Exercise 3.4.1a

This is the initial tableau:

A	B	C	D	E
a	b	c	d_1	e_1
a_1	b	c	d	e_1
a	b_1	c	d_1	e

This is the final tableau after applying FDs B→E and CE→A.

A	B	C	D	E
a	b	c	d_1	e_1
a	b	c	d	e_1
a	b_1	c	d_1	e

Since there is not an unsubscripted row, the decomposition for R is not lossless for this set of FDs.

We can use the final tableau as an instance of R as an example for why the join is not lossless. The projected relations are:

A	B	C
a	b	c
a	b_1	c

B	C	D
b	c	d_1
b	c	d
b_1	c	d_1

A	C	E
a	c	e_1
a	c	e

The joined relation is:

A	B	C	D	E
a	b	c	d_1	e_1
a	b	c	d	e_1
a	b_1	c	d_1	e_1

a	b	c	d_1	e
a	b	c	d	e
a	b_1	c	d_1	e

The joined relation has three more tuples than the original tableau.

Exercise 3.4.1b

This is the initial tableau:

A	**B**	**C**	**D**	**E**
a	b	c	d_1	e_1
a_1	b	c	d	e_1
a	b_1	c	d_1	e

This is the final tableau after applying FDs AC→E and BC→D

A	**B**	**C**	**D**	**E**
a	b	c	d	e
a_1	b	c	d	e_1
a	b_1	c	d_1	e

Since there is an unsubscripted row, the decomposition for R is lossless for this set of FDs.

Exercise 3.5.1a

In the solution to Exercise 3.3.1a we found that there are 14 nontrivial dependencies. They are: C→A, C→D, D→A, AB→D, AB→ C, AC→D, BC→A, BC→D, BD→A, BD→C, CD→A, ABC→D, ABD→C, and BCD→A.

We also learned that the three keys were AB, BC, and BD. Since all the attributes on the right sides of the FDs are prime, there are no 3NF violations.

Since there are no 3NF violations, it is not necessary to decompose the relation.

Exercise 3.5.2a

The usual procedure to find the keys would be to take the closure of all 63 nonempty subsets. However, if we notice that none of the right sides of the FDs contains attributes H and S. Thus we know that attributes H and S must be part of any key. We eventually will find out that HS is the only key for the Courses relation.

Exercise 3.5.2b

The first step to verify that the given FDs are their own minimal basis is to check to see if any of the FDs can be removed. However, if we remove any one of the five FDs, the remaining four FDs do not imply the removed FD.

The second step to verify that the given FDs are their own minimal basis is to check to see if any of the left sides of an FD can have one or more attributes removed without losing the dependencies. However, this is not the case for the four FDs that contain two attributes on the left side.

Thus, the given set of FDs has been verified to be the minimal basis.

Exercise 3.5.2c

Since the only key is HS, the given set of FDs has some dependencies that violate 3NF. We also know that the given set of FDs is a minimal basis. Thus the decomposed relations are CT, HRC, HTR, HSR and CSG. Since the relation HSR contains a key, we do not need to add an additional relation. The final set of decomposed relations is CT, HRC, HTR, HSR and CSG.

None of the decomposed relations violate BCNF. This can be verified by projecting the given set of FDs onto each of the decomposed relations. All of the projections of FDs have superkeys on their left sides.

Exercise 3.6.1

Since $A \rightarrow\rightarrow B$, and all the tuples have the same value for attribute A, we can pair the B-value from any tuple with the value of the remaining attribute C from any other tuple. Thus, we know that R must have at least the nine tuples of the form (a,b,c), where b is any of b_1, b_2, or b_3, and c is any of c_1, c_2, or c_3. That is, we can derive, using the definition of a multivalued dependency, that each of the tuples (a,b_1,c_2), (a,b_1,c_3), (a,b_2,c_1), (a,b_2,c_3), (a,b_3,c_1), and (a,b_3,c_2) are also in R.