HO CHI MINH CITY UNIVERSITY OF TRANSPORT

Kiến thức - Kỹ năng - Sáng tạo - Hội nhập

Sứ mệnh - Tầm nhìn

Triết lý Giáo dục - Giá trị cốt lõi

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1 Conceptual database design

1.1 ER Diagram

Exercise 1.1.1

Draw an ER diagram for an entity called **HOTEL** and include no fewer than five attributes for the entity. Of the five attributes, include at least one composite attribute and one multivalued attribute.

Exercise 1.1.2

Consider **STUDENT** entity, and the only attributes of student are ***student number*** and ***name***. Let us suppose we have another entity called **HIGH SCHOOL** — the high school from which the student graduated. For the **HIGH SCHOOL** entity, we will record the *high school name* and the ***location*** (meaning ***city*** and ***state***). Draw the ER diagram for it.

Exercise 1.1.3

If we have two entities, a **PLANE** and a **PILOT**, and describe the relationship between the two entities as
"A **PILOT** **flies** a **PLANE**."
What should the relationship read from the side of the other entity?

Exercise 1.1.4

Suppose a college had one dormitory with many rooms. The **DOMITORY** entity, which is actually a "dormitory room" entity since there is only one dorm. Dormitory has the attributes ***room number*** and singledouble (meaning there are private rooms and double rooms). Let us suppose the **STUDENT** entity in this case contains the attributes ***student number, student name***, and ***cell telephone number***. Draw the ER diagram linking the two entities. Name your relationships.

Exercise 1.1.5

West Florida Mall
A new mall, West Florida Mall, just had its grand opening three weeks ago in Pensacola, Florida. This new mall is attracting a lot of customers and stores. West Florida Mall, which is part of a series of malls owned by a parent company, now needs a database to keep track of the management of the mall in terms of all its stores as well as the owners and workers in the stores. Before we build a database for this system of malls, the first step will be to design an ER diagram for the mall owner. We gathered the following initial user specifications about the mall, with which we can start creating the ER diagram:

1. We need to record information about the mall and each store in the mall. We need to record the mall's name and address. A mall, at any point in time, must contain one or more stores.

2. For each store we will need to keep the following information: store number (which will be unique), the name of the store, location of store (room number), departments, the owner of the store, and manager of the store. Each store may have more than one department with each department having a manager. Each store will have only one manager. Each store is owned by only one owner. Each store is located in one and only one mall.

3. A store manager can manage only one store. We must record information on the store manager—the name, Social Security number, which store he or she is working for, and the salary.

4. The store owner is a person. We will record name, address, and of cell phone about the store owner. A store owner must own at least one store and may own more than one.

1.2 Mapping to Relational Model

Exercise 1.2.1

Map ERD **exercise 1.1.1** to Relational Model

Exercise 1.2.2

Map ERD **exercise 1.1.2** to Relational Model

Exercise 1.2.3

Map ERD **exercise 1.1.3** to Relational Model

Exercise 1.2.4

Map ERD **exercise 1.1.4** to Relational Model

Exercise 1.2.5

Map ERD **exercise 1.1.5** to Relational Model

2 Logical database design

2.1 Functional Dependencies (FDs)

Exercise 2.1.1

Consider relation r below:

r:	R(A	B	C	D	E)
t_1	0	0	0	0	0
t_2	0	1	1	1	0
t_3	1	0	2	2	0
t_4	1	0	3	2	0
t_5	2	1	4	0	0

Which of the following FDs does r satisfy (why?):

a) $A \to B$

b) $AB \to D$

c) $C \to BDE$

d) $E \to A$

e) $A \to E$

Exercise 2.1.2

Prove that r satisfies $X \to Y$ if and only if X is a key of $\pi_{XY}(r)$.

Exercise 2.1.3

Let r be a relation on R, with X a subset of R. Show that if $\pi_X(r)$ has the same number of tuples as r, then r satisfies $X \to Y$ for any subset Y of R.

Exercise 2.1.4

Prove or disprove the following inference rules for a relation $r(R)$ with $W,\ X,\ Y,\ Z$ subsets of R.

a) $X \to Y$ and $Z \to W$ imply $XZ \to YW$.

b) $XY \to Z$ and $Z \to X$ imply $Z \to Y$.

c) $X \to Y$ and $Y \to Z$ imply $X \to YZ$.

d) $X \to Y$, $W \to Z$, and $Y \supseteq W$ imply $X \to Z$.

2.2 Amstrong's Axiom

Exercise 2.2.1

Consider $F = \{\ AB \to CD,\ A \to BE,\ BH \to DK,\ H \to BC\ \}$
Prove by Amstrong: $F \models AH \to CK$

Exercise 2.2.2

Consider $F = \{\ AB \to E,\ AG \to J,\ BE \to I,\ E \to G,\ GI \to H\ \}$
Prove by Amstrong: $F \models AB \to GH$

Exercise 2.2.3

Consider $F = \{\ A \to D,\ B \to CE,\ E \to H,\ D \to E,\ E \to C\ \}$
Prove by Amstrong:

a) $F \models B \to H$

b) $F \models AB \to CH$

Exercise 2.2.4

Consider $F = \{\ D \to BK,\ AB \to GK,\ B \to H,\ CE \to AG,\ H \to E,\ K \to G,\ EH \to K,\ G \to AH\ \}$
Prove by Amstrong:

a) $F \models AB \to GH$

b) $F \models DE \to AG$

c) $F \models BH \to EK$

2.3 Closure

Exercise 2.3.1

Show that for any set of FDs F, $F^+ = (F^+)^+$.

Exercise 2.3.2

Suppose $R(ABCDE)$ and set of functional dependencies:
$F = \{\ A \to BC,\ CD \to E,\ B \to D,\ E \to A\ \}$. Compute:

a) CD_F^+

b) E_F^+

Exercise 2.3.3

Suppose $R(ABCDEK)$ and set of functional dependencies:
$F = \{\ AB \to C,\ BC \to AD,\ D \to E,\ CK \to B\ \}$. Compute:

a) BCK_F^+

b) CD_F^+

c) D_F^+

Exercise 2.3.4

Suppose $R(ABCDEKGH)$ and set of functional dependencies:
$F = \{\ A \to BC,\ E \to C,\ AH \to D,\ CD \to E,\ D \to AEH,\ DH \to BC\}$. Compute:

a) AE_F^+
b) BCD_F^+

Exercise 2.3.5

Consider:
$F_1 = \{\ AB \to CD,\ A \to BE,\ BH \to DK,\ H \to BC\ \}$
$F_2 = \{\ AB \to E,\ AG \to J,\ BE \to I,\ E \to G,\ GI \to H\ \}$
$F_3 = \{\ A \to D,\ B \to CE,\ E \to H,\ D \to E,\ E \to C\ \}$
$F_4 = \{\ D \to BK,\ AB \to GK,\ B \to H,\ CE \to AG,\ H \to E,\ K \to G,\ EH \to K,\ G \to AH\ \}$
Compute:

a) $AH_{F_1}^+$
b) $AB_{F_2}^+$
c) $B_{F_3}^+$
d) $AB_{F_3}^+$
e) $AB_{F_4}^+$
f) $DE_{F_4}^+$
g) $BH_{F_4}^+$

Exercise 2.3.6

Consider $F = \{\ A \to B,\ A \to C,\ CD \to E,\ B \to D,\ E \to A\ \}$
Which of the following functional dependencies is NOT implied by the above set ?

a) $CD \to AC$
b) $BD \to CD$
c) $BC \to CD$
d) $AC \to BC$

Exercise 2.3.7

From Axiom 1, 2, 3 prove Axiom 4, 5 and 6.

Exercise 2.3.8

Prove that inference axioms 1, 2, and 3 are independent. That is, no one of them can be proved from the other two.

Exercise 2.3.9

$R(ABCD)$ having two FDs sets:
$F = \{\ A \to B,\ B \to C,\ AB \to D\ \}$,
$G = \{\ A \to B,\ B \to C,\ A \to C,\ A \to D\ \}$
Are the two sets equivalent ?

Exercise 2.3.10

$R(ABCD)$ having two FDs sets:
$F = \{\ A \to B,\ B \to C,\ A \to C\ \}$,
$G = \{\ A \to B,\ B \to C,\ A \to D\ \}$
Are the two sets equivalent ?

Exercise 2.3.11

$R(ACDEH)$ having two FDs sets:
$F = \{\ A \to C,\ AC \to D,\ E \to AD,\ E \to H\ \}$,
$G = \{\ A \to CD,\ E \to AH\ \}$
Are the two sets equivalent ?

Exercise 2.3.12

$R(ABCDE)$ having two FDs sets:
$F = \{ A \to BC,\ A \to D,\ CD \to E \}$,
$G = \{ A \to BCE,\ A \to ABD,\ CD \to E \}$
Are the two sets equivalent ?

Exercise 2.3.13

$R(ABCDE)$ having two FDs sets:
$F = \{ AB \to C,\ A \to B,\ B \to C,\ A \to C \}$,
$G = \{ AB \to C,\ A \to B,\ B \to C \}$
Are the two sets equivalent ?

Exercise 2.3.14

Consider $F = \{ A \to B,\ B \to C,\ C \to A,\ B \to A,\ A \to C \}$

a) Find a minimum cover F_c of F by loop from right to left
b) Find a minimum cover F_c of F by loop from left to right

Exercise 2.3.15

Consider $F = \{ A \to BC,\ B \to C,\ A \to B,\ AB \to C \}$
Find a minimum cover F_c of F

Exercise 2.3.16

Consider $F = \{ A \to BC,\ CD \to E,\ B \to D,\ E \to A \}$
Find a minimum cover F_c of F

Exercise 2.3.17

Consider $F = \{ B \to A,\ AD \to BC,\ C \to ABD \}$
Find a minimum cover F_c of F

Exercise 2.3.18

Consider $R(ABC)$,
$F = \{ AB \to C,\ A \to B \}$
$G = \{ A \to B,\ B \to C \}$

a) Find a minimum cover F_c of F
b) Is G a minimal cover of F ? Otherwise give a data instance of R satisfy F but not G

Exercise 2.3.19

Consider $R(ABCDE)$, $F = \{ AB \to CD,\ B \to CD,\ CD \to AE,\ DE \to AB,\ D \to E \}$
Compute Projected Functional Dependencies:

a) $\pi_{R_1(ABC)}(F)$
b) $\pi_{R_2(BCD)}(F)$
c) $\pi_{R_3(CDE)}(F)$
d) $\pi_{R_4(ADE)}(F)$
e) $\pi_{R_5(BDE)}(F)$
f) $\pi_{R_6(AE)}(F)$
g) $\pi_{R_7(DE)}(F)$

Exercise 2.3.20

Consider $R(ABCDEGH)$,
$F = \{\ AB \to CD,\ E \to D,\ ABC \to DE,\ E \to AB,\ D \to AG,\ ACD \to BE\ \}$
Compute Projected Functional Dependencies:

a) $\pi_{R_1(ABCD)}(F)$
b) $\pi_{R_2(DEGH)}(F)$
c) $\pi_{R_3(CDE)}(F)$
d) $\pi_{R_4(ADE)}(F)$
e) $\pi_{R_5(BDE)}(F)$
f) $\pi_{R_6(AE)}(F)$
g) $\pi_{R_7(DE)}(F)$

2.4 Keys

Exercise 2.4.1

Consider $R(ABCDEH)$ with a set of FDs
$F = \{\ A \to B,\ BC \to D,\ E \to C,\ D \to A\ \}$
What are the candidate keys of R

a) $AE,\ BE$
b) $AE,\ BE,\ DE$
c) $AEH,\ BEH,\ BCH$
d) $AEH,\ BEH,\ DEH$

Exercise 2.4.2

Consider $R(DEGHIJKLMN)$ with a set of FDs
$F = \{\ DE \to G,\ D \to IJ,\ EH \to KL,\ K \to M,\ L \to N\ \}$
What is the key for R ?

a) EF
b) DEH
c) $DEHKL$
d) E

Exercise 2.4.3

Consider $R(ABCDEKGH)$ with a set of FDs
$F = \{\ ABC \to DE,\ AB \to D,\ DE \to ABCK,\ E \to C\ \}$
Find all the candidate keys of R

Exercise 2.4.4

Consider $R(ABCDEGHK)$ with a set of FDs
$F = \{\ CD \to A,\ EC \to H,\ GHB \to AB,\ C \to D,\ EG \to A,\ H \to B,\ BE \to CD,\ EC \to B\ \}$
Find all the candidate keys of R

2.5 Normal Form by FDs

Exercise 2.5.1

Which normal form of relational scheme below:

a) $R_1(ABC), F_1 = \{\ A \to C\ \}$
b) $R_2(ABC), F_2 = \{\ C \to B\ \}$
c) $R_3(ABCD), F_3 = \{\ A \to B,\ B \to A\ \}$
d) $R_4(ABCD), F_4 = \{\ D \to C,\ B \to A\ \}$
e) $R_5(ABCD), F_5 = \{\ B \to D,\ C \to D\ \}$

f) $R_6(ABCDE), F_6 = \{\ AB \to C,\ B \to A,\ D \to A\ \}$
g) $R_7(ABCDE), F_7 = \{\ AB \to C,\ C \to D,\ D \to A\ \}$
h) $R_8(ABCDE), F_8 = \{\ AB \to CD,\ CD \to AE,\ D \to A\ \}$
i) $R_9(ABCDE), F_9 = \{\ D \to A,\ BC \to E,\ A \to C\ \}$
j) $R_{10}(ABCDEG), F_{10} = \{\ AB \to CG,\ G \to D,\ B \to D\ \}$
k) $R_{11}(ABCDE), F_{11} = \{\ E \to D,\ C \to B,\ A \to E\ B \to A,\ D \to C\ \}$
l) $R_{12}(ABCDE), F_{12} = \{\ AC \to B,\ BD \to C,\ CE \to D\ \}$
m) $R_{13}(ABCD), F_{13} = \emptyset$

Exercise 2.5.2

Consider $R(ABCD), F = \{\ A \to C,\ B \to D\ \}$

a) Keys and Normal form?
b) Decompose R

Exercise 2.5.3

Consider $R(ABCD), F = \{\ AC \to D\ \}$

a) Keys and Normal form?
b) Decompose R

Exercise 2.5.4

Consider $R(ABCDE), F = \{\ AB \to C,\ B \to A,\ D \to A\ \}$

a) Keys and Normal form?
b) Decompose R

Exercise 2.5.5

Consider $R(ABCDE), F = \{\ CD \to A,\ EC \to B,\ AD \to C\ \}$

a) Keys and Normal form?
b) Decompose R

Exercise 2.5.6

Consider $R(ABCDEGH)$,
$F = \{\ CD \to A,\ EC \to H,\ GHB \to AB,\ C \to D,\ EG \to A,\ H \to B,\ BE \to CD,\ EC \to B\ \}$

a) Keys and Normal form ?
b) Decompose R

Exercise 2.5.7

Consider $R(ABCD),\ F = \{\ A \to B,\ B \to C,\ D \to B\ \}$

a) Normal form of R ?
b) If R is not good, let try to find a good decomposition for R

Exercise 2.5.8

Consider $R(ABCD),\ F = \{\ A \to B,\ B \to C,\ A \to D,\ D \to C\ \}$
One decomposition ρ of R:

$R_1(AB), F_1$
$R_2(AC), F_2$
$R_3(BD), F_3$

a) F_i ?
b) Keys and Normal form of R_i ?

Exercise 2.5.9

Consider $R(A\ B\ D\ E\ M\ N\ O\ P\ X\ Y\ Z\ V\ W)$,
$F = \{\ D \to XMNPE,\ MPN \to EYABO,\ MN \to ZO,\ O \to V,\ P \to ABW,\ AB \to P,\ NE \to MP\ \}$
One decomposition ρ of R:

$R_1(DXMNPE)$, F_1
$R_2(MNPEYABO)$, F_2
$R_3(MNZO)$, F_3
$R_4(OV)$, F_4
$R_5(PABW)$, F_5

a) F_i ?

b) Keys and Normal form of R_i ?

c) Evaluate the quality of ρ (Normal form, Conserve information, Conserve FDs)

d) If ρ is not good, let make a improvement of ρ

Exercise 2.5.10

Consider $R(ABCDEGH)$,
$F = \{\ CD \to A,\ EC \to H,\ GHB \to AB,\ C \to D,\ EG \to A,\ H \to B,\ BE \to CD,\ EC \to B\ \}$
Evaluate the decomposition below (Normal form, Conserve information, Conserve FDs)
$\rho = \{\ R_1(ABC),\ R_2(CDEG),\ R_3(EGH)\ \}$

Exercise 2.5.11

Give an example of a relation in 3NF that has some prime attribute transitively dependent upon a key

Exercise 2.5.12

Let R_1 and R_2 be relation schemes with $R_1 \cap R_2 = X$. Show that for any relation $r(R_1R_2)$ that satisfies $X \to R_2$,
$r = \pi_{R_1}(r) \bowtie \pi_{R_2}(r)$

2.6 Multivalued Dependencies (MVDs)

Exercise 2.6.1

Consider relation r below:

r:	R(A	B	C	D	E)
t_1	0	0	1	0	0
t_2	0	0	2	1	0
t_3	0	2	2	0	1

From data instance R above make R satisfies each MVD below:

a) $AB \twoheadrightarrow C$

b) $AB \twoheadrightarrow E$

c) $D \twoheadrightarrow C$

d) $AD \twoheadrightarrow C$

e) $C \twoheadrightarrow DE$

Exercise 2.6.2

Let $R(ABCDE)$, $\mathfrak{D} = \{\ A \twoheadrightarrow BC,\ A \twoheadrightarrow E,\ E \twoheadrightarrow CD\ \}$
Proving by MVDs axiom:

a) $\mathfrak{D} \models A \twoheadrightarrow C$

b) $\mathfrak{D} \models A \twoheadrightarrow BD$

c) $\mathfrak{D} \models AC \twoheadrightarrow BD$

d) $\mathfrak{D} \models AC \twoheadrightarrow BE$

e) $\mathfrak{D} \models DE \twoheadrightarrow AC$

f) $\mathfrak{D} \models DE \twoheadrightarrow AB$

Exercise 2.6.3

Let $R(ABCDGH)$, $\mathfrak{D} = \{\, A \twoheadrightarrow B,\ B \twoheadrightarrow GH,\ CD \twoheadrightarrow G \,\}$
Proving by MVDs axiom:

a) $\mathfrak{D} \models BC \twoheadrightarrow AD$
b) $\mathfrak{D} \models BC \twoheadrightarrow GH$
c) $\mathfrak{D} \models BC \twoheadrightarrow DG$
d) $\mathfrak{D} \models CD \twoheadrightarrow AB$
e) $\mathfrak{D} \models CD \twoheadrightarrow BG$
f) $\mathfrak{D} \models CD \twoheadrightarrow GH$

Exercise 2.6.4

Let $R(ABCGHI)$, $\mathfrak{D} = \{\, A \twoheadrightarrow B,\ B \twoheadrightarrow HI,\ CG \twoheadrightarrow H \,\}$
Compute $X^{++}_{\mathfrak{D}}$:

a) $A^{++}_{\mathfrak{D}}$
b) $AG^{++}_{\mathfrak{D}}$
c) $BG^{++}_{\mathfrak{D}}$
d) $BC^{++}_{\mathfrak{D}}$
e) $HG^{++}_{\mathfrak{D}}$

Exercise 2.6.5

Prove the correctness of inference axioms M1 and M2.

Exercise 2.6.6

Prove the correctness of inference axiom M3.

Exercise 2.6.7

We know axiom M7 is correct from Lemma 8.3
Prove the correctness of inference axiom M4 using axioms M3 and M7.

Exercise 2.6.8

Prove the correctness of inference axiom M5 using axioms M4.

Exercise 2.6.9

Prove the correctness of inference axiom M6 using axioms M1-M5 and M7

2.7 Tableau Chase Test

Exercise 2.7.1

Consider $\mathfrak{D} = \{\, AB \to CD,\ A \to BE,\ BH \to DK,\ H \to BC \,\}$
Prove by Tableau Chase test: $\mathfrak{D} \models AH \to CK$

Exercise 2.7.2

Consider $\mathfrak{D} = \{\, AB \to E,\ AG \to J,\ BE \to I,\ E \to G,\ GI \to H \,\}$
Prove by Tableau Chase test: $\mathfrak{D} \models AB \to GH$

Exercise 2.7.3

Consider $\mathfrak{D} = \{\, A \to D,\ B \to CE,\ E \to H,\ D \to E,\ E \to C \,\}$
Prove by Tableau Chase test:

a) $\mathfrak{D} \models B \to H$
b) $\mathfrak{D} \models AB \to CH$

Exercise 2.7.4

Consider $\mathfrak{D} = \{ D \to BK,\ AB \to GK,\ B \to H,\ CE \to AG,\ H \to E,\ K \to G,\ EH \to K,\ G \to AH \}$
Prove by Tableau Chase test:

a) $\mathfrak{D} \models AB \to GH$

b) $\mathfrak{D} \models DE \to AG$

c) $\mathfrak{D} \models BH \to EK$

Exercise 2.7.5

Suppose $R(ABCDE)$ and set of functional dependencies:
$\mathfrak{D} = \{ A \to BC,\ CD \to E,\ B \to D,\ E \to A \}$. **Using Tableau Chase test to compute**:

a) $CD^+_{\mathfrak{D}}$

b) $E^+_{\mathfrak{D}}$

Exercise 2.7.6

Suppose $R(ABCDEK)$ and set of functional dependencies:
$\mathfrak{D} = \{ AB \to C,\ BC \to AD,\ D \to E,\ CK \to B \}$. **Using Tableau Chase test to compute**:

a) $BCK^+_{\mathfrak{D}}$

b) $CD^+_{\mathfrak{D}}$

c) $D^+_{\mathfrak{D}}$

Exercise 2.7.7

Suppose $R(ABCDEKGH)$ and set of functional dependencies:
$\mathfrak{D} = \{ A \to BC,\ E \to C,\ AH \to D,\ CD \to E,\ D \to AEH,\ DH \to BC \}$. **Using Tableau Chase test to compute**:

a) $AE^+_{\mathfrak{D}}$

b) $BCD^+_{\mathfrak{D}}$

Exercise 2.7.8

Consider:
$\mathfrak{D}_1 = \{ AB \to CD,\ A \to BE,\ BH \to DK,\ H \to BC \}$
$\mathfrak{D}_2 = \{ AB \to E,\ AG \to J,\ BE \to I,\ E \to G,\ GI \to H \}$
$\mathfrak{D}_3 = \{ A \to D,\ B \to CE,\ E \to H,\ D \to E,\ E \to C \}$
$\mathfrak{D}_4 = \{ D \to BK,\ AB \to GK,\ B \to H,\ CE \to AG,\ H \to E,\ K \to G,\ EH \to K,\ G \to AH \}$
Using Tableau Chase test to compute:

a) $AH^+_{\mathfrak{D}_1}$

b) $AB^+_{\mathfrak{D}_2}$

c) $B^+_{\mathfrak{D}_3}$

d) $AB^+_{\mathfrak{D}_3}$

e) $AB^+_{\mathfrak{D}_4}$

f) $DE^+_{\mathfrak{D}_4}$

g) $BH^+_{\mathfrak{D}_4}$

Exercise 2.7.9

Consider $\mathfrak{D} = \{ A \to B,\ A \to C,\ CD \to E,\ B \to D,\ E \to A \}$
Using Tableau Chase test to compute: Which of the following functional dependencies is NOT implied by the above set ?

a) $CD \to AC$

b) $BD \to CD$

c) $BC \to CD$

d) $AC \to BC$

Exercise 2.7.10

Let $R(ABCDE)$, $\mathfrak{D} = \{\ A \twoheadrightarrow BC,\ A \twoheadrightarrow E,\ E \twoheadrightarrow CD\ \}$
Using Tableau Chase test to compute:

a) $\mathfrak{D} \models A \twoheadrightarrow C$
b) $\mathfrak{D} \models A \twoheadrightarrow BD$
c) $\mathfrak{D} \models AC \twoheadrightarrow BD$
d) $\mathfrak{D} \models AC \twoheadrightarrow BE$
e) $\mathfrak{D} \models DE \twoheadrightarrow AC$
f) $\mathfrak{D} \models DE \twoheadrightarrow AB$

Exercise 2.7.11

Let $R(ABCDGH)$, $\mathfrak{D} = \{\ A \twoheadrightarrow B,\ B \twoheadrightarrow GH,\ CD \twoheadrightarrow G\ \}$
Using Tableau Chase test to compute:

a) $\mathfrak{D} \models BC \twoheadrightarrow AD$
b) $\mathfrak{D} \models BC \twoheadrightarrow GH$
c) $\mathfrak{D} \models BC \twoheadrightarrow DG$
d) $\mathfrak{D} \models CD \twoheadrightarrow AB$
e) $\mathfrak{D} \models CD \twoheadrightarrow BG$
f) $\mathfrak{D} \models CD \twoheadrightarrow GH$

2.8 More Normal form and Dependencies

Exercise 2.8.1

Modify the relation r below to satisfy the MVDs $A \twoheadrightarrow BC$ and $CD \twoheadrightarrow BE$ by adding rows.

r:	R(A	B	C	D	E)
t_1	0	0	0	0	0
t_2	0	1	0	1	0
t_3	1	0	0	0	1

Exercise 2.8.2

Prove that if a relation $r(R)$ satisfies the MVDs $X \twoheadrightarrow Y_1,\ X \twoheadrightarrow Y_2$ ... $X \twoheadrightarrow Y_k$, where $R = XY_1Y_2...Y_k$, then r decomposes converse information onto the relation schemes $XY_1,\ XY_2,\ ...,\ XY_k$.

Exercise 2.8.3

Let $r(R)$ be a relation where $R_1 \subseteq R,\ R_2 \subseteq R$ and $R = R_1R_2$. Prove that $r = \pi_{R_1}(r) \bowtie \pi_{R_2}(r)$ if and only if:
$Count(\pi_R([X = x](r))) = Count(\pi_{R_1}([X = x](r))) \times Count(\pi_{R_2}([X = x](r)))$ for every X-value x in r

Exercise 2.8.4

Prove that if relation $r(R)$ satisfies $X \twoheadrightarrow Y$ and $Z = R - XY$, then
$$\pi_Z(\sigma_{X=x}(r)) = \pi_Z(\sigma_{XY=xy}(r))$$
for every XY-value xy in r

Exercise 2.8.5

Let relation scheme R and let $W,\ X,\ Y,\ Z \subseteq R$. Show that:
$\{\ X \twoheadrightarrow Y\ ,\ Z \subseteq W\ \} \models XW \twoheadrightarrow YZ$

Exercise 2.8.6

Prove the correctness of inference axiom M6 using axioms M1-M5 and M7

Exercise 2.8.7

Let relation scheme R and let $X,\ Y,\ Z \subseteq R$. Show that:
$\{\ X \twoheadrightarrow Y\ ,\ XY \rightarrow Z\ \} \models X \rightarrow Z - Y$

3 Physical database design

Exercise 3.0.1

Sales and order management system:

- Customers: Stores information about customers, such as name, address, phone number, and email.
- Products: Stores information about the products, such as name, price, quantity, and description.
- Orders: Stores information about orders, such as order date.
- Invoice: Stores information about the invoice, such as invoice date, amount, tax, and total value.

The relationships between entities are described as follows:

- A customer can place multiple orders.
- An order can include many products and corresponding quantities ordered.
- An invoice can be created from an order to calculate delivery charges. Delivered goods may have a different quantity than when ordered and the unit price may be different from the original unit price in stock.

Request:

1. Conceptual Model Design (EER).
2. Switch to the relational model.
3. Logical design.
4. Physical design.

Exercise 3.0.2

Order and Delivery Management System: (considered by ChatGPT)

You are tasked with designing an ERD for a complex order and delivery management system for a global e-commerce platform. This system handles orders for a wide range of products and manages deliveries across multiple regions. Consider the following entities and relationships:

Entities:

1. Customer
2. Product
3. Order
4. Delivery
5. Warehouse
6. Shipping Carrier
7. Payment
8. Address
9. Region

Relationships:

- Customers can place multiple orders.
- Each order is associated with one customer.
- Orders can contain multiple products, and products can be in multiple orders.
- Each order requires a payment, and payments are associated with orders.
- Orders are shipped through deliveries, and each order is associated with one delivery.
- Deliveries can be assigned to different warehouses, and warehouses can handle multiple deliveries.
- Deliveries are assigned to specific shipping carriers.

- Deliveries are made to customer addresses, which are linked to regions.
- Regions represent different geographical areas where deliveries are made.

Requirements:

1. Conceptual Model Design (EER).
2. Switch to the relational model.
3. Logical design.
4. Physical design.

Exercise 3.0.3

Restaurant Order and Delivery with Special Orders: (considered by ChatGPT)
a high-end restaurant's order and delivery management system. This restaurant not only handles regular menu items but also allows customers to place special orders with unique customization requests. Here are some additional complexities to consider:

Entity:

1. Customer
2. Order
3. Menu Item
4. Special Order
5. Ingredient
6. Delivery Driver
7. Delivery Location
8. Table (for dine-in orders)

Relationships:

- Customers can place multiple orders.
- Each order is associated with one customer.
- Orders can include multiple regular menu items, and menu items can be in multiple orders.
- Customers can place special orders with specific ingredient customizations, and these special orders are associated with regular menu items.
- Special orders can have multiple ingredients, and ingredients can be in multiple special orders.
- Some orders are for dine-in, and some are for delivery.
- Each delivery order is associated with one delivery driver and one delivery location.
- For dine-in orders, orders are associated with a specific table.

Requirements:

1. Conceptual Model Design (EER).
2. Switch to the relational model.
3. Logical design.
4. Physical design.