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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 querlanguage Structured English Query Language (SEQUEL)
- SEQUEL later renamed SQL
- Various juniters, version of SV unce dictate 177 (start) 1980s

 - 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

```
ARSIGNMENT Project branch Help

sortcode Integer Not Null,
bname VARCHAR(20) NOT NULL,
cash DECIMAL(10,2) NOT NULL

)

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CREATE TABLE account (
no INTEGER NOT NULL,
type VARCHAR(8) NOT NULL,
cname VARCHAR(8) NOT NULL,
cname VARCHAR(20) When the control of the control of
```

SQL DML: SQL Data Types

		Some SQL Data Types
	Keyword	Semantics
Z	BSSEP 21 ME	Hotica Para TRUE CALSE TUNING HON HE
-	FasiSillic	
	INTEGER	32 bit integer
	BIGINT	64 bit integer
	FLOAT(m	An n bit mantissa floating point number
	REAL NITTOS	32/b1 (bail A) (int n) n (C) F(O) (T) (A)
	DOUBLE PRECISION	64 bt 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(1)	A varying length string of upto n characters
	DATE AUU	Avarying length string of upto a characters der Vallandac date (day) mollon Veal Oder
	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

```
LE Project Exam Help
cash DECIMAL(10,2) NOT NULL,
CONSTRAINT branch_pk PRIMARY KEY (sortcode)
       ttps://powcoder.com
type VARCHAR(8) NOT NULL,
                              account(sortcode) \stackrel{fk}{\Rightarrow} branch(sortcode)
cname VARCHAR(20) NOT NULL,
                                powcoder
CONSTRAINT account_fk FOREIGN KEY (sortcode)
REFERENCES branch
```

Keys and the Primary Key

Kevs

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 ail operation impact: index created that iccesses the data faster
 All other keys are called secondary keys defined

Declaring Primary Keys after table creation

ALTER TAKE GOLD CONSTRAINT Branch_pk PRIMARY KEY (sortcode);

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	account						
	no	type	cname	rate	sortcode		
VALUES (100, 'current', 'McBrien, P.', NULL, 67),	100	'current'	'McBrien, P.'	→NULL	1 67		
ASSI PRIMERIE POI	103	lepos 'urrer'	VicBring P.	5 25 NU L	1)4		
(110) Currer Pourovassilis , At , NOLL, 30)	107	'current'	'Poulovassilis, A.'	NULL	56		
(119, 'deposit', 'Poulovassilis, A.', 5.50, 56),	119	'deposit'	'Poulovassilis, A.'	5.50	56		
(125, 'current', 'Bailey, J.', NULL, 56)	125	'current'	'Bailey, J.'	NULL	56		
UPDATE adcount //		4	account				
	6	ype	cname	rate	sortcode		
SET type Him Helit // / I	1.00	d monit	Mar ga 15	NILILI	67		

SET WHERE bites://powc

no	ype 4	cname	rate	sortc
.00	depoși '	Mçl rie , P.	NULL	
61	deposit	wcBrien, P.	5.25	
.03	'current'	'Boyd, M.'	NULL	
.07	'current'	'Poulovassilis, A.'	NULL	
19	'deposit'	'Poulovassilis, A.'	5.50	
25	'current'	'Bailey, J.'	NULL	

account

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DELETE FROM WHFRF

account no=100

110	– type
101	'deposit'
103	'current'
107	'current'
119	'deposit'
125	'current'

account		
cname	rate	sortco
'McBrien, P.'	5.25	(
'Boyd, M.'	NULL	3
'Poulovassilis, A.'	NULL	į
'Poulovassilis, A.'	5.50	į
'Bailev. J.'	NULL	

67 34

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 ALTER Project Exam Help AND Pk SQL SELENT ALTER Project Exam Help **AND Pk *

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

SELECT Add WeChat powcoder

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 SS12 us ment to inplicate all columns (i.e. have no projection Help



SELECT branch.*,

AND

FROM account . branch WHFRF

ccount.sortcode=	
branch.sortcode	
vne='current'	

	sortcode	bname	cash	no
N.	67	'Strand'	34005.00	100
\Box	34	'Goodge St'	8900.67	103
५⁄	56	'Wimbledon'	94340.45	107
,	56	'Wimbledon'	94340.45	125

Which SQL query implements $\pi_{bname,no} \sigma_{type='deposit'}$ (account \bowtie branch)? Assignment Project Exam Help SELECT. SELECT bname, no https://pow@der.com **FROM** WHFRF hadd WeChatepowcoo **SELECT FROM** WHERE branch . sortcode= WHERE 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 ∩

Note that two tables must be union compatibles have the same number and type of columns $\frac{1}{1} \frac{1}{1} \frac{1}$

π_{no} account — π_{no} movement

SELECT no ROM 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 bhttps://pow.coder.com

Special Syntax for Natural Join
SELECT * Add WeChat powcoder

branch NATURAL JOIN account **FROM**

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 SELECT

TOTAL SCHOOL OF CONTROL OF CONTR

Try some examples yourself . . .

ledera 2 pm - 4% pscl - rub - J lab - d tan : b : n in W EX and Help Password: bank_branch=> SELECT * bank_branch=> FROM branch NATURAL JOIN account;

sortcode	https	/gash)	O₩.	cod	er.com	rate
67	Strand	34005.00	100	current	McBrien, P.	I
67	Strand	34005.00	101	deposit	McBrien, P.	5.25
34	Goodge St	I 8900.67	J 103	current	Boyd, M.	4
56	Nimbledol	1 14140 45	10	Quiren	Boyd, M. PoulovassChi,	P
56	Wimsleden	94340.48	1104	deposit	Politovas lis,	↓ 1 1 1 1 1 1 1 1 1 1
	Wimbledon					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> FROM branch NATURAL JOIN account
[21] sqlserver.bank_branch.3> /g
```

```
Msg 102, Level 15, State 1
Server 'DOWITCHER', Line 2
Line 2: Incorred Synta near WeChat powcoder
```

SQL: Bags and Sets

SELECT DISTINCT sortcode SELECT ALL sortcode FROM account nment Project Exam Help sortcode sortcode https://powcoder:com

Add WeChat powcoder 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 Project Exam Help possibility of a bag being produced?



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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SFLECT * **FROM**

branch NATURAL JOIN

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

account Add WeChat powcoder

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

FROM

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

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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 D σR $R \cup S$ $R \times S$

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Bag and Set operations in SQL

Chosing between sytand happenentic oder.com

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

SELECT ALL

UNION DISTINCT

EXCEPT DISTINCT We Chat powcoder

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

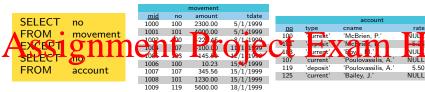
Project-Select-Product Queries

```
Estatement xx Pequagno (RExam Help
 SÉLECT DISTINCT A1, ..., An
 FROM
      R_1, ..., R_m
\frac{\text{Phere P}_1}{\text{Phere P}_k}://powcoder.com
```

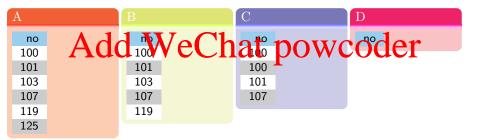
- SQL SELECT implements RA π , σ and \times
- Omit Atticulation Chat powcoder

 - you want a bag (rather than set) answer

Quiz 5: SQL EXCEPT



What is the tps://powcoder.com



sortcode



		movement	
mid	no	amount	tdate
1000	100	2300.00	5/1/1999
1001	101	4000.00	5/1/1999
1002	400	-22 .45	8/1/1999
100 1	07	100.00	11 1 1 199
1005	193	145.50	12/1 1999
1006	100	10.23	15 1999
1007	107	345.56	15/1/1999
1008	101	1230.00	15/1/1999
1009	119	5600.00	18/1/1999
	1000 1001 1001 1001 1001 1006 1007 1008	1000 100 1001 101 1002 00 1001 07 1005 100 1006 100 1007 107 1008 101	mid no amount 2300.00 100 2300.00 100 2300.00 100 101 4000.00 102 45 100 105 105 100 102 100 102 100 102 100 102 100 102 100 102 3 100 101 1230.00

			account		
	no	type	cname	rate	sortcode
	100	'urrent'	'McBrien, P.'	NUL .	67
1	10 ['eposit'	'Mchrie ,	5.2	
L	_10B	'urrent'	'F 6v , I I.'	NUL.	
7	107	'current'	'Poulovassilis, A.'	NULL	5 5
	119	'deposit'	'Poulovassilis, A.'	5.50	56
	125	'current'	'Bailey, J.'	NULL	56

What is the tips://powcoder.com

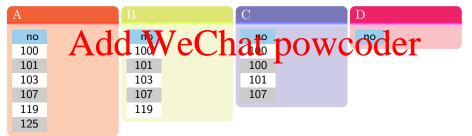


Table Aliases and Self Joins

Table and Column Aliases

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

Assisting minimenta Project Exam Help

List people with a current and a deposit account

SELECT

https://tpowcoder.com

FROM

account AS current_account

JOIN account AS deposit_account

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AND deposit_account.type='deposit



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

Table Aliases

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

56

Worksheet: Translating Between Relational Algebra and SQL

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			1000 100	2300.00	5/1/1999
			1001 101		5/1/1999
1 the cooperate	OTTIO	00	1002, 100	-223.45	8/1/1999
no hettps: coount	O MAY Sort	tore	100 107	-223.45 100 01	1/1/1999
100 'current' 'McBrien, P.	NULL	67	1005 103		12/1/1999
101 'deposit' 'McBrien, P.'	5.25	67	1006 100	10.23	15/1/1999
103 'current' 'Boyd, M.'	NULL	34	1007 107	345.56	15/1/1999
107 'current' 'Poulovasilis, A.	.' NULL	, 56			15/1/1999
119 'de oft PuloviAil's A 125 current Bailey, J.	. 5.1 0 2	56	1009 119	5500.00	1999
125 current Bailey, J.'	MAFF	56			
•		_	movemen	t(no) ⇒ a	ccount no

IN operator tests for membership of a set

ssignment Project Exam Help

FROM account

WHERE type='current'

AND

"https://powcoder.com

Can use nested SELECT to generate set

dd WeChat powcoder SELECT **FROM** WHERE (SELECT no AND WHERE type='current' **FROM**

WHERE

movement

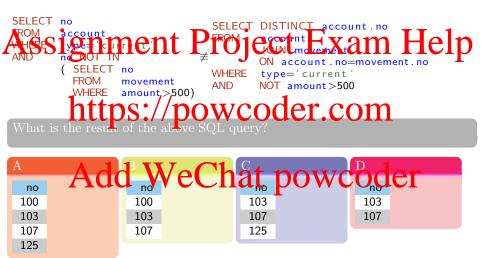
AND

amount >500

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

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List people without a deposit account **TTO STATE OF THE COMPANY OF THE COUNTY OF THE

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 is contained to the subquery in the subquery is contained to the subquery in t

```
List people without a deposit account

SELECT DISTINCT cname

FROM account
WHERE NOT EXISTS
(SELECT Add AWe Chat powcoder
FROM Account cname=cname)

Cname

'Boyd, M.'
```

'Bailey, J.'

MOST CONTROLL PROJECT EXAMELED Most Control and Also written using NOT EXISTS

■ 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

V op ALL S is TRUE is there are no values $V_s \in S$ such that NOT V_s 1 or V_s ASSIGNMENT Project names of branches that only have current accounts

SELECT bname https://pow.coder.com **FROM** WHERE

WHERE branch.sortcode=account.sortcode)

names of branches that have general the country of the contraction of

SELECT bname **FROM** branch

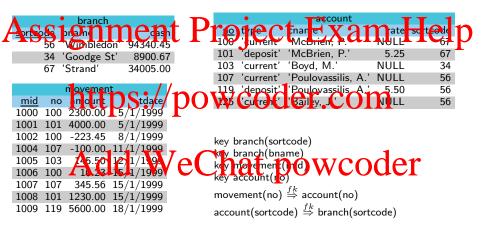
WHFRF 'deposit'=SOME (SELECT type

> **FROM** account

WHERE

branch.sortcode=account.sortcode)

Worksheet: Set Operations



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) that list accounts with no movements on or before the 11-Jan-1999.

```
SELECT nhttps://powcoder.com
WHERE '11-jan-1999'<ALL (SELECT tdate
FROM movement
```

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Worksheet: Set Operations (4)

Are or set name is the Projecters Lityaam ty-lelp

```
SELECT DISTINCT cname
FROM where Notes is constructed account except

Add Vice Capat powcoder.

Where account pame=cust_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 https://powcoder.com **FROM** 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
- null represents something that might be present in the UoD, but we do not know
- null repetent Constraint Describing Dates westered to the first the limit of the know its value at present

- SQL handling of NULL value logic optical WHEREPRACE OUCT
 - 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	'curent'	'McBrien, P.'	ŅULL	67
101	derosit	1 McBrism P	5.25	1001
03	ui rent'	'Lovd, M	NULL	34
107	'curre it'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Railey I'	NHH	56

What is threelest Mark by the state of the s



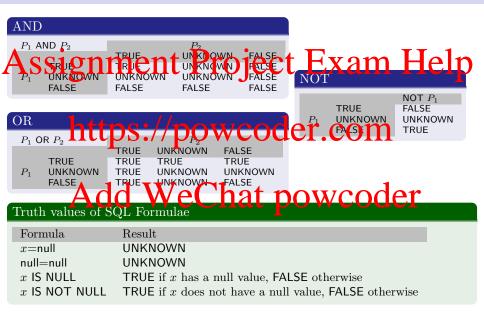
Quiz 9: SQL handling of NULL (2)

		account						
no	type	cname	rate	sortcode		SELECT	no	
<u>100</u>	'cu ⊮ ent'	'McBrien, P.'	ŅULL	67		E 00 14	→	T 4
101	de osit	McBrism P	5.25	1007 1	OOt	. FKUIVI	account	$-1 \wedge 1 \wedge$
03	ur rent	'I o d, M	NULL	34	ICUI	WHEEK	te = n III	1611)
107	'curre (t'	'Poulovassilis, A.'	NULL	56		0.0		
119	'deposit'	'Poulovassilis, A.'	5.50	56		OR	rate<>null	_
125	'current'	'Bailey, J.'	NULL	56				

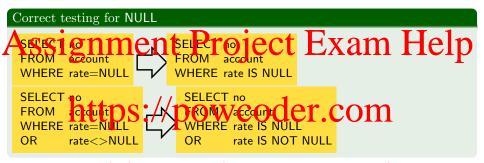
What is the the state of the st



SQL implements three valued logic



'Correct' SQL Queries Using null



Testing for Age Let uth value Chat DOWCOCET

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

Quiz 10: SQL 'Might Be'



What is thttps://powcoder.com



Worksheet: Null values in SQL

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11110		annount	tuate	J	
0999	119	45.00	null	_	
1000	100	2300.00	5/1/1999		
		4000.00	5/1/1999		
1002	100	1223,45	8/1/1999	account	
1004	107	-100.00	11//1//1999	Ont to One Sorted Condition of the Condi	
1005			12/1/1999		
1006			15/1/1999	101 deposit McBrien, P. 5.25 67	
			15/1/1999	119 deposit Poulovassilis, A. 5.50 50	
			18/1/1999)
				Chat passagar	
1010 1011	11.0	uu	2 1/1999 20/1/1999	Chat powcoder	
1012			20/1/1999		
1013	nulli	-40 00	/0/1/1999		

Quiz 11: SQL EXCEPT and NULL



What is the result of the above SQL query?



Equivalences Between EXCEPT, NOT IN and NOT EXISTS

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

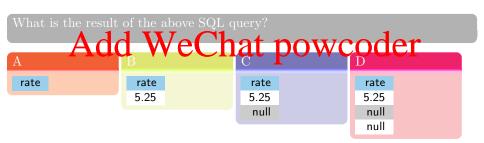
R(A) and S(B), A or B are nullable

```
SELECT A Addelew Rechat power oder FROM R WHERE NOT EXISTS \neq WHERE S.B=R.A) WHERE S.B=R.A)
```

Quiz 12: SQL EXCEPT and NOT IN



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Quiz 13: SQL EXCEPT and NOT EXISTS



