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Imperial College London

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Development of Relational Database Systems

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- IBM deleveped a prototype relational database called **System R** with a query language **Structured English Query Language** (**SEQUEL**)
- SEQUEL later renamed SQL
- Various tunners version Uf SO Jam Sed in all 1770's/early 1980s
 - DB2
 - 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: SQL Data Types

		Some SQL Data Types
	Keyword	Semantics
H	Bostignme	Horica Palmo (TRUE FALSE ETUNKNOWN) He
	INTEGER	32 bit integer
	BIGINT	64 bit integer
	FLOAT(m)	An n bit mantissa floating point number
	REAL NITTOS	32/bt Idatig point number (= FLOAT(24)) 64 bit floating point number (= FLOAT(53))
	DOUBLE PRECISION	64 bit floating point number (≡ FLOAT(53))
	DECIMAL(p,s)	A p digit number with s digits after the decimal point
	CHAR(n)	A fixed length string of <i>n</i> characters
	VARCHAR(A)	A varying length string of upto p characters
	DATE VV CC.	A varying length string of upto p characters A calebdar date (day month and year)
	TIME	A time of day (seconds, minutes, hours)
	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

SQL DML: Definition of Keys

```
ntul Project Exam Help
cash DECIMAL(10,2) NOT NULL,
CONSTRAINT branch_pk PRIMARY KEY (sortcode)
    https://tutores.com
no INTEGER NOT NULL.
type VARCHAR(8) NOT NULL,
                                account(sortcode) \stackrel{fk}{\Rightarrow} branch(sortcode)
cname VARCHAR(20) NOT NULL,
CONSTRAINT account pk PRIMARY KEY Inc
CONSTRAINT account_fk FOREIGN KEY (sortcode)
REFERENCES branch
```

Keys and the Primary Key

Keys

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

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- Choose the key most often used to access a table as the **primary key**
- Has no logical impact on the relational model
- Has an operation impact index created that accesses the data faster
- All other keys are called secondary keys. COM

Declaring Primary Keys after table creation

ALTER TAKE Chat: CSTUTOTCS

ADD CONSTRAINT branch_pk PRIMARY KEY (sortcode);

Declaring Secondary Keys for a table

CREATE UNIQUE INDEX branch_bname_key ON branch(bname)

type

account

rate

NULL

NULL

5.50

sortcode

'Poulovassilis, A.'

'Poulovassilis, A.'

'Bailey, J.'

SQL DML: Inserting, Updating and Deleting Data

		cname	rate	sortcode
• 100	'current'	'McBrien, P.'	NULL	1 67
1 (1)	🖜 🎁 tepos 🗀	WcBrin, P.	_5.25 <i>C</i>	177
103	'urrer_'	Boy (M.	NU L	ノ 【 3 4
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56
		account		
_ no.	type _		rate	sortcode
15	dep sit	M Brien, P.'		67
107	genosit			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
44		•		
шш				
CUI		account		
<u>no</u>	type	cname	rate	sortcode
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
	107 119 125 103 107 119 125 103 107 119 125	100 'current' 101 'tepos' 107 'current' 119 'deposit' 125 'current' 107 'deposit' 125 'current' 107 'deposit' 107 'deposit' 107 'current' 107 'current' 119 'deposit' 125 'current' 111 OT (no type 101 'deposit'	100 'curren' 'McBrien, P.' 101 'tepos ' 'McBrien, P.' 107 'current' 'Poulovassilis, A.' 119 'deposit' 'Poulovassilis, A.' 125 'current' 'Bailey, J.' 107 'current' MBrien, P.' 108 'deposit MBrien, P.' 107 'current' 'Boyd, M.' 119 'deposit' 'Poulovassilis, A.' 119 'deposit' 'Poulovassilis, A.' 125 'current' 'Bailey, J.' 110 'deposit' 'McBrien, P.' 110 'deposit' 'McBrien, P.'	100

INSERT INTO account

107

119

125

'current'

'deposit'

'current'

56

56

56

SQL DML: An Implementation of the RA

SQL SELECT statements: Rough Equivalence to RA

Assignment Project Exam Help WHERE P1 AND ... AND Pk SQL SELENT A1 An Project Exam Help AND Pk SQL SELENT A1 An Project Exam Help AND Pk SQL SELENT A1 An Project Exam Help AND Pk SQL SELENT A1 An Project Exam Help AND Pk SQL SELENT A1 An Project Exam Help AND Pk SQL SELENT A1 An Project Exam Help AND Pk SQL SELENT A1 An Project Exam Help AND Pk

 $\pi_{\mathsf{bname},\mathsf{no}}\,\sigma_{\mathsf{branch}.\mathsf{sortcode} = \mathsf{account}.\mathsf{sortcode}} \land \mathsf{account.type} = `\mathsf{current'}(\mathsf{branch} \times \mathsf{account})$

SELECT by Chat: cstutorcs

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
- ASSIBUMMENT of indicate all columns (i. have no projection Help



SELECT branch.*,

FROM account, branch
WHERE account.sortcode
branch.sortcode
AND type='current'

	sortcode	bname	cash	no
N.	67	'Strand'	34005.00	100
\Box	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_{bname,no} \sigma_{type='deposit'}(account \bowtie branch)?
Assignment Project Exam Help
 SELECT.
                                          SELECT bname, no
          adcount branch // tutor Green decount branch type to be to be the posit
 FROM
 WHERE
          bn We Chat: cstutores
 SELECT
                                                   account branch
 FROM
 WHERE
                                          WHERE
                                                   branch sortcode=
          branch.sortcode=
              account sortcode
                                                       account no
 AND
          type='deposit'
                                          AND
                                                   type='deposit'
```

Connectives Between SQL SELECT statements

Binary operators between SELECT statements

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■ SQL INTERSECT implements RA ∩

π_{no} account $-\pi_{no}$ movement

FROM LECT CSTUTORS

EXCEPT

SELECT no

FROM movement

SQL Joins: Four ways of asking branch ⋈ account

'Classic' SQL Join Syntax

```
SELECT branch.*, no, type, cname, rate
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```

Modern SQL Join Syntax

```
SELECT branch branch branch sortcode account sortcode
```

Special Syntax for Natural Join
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FROM branch NATURAL JOIN account

Another Special Syntax for Natural Join

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

Overview of RA and SQL correspondances

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RA Operator SQL Operator π SELECT

WHERE FROM R₁ TROS JOIN R₂

R₁ \bowtie R₂ FROM R₁ NATURAL JOIN R₂

R₁ \bowtie R₂ FROM R₁ JOIN R₂ ON θ R₁ EXCEPT R₂

R₂ INIOURS TUTORS

Try some examples yourself ...

ledesa s2 pm - 4% pscl - rub - J lab - d ban : been in W | E X and He Password: bank_branch=> SELECT * bank_branch=> FROM branch NATURAL JOIN account;

sortcode	htteps://atutorcse.comname	rate
67	Strand 34005.00 100 current McBrien, P.	I
	Strand 34005.00 101 deposit McBrien, P.	5.25
34	Goodge St 8900.67 103 current Boyd, M.	1
56	Wybleich 1349.15 100 c thrieft 1701 c assilis Wimble do	s, A.
56	Wimbledon 04810.45 M90 deposit Porleyassilis	s, A. 5.50
56	Wimbledon 94340.45 125 current Bailey, J.	1

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

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```
medusa-s2(pjm)-4$ sqsh -S sqlserver -X -U lab -D bank_branch
Password:
[21] sqlserver.bank_branch.1> SELECT *
[21] sqlserver.bank_branch.2> FKOM branch NATURAL JOIN account
[21] sqlserver.bank_branch.3> /g
```

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

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```

SQL: Bags and Sets

SELECT ALL sortcode
FROM account

SELECT DISTINCT sortcode
FROM account
FROM account
FROM account
FROM account
FROM account
Sortcode
67
34

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WeChat: cstutorcs 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)

Assignment Psroject Exam Help possibility of a bag being produced?

nttps://tutorcs.com SELECT sortcode SELECT branch **FROM** branch **FROM** WHERE WHERE cash > 10000 $cash \ge 10000$ VeChat: cstutorcs \mathbf{C} SELECT. bname, cash SFLECT cash branch **FROM FROM** branch WHFRF 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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nttps://tutorcs.com

SFIFCT * **FROM**

branch NATURAL JOIN

account

branch . sortcode , type , rate **FROM** branch NATURAL IOIN account

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FROM

SELECT branch.sortcode, no branch NATURAL JOIN

FROM

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

account

Quiz 4: Operators that might produce bags

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If R and S are sets, which RA operator could produce a bag result if the implementation did not check for duplicates?

A

B

C

D σR $R \cup S$ R - S $R \times S$

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Bag and Set operations in SQL

RA Operator Set Based SQL SELECT DISTINCT A_1, \ldots, A_n SELECT ALL A_1, \ldots, A_n FROM R_1, \ldots, R_n UNION ALL R_2 R_1 UNION ALL R_2 R1 EXCEPT DISTINCT R_2 R2 EXCEPT ALL R_2 R3 INTERSECT ALL R_2

Chosing between set and bag sententies CS. COM

If you omit DISTIACT or ALL, then the defaults are:

SELECT ALL

UNION DISTINCT

EXCEPT DENICE Chat: cstutorcs

No FROM DISTINCT or WHERE DISTINCT?

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

Project-Select-Product Queries

```
ECT statuments I was Equivalence of R. - X 2 111 - C 1
  SELECT DISTINCT A1, ..., An
  FROM R<sub>1</sub>, ..., R<sub>m</sub>
 where P_1 = \pi_{A_1,...,A_n}\sigma_{P_1\wedge...\wedge P_k}R_1\times...\times R_m
```

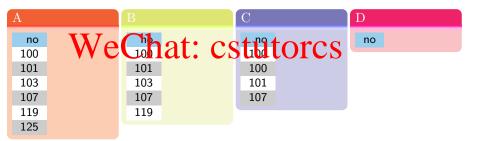
- SQL SELECT implements RA π , σ and \times
- Omit Wyou known A₁,..., A_n cover a key

 - you want a bag (rather than set) answer

Quiz 5: SQL EXCEPT



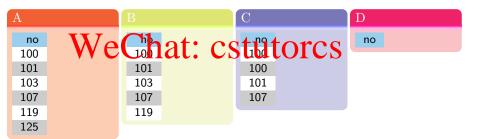
What is the tips://tutores.com



Quiz 6: SQL EXCEPT ALL



What is the tips://tutores.com



sortcode

Table Aliases and Self Joins

Table and Column Aliases

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

Assential wernerding to init a Problect Exam Help

List people with a current and a deposit account

SELECT

https://tutorcs.com

deposit_account.no AS deposit_no

FROM

account AS current_account

JOIN account AS deposit_account

ON arrentagent crarge ount. cname

AND Cartent action to the latest the state of the state o

AND deposit_account.type='deposit



cname	current_no	deposit _ no
'McBrien, P.'	100	101
'Poulovassilis, A.'	107	119

Table Aliases

```
current_account
                                                sortcoder
      type
                  cname
                                         rate
                                                         Exam Help
                                                    67
                   McBrien, P.
       'desesit
103
      'current'
                  'Boyd, M.'
                                       NULL
                                                      34
107
      'current'
                  'Poulovassilis. A.'
                                       NULL
                                                      56
119
      'de posit'4
                  'Poulovass/lis. A
125
                    deposit_account
                                                sortcode
                  cname.
 <u>no</u>
                                         rate
      'cur
100
101
      'deposit
                   McBrien, P
                                       NULL
103
      'current'
                  'Boyd, M.'
                                                      34
107
      'current'
                  'Poulovassilis, A.'
                                       NULL
                                                      56
119
      'deposit'
                  'Poulovassilis, A.'
                                         5.50
                                                      56
```

'current'

'Bailey, J.'

125

NULL

56

Worksheet: Translating Between Relational Algebra and SQL

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1000 100 2200 00

E /1 /1000

			1000	TOO	2300.00	5/1/1999
			1001	101	4000.00	5/1/1999
http://acgount	+000	20	1002	100	-223.45	8/1/1999
no hettps: coountu	late so	tegge.	1(04)	.07	-100.00	11/1/1999
100 'current' 'McBrien, P.'	NULL	67	1005	103	145.50	12/1/1999
101 'deposit' 'McBrien, P.'	5.25	67	1006	100		15/1/1999
103 'current' 'Boyd, M.'	NULL	34	1007			15/1/1999
107 'current' 'Poulovassilis, A.'	NULL	56	1008	101	1230.00	15/1/1999
119 'deposite foulovassilla, A. 125 'current Bailey, J.	7.30C 1	16	(1609)	119	5600.00	18/1/1999
125 'current Bailey, J.'	NOTE	56		<i>,</i>	f_k	account no
			moven	nent	(no)⇒ a	account no

IN operator tests for membership of a set

ssignment Project Exam Help

FROM account

WHERE type='current'

AND

"https://tutorcs.com

Can use nested SELECT to generate set

SELECT **FROM** WHERE (SELECT no AND

no we Chat: CS FITTO SCCOUNT. NO account Company of the Company of

ON account.no=movement.no type='current'

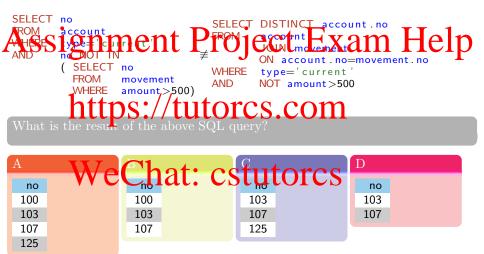
FROM movement WHERE amount >500)

WHERE AND

amount >500

P.J. McBrien (Imperial College London)

Quiz 7: SQL Set Membership Testing



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 statement4 It Project Exam. He

```
List people without a deposit account
```

SELECT. **FROM** account WHFRF cname NOT IN SELECT **FROM**

WHERE type='deposit')

FROM account WHERE NOT EXISTS

account AS deposit_account type='deposit

AND account.cname=cname)

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 to the subquery in the subquery in the subquery in the subquery in the subquery was a subquery with the subquery was a subquery was a subquery with the subquery was a sub

```
List people without a deposit account
       muds://tutores.com
SELECT.
FROM
      account
WHERE NOT EXISTS
 SELECT *
              Chat: cstutores
 FROM
 WHFRF
        type='deposit
 AND
        account.cname=cname)
 cname
 'Boyd, M.'
 'Bailey, J.'
```

Set Operations: EXISTS

NOT EXISTS and EXCEPT Droject Exam Lep

■ EXCEPT relatively recent addition to SQL



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

A SSIGNMENT Project Exam Help names of branches that only have current accounts

FROM WHERE SALL TULE OF CS. COM

WHERE branch.sortcode=account.sortcode)

names of branches that have deposit accounts OTCS

SELECT bname

FROM branch

WHERE 'deposit'=SOME (SELECT type

FROM account

WHERE branch.sortcode=account.sortcode)

Worksheet: Set Operations

```
branch
            Vimbledon
                                                    'deposit'
                                                              'McBrien, P.'
                                                                                    5.25
          'Goodge St'
                           8900.67
                                                              'Boyd, M.
                                                                                  NULL
                                              103
                                                   'current'
          'Strand'
                         34005.00
                                                              'Poulovassilis, A.'
                                                                                  NULL
                                                                                                 56
                                                    'current'
           movement
                                                  'deposit'
                                                              'Poulovassilis, A.'
                                                                                    5.50
                                                                                                 56
 mid
        no
                                                                                  NULL
                                                                                                 56
1000
      100
                      5/1/1999
1001
      101
            4000.00
                       5/1/1999
                       8/1/1999
1002
      100
            -223.45
                                             key branch(sortcode)
      107
1004
            -100.00
                      11/1/1999
                                             key branch(bname)
      103
1005
                                             key movement mid
1006
      100
1007
      107
             345.56
                      15/1/1999
                                             movement(no) \stackrel{fk}{\Rightarrow} account(no)
            1230.00
                      15/1/1999
1008
      101
                                             account(sortcode) \stackrel{fk}{\Rightarrow} branch(sortcode)
      119
            5600.00
                      18/1/1999
1009
```

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Write an SQL query without using any negation (i.e. without the use of NOT or EXCEPT) that list accounts with no movements on or before the 11-Jan-1999.

```
select https://tutorcs.com
```

WHERE '11-jan-1999'<ALL (SELECT tdate FROM movement

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Worksheet: Set Operations (4)

Arie on set many is the line i etentrs hat wagmy tybe elp

```
SELECT DISTINCT cname

FROM account

EXCEPT

WHERE SELECT type

WHERE SELECT type

Continuous account cname

Continuous account cname
```

Set Operations: NOT SOME NOT and ALL

Equivalence between exists and for all

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

ssignment Project Exam Help

```
SELECT no
FROM
     https://tutorcs.com
WHERE
                 movement
             WHERE
                   account.no=movement.no)
```

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FROM account

WHERE NOT 500<SOME (SELECT amount

FROM movement

WHERE account.no=movement.no)

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- 1 null represents a something that is not present in the UoD
- 2 null represents something that might be present in the UoD, but we do not know its value at present //4--4 constant of the unit of the constant of the unit of t
- its value at present .//that to rec is the Collin we do not know its value at present

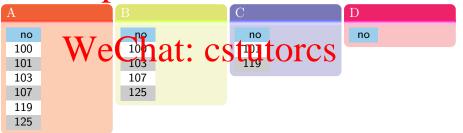
SQL handling of NULL

- SQL uses a three valuables to Grodes WHERE predicate
- 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		CELECT	
	100	'cu ⊮ ent'	'McBrien, P.'	NULL	67		SELECT no)
1	101	derosit	1 McBrison P	5.25	10/07/1	α	ENAME OF	400
F	03	ur ent'	'Lovd, M	NULL	34		F KOIVIX ax	Срип
•	107	'current'	'Poulovassilis, A.'	NULL	56		WHERE ra	te=NULI
	119	'deposit'	'Poulovassilis, A.'	5.50	56			
	125	'current'	'Bailey. J.'	NULL	56			

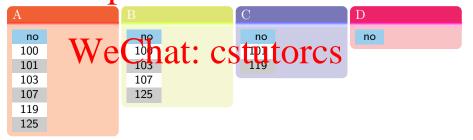




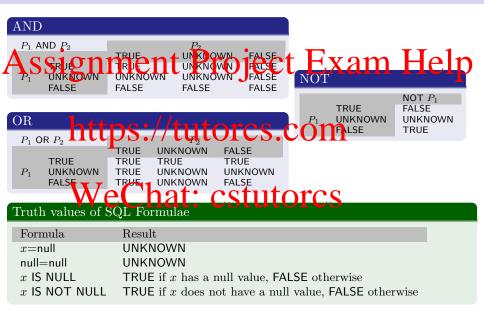
Quiz 9: SQL handling of NULL (2)

			account						
	<u>no</u>	type	cname	rate	sortcode		SELECT	no	
1	100	'cu ⊮ ent'	'McBrien, P.'	NULL	67	,		-	T 1
_/	101	denosit	1 Morrison PA 1	5.25	10071		. FROW	account	Jala
F	03	urrenc	'Loyd, M	NULL	3/	ICUI	WHERE	ate=null	
-1	107	'curre it'	'Poulovassilis, A.'	NULL	56		OD		
	119	'deposit'	'Poulovassilis, A.'	5.50	56		OR	rate<>null	
	125	'current'	'Bailey, J.'	NULL	56				

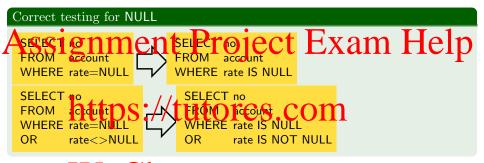
What is the the state of the st



SQL implements three valued logic



'Correct' SQL Queries Using null



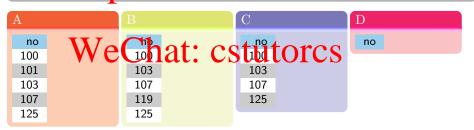
Testing for logical ruth relict. CSTULOTCS

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

Quiz 10: SQL 'Might Be'



What is thttps://tutores.com



Worksheet: Null values in SQL

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11114		announc	taute
0999	119	45.00	null
1000	100	2300.00	5/1/1999
		4000.00	5/1/1999
1002	100	1223.45	8/1/1999
1004	107	-100.00	11//1//1999
1005	103	145.50	12/1/1999
1006	100	10.23	15/1/1999
1008	101	1230.00	15/1/1999
		5600.00	18/1/1999
1010	100	(ull	2771/1919 20/1/1999
1011	hull	null	20/1/1999 •
1012	null	600.00	20/1/1999
1013	null	-46.00	20/1/1999

4			account		
Ì	ng	Tyre C	cane 111, MicBrien, F.	rate	sortcode
ļ	100	current	MicBrien, F.'	null	67
	101	'deposit'	'McBrien, P.'	5.25	67
	119	'deposit'	'Poulovassilis, A	4.' 5.50	56
	125	'current'	'Bailey, J.'	null	56

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Quiz 11: SQL EXCEPT and NULL





Equivalences Between EXCEPT, NOT IN and NOT EXISTS

R(A) and S(B), A and B are not nullable Assignment Project Exam Help FROM R EXCEPT SELECT B FROM S https://turorcs.com

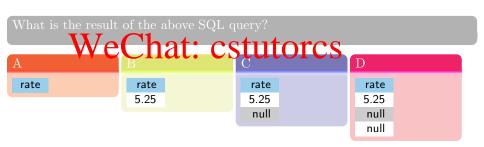
R(A) and S(B), A or B are nullable

```
SELECT A RECORD RELEGIAT. CSTUTOREST A FROM REXCEPT SELECT B FROM S SELECT B FROM S WHERE S.B=R.A)
```

Quiz 12: SQL EXCEPT and NOT IN



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Quiz 13: SQL EXCEPT and NOT EXISTS



