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# SQL Introduction

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# ❖ SQL vs Relational Model

The relational model is a formal system for

- describing data (relations, tuples, attributes, domains, constraints)
- manipulating data (relational algebra ... covered elsewhere)

SQL is a "programming" language for

- describing data (tables, rows, fields, types, constraints)
- manipulating data (query language)

SQL extends the relational model in some ways (e.g bags vs sets of tuples)

SQL omits some aspects of the relational model (e.g. general constraints)

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# ❖ SQL History

Developed at IBM in the mid-1970's (System-R)

Standardised in 1986, and then in 1989, 1992, 1999, 2003, ... 2019

Many database management systems (DBMSs) have been built around SQL

- System-R, Oracle, Ingres, DB2, PostgreSQL, MySQL, SQL-server, SQLite, ...

DBMSs vs the standard

- all DBMSs implement a subset of the 1999 standard (aka SQL3)
- all DBMSs implement proprietary extensions to the standard

Conforming to standard should ensure portability of database applications

# ❖ SQL Intro

SQL has several sub-languages ...

- meta-data definition language (e.g. **`create table`**, etc.)
- meta-data update language (e.g. **`alter table, drop table`**)
- data update language (e.g. **`insert, update, delete`**)
- query language (e.g. **`select ... from ... where`**, etc.)

Meta-data languages manage the database schema

Data update language manages sets of tuples

# ❖ SQL Intro (cont)

Syntax-wise, SQL is similar to other programming languages

- has keywords, identifiers, constants, operators
- but strings are different to most PLs
  - `'...'` are constant strings, e.g. `'a'`, `'abc123'`, `'John''s bag'`
  - `"..."` allow non-alpha chars in identifiers and make id's case-sensitive

In the standard, all non-quoted identifiers map to all upper-case

- e.g. **`BankBranches`** = **`bankbranches`** are treated as **`BANKBRANCHES`**

In PostgreSQL, all non-quoted identifiers map to all lower-case

- e.g. **`BankBranches`** = **`BANKBRANCHES`** are treated as **`bankbranches`**

In all standards-adhering DBMSs, different quoted identifiers are different

- **"BankBranches" ≠ "bankbranches" ≠ "BANKBRANCHES"**

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# ❖ SQL Syntax in a Nutshell

SQL definitions, queries and statements are composed of:

- comments ... `--` comments to end of line
- identifiers ... similar to regular programming languages
- keywords ... a large set (e.g. **`CREATE`**, **`DROP`**, **`TABLE`**)
- data types ... small set of basic types (e.g. **`integer`**, **`date`**)
- operators ... similar to regular programming languages
- constants ... similar to regular programming languages

*Similar* means "often the same, but not always" ...

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# ❖ SQL Syntax in a Nutshell (cont)

Comments: everything after `--` *is a comment*

Identifiers: alphanumeric (a la C), but also **`"An Identifier"`**

Reserved words: many e.g. **`CREATE`**, **`SELECT`**, **`TABLE`**, ...

Reserved words cannot be used identifiers unless quoted e.g **`"table"`**

Strings: e.g. **`'a string'`**, **`'don''t ask'`**, but no **`'\n'`** (use **`e'\n'`**)

Numbers: like C, e.g. **`1`**, **`-5`**, **`3.14159`**, ...

Types: **`integer`**, **`float`**, **`char(`***n*`)`**, **`varchar(`***n*`)`**, **`date`**, ...

Operators: **`=`**, **`<>`**, **`<`**, **`<=`**, **`>`**, **`>=`**, **`AND`**, **`OR`**, **`NOT`**, ...

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# ❖ Names in SQL

Identifiers denote:

- database objects such as tables, attributes, views, ...
- meta-objects such as types, functions, constraints, ...

Naming conventions that I (try to) use in this course:

- relation names: e.g. **`Branches`**, **`Students`**, ... (use plurals)
- attribute names: e.g. **`name`**, **`code`**, **`firstName`**, ...
- foreign keys: named after either or both of
  - table being referenced e.g. **`staff`** or **`staff_id`**, ...
  - relationship being modelled e.g. **`teaches`**, ...

We initially write SQL keywords in all upper-case in slides.

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# ❖ Types/Constants in SQL

Numeric types: **`INTEGER`**, **`REAL`**, **`NUMERIC(`***w*`,`*d*`)`**

```
10    -1    3.14159    2e-5    6.022e23
```

String types: **`CHAR(`***n*`)`**, **`VARCHAR(`***n*`)`**, **`TEXT`**

```
'John'   'some text'   '!%#%!$'   'O''Brien'
'"'   '[A-Z]{4}\d{4}'   'a VeRy! LoNg String'
```

PostgreSQL provides extended strings containing **`\`** escapes, e.g.

```
E'\n'   E'O\'Brien'   E'[A-Z]{4}\\d{4}'   E'John'
```

Type-casting via *Expr* **`::`** *Type* (e.g. **`'10'::integer`**)

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# ❖ Types/Constants in SQL (cont)

Logical type: **`BOOLEAN`**, **`TRUE`** and **`FALSE`** (or **`true`** and **`false`**)

PostgreSQL also allows **`'t'`**, **`'true'`**, **`'yes'`**, **`'f'`**, **`'false'`**, **`'no'`**

Time-related types: **`DATE`**, **`TIME`**, **`TIMESTAMP`**, **`INTERVAL`**

```
'2008-04-13'  '13:30:15'  '2004-10-19 10:23:54'
'Wed Dec 17 07:37:16 1997 PST'
'10 minutes'  '5 days, 6 hours, 15 seconds'
```

Subtraction of timestamps yields an interval, e.g.

```
now()::TIMESTAMP - birthdate::TIMESTAMP
```

PostgreSQL also has a range of non-standard types, e.g.

- geometric (point/line/...), currency, IP addresses, JSON, XML, objectIDs, ...
- non-standard types typically use string literals (`'...'`) which need to be interpreted

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# ❖ Types/Constants in SQL (cont)

Users can define their own types in several ways:

```
-- domains: constrained version of existing type

CREATE DOMAIN Name AS Type CHECK ( Constraint )

-- tuple types: defined for each table

CREATE TYPE Name AS ( AttrName AttrType, ... )

-- enumerated type: specify elements and ordering

CREATE TYPE Name AS ENUM ( 'Label', ... )
```

# ❖ Examples of Defining Domains/Types

```
-- positive integers
CREATE DOMAIN PosInt AS integer CHECK (value > 0);

-- a UNSW course code
CREATE DOMAIN CourseCode AS char(8)
    CHECK (value ~ '[A-Z]{4}[0-9]{4}');

-- a UNSW student/staff ID
CREATE DOMAIN ZID AS integer
    CHECK (value betweem 1000000 and 9999999);

-- standard UNSW grades (FL,PS,CR,DN,HD)
CREATE DOMAIN Grade AS char(2)
    CHECK (value in ('FL','PS','CR','DN','HD'));
-- or
CREATE TYPE Grade AS ENUM ('FL','PS','CR','DN','HD');
```

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# ❖ Tuple and Set Literals

Tuple and set constants are both written as:

( $val_1$, $val_2$, $val_3$, ... )

The correct interpretation is worked out from the context.

Examples:

```
INSERT INTO Student(studeID, name, degree)
   VALUES (2177364, 'Jack Smith', 'BSc')
          -- tuple literal

CONSTRAINT CHECK gender IN ('male','female','unspecified')
                           -- set literal
```

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