Solutions to selected problems from “Övning2” from Spring 1996.

Please report any errors in these solutions to S. Hegner.

For convenience, things are translated into English.
The schemata are presented with the (presumed) primary keys underlined.

ASSIGNMENT(<u>ROOM, FAC_ID, COURSE_ID, DATE</u>)
COURSE(<u>COURSE_ID</u>, COURSE_NAME, HOURS)
TEACHER(<u>FAC_ID</u>, FAC_NAME, POSITION)

1. The names of the teachers with no teaching assignments.

$X_1 \leftarrow \text{TEACHER} \bowtie \text{ASSIGNMENT}$
$X_2 \leftarrow \pi_{\text{FAC\_ID,FAC\_NAME}}(X_1)$
$X_3 \leftarrow \pi_{\text{FAC\_ID,FAC\_NAME}}(\text{TEACHER})$
$X_4 \leftarrow X_3 \setminus X_2$
$X_5 \leftarrow \pi_{\text{FAC\_NAME}}(X_4)$

$$\{x.\text{FAC\_NAME} \mid \text{TEACHER}(x) \wedge \neg(\exists y)(\text{ASSIGNMENT}(y) \wedge (y.\text{FAC\_ID} = x.\text{FAC\_ID}))\}$$

$$\{x \mid (\exists y)(\exists z)(\text{TEACHER}(z,x,y) \wedge \neg(\exists w)(\exists u)(\exists v)(\text{ASSIGNMENT}(w,z,u,v)))\}$$

2. The names of the courses which are taught by both Kurt Klok and Kent Kall.

$X_1 \leftarrow \text{COURSE} \bowtie \text{ASSIGNMENT} \bowtie \text{TEACHER}$
$X_2 \leftarrow \sigma_{(\text{FAC\_NAME = "Kurt Klok"})}(X_1)$
$X_3 \leftarrow \sigma_{(\text{FAC\_NAME = "Kent Kall"})}(X_1)$
$X_4 \leftarrow \pi_{\text{COURSE\_NAME,COURSE\_ID}}(X_2)$
$X_5 \leftarrow \pi_{\text{COURSE\_NAME,COURSE\_ID}}(X_3)$
$X_6 \leftarrow X_4 \cap X_5$
$X_7 \leftarrow \pi_{\text{COURSE\_NAME}}(X_6)$

{x.COURSE_NAME | COURSE(x) $\wedge$
  ($\exists$y)($\exists$z)($\exists$u)($\exists$w)($\exists$s)($\exists$t)
    (TEACHER(y) $\wedge$ TEACHER(z) $\wedge$
    COURSE(u) $\wedge$ COURSE(w) $\wedge$
    ASSIGNMENT(s) $\wedge$ ASSIGNMENT(t) $\wedge$
    (y.FAC_NAME = “Kurt Klok”) $\wedge$
    (z.FAC_NAME = “Kent Kall”) $\wedge$
    (x.COURSE_ID = u.COURSE_ID) $\wedge$
    (u.COURSE_ID = w.COURSE_ID) $\wedge$
    (y.FAC_ID = s.FAC_ID) $\wedge$
    (z.FAC_ID = t.FAC_ID) $\wedge$
    (u.COURSE_ID = s.COURSE_ID) $\wedge$
    (w.COURSE_ID =t.COURSE_ID))}

{x.COURSE_NAME | COURSE(x) $\wedge$
  ($\exists$y)($\exists$z)($\exists$s)($\exists$t)
    (TEACHER(y) $\wedge$ TEACHER(z) $\wedge$
    ASSIGNMENT(s) $\wedge$ ASSIGNMENT(t) $\wedge$
    (y.FAC_NAME = “Kurt Klok”) $\wedge$
    (z.FAC_NAME = “Kent Kall”) $\wedge$
    (y.FAC_ID = s.FAC_ID) $\wedge$
    (z.FAC_ID = t.FAC_ID) $\wedge$
    (x.COURSE_ID = s.COURSE_ID) $\wedge$
    (x.COURSE_ID = t.COURSE_ID))}

3. The names and number of hours of courses which are held in room S115.

$X_1 \leftarrow \text{ASSIGNMENT} \bowtie \text{COURSE}$
$X_2 \leftarrow \sigma_{(\text{ROOM} = \text{"S115"})}(X_1)$
$X_3 \leftarrow \pi_{\text{COURSE\_NAME,HOURS}}(X_2)$

{(x.COURSE_NAME,x.HOURS) | COURSE(x) $\wedge$
(∃y)(ASSIGNMENT(y) $\wedge$ (y.ROOM = "S115") $\wedge$
x.COURSE_ID = y.COURSE_ID)}

4. The names of courses which are taught by Bertil Bo.

$X_1 \leftarrow \text{ASSIGNMENT} \bowtie \text{COURSE} \bowtie \text{TEACHER}$
$X_2 \leftarrow \sigma_{(\text{FAC\_NAME} = \text{"Bertil Bo"})}(X_1)$
$X_3 \leftarrow \pi_{\text{COURSE\_NAME}}(X_2)$

{x.COURSE_NAME | COURSE(x) $\wedge$
(∃y)(∃z)(TEACHER(y) $\wedge$ ASSIGNMENT(z) $\wedge$
(y.FAC_NAME = "Bertil Bo" $\wedge$
(y.FAC_ID = z.FAC_ID) $\wedge$
(x.COURSE_ID = z.COURSE_ID))}

5. The dates and course ID's for systems courses.

$X_1 \leftarrow \text{ASSIGNMENT} \bowtie \text{COURSE}$
$X_2 \leftarrow \sigma_{(\text{COURSE\_NAME} = \text{"Systems"})}(X_1)$
$X_3 \leftarrow \pi_{\text{DATE,COURSE\_ID}}(X_2)$

{(x.DATE, x.COURSE_ID) | ASSIGNMENT(x) $\wedge$
(∃y)(COURSE(y) $\wedge$ y.COURSE_NAME = "Systems" $\wedge$
x.COURSE_ID = y.COURSE_ID)}

6. The names of the teachers who teach all of the programming courses.

The following solution almost works, but fails when there is a course which no one is listed to teach.

$X_1 \leftarrow \text{ASSIGNMENT} \bowtie \text{COURSE} \bowtie \text{TEACHER}$

$X_2 \leftarrow \sigma_{(\text{COURSE\_NAME} = \text{“Programming”})}(X_1)$

$X_3 \leftarrow \pi_{\text{FAC\_ID,FAC\_NAME,COURSE\_ID}}(X_2)$

$X_4 \leftarrow \pi_{\text{COURSE\_ID}}(X_2)$

$X_5 \leftarrow X_3 \div X_4$

$X_6 \leftarrow \pi_{\text{FAC\_NAME}}(X_5)$

The following solution fixes that problem.

$X_1 \leftarrow \sigma_{(\text{COURSE\_NAME} = \text{“Programming”})}(\text{COURSE})$

$X_2 \leftarrow \pi_{\text{COURSE\_ID}}(X_1)$

$X_3 \leftarrow \text{ASSIGNMENT} \bowtie \text{TEACHER}$

$X_4 \leftarrow \pi_{\text{FAC\_ID,FAC\_NAME,COURSE\_ID}}(X_3)$

$X_5 \leftarrow X_4 \div X_2$

$X_6 \leftarrow \pi_{\text{FAC\_NAME}}(X_5)$

$$
\begin{aligned}
\{&x.\text{FAC\_NAME} \mid \text{TEACHER}(x) \wedge \\
&\quad (\forall z)(((\text{COURSE}(z) \wedge \\
&\qquad\quad (z.\text{COURSE\_NAME} = \text{“Programming”})) \Rightarrow \\
&\qquad (\exists y)(\text{ASSIGNMENT}(y) \wedge \\
&\qquad\qquad\quad (x.\text{FAC\_ID} = y.\text{FAC\_ID}) \wedge \\
&\qquad\qquad\quad (z.\text{COURSE\_ID} = y.\text{COURSE\_ID}))))\}
\end{aligned}
$$

Here is the second schema, with presumed keys underlined. Note that SALE has no non-trivial key.

SALE(CUST_NO, ART_NO, QUANTITY, REBATE)
CUSTOMER
(CUST_NO, CUST_NAME, ADDRESS, SALES)
ARTICLE(ART_NO, ART_NAME, PRICE)

1. The article number and price of articles which have not been sold to anyone.

$X_1 \leftarrow \text{ARTICLE} \bowtie \text{SALE}$
$X_2 \leftarrow \pi_{\text{ART\_NO,PRICE}}(X_1)$
$X_3 \leftarrow \pi_{\text{ART\_NO,PRICE}}(\text{ARTICLE})$
$X_4 \leftarrow X_3 \setminus X_2$

$\{(x.\text{ART\_NO}, x.\text{PRICE}) \mid \text{ARTICLE}(x) \wedge$
$\neg(\exists y)(\text{SALE}(y) \wedge (x.\text{ART\_NO} = y.\text{ART\_NO}))\}$

2. The names of customers to whom either article 12777 or 13222 has been sold.

$X_1 \leftarrow \text{CUSTOMER} \bowtie \text{SALE}$
$X_2 \leftarrow \sigma(_{\text{ART\_NO = "12777"} \vee \text{ART\_NO = "13222"})}(X_1)$
$X_3 \leftarrow \pi_{\text{CUST\_NAME}}(X_2)$

$\{x.\text{CUST\_NAME} \mid \text{CUSTOMER}(x) \wedge$
$(\exists y)(\text{SALE}(y) \wedge (x.\text{CUST\_NO} = y.\text{CUST\_NO}) \wedge$
$((y.\text{ART\_NO} = \text{"12777"}) \vee (y.\text{ART\_NO} = \text{"13222"})))\}$

3. The name and sales of customers who have received a 2% rebate.

$X_1 \leftarrow \text{CUSTOMER} \bowtie \text{SALE}$
$X_2 \leftarrow \sigma_{(\text{REBATE = 2\%})}(X_1)$
$X_3 \leftarrow \pi_{\text{CUST\_NAME,SALES}}(X_2)$

{(x.CUST_NAME,x.SALES) | CUSTOMER(x) $\wedge$
(∃y)(SALE(y) $\wedge$ (x.CUST_NO = y.CUST_NO) $\wedge$
(y.REBATE = “2%”))}

4. The addresses of customers to whom articles 13222 and 12746 have been sold.

$X_1 \leftarrow \text{CUSTOMER} \bowtie \text{SALE}$
$X_2 \leftarrow \sigma_{(\text{ART\_NO =13222})}(X_1)$
$X_3 \leftarrow \sigma_{(\text{ART\_NO =12746})}(X_1)$
$X_4 \leftarrow \pi_{\text{CUST\_NO,ADDRESS}}(X_2)$
$X_5 \leftarrow \pi_{\text{CUST\_NO,ADDRESS}}(X_3)$
$X_6 \leftarrow X_4 \cap X_5$
$X_7 \leftarrow \pi_{\text{ADDRESS}}(X_6)$

{(x.ADDRESS | CUSTOMER(x) $\wedge$
(∃y) (∃z) (SALE(y) $\wedge$ SALE(z) $\wedge$
(x.CUST_NO = y.CUST_NO) $\wedge$
(x.CUST_NO = z.CUST_NO) $\wedge$
(y.ART_NO = “13222”) $\wedge$ (z.ART_NO = “12746”))}

5. The names of customers to whom every article has been sold.

$X_1 \leftarrow \text{CUSTOMER} \bowtie \text{SALE}$
$X_2 \leftarrow \pi_{\text{CUST\_NO,CUST\_NAME,ART\_NO}}(X_1)$
$X_3 \leftarrow \pi_{\text{ART\_NO}}(\text{ARTICLE})$
$X_4 \leftarrow X_2 \div X_3$
$X_5 \leftarrow \pi_{\text{CUST\_NAME}}(X_4)$

{x.CUST_NAME | CUSTOMER(x) $\wedge$
  ($\forall$y) ($\exists$z) (ARTICLE(y) $\Rightarrow$ (SALE(z) $\wedge$
    (y.ART_NO = z.ART_NO) $\wedge$
    (x.CUST_NO = z.CUST_NO)))}

6. The article number and quantity sold for articles which have been sold to customers in Stockholm. (No summary.)

$X_1 \leftarrow \text{CUSTOMER} \bowtie \text{SALE}$
$X_2 \leftarrow \sigma_{(\text{ADDRESS = “Stockholm”})}(X_1)$
$X_3 \leftarrow \pi_{\text{ART\_NUMBER, QUANTITY}}(X_2)$

{(x.ART_NO,x.QUANTITY) | SALE(x) $\wedge$
  ($\exists$y) (CUSTOMER(y) $\wedge$
    (x.CUST_NO = y.CUST_NO) $\wedge$
    (y.ADDRESS = “Stockholm”))}

Here is the third and final schema, again with presumed keys underlined.

OWNERSHIP
(PERS_ID, <u>REG_NR</u>, USE, INSURANCE, PRICE)
PERSON(<u>PERS_ID</u>, NAME, ADDRESS, PROFESSION)
AUTO(<u>REG_NR</u>, BRAND, YEAR)

1. The names and addresses of persons who do not own an automobile.

$X_1 \leftarrow \text{OWNERSHIP} \bowtie \text{PERSON}$
$X_2 \leftarrow \pi_{\text{PERS\_ID,NAME,ADDRESS}}(X_1)$
$X_3 \leftarrow \pi_{\text{PERS\_ID,NAME,ADDRESS}}(\text{PERSON})$
$X_4 \leftarrow X_3 \setminus X_2$
$X_5 \leftarrow \pi_{\text{NAME,ADDRESS}}(X_4)$

$\{(x.\text{NAME},x.\text{ADDRESS}) \mid \text{PERSON}(x) \wedge$
$\neg(\exists y)\ (\text{OWNERSHIP}(y) \wedge$
$(x.\text{PERS\_ID} = y.\text{PERS\_ID}))\}$

2. The names of persons who own either a Volvo or a Mercedes.

$X_1 \leftarrow \text{OWNERSHIP} \bowtie \text{PERSON} \bowtie \text{AUTO}$
$X_2 \leftarrow \sigma_{(\text{BRAND = “Volvo”} \vee \text{Brand = “Mercedes)}}(X_1)$
$X_3 \leftarrow \pi_{\text{NAME}}(X_2)$

$\{x.\text{NAME} \mid \text{PERSON}(x) \wedge$
$(\exists y)(\exists z)\ (\text{OWNERSHIP}(y) \wedge \text{AUTO}(z) \wedge$
$(x.\text{PERS\_ID} = y.\text{PERS\_ID}) \wedge$
$(y.\text{REG\_NR} = z.\text{REG\_NR}) \wedge$
$((z.\text{BRAND} = \text{“Volvo”}) \vee (z.\text{BRAND} = \text{“Mercedes”})))\}$

3. The model year and brand of automobiles which have full insurance.

$X_1 \leftarrow \text{OWNERSHIP} \bowtie \text{AUTO}$

$X_2 \leftarrow \sigma_{(\text{INSURANCE = “full”})}(X_1)$

$X_3 \leftarrow \pi_{\text{YEAR,BRAND}}(X_2)$

$\{(x.\text{YEAR},x.\text{BRAND}) \mid \text{AUTO}(x) \wedge$
$(\exists y)(\text{OWNERSHIP}(y)$
$(x.\text{REG\_NR} = y.\text{REG\_NR}) \wedge$
$(y.\text{INSURANCE} = \text{“Full”}))\}$

4. The names and addresses of persons who own the vehicles with registration KAF-094 or GEL-175.

$X_1 \leftarrow \text{OWNERSHIP} \bowtie \text{PERSON}$

$X_2 \leftarrow \sigma_{(\text{REG\_NR = “KAF-094} \vee \text{REG\_NR = “GEL-175})}(X_1)$

$X_3 \leftarrow \pi_{\text{NAME,ADDRESS}}(X_2)$

$\{(x.\text{NAME},x.\text{ADDRESS}) \mid \text{PERSON}(x) \wedge$
$(\exists y)\ (\text{OWNERSHIP}(y) \wedge$
$(x.\text{PERS\_ID} = y.\text{PERS\_ID}) \wedge$
$((y.\text{REG\_NO} = \text{“KAF-094”}) \vee$
$(y.\text{REG\_NO} = \text{“GEL-175”})))\}$

5. The names and addresses of persons who own a 1970 model-year vehicle.

$X_1 \leftarrow \text{OWNERSHIP} \bowtie \text{PERSON} \bowtie \text{AUTO}$
$X_2 \leftarrow \sigma_{(\text{YEAR = "1970"})}(X_1)$
$X_3 \leftarrow \pi_{\text{NAME,ADDRESS}}(X_2)$

{(x.NAME,x.ADDRESS) | PERSON(x) ∧
(∃y)(∃z) (OWNERSHIP(y) ∧ AUTO(z) ∧
(y.REG_NR = Z.REG_NR) ∧
(x.PERS_ID = y.PERS_ID) ∧
(z.YEAR = “1970”))}

6. The registration numbers and model years for vehicles which are owned by students.

$X_1 \leftarrow \text{OWNERSHIP} \bowtie \text{PERSON} \bowtie \text{AUTO}$
$X_2 \leftarrow \sigma_{(\text{PROFESSION = "Student"})}(X_1)$
$X_3 \leftarrow \pi_{\text{REG\_NO,YEAR}}(X_2)$

{(x.REG_NO,x.YEAR) | AUTO(x) ∧
(∃y)(∃z)(OWNERSHIP(y) ∧ PERSON(z) ∧
(x.REG_NO = y.REG_NO) ∧
(y.PERS_ID = z.PERS_ID) ∧
(z.PROFESSION = “Student”))}