SQL Cheat Sheet

(The running example will be a library database with books. Later on, we introduce a reviews table to perform joins.)

More information can be found in the MySQL docs: https://dev.mysql.com/doc/refman/8.0/en/

SETTING UP DATABASES

Before creating tables etc. we need somewhere to store them. This is done inside a database. They are created as follows:

```
CREATE DATABASE library;
```

To delete (or drop) a database we use:

```
DROP DATABASE library;
```

Once we create a database we need to enter it before we can create tables etc. We do this via:

```
USE library;
```

Note: 'USE' and not 'USE DATABASE'.

DATATYPES

When creating tables, columns are given a datatype. Some common types are:

- VARCHAR(n) - variable-length strings with up to n characters.
- INT or INTEGER - stores integers.
- DECIMAL(n,d) - numbers with n digits, d of which occur after the decimal point.
- DATETIME - stores datetimes in the format 'YYYY-MM-DD hh:mm:ss'. Functions can be used to extract information (see later).

SETTING UP TABLES

To create a table, we pass a name for the table and a list of column names along with their datatypes. Let's create a 'books' table for our library database.

```
CREATE TABLE books (
    title VARCHAR(30),
    author VARCHAR(30),
    pages INT
);
```

We can drop (or delete) unwanted tables using:

```
DROP TABLE books;
```

We may describe tables using

```
DESC books;
```

This query gives the following output:

Field	Type	Null	Key	Default	Extra
title	varchar(30)	YES		NULL	
author	varchar(30)	YES		NULL	
pages	int	YES		NULL	

NULL, KEY, DEFAULT & EXTRA?

The other four columns in the desc table give the following information:

- NULL: use 'NOT NULL' after datatype in table creation to ensure values inserted into the table cannot be null
- Key: If the column is a primary key (use PRIMARY KEY in initialisation), or has a uniqueness constraint on it (UNIQUE) etc
- Default: If no value is specified, what should the column value be set to by default (DEFAULT ... in initialisation)
- Extra: extra information, such as whether the column has auto-increment is included here (e.g. AUTO_INCREMENT in the initialisation.)

CONSTRAINTS ON COLUMNS

Some constraints that can be put on columns are:

- NOT NULL - values in this column cannot be null.
- UNIQUE - values in this column must be unique.
- PRIMARY KEY - NOT NULL + UNIQUE, this uniquely identifies a row. (For books this could be the ISBN, for example.)
- DEFAULT - sets a default value if no value is passed.
- CHECK - ensures values satisfy a certain condition.

Let's drop and recreate our 'books' table with some reasonable constraints.

```
DROP TABLE books;

CREATE TABLE books (
id INT PRIMARY KEY AUTO_INCREMENT,
title VARCHAR(30) NOT NULL,
author VARCHAR(30) NOT NULL,
pages INT CHECK (pages > 0)
);
```

INSERTING INTO TABLES

We insert rows into tables using 'VALUES'. Columns with the NOT NULL constraint must be given a value, columns which auto increment do not need a value passed as this is handled automatically.

```
INSERT INTO books
    (title, author, pages)
VALUES
    ('Great Expectations', 'Charles
        Dickens', 544),
    ('1984', 'George Orwell', 311);
```

SELECT

We may view our table using SELECT. The query SELECT * allows us to view all columns.

```
SELECT * FROM books;
```

Output:

id	title	author	pages
1	Great Expectations	Charles Dickens	544
2	1984	George Orwell	311

SELECT [column names] allows us to view some of the columns. We may also relabel columns (temporarily, as part of the output only) using AS. For example:

```
SELECT title AS book_title FROM books;
```

Output:

book_title
Great Expectations
George Orwell

Furthermore, we may use the WHERE clause to only return rows which satisfy current conditions. For example, the query

```
SELECT * FROM books WHERE id = 1;
```

gives the output:

id	title	author	pages
1	Great Expectations	Charles Dickens	544

Some comparisons we may use with the WHERE clause include <, >, =, !=, BETWEEN, OR, AND, LIKE, IN, IS NULL .... For the most part the word NOT can go in front of these words.

Subqueries also work well with the WHERE clause. The inner query is completed first, to be used within the main query. As a silly example, this query gives the same output as above:

```
SELECT *
FROM books
WHERE id =
    (
        SELECT id FROM books WHERE
            title LIKE 'G%'
    );
```

UPDATING ROWS WITHIN TABLES

We update rows in tables using queries of the form

```
UPDATE table_name
SET column_name = something
WHERE condition;
```

Primary keys work well with the WHERE clause when wanting to update a specific row. For example, if we later discovered that '1984' has 312 pages and not 311 we may update this row using its unique identifier 'id = 2' as follows

```
UPDATE books
SET pages = 312
WHERE id = 2;
```

DELETING ROWS WITHIN TABLES

We delete rows in tables using queries of the form

```
DELETE FROM table_name
WHERE condition;
```

For example, if we only wanted to stock books with less than 500 pages in our library, and wanted to update our table accordingly, we could perform the query.

```
DELETE FROM books
WHERE pages >= 500;
```

ALTERING TABLES

We may alter tables using the ALTER TABLE keyword. Examples of things we can do are:

- ADD ...; (adds a column)
- ADD COLUMN ...; (same as above)
- DROP COLUMN ...;
- RENAME COLUMN ... TO ...;
- MODIFY COLUMN ...; (to change datatype of existing column, for example)

FUNCTIONS ON DATATYPES

We may perform functions on datatypes (as part of the output). Functions on strings include:

- CONCAT: concatenates strings together.
- SUBSTRING or SUBSTR: extract substring from a string.
- UPPER: replaces all characters with their upper case counterpart.
- LOWER: replaces all characters with their lowercase counterpart.
- CHAR_LENGTH: returns the number of characters in the string as an integer. Note that this is not the same as the LENGTH function, which may produce unexpected results when considering multi-byte characters.

For example, the following query creates a sentence from each row in the table, making use of the CONCAT string function.

```
SELECT
    CONCAT(title, ' was written by ',
        author) AS title_and_author
FROM
    books;
```

Output:

title_and_author
Great Expectations was written by Charles Dickens
1984 was written by George Orwell

There exist functions for other datatypes, for example, the datetime datatype has functions such as DAYNAME, MONTH, YEAR, HOUR, ... See documentation for more.

REFINING SELECT QUERIES

We may refine SELECT queries using keywords such as DISTINCT, ORDER BY, and LIMIT. We see some examples. First, we add another row to the table, obtaining the following.

id	title	author	pages
1	Great Expectations	Charles Dickens	544
2	1984	George Orwell	311
3	Oliver Twist	Charles Dickens	608

```
SELECT DISTINCT author
FROM books;
```

Output:

author
Charles Dickens
George Orwell

```
SELECT title, pages
FROM books
ORDER BY pages DESC;
```

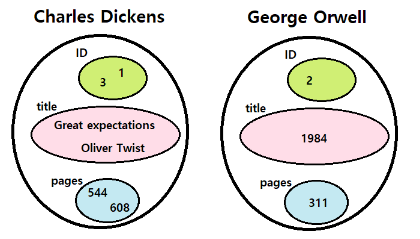
This query selects the title and pages of each row, and orders the rows using the number of pages, in descending order.

Output:

title	pages
Oliver Twist	608
Great Expectations	544
1984	311

GROUP BY AND AGGR. FUNCS

We may group the data within the table using the entries in specific columns. Such a grouping does not preserve the table structure, however, we can perform aggregate functions such as COUNT, AVG, MIN, MAX, and SUM on each group to extract information.
For example, grouping by 'author' gives us the following grouping.



Now SELECT queries can make use of 'author' and aggregate functions on 'id', 'title', and 'pages'. We cannot query, for example, pages directly since pages are now within groups, and have lost their structure as part of a row.

```
SELECT author, COUNT(title)
FROM books
GROUP BY author;
```

This query groups all books in the 'books' table using the 'author' column, then selects the author along with COUNT(title), i.e. the number of titles in the 'title' bubble (see diagram).

Output:

author	COUNT(title)
Charles Dickens	2
George Orwell	1

We can restrict which groups we wish to consider using the HAVING clause. This ensures we select only the groups which satisfy certain properties. For example the query

```
SELECT author, AVG(pages)
FROM books
GROUP BY author
HAVING count(title) >= 2;
```

will output a table with the author and the average page count, but only for authors with at least 2 books.

Lastly, we can GROUP BY ... WITH ROLLUP. This does what it says on the tin, it queries within groups based on the given grouping, then 'rolls up' or 'steps back a level of grouping' and queries again until all levels have been exhausted. For example,

```
SELECT author, count(title).
FROM books
GROUP BY author
WITH ROLLUP;
```

gives the output:

author	COUNT(title)
Charles Dickens	2
George Orwell	1
NULL	3

What has happened is 'author' and count have been carried out using the author grouping, and then we have 'rolled up', resulting in the trivial grouping (in the diagram, imagine both big bubbles and the corresponding small coloured bubbles merging together) where the query is carried out once again.

VIEWS & CTEs (VIRTUAL TABLES)

Views and CTEs (Common Table Expressions) are both 'virtual tables' in some sense. The difference is that views are stored in the database (just like regular tables). CTEs are created and exist only within the scope of the query, so they exist only temporarily.
Suppose the | author | COUNT(title) | table (from the GROUP BY section) is something we wish to work with.

If we want to work with it frequently we may store it as a view.

```
CREATE VIEW author_book_count AS (
    SELECT author, COUNT(title)
    FROM books
    GROUP BY author );
```

A view is as it says, it is a stored 'viewpoint' of the data. Therefore we may read from the view (using SELECT) but we cannot UPDATE or DELETE rows from a view (as this would affect the data in the original table(s)).We can read from it just like we would from a normal table.

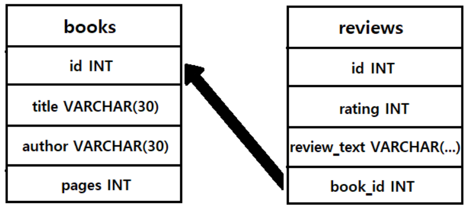
```
SELECT * FROM author_book_count;
```

This will produce the same output as the first query within the GROUP BY section. (This should be no surprise since this was the query used to create the view.)
If we want to produce this table and work with it further there-and-then, then creating a CTE may be best.

```
WITH author_book_counts AS (
    SELECT author, COUNT(title) AS
        book_count
    FROM books
    GROUP BY author
    )
*query involving author_book_counts*;
```

FOREIGN KEYS

For use in upcoming sections, we produce another table called 'reviews'. Each review corresponds to a book, and to signify this in SQL we include a column in 'reviews' called 'book_id' (or something meaningful) which references the id of the book in the 'books' table. This is done using a foreign key.




```sql
CREATE TABLE reviews (
    id INT PRIMARY KEY AUTO_INCREMENT,
    rating INT CHECK (rating BETWEEN 0
        AND 5),
    review_text VARCHAR(1000) DEFAULT '
        No review text',
    book_id INT,
    FOREIGN KEY (book_id)
        REFERENCES books(id)
);
```

We insert two reviews for Oliver Twist (book.id = 3) into the 'reviews' table, producing the following output via a SELECT * query.

id	rating	review_text	book_id
1	4	Great book	3
2	5	Couldn't put it down	3

INNER JOINS & LEFT/RIGHT JOINS

The idea behind a join is that we can glue two tables together along a specified column.

Inner joins work a bit like the intersection of two sets, $A \cap B$, where only rows with at least one matching row from the other table (along the specified column) will be included.

Left joins, in contrast, are like taking the whole set A. All rows of the 'left table' are taken, and rows of the 'right' table are joined onto the 'left table' where they match (along the specified column). Right join is analogous, with the roles of left and right reversed.

Let's join the 'books' table and the 'reviews' table along the columns corresponding to the book id. For the 'books' table this is column 'id' and for the 'reviews' table this is column 'book_id'.

```sql
SELECT *
FROM books
    JOIN reviews
        ON books.id = reviews.book_id;
```

This results in the following table (a zoom-in may be required...)

id	title	author	pages	id	rating	review_text	book_id
3	Oliver Twist	Charles Dickens	608	1	4	Great book	3
3	Oliver Twist	Charles Dickens	608	2	5	Couldn't put it down!	3

Observe that only 'Oliver Twist' appears, as it is the only book with a review. We now do the same thing, but use left join instead of a (inner) join. Notice that all three books appear, with two of them having NULL reviews.

```sql
SELECT *
FROM books
    LEFT JOIN reviews
        ON books.id = reviews.book_id;
```

Output:

id	title	author	pages	id	rating	review_text	book_id
1	Great Expectations	Charles Dickens	544	NULL	NULL	NULL	NULL
2	1984	George Orwell	311	NULL	NULL	NULL	NULL
3	Oliver Twist	Charles Dickens	608	1	4	Great book	3
3	Oliver Twist	Charles Dickens	608	2	5	Couldn't put it down!	3

MANY TO MANY JOINS

For the previous joins, each review belonged to exactly one book. However, some pairs of tables have a many-to-many relationship (e.g. books and reviewers, as a book can have many reviewers, and a reviewer can review many books).

In this case, we should use a third table (perhaps called 'books_reviewers') with two columns, named 'book_id' and 'reviewer_id', which are both foreign keys.

This third table, along with a double join, can be used to join data from the 'books' and 'reviewers' tables.
For example:

```sql
SELECT * FROM books
    JOIN books_reviewers
        ON books.id = books_reviewers.
            book_id
    JOIN reviewers
        ON reviewers.id =
            books_reviewers.
            reviewer_id;
```

WINDOW FUNCTIONS

Window functions are a little bit like functions on groups, in the sense that we can do calculations on groups of data (however in the case of window functions, these groups are called partitions).

The main difference is that the partitions created when performing window functions do not collapse the rows with respect to the grouping (or partition), but instead keep all rows separate and intact.

So, when a partition column is specified, all rows are partitioned with respect to this column, with the row structure being preserved. We can perform aggregate functions on the partitions, but also functions which require the rows to be intact, for example, ranking the rows based on an ordering within the partitions.

A rough visualisation of this is the following (assuming a partition over the 'author' column)

id	title	author	pages
1	Great Expectations	Charles Dickens	544
2	1984	George Orwell	311
3	Oliver Twist	Charles Dickens	608

1	Great Expectations	Charles Dickens	544
3	Oliver Twist	Charles Dickens	608

Partition:
Charles Dickens

2	1984	George Orwell	311

Partition:
George Orwell

So, window functions can take an aggregate function (e.g. AVG) and produce honest columns in our table, where the value on each row corresponds to the value of the aggregate function on the associated partitioned piece.

Additionally, we can put an order on the partition. This allows us to do things like rank rows within partitions, or label rows by quartiles, or more generally n-tiles, within each partition. The following query will rank the books by each author from longest to shortest.

```sql
SELECT *,
        rank() over (partition by author
            order by pages desc) as
            author_book_length_rank
FROM books;
```

Output:

id	title	author	pages	author_book_length_rank
3	Oliver Twist	Charles Dickens	608	1
1	Great Expectations	Charles Dickens	544	2
2	1984	George Orwell	311	1

How has this happened?
The 'over (partition by author ...)' has partitioned the rows by author. Then inside each partition, the rows are ordered with respect to the number of pages, '(... order by pages desc)'. The window function 'rank()' then returns a rank based on this ordering.

Note that the partition belongs to the column, we can make use of different partitions and orderings for different columns.

Another example is finding the average book length of the long books (say books with length > 500) and the short books. We do this using CASE (not seen elsewhere in the cheat sheet).

```sql
SELECT title, AVG(pages) OVER (
    PARTITION BY
                CASE
                    WHEN pages > 500 THEN
                        'Long Book'
                    ELSE 'Short Book'
                END) as
                    avg_pages_long_short
                from books;
```

Output:

title	avg_pages_long_short
Great Expectations	576.0000
Oliver Twist	576.0000
1984	311.0000

This works by first partitioning the rows based on whether they are a 'long book' or a 'short book'. Within these partitions, the average page count is computed and appended to its corresponding row.

A list of some window functions are:

- Most aggregate functions, such as AVG, COUNT, MIN, MAX.
  If an order by is provided, these functions become rolling functions e.g. SUM becomes a cumulative sum.
- rank(): determines the rank with respect to some order (note: order by must be provided).
- lead() and lag() (note: order by must be provided).
- ntile(n) (note: order by must be provided).
- first_value(), last_value() (note: order by must be provided).