>>> A crash course in SQL
>>> Statistical Society of Australia

Daniel Fryer [†]

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[†]daniel@vfryer.com

>>> Overview

Day 1

1. Introduction
2. Intro to relational model
3. Tables and relationships
4. Programming in SQL
5. Basic SQL
6. Search conditions
7. Subqueries
8. Joining and join exercises

Page is hyperlinked: click a topic above to jump to it.

>>> Overview

Day 2

1. Reading the docs
2. Aggregating
3. Expanding the toolkit
4. Creating and editing tables
5. Independent development

   Send me questions and give feedback

Click here to find the day 2 slides.

>>> Daily schedule

Timetable				
9:00am	-	10:30am	lecture 1	(1.5 hr)
10:30am	-	11:00am	morning tea	(30 min)
11:00am	-	12:30pm	lecture 2	(1.5 hr)
12:30pm	-	1:30pm	lunch	(1 hr)
1:30pm	-	3:00pm	guided exercises	(1.5 hr)
3:00pm	-	5:00pm	one-on-one help	(2 hr)

>>> How to pronounce SQL

* S. Q. L. (Structured Query Language)
* 'SEQUEL' (Structured English Query Language)

We will be boldly using two dialects of (ISO/ANSI) SQL:

* T-SQL (Microsoft, proprietary)
* MySQL (Oracle, open-source)

>>> Working together on problems

Not yet, but soon

>>> Show of hands

Past experience

>>> The Kahoots!

Definition

A Kahoot is a fun group quiz that we'll do here and there throughout the course. Join in to test your skills.

And now for a practice Kahoot…

>>> Where are we now?

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>>> Let the learning begin

A Relational Database Management System (RDBMS).

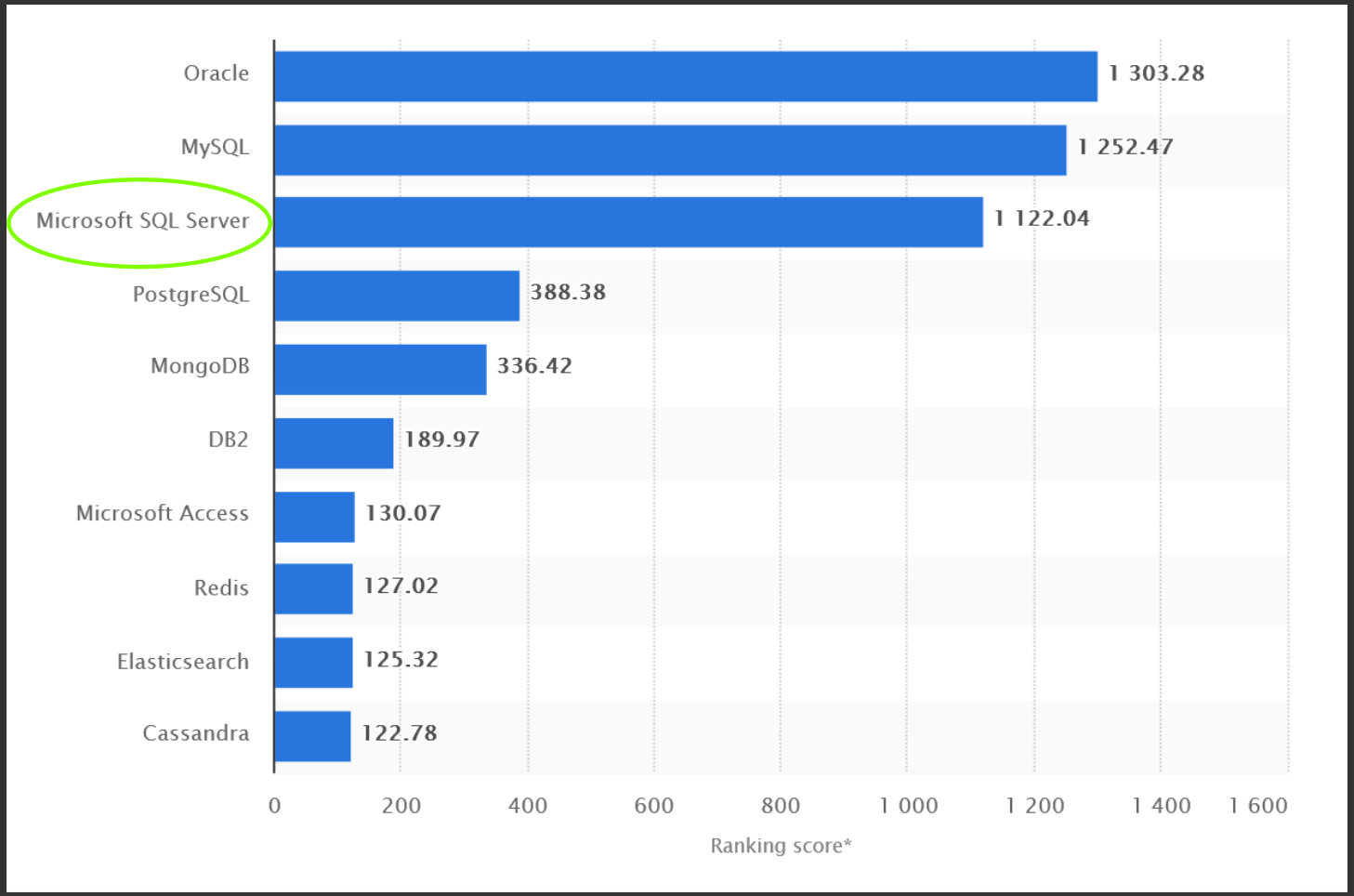
Definition

A DBMS is a large collection of interdependent programs all working together to define, construct, manipulate, protect and otherwise manage a database. An RDBMS is the most popular kind of DBMS.

SQL is a programming language for talking to your RDBMS.

>>> RDBMS

The most popular Relational Database Management Systems



Source: statista.com

>>> The SQL bridge

Data Analyst

Responsibilities

-Curate the data
-Visualize and report data

Tools

- Excel
- SQL
- Tableau

Skills

- Analytics
- Communication & Visualization

Business Facing

- Sometimes

Salary

$65,000

Data Scientist

Responsibilities

-Source data
-Analyze data
-Run experiments
-Build models
-Recommend solutions
-Storytell

Tools

- Python
- R
- SQL

Skills

- Analytics
- Communication
- Story-tell
- Model building
- Math
- Coding

Business Facing

- Yes

Salary

$120,000

Data Engineer

Responsibilities

-Build data pipelines and warehouse
-Manage scalability of data products

Tools

- Java
- C++
- Kubernetes
- Hadoop
- Spark
- Python

Skills

- Coding
- Model implementation

Business Facing

- Not Really

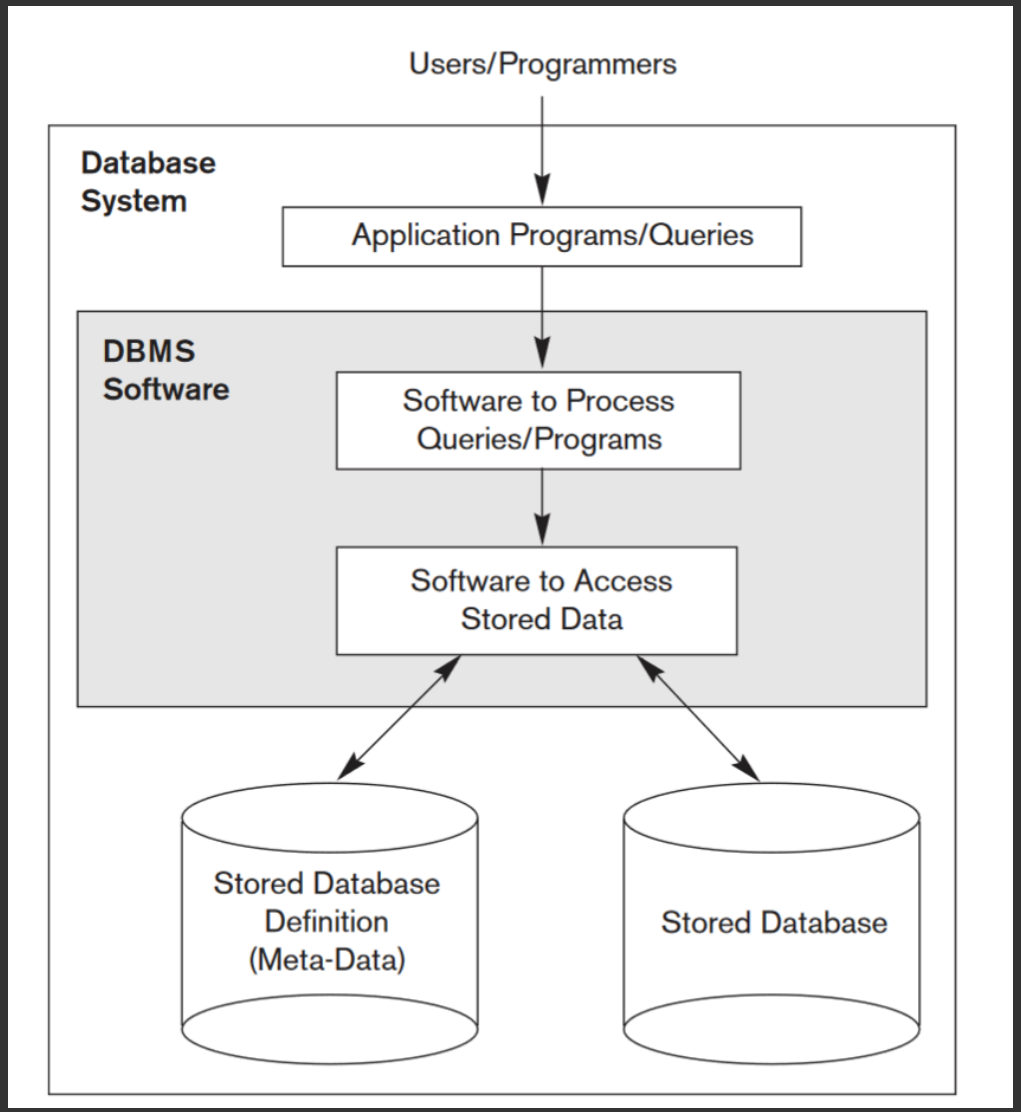
Salary

$110,000

mathaMagicians

>>> DBMS

A layer of abstraction between human and machine



>>> RDBMS

Grandfather of SQL and RDBMS, in the 1970s:

> ''Future users of databases should be protected from having to know how the data is organised in the machine.'' - Ted Codd (IBM researcher).

To talk to humans and machines, the RDBMS should have a model of the world that is intuitive to both. This model is called the Relational Model.

Intuition

The Relational Model is the 'common tongue' between the humans and the machines. It has a nice formal mathematical definition, so it is easy for machines to work with. For the humans, it has a simple intuitive description in terms of tables and relationships between tables!

>>> Our very first table

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

>>> What's the takeaway from all this??

When using SQL, you'll always be working with tables. This is (deceptively) simple and intuitive. Underlying that, there is a really powerful system that let's you talk to the machine in a fairly ideal way. This makes SQL very efficient.

The tradeoff? Some parts of SQL will be really simple and intuitive. Others can at first be frustrating and confusing. A little practice goes a looooooong way.

>>> The anatomy of a table

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

>>> The anatomy of a table

Table name

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

>>> The anatomy of a table

Row (record)

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

>>> The anatomy of a table

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

Column (attribute)

>>> The anatomy of a table

Column names (attribute names)

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

>>> The anatomy of a table

Primary key	Friends		
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

>>> The anatomy of a table

Primary key	Friends		
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

* Every table should have a primary key
* No two rows can have the same entry
* There must be no NULL entries

>>> One more thing: The data types of attributes

Friends(FriendID, FirstName, LastName, FavColour)

>>> One more thing: The data types of attributes

Friends(FriendID, FirstName, LastName, FavColour)

int

Definition

An integer is a positive or negative whole number.

>>> One more thing: The data types of attributes

Definition

Varchar stands for 'variable length character.'
It is a string of characters of undetermined length.

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>>> What are relationships between tables?

>>> What are relationships between tables?

>>> Relationships between tables overview

1. One-to-many relationships
2. Primary and foreign keys
3. Many-to-many relationships
4. One-to-one relationships

>>> One-to-many relationships

* For each car there are *many* wheels.

>>> One-to-many relationships

* For each car there are *many* wheels.

>>> One-to-many relationships

* For each car there are *many* wheels.
  But each wheel belongs to only *one* car.

>>> One-to-many relationships

* For each car there are *many* wheels.
  But each wheel belongs to only *one* car.
* One bank can have *many* accounts.
  But each account belongs to *one* bank.

>>> One-to-many relationships

* For each friend there are *many* pets.
  But each pet belongs to only *one* friend.

Where do we put the extra pets?

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

>>> One-to-many relationships

* For each friend there are *many* pets.
  But each pet belongs to only *one* friend.

Where do we put the extra pets?

Friends				
FriendID	FirstName	…	PetName_1	PetName_2
1	X	…	NULL	NULL
2	Y	…	Chikin	NULL
3	Z	…	Cauchy	Gauss

>>> Problems with putting them in the same table

Ideas?

Friends				
FriendID	FirstName	…	PetName_1	PetName_2
1	X	…	NULL	NULL
2	Y	…	Chikin	NULL
3	Z	…	Cauchy	Gauss

>>> Problems with putting them in the same table

* Have to store NULL in every entry with no pet

>>> Problems with putting them in the same table

* Have to store NULL in every entry with no pet
* What if I meet a friend with 3+ pets? Many more NULLs

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* New one-to-many relationship between pets and toys?

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* Have to store NULL in every entry with no pet
* What if I meet a friend with 3+ pets? Many more NULLs
* New one-to-many relationship between pets and toys?
* Pets are tied to owners. Delete an owner → delete pets

>>> Problems with putting them in the same table

* Have to store NULL in every entry with no pet
* What if I meet a friend with 3+ pets? Many more NULLs
* New one-to-many relationship between pets and toys?
* Pets are tied to owners. Delete an owner $\rightarrow$ delete pets
* Ambiguity. Is information related to pets or owners?

>>> So what do we do instead?

>>> So what do we do instead?

Suspense.

The second Kahoot.

>>> What if we do this instead?

Friends			
FriendID	FirstName	…	PetName
1	X	…	NULL
2	Y	…	Chikin
3	Z	…	Cauchy
3	Z	…	Gauss

>>> What if we do this instead?

Friends			
FriendID	FirstName	…	PetName
1	X	…	NULL
2	Y	…	Chikin
3	Z	…	Cauchy
3	Z	…	Gauss

This causes data redundancy

>>> What we do instead is…

Create another table.

>>> What we do instead is…

Create another table.

Pets			
PetID	PetName	PetDOB	FriendID
1	Chikin	24/09/2016	2
2	Cauchy	01/03/2012	3
3	Gauss	01/03/2012	3

>>> What we do instead is…

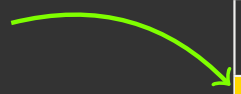
Create another table.

Pets			
PetID	PetName	PetDOB	FriendID
1	Chikin	24/09/2016	2
2	Cauchy	01/03/2012	3
3	Gauss	01/03/2012	3

Foreign key

>>> The foreign key 'points at' the primary key

Pets			
PetID	PetName	…	FriendID
1	Chikin	…	2
2	Cauchy	…	3
3	Gauss	…	3

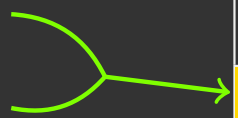


Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

>>> The foreign key 'points at' the primary key

Pets			
PetID	PetName	…	FriendID
1	Chikin	…	2
2	Cauchy	…	3
3	Gauss	…	3

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…



Many

>>> The foreign key 'points at' the primary key

Pets			
PetID	PetName	…	FriendID
1	Chikin	…	2
2	Cauchy	…	3
3	Gauss	…	3

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

>>> Check that we fixed all these problems

* Have to store NULL in every entry with no pet
* What if I meet a friend with 3+ pets? Many more NULLs
* New one-to-many relationship between pets and toys?
* Pets are tied to owners. Delete an owner $\rightarrow$ delete pets
* Ambiguity. Is information related to pets or owners?

>>> Joining the tables

FriendsPets						
PetID	PetName	…	FriendID	FriendID	FirstName	…
1	Chikin	…	2	2	Y	…
2	Cauchy	…	3	3	Z	…
3	Gauss	…	3	3	Z	…

>>> Joining the tables

FriendsPets						
PetID	PetName	…	FriendID	FriendID	FirstName	…
1	Chikin	…	2	2	Y	…
2	Cauchy	…	3	3	Z	…
3	Gauss	…	3	3	Z	…

Primary/foreign key pair

Challenge: Can you create a one-to-many relationship between Friends and Friends? How will you model it?

>>> A solution to the challenge question

* Game in which friends fight to the death. A friend can beat many others, but can only be beaten by one at most.

Friends				
FriendID	FirstName	LastName	FavColour	DefeatedByID
1	X	A	red	2
2	Y	B	blue	NULL
3	Z	C	NULL	2

>>> Primary and foreign keys

* Foreign key 'points at' the primary key
* Two rows can share same foreign key value
* Two rows can not share same primary key value
* Primary key can never be NULL
* All tables should have a primary key
* A PK or FK can be made of more than one column.

>>> Primary and foreign keys

* Foreign key 'points at' the primary key
* Two rows can share same foreign key value
* Two rows can not share same primary key value
* Primary key can never be NULL
* All tables should have a primary key
* A PK or FK can be made of more than one column.

For example, a company might sell group holiday packages and the primary key of their Customer table might be made of a GroupID and GroupMemberNumber.

>>> Referential integrity

When there is a foreign key entry that is not NULL, the primary key entry that it 'points at' must exist.

>>> Referential integrity

When there is a foreign key entry that is not NULL, the primary key entry that it 'points at' must exist.

Guarantees that a foreign key is not 'meaningless'.

>>> Referential integrity

Guarantees that a foreign key is not 'meaningless'.

Friends				
FriendID	FirstName	LastName	FavColour	DefeatedByID
1	X	A	red	4
2	Y	B	blue	NULL
3	Z	C	NULL	2

>>> Identifying a primary / foreign key pair?

A foreign key is any column (or collection of columns) where each record is guaranteed to equal one, and only one, primary key entry in the other table.

Problem: What happens if the database is sloppy, and there aren't any foreign keys??

>>> An example to contemplate

```
Houses(Bedrooms, Bathrooms, LandSize, PostCode)
Suburbs(PostCode, SuburbName).
```

>>> An example to contemplate

Houses(Bedrooms, Bathrooms, LandSize, PostCode)
Suburbs(PostCode, SuburbName).

1. Is every PostCode entry in Suburbs unique?
2. Is every PostCode in Houses also in Suburbs?

Does it really matter if we can't tell?

>>> An example to contemplate

Houses(Bedrooms, Bathrooms, LandSize, PostCode)
Suburbs(PostCode, SuburbName).

1. Is every PostCode entry in Suburbs unique?
2. Is every PostCode in Houses also in Suburbs?

Does it really matter if we can't tell?

* From 1: can't be sure which suburb a house is in.
* From 1: joining can lead to unexpected duplicates.
* From 2: can't find any matching suburb.

>>> Many-to-many relationship

* A class has many students,
  and a student attends many classes.
* A company has many investors,
  and an investor invests in many companies.
* A person engages with many government departments,
  and a government department engages with many people.

>>> Many-to-many relationship

* Each friend can scratch many backs,
  and a back can be scratched by many friends

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

Scratched			
ScratcherID	Date	Time	ScratcheeID
1	05/09/2018	12:00pm	2
1	05/09/2018	12:30pm	3
2	06/09/2018	11:00am	1
3	07/09/2018	10:00am	1

>>> Many-to-many relationship

* Each friend can scratch many backs,
  and a back can be scratched by many friends

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

Scratched			
ScratcherID	Date	Time	ScratcheeID
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1	05/09/2018	12:30pm	3
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>>> Many-to-many relationship

* Each friend can scratch many backs,
  and a back can be scratched by many friends

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

Scratched			
ScratcherID	Date	Time	ScratcheeID
1	05/09/2018	12:00pm	2
1	05/09/2018	12:30pm	3
2	06/09/2018	11:00am	1
3	07/09/2018	10:00am	1

>>> Many-to-many relationship

* Each friend can scratch many backs,
  and a back can be scratched by many friends

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

Friends		
FriendID	FirstName	…
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>>> Many-to-many relationship

* Each friend can scratch many backs,
  and a back can be scratched by many friends

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

Friends		
FriendID	FirstName	…
1	X	…
2	Y	…
3	Z	…

Scratched			
ScratcherID	Date	Time	ScratcheeID
1	05/09/2018	12:00pm	2
1	05/09/2018	12:30pm	3
2	06/09/2018	11:00am	1
3	07/09/2018	10:00am	1

>>> Joining the tables

Friend_Scratched_Friend								
FrID	FriendName	…	SrID	…	SeID	FrID	FriendName	…
1	X	…	1	…	2	2	Y	…
1	X	…	1	…	3	3	Z	…
2	Y	…	2	…	1	1	X	…
3	Z	…	3	…	1	1	X	…

>>> Joining the tables

Friend_Scratched_Friend								
FrID	FriendName	…	SrID	…	SeID	FrID	FriendName	…
1	X	…	1	…	2	2	Y	…
1	X	…	1	…	3	3	Z	…
2	Y	…	2	…	1	1	X	…
3	Z	…	3	…	1	1	X	…

Pair 1

>>> Joining the tables

Friend_Scratched_Friend								
FrID	FriendName	…	SrID	…	SeID	FrID	FriendName	…
1	X	…	1	…	2	2	Y	…
1	X	…	1	…	3	3	Z	…
2	Y	…	2	…	1	1	X	…
3	Z	…	3	…	1	1	X	…

Pair 2

>>> Will see again during the exercises

* A friend can play with many pets,
  and a pet can play with many friends

Pets		
PetID	PetName	…
1	Chikin	
2	Cauchy	
3	Gauss	

Friends		
FriendID	FirstName	…
1	X	
2	Y	
3	Z	

PlayCount		
PetID	Count	FriendID
1	3	1
1	5	2
3	4	2

>>> One-to-one relationship

* A person can have at most one head,
  and each head belongs to only one person
* A table record has exactly one primary key value,
  and each primary key value belongs to exactly one record
* A user has one set of log-in details,
  and each set of log-in details belong to one user

>>> One-to-one relationship

* One friend can have at most one passport, and each passport belongs to only one friend

Friends					
FriendID	FirstName	…	PptCountry	PptNo	PptExpiry
1	X		Australia	E1321	12/03/2021
2	Y		New Zealand	LA123	01/09/2032
3	Z		Monaco	S9876	19/06/2028

>>> Why not keep one-to-one relationships in the same table?

>>> Why not keep one-to-one relationships in the same table?

* NULLs (many passport attributes? few people have them?)

>>> Why not keep one-to-one relationships in the same table?

* NULLs (many passport attributes? few people have them?)
* Dependence: Delete friend $\rightarrow$ delete passport.

>>> Goodbye, Mr. X

Friends					
FriendID	FirstName	…	PptCountry	PptNo	PptExpiry
2	Y		New Zealand	LA123	01/09/2032
3	Z		Monaco	S9876	19/06/2028

>>> Solution

How do we delete a friend without deleting their passport?

>>> Solution

How do we delete a friend without deleting their passport?

Passports			
PptNo	PptCountry	PptExpiry	FriendID
E1321	Australia	12/03/2021	NULL
LA123	New Zealand	01/09/2032	2
S9876	Monaco	19/06/2028	3

>>> Solution

How do we delete a friend without deleting their passport?

Passports			
PptNo	PptCountry	PptExpiry	~~FriendID~~
E1321	Australia	12/03/2021	NULL
LA123	New Zealand	01/09/2032	2
S9876	Monaco	19/06/2028	3

Mr. X

>>> Any problems with this approach though?

How do we delete a friend without deleting their passport?

Passports			
PptNo	PptCountry	PptExpiry	FriendID
E1321	Australia	12/03/2021	NULL
LA123	New Zealand	01/09/2032	2
S9876	Monaco	19/06/2028	3

>>> Any problems with this approach though?

How do we delete a friend without deleting their passport?

Passports			
PptNo	PptCountry	PptExpiry	FriendID
E1321	Australia	12/03/2021	NULL
LA123	New Zealand	01/09/2032	2
S9876	Monaco	19/06/2028	3

Deleting a friend will delete the owner's name

>>> Any idea how to fix this?

We should avoiding keeping the person's name in both tables, since otherwise we have redundant data.

>>> Any idea how to fix this?

* Create 'people' table with binary variable for friend?

Definition

A binary variable is always either 0, 1 or NULL.
Usually, 0 represents false and 1 repesents true.

>>> Any idea how to fix this?

* Create 'people' table with binary variable for friend?
* Create separate tables for friends, enemies, etc…?

Leave it to the database designers.

>>> How a database design can damage research

* Missing information
* Conflicting information (due to redundancy)
* Not enough levels of a categorical variable
* Binary answer when binary is not appropriate
* Hard to join the tables and connect records
* Hard to search for information in the database
* Many more, keep eyes open…

>>> The third Kahoot

Good luck

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Time for the real deal

If you've completed set-up, that's great!
Otherwise, we can troubleshoot it this afternoon.

If you're on macOS, don't worry!
I'll be giving a demo of Sequel Ace later.

>>> Demonstration

In Azure Data Studio, I'll do the following:

* Connect to 'localhost'.
* Open a new query tab.
* Change between databases.
* Figure out what tables are in a database.
* Explain what a schema is.
* Figure out what columns are in a table.
* Figure out what the data types are.
* Figure out what the primary/foreign keys are.
* Figure out if NULL values are allowed.

>>> Bonus demo

Sneak preview of SQL code

* The USE clause.
* Retrieve Friends.
* Retrieve Pets.
* Join Friends with Pets.
* Aliases.
* Quoting identifiers.

>>> A note on syntax

SeLeCt*FrOm[NoTeS].
[pEtS]rIpHaRaMbE20160528

---

* Upper/lower-case has no effect
* Spaces usually have no effect
* Square brackets can be omitted
* New lines have no effect
* Alias can be almost anything

So pay attention to style

The concept of an alias is explained on the next slide.

>>> A note on syntax

Aliases give temporary names to tables, and should be used to simplify and shorten your queries.

Without aliases:

```
SELECT *
FROM Notes.Friends JOIN Notes.Pets
ON Notes.Friends.friendID = Notes.Pets.friendID;
```

With aliases:

```
SELECT *
FROM Notes.Friends F JOIN Notes.Pets P
ON F.friendID = P.friendID;
```

From now on, we will **always use aliases**.

>>> A note on syntax

Another (optional) way to write aliases

```
SELECT *
FROM Notes.Friends AS F JOIN Notes.Pets AS P
ON F.friendID = P.friendID;
```

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>>> Time to learn SQL

We will now look closely at some basic clauses

>>> SQL clause: FROM

The FROM clause specifies table(s)
to access in the SELECT statement (and others).

```
FROM MySchema.MyTable MyAlias
```

The above will not run because there is no SELECT. You'll use FROM in almost every query, though.

>>> SQL clause: FROM

The FROM clause specifies table(s)
to access in the SELECT statement (and others).

```
FROM MySchema.MyTable MyAlias
```

The above will not run because there is no SELECT. You'll use FROM in almost every query, though.

Remember: MySQL doesn't have schemas (but don't Google it)

>>> SQL clause: SELECT

The SELECT clause allows you to choose columns.
You can select all columns with SELECT *

We will look at the execution of this query:

```
SELECT F.FirstName, F.FavColour
FROM Notes.Friends F;
```

Note: the alias F seems to have been used before it was created! We will learn about the (sometimes confusing) SQL order of execution.

FROM Notes.Friends

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

```
SELECT F.FirstName, F.FavColour
```

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

result

Unnamed	
FirstName	FavColour
X	red
Y	blue
Z	NULL

>>> Order of execution

But did you see that order of execution?

>>> Order of execution

But did you see that order of execution?

* Syntactic order of execution
* Logical order of execution
* Optimal order of execution

>>> SQL clause: WHERE

The WHERE clause allows you to choose rows,
using a search condition.

We will look at the execution of this query:

```
SELECT F.firstName, F.lastName
FROM Notes.Friends F
WHERE favColour = 'red';
```

FROM Notes.Friends

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

```
WHERE FavColour = 'red'
```

Friends			
FriendID	FirstName	LastName	FavColour
1	X	A	red
2	Y	B	blue
3	Z	C	NULL

```
SELECT FirstName, LastName
```

Unnamed			
ID	FirstName	LastName	FavColour
1	X	A	red

result

Unnamed	
FirstName	LastName
X	A

>>> Order of execution

1. FROM
2. WHERE
3. SELECT

>>> Order of execution

Order of execution is irrelevant, Danny!

>>> Order of execution

Order of execution is irrelevant, Danny!

Wrong you are.

Aliases can be created in the SELECT clause too!

```
SELECT F.FirstName AS Nombre, F.FavColour AS ColorFavorito
FROM Notes.Friends F
WHERE ColorFavorito = 'red';
```

Let's try executing the above. What will happen?

>>> Why do you keep saying 'clause'?

SQL is like speaking ... or cooking.

* Clauses are components of statements.
* The statements we're learning are called queries.
* A statement is somewhat comparable to a 'sentence'.
* Better to think of them as ingredients in a recipe?

>>> Chopping and changing

* We've seen how to 'chop' (with SELECT and WHERE).
* We've seen how to 'change' (with table/column aliases).

Can we also change the entries?

>>> Chopping and changing

* We've seen how to 'chop' (with SELECT and WHERE).
* We've seen how to 'change' (with table/column aliases).

Can we also change the entries?

Change entries with the CASE WHEN expression.

```
SELECT *, CASE WHEN FavColour = 'red' THEN 'rojo'
               WHEN FavColour = 'blue' THEN 'azul'
               ELSE FavColour END AS ColorFavorito
FROM Notes.Friends;
```

Let's execute the above. What will it do?

>>> Ordering

We can also reorder the results!

```
SELECT *
FROM Notes.Friends
ORDER BY FriendID DESC;
```

Let's execute it to experiment.

>>> Lexicographic ordering

What happens if we order by a character string?

Numbers	
Num	NumString
111	'111'
31	'31'
32	'32'
211	'211'

```
SELECT *
FROM Notes.Numbers
ORDER BY NumString;
```

Let's execute it to find out.

>>> Where are we now?

Day 1

1. Introduction
2. Intro to relational model
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5. Basic SQL
6. Search conditions
7. Subqueries
8. Joining and join exercises

Page is hyperlinked: click a topic above to jump to it.

>>> Search conditions

Search conditions appear in a WHERE clause.
They check which rows match the conditions you specify,
by making use of:

* Comparison operators
* Logical operators
* Other operators

>>> Search conditions

Search conditions appear in a WHERE clause.
They check which rows match the conditions you specify,
by making use of:

* Comparison operators
* Logical operators
* Other operators

Definition
A comparison operator is used to compare two things
and return true, false or NULL.

* Click here for comparison operators in the T-SQL docs.
* Click here for comparison operators in the MySQL docs.

>>> Search conditions

Search conditions appear in a WHERE clause.
They check which rows match the conditions you specify,
by making use of:

- Comparison operators
- Logical operators
- Other operators

Definition
Logical operators compare true, false or NULL
and also return true, false or NULL.

- Click here for logical operators in the T-SQL docs.
- Click here for logical operators in the MySQL docs.

>>> Search conditions

Search conditions appear in a WHERE clause.
They check which rows match the conditions you specify,
by making use of:

* Comparison operators
* Logical operators
* Other operators

Definition
MySQL and T-SQL disagree on where to put this category of operators. I just call them 'other operators'. They include IN, LIKE, BETWEEN, EXISTS and more.

* Click here for other operators in the T-SQL docs.
* Click here for other operators in the MySQL docs.

>>> Comparison operators

* `WHERE FavColour = 'blue'` (equal)

>>> Comparison operators

* `WHERE FavColour = 'blue'` (equal)
* `WHERE FavColour <> 'blue'` (not equal)
* `WHERE FavColour != 'blue'` (also not equal)

>>> Comparison operators

```
*  WHERE  FavColour = 'blue'    (equal)
*  WHERE  FavColour <> 'blue'   (not equal)
*  WHERE  FavColour != 'blue'   (also not equal)
*  WHERE  Age > 35              (greater than)
*  WHERE  Year <= 1995          (less than or equal)
```

>>> Logical operators

AND				
true	AND	true	=	true
false	AND	true	=	false
true	AND	false	=	false
false	AND	false	=	false

OR				
true	OR	true	=	true
false	OR	true	=	true
true	OR	false	=	true
false	OR	false	=	false

NOT			
NOT	true	=	false
NOT	false	=	true

>>> Other operators

* `WHERE FavColour IN ('blue', 'red', 'green')`

>>> Other operators

* `WHERE FavColour IN ('blue', 'red', 'green')`
* `WHERE Age BETWEEN 25 AND 35`

>>> Other operators

* `WHERE FavColour IN ('blue', 'red', 'green')`
* `WHERE Age BETWEEN 25 AND 35`
* `WHERE FirstName LIKE 'b%'`

>>> Other operators

* `WHERE FavColour IN ('blue', 'red', 'green')`
* `WHERE Age BETWEEN 25 AND 35`
* `WHERE FirstName LIKE 'b%'`
* `WHERE FirstName LIKE '%b'`

>>> Other operators

* `WHERE FavColour IN ('blue', 'red', 'green')`
* `WHERE Age BETWEEN 25 AND 35`
* `WHERE FirstName LIKE 'b%'`
* `WHERE FirstName LIKE '%b'`
* `WHERE FirstName LIKE '%b%'`

>>> Other operators

* `WHERE FavColour IN ('blue', 'red', 'green')`
* `WHERE Age BETWEEN 25 AND 35`
* `WHERE FirstName LIKE 'b%'`
* `WHERE FirstName LIKE '%b'`
* `WHERE FirstName LIKE '%b%'`
* `WHERE FirstName LIKE 'b__%'`

>>> Operator precedence

Precedence	Operators
1	Anything in round brackets
2	=,<,>,<=,>=,!=,!<,!> (comparison operators)
3	NOT
4	AND
5	OR, ALL, ANY, SOME, EXISTS, BETWEEN, IN, LIKE

>>> Examples

1. `2 = 1 AND 1 = 1`
2. `1 = 1 OR 2 = 1 AND 1 = 1`
3. `('red' IN ('green', 'red')) AND ('red' LIKE 'r%')`
4. `NOT ( 1 = 1 AND 2 = 2 AND 3 = 3 )`

>>> Solution

1. `2 = 1 AND 1 = 1`
2. `1 = 1 OR 2 = 1 AND 1 = 1`
3. `('red' IN ('green', 'red')) AND ('red' LIKE 'r%')`
4. `NOT (  1 = 1 AND 2 = 2 AND 3 = 3  )`

>>> Solution

1. `2 = 1 AND true`
2. `1 = 1 OR 2 = 1 AND 1 = 1`
3. `('red' IN ('green', 'red')) AND ('red' LIKE 'r%')`
4. `NOT (  1 = 1 AND 2 = 2 AND 3 = 3  )`

>>> Solution

1. `false AND true`
2. `1 = 1 OR 2 = 1 AND 1 = 1`
3. `('red' IN ('green', 'red')) AND ('red' LIKE 'r%')`
4. `NOT (  1 = 1 AND 2 = 2 AND 3 = 3  )`

>>> Solution

1. `false`
2. `1 = 1 OR 2 = 1 AND 1 = 1`
3. `('red' IN ('green', 'red')) AND ('red' LIKE 'r%')`
4. `NOT (  1 = 1 AND 2 = 2 AND 3 = 3  )`

>>> Solution

1. `false`
2. `1 = 1 OR false`
3. `('red' IN ('green', 'red')) AND ('red' LIKE 'r%')`
4. `NOT (  1 = 1 AND 2 = 2 AND 3 = 3  )`

>>> Solution

1. `false`
2. `true OR false`
3. `('red' IN ('green', 'red')) AND ('red' LIKE 'r%')`
4. `NOT (  1 = 1 AND 2 = 2 AND 3 = 3  )`

>>> Solution

1. false
2. true
3. `('red' IN ('green', 'red')) AND ('red' LIKE 'r%')`
4. `NOT (  1 = 1 AND 2 = 2 AND 3 = 3  )`

>>> Solution

1. false
2. true
3. true AND ('red' LIKE 'r%')
4. NOT (1 = 1 AND 2 = 2 AND 3 = 3)

>>> Solution

1. false
2. true
3. true AND true
4. NOT (1 = 1 AND 2 = 2 AND 3 = 3)

>>> Solution

1. false
2. true
3. true
4. `NOT (  1 = 1 AND 2 = 2 AND 3 = 3  )`

>>> Solution

1. false
2. true
3. true
4. `NOT (  true AND 3 = 3  )`

>>> Solution

1. false
2. true
3. true
4. NOT (true AND true)

>>> Solution

1. false
2. true
3. true
4. NOT (true)

>>> Solution

1. false
2. true
3. true
4. false

>>> Perils of operator precedence

```
-- this one evaluates to FALSE
1 != 1 AND (2 < 3 OR 3 = 3)

-- but this one evaluates to TRUE
1 != 1 AND 2 < 3 OR 3 = 3
```

>>> Perils of operator precedence

```
-- this one evaluates to FALSE
1 != 1 AND (2 < 3 OR 3 = 3)

-- but this one evaluates to TRUE
1 != 1 AND 2 < 3 OR 3 = 3
```

More concretely, consider the following two:

```
-- matches 50 or 60 year old females only
Gender = 'F' AND (Age = 50 OR Age = 60)

-- matches 50 year old females, or anyone aged 60
Gender = 'F' AND Age = 50 OR Age = 60
```

>>> A note on NULL

NULL				
(anything	AND	NULL)	=	NULL
(anything	OR	NULL)	=	NULL
(anything	=	NULL)	=	NULL

We will get practice with NULLs during the exercises.

>>> Where are we now?

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>>> Basic subquery

Subqueries (next slide) are powerful with search conditions.
In fact, some logical operators only work with subqueries:

* EXISTS
* ALL
* ANY

Subqueries are also known as nested queries.

>>> Class practice

Can anyone figure out what this does?
Note: the subquery is executed first.

```
SELECT *
FROM Notes.Friends F
WHERE F.friendID IN (SELECT P.friendID
                     FROM Notes.Pets P);
```

>>> Solution

```
1. SELECT P.friendID FROM Notes.Pets P
```

>>> Solution

1. `SELECT P.friendID FROM Notes.Pets P`
   Retrieves a table of all the FriendIDs in Notes.Pets.

>>> Solution

1. `SELECT P.friendID FROM Notes.Pets P`
   Retrieves a table of all the FriendIDs in Notes.Pets.

2. Let's refer to the output of Step 1 as RESULT.

>>> Solution

1. `SELECT P.friendID FROM Notes.Pets P`
   Retrieves a table of all the FriendIDs in Notes.Pets.
2. Let's refer to the output of Step 1 as `RESULT`.
3. `SELECT * FROM Notes.Friends F WHERE F.FriendID IN RESULT`

>>> Solution

1. `SELECT P.friendID FROM Notes.Pets P`
   Retrieves a table of all the FriendIDs in Notes.Pets.

2. Let's refer to the output of Step 1 as RESULT.

3. `SELECT * FROM Notes.Friends F WHERE F.FriendID IN RESULT`
   Retrieves only the rows of Notes.Friends
   whose FriendID is in RESULT.

>>> Solution

1. `SELECT P.friendID FROM Notes.Pets P`
   Retrieves a table of all the FriendIDs in Notes.Pets.

2. Let's refer to the output of Step 1 as RESULT.

3. `SELECT * FROM Notes.Friends F WHERE F.FriendID IN RESULT`
   Retrieves only the rows of Notes.Friends
   whose FriendID is in RESULT.

It retrieved the details of all friends who have pets.
Let's execute it to experiment.

>>> Subquery anywhere!

Quick note: a subquery does not have to be used only in the WHERE clause. It can be used almost anywhere, but we will look at this later.

>>> The fourth Kahoot

Enjoy

>>> Where are we now?

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>>> SQL query: JOIN

A JOIN (also known as an INNER JOIN) pairs the records from one table with the records from another table, using a primary/foreign key pair.

We will look at the execution of this query:

```
SELECT F.firstName, P.petName
FROM Notes.Friends F JOIN Notes.Pets P
ON F.friendID = P.friendID;
```

>>> SQL query: JOIN

We will look at the execution of this query:

```
SELECT F.firstName, P.petName
FROM Notes.Friends F JOIN Notes.Pets P
ON F.friendID = P.friendID;
```

Another way to write the same query: implicit syntax

```
SELECT F.firstName, P.petName
FROM Notes.Friends F, Notes.Pets P
WHERE F.friendID = P.friendID;
```

>>> SQL query: JOIN

Yet another way to write the same query:

```
SELECT F.firstName, P.petName
FROM Notes.Friends F INNER JOIN Notes.Friends P
ON F.friendID = P.friendID
```

>>> SQL query: JOIN

Note that JOIN is an operator that is inside the FROM clause.

```
FROM Friends F JOIN Pets P ON F.FriendID = P.FriendID
```

Pets			
PetID	PetName	…	FriendID
1	Chikin		2
2	Cauchy		3
3	Gauss		3

Friends		
FriendID	FirstName	…
1	X	
2	Y	
3	Z	

```
SELECT F.FirstName, P.PetName
```

Unnamed						
PetID	PetName	…	FriendID	FriendID	FirstName	…
1	Chikin	…	2	2	Y	…
2	Cauchy	…	3	3	Z	…
3	Gauss	…	3	3	Z	…

result

Unnamed	
PetName	FirstName
Chikin	Y
Cauchy	Z
Gauss	Z

>>> Order of execution

JOIN is technically an operator, not a clause.

1. FROM (and JOIN)
2. WHERE
3. SELECT

>>> Group practice

Table1		
A	B	C
1	Ignorance	is
2	War	is
3	Freedom	is
4	Friendship	is

Table2		
D	E	A
slavery.	3	1
weakness.	4	2
strength.	1	3
peace.	2	4

* `SELECT B,C,D FROM Table1 T1, Table2 T2 WHERE T1.A = T2.A`
* `SELECT B,C,D FROM Table1 T1, Table2 T2 WHERE T1.A = T2.E`

>>> Solutions

* SELECT B,C,D FROM Table1 T1, Table2 T2 WHERE T1.A = T2.A

B	C	D
Ignorance	is	slavery.
War	is	weakness.
Freedom	is	strength.
Friendship	is	peace.

>>> Solutions

* `SELECT B,C,D FROM Table1 T1, Table2 T2 WHERE T1.A = T2.A`

B	C	D
Ignorance	is	slavery.
War	is	weakness.
Freedom	is	strength.
Friendship	is	peace.

* `SELECT B,C,D FROM Table1 T1, Table2 T2 WHERE T1.A = T2.E`

B	C	D
Ignorance	is	strength.
War	is	peace.
Freedom	is	slavery.
Friendship	is	weakness.

>>> SQL query: LEFT JOIN

The join query below (that we looked at earlier)
excludes any friends that have no pets (and vice versa).

```
SELECT F.firstName, P.petName
FROM Notes.Friends F JOIN Notes.Pets P
ON F.friendID = P.friendID;
```

>>> SQL query: LEFT JOIN

The join query below (that we looked at earlier)
excludes any friends that have no pets (and vice versa).

```
SELECT F.firstName, P.petName
FROM Notes.Friends F JOIN Notes.Pets P
ON F.friendID = P.friendID;
```

LEFT JOIN keeps every row from the table on the left.

```
SELECT F.firstName, P.petName
FROM Notes.Friends F LEFT JOIN Notes.Pets P
ON F.friendID = P.friendID;
```

>>> SQL query: LEFT JOIN. Remember this?

```
FROM Friends F JOIN Pets P ON F.FriendID = P.FriendID
```

Pets			
PetID	PetName	…	FriendID
1	Chikin		2
2	Cauchy		3
3	Gauss		3

Friends		
FriendID	FirstName	…
1	X	
2	Y	
3	Z	

>>> The result was...

Unnamed						
PetID	PetName	…	FriendID	FriendID	FirstName	…
1	Chikin	…	2	2	Y	…
2	Cauchy	…	3	3	Z	…
3	Gauss	…	3	3	Z	…

If we did a LEFT JOIN instead we would get:

```
FROM Friends F LEFT JOIN Pets P ON F.FriendID = P.FriendID
```

Unnamed						
PetID	PetName	…	FriendID	FriendID	FirstName	…
NULL	NULL	…	NULL	1	X	…
1	Chikin	…	2	2	Y	…
2	Cauchy	…	3	3	Z	…
3	Gauss	…	3	3	Z	…

result

Unnamed	
PetName	FirstName
NULL	X
Chikin	Y
Cauchy	Z
Gauss	Z

Question for the class:

What does RIGHT JOIN do?

>>> Exercises

Do exercises at the ends of Chapters 1 and 2.
That is, Sections 1.5, 2.6 and 2.7.

Click here to find the textbook.

>>> End of day 1

School's out