to X$, $Z \to W$.

$U \to Y$, $X \to U$ $\Rightarrow X \to Y \Rightarrow$ $YX \to V$, $YX \to U$ $\Rightarrow$ $X \to V$, $\boxed{X \to U}$ (duplicate, removed)

Step 3: Remove redundant FDs.

$Z \to X$, $X \to U$ $\Rightarrow Z \to U$ so $Z \to U$ is redundant.

The final result is.

$Z \to X$

$Z \to W$

$X \to V$

$X \to U$

$U \to Y$

5. Yes. It is lossless.

$ZYXW \cap ZXVU = ZX$, and $(ZX)_F^+ = \{Z, X, W, V, U, Y\}$,

So $ZX \to ZYXW$ (or $ZXVU$).