**R1**

| sid | bid | day |
|---|---|---|
| 22 | 101 | 10/10/96 |
| 58 | 103 | 11/12/96 |

**B1**

| bid | bname | color |
|---|---|---|
| 101 | tiger | red |
| 103 | lion | green |
| 105 | hero | blue |

**S1**

| sid | sname | rating | age |
|---|---|---|---|
| 22 | dustin | 7 | 45.0 |
| 31 | lubber | 8 | 55.5 |
| 58 | rusty | 10 | 35.0 |

**S2**

| sid | sname | rating | age |
|---|---|---|---|
| 28 | yuppy | 9 | 35.0 |
| 31 | lubber | 8 | 55.5 |
| 44 | guppy | 5 | 35.0 |
| 58 | rusty | 10 | 35.0 |

**Q1:** $\pi_{sid,sname,age}\left(\sigma_{age>35}(S_1)\right)$

**Q2:** $\pi_{sname,rating}\left(\sigma_{S_1.sid>R_1.sid}(S_1 \times R_1)\right)$

**Q3:** $\pi_{sid,bname}\left(\sigma_{bid}(R_1 \times B_1)\right)$

**Q4:** $S_2/\left(\pi_{sid,age}(S_2)/\pi_{sid}\left(\sigma_{bid=103}(R_1)\right)\right)$

**Q5:** $(S_2 \bowtie_* R_1) \cup (B_1 *\bowtie_* R_1)$

**Q6:** $\pi_{sname,rating,age,bname,color}\left(\left((S_1 \cup S_2) \bowtie_{sid} R_1\right) \bowtie_{bid} \sigma_{color=red}(B_1)\right)$

**Q7:** $\pi_{sid}(S_2) - \pi_{sid}\left(\pi_{sid}\left(\pi_{sid,sname}(S_2)\right) \times \pi_{sname}\left(\sigma_{rating>7}(S_1)\right) - \pi_{sid,sname}(S_2)\right)$

**Q8: What's data model? What's data schema?**

**Q9: Students(sid: string, name: string, ID number: string, cid: string)**
**Courses(cid: string, cname:string)**
**List all super keys, candidate keys, primary keys, foreign keys of table Students.**

**Q10: What are the relational operations on the relational data model? What are their differences and similarities?**

**Q11: Conver the query of Q1 to DRC formula and TRC formula.**

# Answer

**Q1:** $\pi_{sid,sname,age}\left(\sigma_{age>35}(S_1)\right)$

$\sigma_{age>35}(S_1)$:

| sid | sname | rating | age |
|---|---|---|---|
| 22 | dustin | 7 | 45 |
| 31 | lubber | 8 | 55.5 |
| ~~58~~ | ~~rusty~~ | ~~10~~ | ~~35~~ |

$\pi_{sid,sname,age}\left(\sigma_{age>35}(S_1)\right)$:

| sid | sname | ~~rating~~ | age |
|---|---|---|---|
| 22 | dustin | ~~7~~ | 45 |
| 31 | lubber | ~~8~~ | 55.5 |

| sid | sname | age |
|---|---|---|
| 22 | dustin | 45 |
| 31 | lubber | 55.5 |

**Q2:** $\boldsymbol{\pi_{sname,rating}\left(\sigma_{S_1.sid>R_1.sid}(S_1 \times R_1)\right)}$

$\sigma_{S_1.sid>R_1.sid}(S_1 \times R_1)$:

| $S_1$.sid | sname | rating | age | $R_1$.sid | bid | day |
|---|---|---|---|---|---|---|
| ~~22~~ | ~~dustin~~ | ~~7~~ | ~~45~~ | ~~22~~ | ~~101~~ | ~~10/10/96~~ |
| ~~22~~ | ~~dustin~~ | ~~7~~ | ~~45~~ | ~~58~~ | ~~103~~ | ~~11/12/96~~ |
| 31 | lubber | 8 | 55.5 | 22 | 101 | 10/10/96 |
| ~~31~~ | ~~lubber~~ | ~~8~~ | ~~55.5~~ | ~~58~~ | ~~103~~ | ~~11/12/96~~ |
| 58 | rusty | 10 | 35.0 | 22 | 101 | 10/10/96 |
| ~~58~~ | ~~rusty~~ | ~~10~~ | ~~35.0~~ | ~~58~~ | ~~103~~ | ~~11/12/96~~ |

$\pi_{sname,rating}\left(\sigma_{S_1.sid>R_1.sid}(S_1 \times R_1)\right)$:

| sname | rating |
|---|---|
| **lubber** | 8 |
| **rusty** | 10 |

**Q3:** $\boldsymbol{\pi_{sid,bname}\left(\sigma_{bid}(R_1 \times B_1)\right)}$

$\sigma_{bid}(R_1 \times B_1)=R_1 \bowtie_{bid} B_1$:

| sid | bid | day | bname | color |
|---|---|---|---|---|
| 22 | 101 | 10/10/96 | tiger | red |
| 58 | 103 | 11/12/96 | lion | green |

$\pi_{sid,bname}\left(\sigma_{bid}(R_1 \times B_1)\right)$:

| sid | bname |
|---|---|
| 22 | tiger |
| 58 | lion |

**Q4:** $S_2/\left(\pi_{sid,age}(S_2)/\pi_{sid}\left(\sigma_{bid=103}(R_1)\right)\right)$

$\pi_{sid,age}(S_2)/\pi_{sid}(R_1)$:

| sid | Age |
|---|---|
| 28 | 35.0 |
| 31 | 55.0 |
| 44 | 35.0 |
| 58 | 35.0 |

| sid |
|---|
| 58 |

| age |
|---|
| 35 |

$S_2/\left(\pi_{sid,age}(S_2)/\pi_{sid}(B_1)\right)$:

| sid | sname | rating |
|---|---|---|
| 28 | yuppy | 9 |
| 44 | guppy | 5 |
| 58 | rusty | 10 |

**Q5:** $(S_2 \bowtie_* R_1) \cup (B_1 *\bowtie_* R_1)$

$S_2 \bowtie_* R_1$:

| sid | sname | rating | age | bid | day |
|---|---|---|---|---|---|
| 22 | null | null | null | 101 | 10/10/96 |
| 58 | rusty | 10 | 35 | 103 | 11/12/96 |

$B_1 *\bowtie_* R_1$:

| sid | bid | day | bname | color |
|---|---|---|---|---|
| 22 | 101 | 10/10/96 | tiger | red |
| 58 | 103 | 11/12/96 | lion | green |
| null | 105 | null | hero | blue |

$(S_2 \bowtie_* R_1) \cup (B_1 *\bowtie_* R_1)$:

| sid | sname | rating | age | bid | day | bname | color |
|---|---|---|---|---|---|---|---|
| 22 | null | null | null | 101 | 10/10/96 | null | null |
| 58 | rusty | 10 | 35 | 103 | 11/12/96 | null | null |
| 22 | null | null | null | 101 | 10/10/96 | tiger | red |
| 58 | null | null | null | 103 | 11/12/96 | lion | green |
| null | null | null | null | 105 | null | hero | blue |

**Q6:** $\pi_{sname,rating,age,bname,color}\left(\left((S_1 \cup S_2) \bowtie_{sid} R_1\right) \bowtie_{bid} \sigma_{color=red}(B_1)\right)$

$S_1 \cup S_2$:

| sid | sname | rating | age |
|---|---|---|---|
| 22 | dustin | 7 | 45 |
| 31 | lubber | 8 | 55.5 |
| 58 | rusty | 10 | 35 |
| 28 | yuppy | 9 | 35 |
| 44 | guppy | 5 | 35 |
| ~~58~~ | ~~rusty~~ | ~~10~~ | ~~35~~ |

$(S_1 \cup S_2) \bowtie_{sid} R_1$:

| sid | sname | rating | age | bid | day |
|---|---|---|---|---|---|
| 22 | dustin | 7 | 45 | 101 | 10/10/96 |

$\pi_{sname,rating,age,bname,color}\left(\left((S_1 \cup S_2) \bowtie_{sid} R_1\right) \bowtie_{bid} \sigma_{color=red}(B_1)\right)$:

| ~~sid~~ | sname | rating | age | ~~bid~~ | ~~day~~ | bname | color |
|---|---|---|---|---|---|---|---|
| ~~22~~ | dustin | 7 | 45 | ~~101~~ | ~~10/10/96~~ | tiger | red |

| sname | rating | age | bname | color |
|---|---|---|---|---|
| dustin | 7 | 45 | tiger | red |

**Q7:** $\pi_{sid}(S_2) - \pi_{sid}\left(\pi_{sid}\left(\pi_{sid,sname}(S_2)\right) \times \pi_{sname}\left(\sigma_{rating>7}(S_1)\right) - \pi_{sid,sname}(S_2)\right)$

$\pi_{sid}\left(\pi_{sid,sname}(S_2)\right) \times \pi_{sname}\left(\sigma_{rating>7}(S_1)\right)$

| sid |
|---|
| 28 |
| 31 |
| 44 |
| 58 |

| sname |
|---|
| Lubber |
| rusty |

| sid | sname |
|---|---|
| 28 | lubber |
| 28 | rusty |
| 31 | lubber |
| 31 | rusty |
| 44 | lubber |
| 44 | rusty |
| 58 | lubber |
| 58 | rusty |

$\pi_{sid}\left(\pi_{sid}\left(\pi_{sid,sname}(S_2)\right) \times \pi_{sname}\left(\sigma_{rating>7}(S_1)\right) - \pi_{sid,sname}(S_2)\right)$

| sid | sname |
|---|---|
| 28 | lubber |
| 28 | rusty |
| ~~31~~ | ~~lubber~~ |
| 31 | rusty |
| 44 | lubber |
| 44 | rusty |
| 58 | lubber |
| ~~58~~ | ~~rusty~~ |

| sid | ~~sname~~ |
|---|---|
| 28 | ~~lubber~~ |
| ~~28~~ | ~~rusty~~ |
| ~~31~~ | ~~lubber~~ |
| 31 | ~~rusty~~ |
| 44 | ~~lubber~~ |
| ~~44~~ | ~~rusty~~ |
| 58 | ~~lubber~~ |
| ~~58~~ | ~~rusty~~ |

$\pi_{sid}(S_2) - \pi_{sid}\left(\pi_{sid}\left(\pi_{sid,sname}(S_2)\right) \times \pi_{sname}\left(\sigma_{rating>7}(S_1)\right) - \pi_{sid,sname}(S_2)\right)$

Null

$$\pi_{sid}(S_2) - \pi_{sid}\left(\pi_{sid}\left(\pi_{sid,sname}(S_2)\right) \times \pi_{sname}\left(\sigma_{rating>7}(S_1)\right) - \pi_{sid,sname}(S_2)\right) = \pi_{sid,sname}(S_2) / \pi_{sname}\left(\sigma_{rating>7}(S_1)\right)$$

**Q8: What's data model? What's data schema?**

**Data model** is a collection of concepts and definitions for describing data.

**Data schema** is a description of a particular collection of data, using a given data model.

**Q9: Students(sid: string, name: string, ID number: string, cid: string)**
**Courses(cid: string, cname:string)**
**List all super keys, candidate keys, primary keys, foreign keys of table Students.**

**super keys:**
{sid}, {ID number},
{sid, name}, {sid, ID number}, {sid, cid}, {ID number, name}, {ID number, cid},
{sid, name, ID number}, {sid, name, cid}, {sid, ID number, cid}, {name, ID number, cid}
{sid, name, ID number, cid}
**candidate keys:** {sid}, {ID number}
**primary keys:** {sid}
**foreign keys:** {cid}

**Q10: What are the relational operations on the relational data model? What are their differences and similarities?**

Relational calculus **vs** Relational algebra

**Differences:** Relational Algebra needs to specify the order of operations; while relational calculus only needs to indicate the logic condition the result must be fulfilled.

**Similiarities:** They are equivalent in terms of expression. SQL language can express any query that is expressible in relational algebra /calculus.

**Q11：Conver the query of Q1 to DRC formula and TRC formula.**

**DRC formula:** $\{< sid, sname, age > \mid < sid, sname, age > \in S_1 \wedge age > 35\}$

**TRC formula:** $\{t[\, sid, sname, age\,] \mid t \in S_1 \wedge t.age > 35\}$