

Exercise 11 - Solutions

1. (a) $\pi_{NAME} \sigma_{GRADE='F'} (Student \bowtie Enroll)$

In SQL:

```
SELECT Name FROM Student, Enroll WHERE Student.SNO = Enroll.SNO AND  
Enroll.Grade = 'F'
```

(b) $\pi_{NAME} \sigma_{DEPT='MATH'} (Student \bowtie Enroll \bowtie Course)$

In SQL:

```
SELECT Name FROM Student, Enroll, Course WHERE  
Student.SNO = Enroll.SNO AND Enroll.CNO = Course.CNO AND Course.DEPT = 'MATH'
```

(Note: SQL also has a JOIN, not covered in class, which allows expressing the relational algebra natural join more directly.)

2. (a)

Type
Checking
Savings

(b)

Account Number	Customer ID	Branch ID	Balance	Type
A0001	001	301	\$ 5,000	Checking
A0003	003	301	\$ 2,500	Savings
A0004	003	301	\$ 3,500	Checking

(c)

Customer ID	Name	Address	Phone	Account No	Branch ID	Balance	Type
001	John Doe	123 Elm Street	555-1234	A0001	B01	\$5,000	Checking
002	Jane Smith	456 Pine Street	555-5678	A0002	B02	\$8,000	Savings
003	Bob Brown	789 Oak Street	555-9012	A0003	B01	\$2,500	Savings
003	Bob Brown	789 Oak Street	555-9012	A0004	B01	\$3,500	Checking

(d)

Name	Branch Name
John Doe	Downtown
Jane Smith	Uptown
Bob Brown	Downtown

3. (a) Recall the formal definition of the natural join: For $r(R)$, $s(S)$,

$r \bowtie s$ is a relation over $R \cup S$ and

$$r \bowtie s = \{t \in \text{domain}(R \cup S) : \pi_R(t) \in r \text{ and } \pi_S(t) \in s\}$$

So $r \bowtie (s \bowtie t)$ is a relation over $R \cup (S \cup T) = (R \cup S) \cup T$ with

$$r \bowtie (s \bowtie t) = \{x \in \text{domain}(R \cup (S \cup T)) : \pi_R(x) \in r \text{ and } \pi_{S \cup T}(x) = \{y : \pi_S(y) \in s \text{ and } \pi_T(y) \in t\}\}$$

$$= \{x \in \text{domain}(R \cup S \cup T) : \pi_R(x) \in r \text{ and } \pi_S(x) \in s \text{ and } \pi_T(x) \in t\}$$

$$= \{x \in \text{domain}((R \cup S) \cup T) : \pi_{R \cup S}(x) = \{y : \pi_R(y) \in r \text{ and } \pi_S(y) \in s\} \text{ and } \pi_T(x) \in t\}$$

$$= r \bowtie (s \bowtie t)$$

(b) Recall: $\sigma_{r.M=r.N}(R)$ is a relation over R with

$$\sigma_{r.M=r.N}(R) = \{t : t \in r \text{ and } t.M = t.N\}$$

So $\sigma_{M=N}(r \bowtie s)$ is a relation over $R \cup S$ with

$$\sigma_{M=N}(r \bowtie s) = \{t : t \in r \bowtie s \text{ and } t.M = t.N\}$$

$$= \{t \in \text{domain}(R \cup S) : \pi_R(t) \in r \text{ and } \pi_S(t) \in s \text{ and } t.M = t.N\}$$

$$= \{t \in \text{domain}(R \cup S) : (\pi_R(t) \in r \text{ and } \pi_R(t).M = \pi_R(t).N) \text{ and } \pi_S(t) \in s\}$$

$$= \sigma_{M=N}(r) \bowtie s$$