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SQL: An Implementation of the Relational Algebra

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SQL

Development of Relational Database Systems

- Relation Model and Algebra proposed by C.J.Codd in 1970
- IBM deleveped a prototype relational database called **System R** with a query language **Structured English Query Language** (**SEQUEL**)
- SEQ [illegible]
- Vario [illegible] 80s
  - [illegible]
  - **Oracle**
  - **Sybase**
  - ...

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SQL Language Components

Data Definition Language (**DDL**): a relational schema with data
Data Manipulation Language (**DML**): a relational query and update language

SQL DML: Definition of Tables

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```
CREATE TABLE branch
(   sortcode INTEGER NOT NULL,
    bname VARCHAR(20) NOT NULL,
    cash
)
```

branch		
sortcode	bname	cash

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```
CREATE TA
    no INTEGER NOT NULL,
    type VARCHAR(8) NOT NULL,
    cname VARCHAR(20) NOT NULL,
    rate DECIMAL(4,2) NULL,
    sortcode INTEGER NOT NULL
)
```

no	type	cname	rate	sortcode

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SQL DML: SQL Data Types

Some SQL Data Types

Keyword	Semantics
BOOLEAN	A logical value (TRUE, FALSE, or UNKNOWN)
BIT	1 bit integer (0, 1, or NULL)
INTEGER	32 bit integer
BIGINT	
FLOAT(	
REAL	
DOUBL	
DECIMAL(p,s)	A p digit number with s digits after the decimal point
CHAR(n)	A fixed length string of
VARCHAR(n)	A varying length string of upto
DATE	A calendar date (day, month a
TIME	A time of day (seconds, minute
TIMESTAMP	time and day together
ARRAY	An ordered list of a certain datatype
MULTISET	A bag (*i.e.* unordered list) of a certain datatype
XML	XML text

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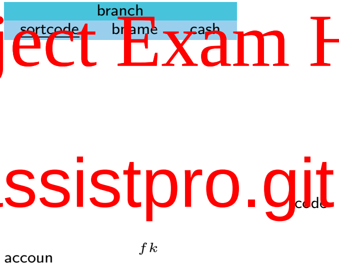
SQL DML: Definition of Keys

```
CREATE TABLE branch
( sortcode INTEGER NOT NULL,
  bname VARCHAR(20) NOT NULL,
  cash DECIMAL(10,2) NOT NULL,
  CONS
)

CREATE TA
  no IN
  type VARCHAR(8) NOT NULL,
  cname VARCHAR(20) NOT NULL,
  rate DECIMAL(4,2) NULL,
  sortcode INTEGER NOT NULL,
  CONSTRAINT account_pk PRIMARY KEY (
  CONSTRAINT account_fk FOREIGN KEY (
  REFERENCES branch
)
```



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Keys and the Primary Key

Keys

The alternative keys of a table are called **candidate keys**

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Primary Key

- Choose the key most often used to access a table as the **primary key**
- Has no l
- Has an o r
- All oth

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Declaring Primary Keys after table creation

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```
ALTER TABLE branch
ADD CONSTRAINT branch_pk PRIMARY KEY
```

Declaring Secondary Keys for a table

```
CREATE UNIQUE INDEX branch_bname_key ON branch(bname)
```

SQL DML: Inserting, Updating and Deleting Data

```
INSERT INTO account
VALUES (100,'current','McBrien, P.',NULL,67),
(101,'deposit','McBrien, P.',5.25,67),
(103,'current','Boyd, M.',NULL,34),
(107,'current','Poulovassilis, A.',NULL,56),
(119,'deposit','Poulovassilis, A.',5.50,56),
(125,'current','Bailey, J.',NULL,56)
```

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

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```
UPDATE a
SET t
WHERE n
```

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[illegible]	[illegible]	[illegible]	ate	sortcode
[illegible]	[illegible]	[illegible]	NULL	67
[illegible]	[illegible]	[illegible]	5.25	67
[illegible]	[illegible]	[illegible]	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	[illegible]	[illegible]	50	56
125	[illegible]	[illegible]	LL	56

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```
DELETE
FROM account
WHERE no=100
```

no	[illegible]	[illegible]	te	sortcode
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

SQL DML: An Implementation of the RA

SQL SELECT statements: Rough Equivalence to RA

```
SELECT A1,...,An
FROM   R1,...,Rm
WHERE  P1
```

$\Leftrightarrow \pi_{A_1,\ldots,A_n} \sigma_{P_1 \wedge \ldots \wedge P_k} R_1 \times \ldots \times R_m$

SQL SELE

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$\pi_{\text{bname,no}} \sigma_{\text{branch.sortcode=account.sortcode} \wedge \text{account.typ}}$

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```
SELECT branch.bname,
       account.no
FROM   account, branch
WHERE  account.sortcode=branch.sortcode
AND    account.type='current'
```

Naming columns in SQL

Column naming rules in SQL

- You must never have an ambiguous column name in an SQL statement
- You can use SELECT * to indicate all columns (*i.e.* have no projection)
- You can use tablename.* to imply all columns from a table

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✓

```
SELECT  branch
        accou
FROM    accou
WHERE   account.sortcode=
            branch.sortcode
AND     account.type='current'
```

```
WHERE   account.sortcode=
            branch.s
AND     type='current'
```

```
                    .sortcode
                    ,branch
WHERE   account.sortcode=
                    sortcode
```

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✓

```
SELECT  branch.*,
        no
FROM    account,branch
WHERE   account.sortcode=
            branch.sortcode
AND     type='current'
```

⇨

sortcode	bname	cash	no
67	'Strand'	34005.00	100
34	'Goodge St'	8900.67	103
56	'Wimbledon'	94340.45	107
56	'Wimbledon'	94340.45	125

Quiz 1: Translating RA into SQL

Which SQL query implements $\pi_{\text{bname,no}}\,\sigma_{\text{type='deposit'}}(\text{account} \bowtie \text{branch})$?

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A

```
SELECT *
FROM   a
WHERE  t
```

B

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C

```
SELECT bname, no
FROM   branch, account
WHERE  branch.sortcode=
         account.sortcode
AND    type='deposit'
```

D

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```
SELE
FRO
WHERE  branch.sortcode=
         account.no
AND    type='deposit'
```

Connectives Between SQL SELECT statements

Binary operators between SELECT statements

- SQL UNION implements RA ∪
- SQL EXCEPT implements RA −
- SQL INTERSECT implements RA ∩

Note that tw ype
of columns

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π_{no}account − π_{no}movement

```
SELECT  no
FROM    account
EXCEPT
SELECT  no
FROM    movement
```

SQL Joins: Four ways of asking branch ⋈ account

‘Classic’ SQL Join Syntax

```
SELECT branch.*, no, type, cname, rate
FROM   branch, account
WHERE  branch.sortcode=account.sortcode
```

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Modern S

```
SELECT b
FROM   b                                              ode
```

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Special Syntax for Natural Join

```
SELECT *
FROM   branch NATURAL JOIN account
```

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Another Special Syntax for Natural Join

```
SELECT branch.*, no, type, cname, rate
FROM   branch JOIN account USING (sortcode)
```

Overview of RA and SQL correspondances

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RA and SQL

RA Operator	SQL Operator
$R_1 \overset{\theta}{\bowtie} R_2$	FROM R_1 JOIN R_2
$R_1 - R_2$	R_1 EXCEPT R_2
$R_1 \cup R_2$	R_1 UNION R_2
$R_1 \cap R_2$	R_1 INTERSECT R_2

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Try some examples yourself . . .

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```
 sortcode |   bname   |   cash    | no  |   type   |       cname       | rate
----------+-----------+-----------+-----+----------+-------------------+---------
       67 | Strand    | 34005.00  | 100 | current  | McBrien, P.       |
       67 | Strand    | 34005.00  | 101 | deposit  | McBrien, P.       | 5.25
       34 | Goodge St |  8900.67  | 103 | current  | Boyd, M.          |
       56 | Wimbledon | 94340.45  | 107 | current  | Poulovassilis, A. |
       56 | Wimbledon | 94340.45  | 119 | deposit  | Poulovassilis, A. | 5.50
       56 | Wimbledon | 94340.45  | 125 | current  | Bailey, J.        |
```

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. . . and find out that not all DBMSs are the same

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```
Msg 102, Level 15, State 1
Server 'DOWITCHER', Line 2
Line 2: Incorrect syntax near 'account'.
```

SQL: Bags and Sets

```
SELECT ALL sortcode
FROM   account
```

```
SELECT DISTINCT sortcode
FROM   account
```

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$\approx \pi_{\text{sortcode}}\text{account}$
sortcode
56
34

$\pi_{\text{sortcode}}\text{account}$
sortcode

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SQL SELECT: Bag semantics

- By default, an SQL SELECT (equivalent to an RA π) does *not* eliminate duplicates, and returns a **bag** (or **multiset**) rather than a set.
- Any SELECT that does not cover a key of the input relation, and requires a set based answer, should use DISTINCT.

Quiz 2: Correct use of SELECT DISTINCT (1)

branch(sortcode,bname,cash)
key branch(sortcode)
key branch(bname)

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Which SQL query requires the use of DISTINCT in order to avoid the possibility of a bag being produced?

A

```
SELECT
FROM    branch
WHERE   cash >10000
```

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```
FROM
WHER
```

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C

```
SELECT  bname, cash
FROM    branch
```

D

```
SELECT  cash
FROM    branch
WHERE   cash >10000
```

Quiz 3: Correct use of SELECT DISTINCT (2)

branch(sortcode,bname,cash)
account(no,type,cname,rate,sortcode)

key branch(sortcode)
key branch(bname)
key account(no)

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Which SQL query requires the use of DISTINCT in order to avoid the possibility of a bag being produced?

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A

```
SELECT  *
FROM    branch NATURAL JOIN
        account
```

B

```
SELECT  branch.sortcode,type,rate
FRO
```

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C

```
SELECT  branch.sortcode,no
FROM    branch NATURAL JOIN
        account
```

D

```
SELECT  branch.sortcode,no,cash
FROM    branch NATURAL JOIN
        account
```

Quiz 4: Operators that might produce bags

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If R and
implemen

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A

σR

$R \cup S$

$R - S$

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Bag and Set operations in SQL

RA Operator	Set Based SQL	Bag Based SQL
$\pi_{A_1,\ldots,A_n}$	SELECT DISTINCT $A_1,\ldots,A_n$	SELECT ALL $A_1,\ldots,A_n$
$R_1 \times \ldots \times R_m$	FROM $R_1,\ldots,R_m$	FROM $R_1,\ldots,R_m$
$\sigma_{P_1,\ldots,P_k}$	WHERE P_1 AND … AND P_k	WHERE P_1 AND … AND P_k
$R_1 \cup R_2$	R_1 UNION DISTINCT R_2	R_1 UNION ALL R_2
$R_1 - R_2$	R_1 EXCEPT DISTINCT R_2	R_1 EXCEPT ALL R_2
$R_1 \cap R_2$		2

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Chosing be [illegible]

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If you omit
SELECT ALL
UNION DISTINCT
EXCEPT DISTINCT
INTERSECT DISTINCT

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No FROM DISTINCT or WHERE DISTINCT?

There is no need for DISTINCT or ALL around FROM (×) and WHERE (σ) cannot introduce any duplicates, and any existing duplicates can be removed in the SELECT

Project-Select-Product Queries

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SQL SELECT statements: Exact Equivalence to RA

SELECT DISTINCT $A_1, ..., A_n$

R_m

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- SQL SELECT implements RA π, σ and $\times$
- Omit DISTINCT when either
  - you known $A_1, ..., A_n$ cover a key
  - you want a bag (rather than set) answer

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Quiz 5: SQL EXCEPT

```
SELECT  no
FROM    movement
EXCEPT
SELECT  no
FROM    account
```

movement			
mid	no	amount	tdate
1000	100	2300.00	5/1/1999
1001	101	4000.00	5/1/1999
1002	100	-223.45	8/1/1999
1004	107	-100.00	11/1/1999
1005	103	145.50	12/1/1999
1006	100	10.23	15/1/1999
1007	107	345.56	15/1/1999
1008	101	1230.00	15/1/1999

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

What is the r

A

no
100
101
103
107
119
125

B

no
100
101
103
107
119

C

no
100
100
101
107

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Quiz 6: SQL EXCEPT ALL

```
SELECT   no
FROM     movement
EXCEPT ALL
SELECT   no
FROM     account
```

movement			
mid	no	amount	tdate
1000	100	2300.00	5/1/1999
1001	101	4000.00	5/1/1999
1002	100	-223.45	8/1/1999
1004	107	-100.00	11/1/1999
1005	103	145.50	12/1/1999
1006	100	10.23	15/1/1999
1007	107	345.56	15/1/1999
1008	101	1230.00	15/1/1999

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

What is the r

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A

no
100
101
103
107
119
125

B

no
100
101
103
107
119

C

no
100
100
101
107

Table Aliases and Self Joins

Table and Column Aliases

The SQL operator AS allows a column or table name to be renamed.

Essential when needing to join a table with itself

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List people with a current and a deposit account

```
SELECT

FROM    account AS current_account
        JOIN account AS deposit_account
        ON   current_account.cname=d
        AND  current_account.type='curr
        AND  deposit_account.type='dep
```

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cname	current_no	deposit_no
'McBrien, P.'	100	101
'Poulovassilis, A.'	107	119

Table Aliases

current_account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'c			
119	'd			
125	'c			

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deposit_account				
no	type	cname	rate	s
100	'current'	'McBrien, P.'	NULL	
101	'deposit'	'McBrien, P.'	5.25	
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

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Worksheet: Translating Between Relational Algebra and SQL

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movement			
mid	no	amount	tdate
			/1/1999
			/1/1999
			/1/1999
			/1/1999
			/1/1999
1006	100	10.23	15/1/1999

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no				
100				
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	3
107	'current'	'Poulovassilis, A.'	NULL	5
119	'deposit'	'Poulovassilis, A.'	5.50	5
125	'current'	'Bailey, J.'	NULL	5

99

99

99

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no

Set Operations: IN

IN operator tests for membership of a set

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```
SELECT  *
FROM    account
WHERE
AND
```

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Can use nested SELECT to generate set

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```
SELECT  no                                          SELECT
FROM    account                                     FROM
WHERE   type='current'                    ≡                                no
AND     no  IN  (SELECT  no                         WHERE  type='current'
                 FROM    movement                   AND    amount>500
                 WHERE   amount>500)
```

Quiz 7: SQL Set Membership Testing

```
SELECT no
FROM   account
WHERE  type='current'
AND    no NOT IN
       ( SELECT no
```

≠

```
SELECT DISTINCT account.no
FROM   account
       JOIN movement
       ON account.no=movement.no
WHERE  type='current'
```

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What is the r

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A

no
100
103
107
125

B

no
100
103
107

C

no
103
107
125

107

Set Operations: EXISTS

Testing for Existence

- IN can be used to test if some value is in a relation, either listed, or produced by some SELECT statement
- EXISTS can be used to test if a SELECT statement returns any rows

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List people

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```
SELECT DI
FROM    account
WHERE   cname NOT IN
( SELECT cname
  FROM   account
  WHERE  type='deposit')
```

```
FROM    account
WHERE N
=( SELEC
   FROM          account
   WHER
   AND      account.cname=cname)
```

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cname
‘Boyd, M.’
‘Bailey, J.’

Correlated Subquery

Correlated Subquery

- A correlated subquery contains a reference to the columns of the outer query in which the subquery is contained
- Conceptually, result is as if the subquery were executed for each row considered by the WHERE clause

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List people

```
SELECT  DIS
FROM    account
WHERE NOT  EXISTS
( SELECT  *
  FROM    account  AS  deposit_account
  WHERE   type='deposit'
  AND     account.cname=cname)
```

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cname
'Boyd, M.'
'Bailey, J.'

Set Operations: EXISTS

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NOT EXISTS and EXCEPT

- Most queries involving EXCEPT can be also written using NOT EXISTS
- EXCEPT relatively recent addition to SQL

π_{no}accou

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```
SELECT  no                 SELECT  no
FROM    account            FROM    account
EXCEPT               ≡     WHERE   NOT EXISTS
SELECT  no
FROM    movement                                                   .no)
```

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Set Operations: SOME and ALL

Can test a value against members of a set

- V op SOME S is TRUE is there is at least one $V_s \in S$ such that V op V_s
- V op ALL S is TRUE is there are no values $V_s \in S$ such that NOT V op V_s

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names of branches that only have current accounts

```
SELECT
FROM
WHERE

                    WHERE   branch                         ode)
```

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names of branches that have deposit accounts

```
SELECT  bname
FROM    branch
WHERE   'deposit'=SOME (SELECT  type
                        FROM    account
                        WHERE   branch.sortcode=account.sortcode)
```

Worksheet: Set Operations

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branch		
sortcode	bname	cash
56	'Wimbledon'	94340.45
34	'Goodge St'	8900.67
67	'	

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
			LL	34
			LL	56
			50	56
			LL	56

mid	no		
1000	100		
1001	101	4000.00	5/1/1999
1002	100	-223.45	8/1/1999
1004	107	-100.00	11/1/1999
1005	103	145.50	12/1/1999
1006	100	10.23	15/1/1999
1007	107	345.56	15/1/1999
1008	101	1230.00	15/1/1999
1009	119	5600.00	18/1/1999

key branch(so

key branch(b

key movemen

key account(n

movement(no) $\overset{fk}{\Rightarrow}$ account(no)

account(sortcode) $\overset{fk}{\Rightarrow}$ branch(sortcode)

Worksheet: Set Operations (3)

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Write an SQL query without using any negation (*i.e.* without the use of NOT or EXCEPT) t -1999.

```
SELECT
FROM
WHERE      _     _        <
                                  FROM     mo
                                  WHERE    mo
```

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Worksheet: Set Operations (4)

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Write an SQL query that lists the cname of customers that have every type of account that appears in account

```
SELECT  DIS
FROM
WHERE   NO
```

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```
                 EXCEPT
                 SELECT  type
                 FROM    account
                 WHERE   account.                    ame
               )
```

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Set Operations: NOT SOME NOT and ALL

Equivalence between *exists* and *for all*

In first order classical logic $\neg\exists\neg \equiv \forall$

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accounts with all movements less than or equal to 500

```
SELECT
FROM
WHERE



                  WHERE   account.no=
```

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$\equiv$

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```
SELECT  no
FROM    account
WHERE   NOT 500<SOME (SELECT  amount
                      FROM    movement
                      WHERE   account.no=movement.no)
```

Null

Several definitions of null have been proposed, including:

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1. null represents a something that is not present in the UoD
2. null re o not know its val
3. null re now its value a

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SQL handling of NULL

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- SQL uses a three valued logic to process W
- Truth values are TRUE, FALSE, and UNKNOWN
- SQL standard vague, but handling of NULL is nearest to option 2

Quiz 8: SQL handling of NULL (1)

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

```
SELECT no
FROM   account
WHERE  rate=NULL
```

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What is the r

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A

no
100
101
103
107
119
125

B

no
100
103
107
125

C

no
101
119

D

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Quiz 9: SQL handling of NULL (2)

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

```
SELECT no
FROM   account
WHERE  rate=null
OR     rate<>null
```

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What is the r

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A

no
100
101
103
107
119
125

B

no
100
103
107
125

C

no
101
119

D

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SQL implements three valued logic

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AND

P_1 AND P_2		P_2		
		TRUE	UNKNOWN	FALSE
P_1	TRUE	TRUE	UNKNOWN	FALSE
	UNKNOWN	UNKNOWN	UNKNOWN	FALSE
	FALSE	FALSE	FALSE	FALSE

NOT

NOT P_1
OWN

OR

P_1 OR P_2				
P_1	TRUE	TRUE	TRUE	TRUE
	UNKNOWN	TRUE	UNKNOWN	UNKNOWN
	FALSE	TRUE	UNKNOWN	FALSE

Truth values of SQL Formulae

Formula	Result
x=null	UNKNOWN
null=null	UNKNOWN
x IS NULL	TRUE if x has a null value, FALSE otherwise
x IS NOT NULL	TRUE if x does not have a null value, FALSE otherwise

‘Correct’ SQL Queries Using null

Correct testing for NULL

```
SELECT no                  SELECT no
FROM   account      ⇒      FROM   account
WHERE  rate=NULL           WHERE  rate IS NULL
```

```
SELECT no
FROM   account
WHERE  rate=NULL      ⇒
OR     rate<>NULL            OR     rate IS NOT NULL
```

Testing for logical truth value

```
SELECT no
FROM   account
WHERE  (rate=5.50) IS NOT TRUE
```

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Quiz 10: SQL 'Might Be'

```
SELECT no
FROM   account
WHERE  (rate=5.25) IS NOT FALSE
```

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
			NULL	56

What is the r

A

no
100
101
103
107
125

B

no
100
103
107
119
125

C

no
100
103
107
125

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Worksheet: Null values in SQL

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movement			
mid	no	amount	tdate
0999	119	45.00	null
100			
100			
100			
100			
100			
1006	100	10.23	15/1/1999
1008	101	1230.00	15/1/1999
1009	119	5600.00	18/1/1999
1010	100	null	20/1/1999
1011	null	null	20/1/1999
1012	null	600.00	20/1/1999
1013	null	-46.00	20/1/1999

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		ortcode
		67
		67
119	'deposit'	6
125	'current'	6

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Quiz 11: SQL EXCEPT and NULL

```
SELECT  rate
FROM    account
WHERE   no<105
EXCEPT
SELECT  rate
FROM    a
WHERE   s
```

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
			LL	56
			.50	56
			LL	56

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What is the r

A

rate

B

rate
5.25

C

rate
5.25
null

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5.25
null
null

Equivalences Between EXCEPT, NOT IN and NOT EXISTS

R(A) and S(B), A and B are not nullable

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```
SELECT  A             SELECT  A                    SELECT  A
FROM    R             FROM    R                    FROM    R
EXCEPT          ≡     WHERE   NOT EXISTS     ≡     WHERE   A NOT IN
SELECT  B                                                      ECT  B
FROM    S                                                    OM     S)
```

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R(A) and S(B), A or B are nullable

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```
SELECT  A             SELECT  A
FROM    R             FROM    R
EXCEPT          ≢     WHERE   NOT EXISTS           ≢   WHERE   A NOT IN
SELECT  B                     (SELECT  *                       (SELECT  B
FROM    S                      FROM    S                        FROM    S)
                               WHERE   S.B=R.A)
```

Quiz 12: SQL EXCEPT and NOT IN

```
SELECT rate
FROM   account
WHERE  no < 105
AND    rate NOT IN
```

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

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What is the result of the above SQL query?

A

rate

B

rate
5.25

C

rate
5.25
null

rate
5.25
null
null

Quiz 13: SQL EXCEPT and NOT EXISTS

```
SELECT rate
FROM   account
WHERE  no<105
AND    NOT EXISTS
       (SELECT *
```

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

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What is the result of the above SQL query?

A

rate

B

rate
5.25

C

rate
5.25
null

rate
5.25
null
null