Solutions (13-17)

13)

```
select m.major
from   Major m
where  not exists (select 1
                   from   Student s, studentMajor sm
                   where  s.sid = sm.sid and
                          sm.major = m.major and
                          s.homeCity = 'Bloomington')
```

14)

(a) •(Problem 2) Find each pair (d, m) where d is the name of a department and m is a major of a student who is employed by that department and who earns a salary of at least 20000.

$$\{(d.deptName, m.major) \mid Department(d) \wedge Majorm \wedge \\ \exists s \in Student(studentMajor(s.sid, m.major) \wedge \\ \exists w \in employedBy(w.sid = s.sid \wedge w.deptName = d.deptName \wedge w.salary \geq 20000))\}.$$

(b) •(Problem 3) Find each pair (s_1, s_2) of sids of different students who have the same (set of) friends who work for the CS department.

$$\{(s_1.sid, s_2.sid) \mid Student(s_1) \wedge Student(s_2) \wedge s_1.sid \neq s_2.sid \wedge \\ \forall w \in employedBy(w.deptName = \texttt{CS} \rightarrow \\ ((hasFriend(s_1.sid, w.sid) \rightarrow hasFriend(s_2.sid, w.sid)) \wedge \\ (hasFriend(s_2.sid, w.sid) \rightarrow hasFriend(s_1.sid, w.sid))))\}$$

15)

(c) •(Problem 4) Find each major for which there exists a student with that major and who does not only have friends who also have that major.

$$\{m.major \mid Major(m) \wedge \exists s \in Student(studentMajor(s.sid, m.major) \wedge \\ \neg(\forall s_1 \in Student(hasFriend(s.sid, s_1.sid) \rightarrow studentMajor(s_1, m.major)))\}$$

Alternatively,

$$\{m.major \mid Major(m) \wedge \exists s \in Student(studentMajor(s.sid, m.major) \wedge \\ \exists s_1 \in Student(hasFriend(s.sid, s_1.sid) \wedge \neg studentMajor(s_1, m.major)))\}.$$

Alternatively,

$$\{m.major \mid Major(m) \wedge \exists s \in Student \exists s_1 \in Student(studentMajor(s.sid, m.major) \wedge \\ hasFriend(s.sid, s_1.sid) \wedge \neg studentMajor(s_1, m.major)))\}.$$

(e) • (Problem 7) Find the sid and sname of each student whose home city is different than those of his or her friends.

$$\{s.sid, s.sname, s.city \mid Student(s) \wedge \exists f(hasFriend(f) \wedge f.sid1 = s.sid) \wedge \\ \neg\exists s_1(Person(s_1) \wedge s.city = s_1.city \wedge hasFriend(s.sid, s_1.sid))\}.$$

16)

(f) • (Problem 9) Find the sid, sname, and salary of each student who has at least two friends such that these friends have a common major but provided that it is not the 'Mathematics' major.

$$\{s.sid \mid Student(s) \wedge \exists f_1 \exists f_2(hasFriend(f_1) \wedge hasFriend(f_2) \wedge \\ f_1.sid1 = s.sid \wedge f_2.sid1 = s.sid \wedge f_1.sid2 \neq f_2.sid2 \wedge \\ \exists sm_1 \exists sm_2(studentMajor(sm_1) \wedge studentMajor(sm_2) \wedge \\ f_1.mid = sm_1.sid \wedge f_2.mid = sm_2.sid \wedge sm_1.major = sm_2.major \wedge \\ sm_1.major \neq \texttt{Mathematics}))\}.$$

(g) • (Problem 11) For each department, list its name along with the highest salary made by students who are employed by it.

$$\{d.dname, w.salary \mid Department(d) \wedge employedBy(w) \wedge w.dname = d.dname \wedge \\ \neg\exists w_1(employedBy(w_1) \wedge w_1.dname = d.dname \wedge w.salary < w_1.salary)\}.$$

17)

(d) • (Problem 5) Find the sid, sname of each student who (a) has home city Bloomington, (b) works for a department where he or she earns a salary that is higher than 20000, and (c) has at least one friend.

$$\{s.sid, s.sname \mid Student(s) \wedge s.city = \texttt{Bloomington} \wedge \\ \exists w(employedBy(w) \wedge s.sid = w.sid \wedge w.salary > 20000) \wedge \\ \exists f(hasFriend(f) \wedge f.sid1 = s.sid)\}.$$

18. a.

Consider the constraint "*Some major has fewer than 2 students with that major.*"

(a) • Formulate this constraint in TRC.

$$\exists m \in Major \land \neg\exists s_1 \in Student \exists s_2 \in Student(s_1.sid \neq s_2.sid \land studentMajor(s_1.sid, m.major) \land studentMajor(s_2.sid, m.major)).$$

Alternatively,

$$\exists m \in Major \land \forall s_1 \in Student \forall s_2 \in Student((studentMajor(s_1.sid, m.major) \land studentMajor(s_2.sid, m.major)) \rightarrow s_1.sid = s_2.sid)$$

19. a.

Consider the constraint "*Each student is employed by a department and has at least two majors.*"

(a) • Formulate this constraint in TRC.

$$\forall s\, Student(s) \rightarrow (\exists w(employedBy(w) \land w.sid = s.sid) \land \exists sm_1 \exists sm_2(studentMajor(sm_1) \land studentMajor(sm_2) \land sm_1.sid = s.sid \land sm_2.sid = s.sid \land sm_1.major \neq sm_2.major))$$

Equivalently,

$$\neg\exists p\, Student(s) \land (\neg\exists w(employedBy(w) \land w.sid = s.sid) \lor \neg\exists ps_1 \exists ps_2(studentMajor(ps_1) \land studentMajor(ps_2) \land ps_1.sid = s.sid \land ps_2.sid = s.sid \land ps_1.major \neq ps_2.major))$$

20. a.

Consider the constraint "*Each student and his or her friends work for the same department.*"

(a) • Formulate this constraint in TRC.

$$\forall f\, \forall w_1\, \forall w_2((hasFriend(f) \land employedBy(w_1) \land employedBy(w_2) \land f.sid1 = w_1.sid \land f.sid2 = w_2.sid) \rightarrow w_1.dname = w_2.dname).$$

Equivalently,

$$\nexists f \exists w_1\, \exists w_2(hasFriend(f) \land employedBy(w_1) \land employedBy(w_2) \land f.sid1 = w_1.sid \land f.sid2 = w_2.sid \land w_1.dname \neq w_2.dname).$$