SQL DDL: CREATE, INSERT, DELETE, UPDATE

COSC 304 – Introduction to Database Systems

SQL Overview

Structured Query Language or SQL is the standard query language for relational databases.

- It first became an official standard in 1986 as defined by the American National Standards Institute (ANSI).
- All major database vendors conform to the SQL standard with minor variations in syntax (different *dialects*).
- SQL consists of both a Data Definition Language (DDL) and a Data Manipulation Language (DML).

SQL is a ***declarative language*** (non-procedural). A SQL query specifies *what* to retrieve but not *how* to retrieve it.

- Basic SQL is not a complete programming language as it does not have control or iteration commands.
  - Procedural extensions: PL/SQL (Oracle), T-SQL (SQL Server)

SQL History

SQL history:

- 1970 - Codd invents relational model and relational algebra
- 1974 - Donald Chamberlin (also at IBM) defined Structured English Query Language (SEQUEL)
- 1976 - SEQUEL/2 defined and renamed SQL for legal reasons.
  - Origin of pronunciation 'See-Quel' but official pronunciation is 'S-Q-L'.
- First standardized in 1986 by the American National Standards Institute (ANSI).
- 1992 - SQL2 (SQL92) revision
- 1999 - SQL3 (supports recursion, object-relational)
- Updates: SQL:2003, SQL:2006, SQL:2008, SQL:2011,SQL:2016

SQL Basic Rules

1) There is a set of *reserved words* that cannot be used as names for database fields and tables.
   - `SELECT`, `FROM`, `WHERE`, etc.

2) SQL is generally *case-insensitive*.
   - Only exception is string constants. 'FRED' not the same as 'fred'.

3) SQL is *free-format* and white-space is ignored.

4) The semi-colon is often used as a statement terminator, although that is not always required.

5) Date and time constants have defined format:
   - Dates: 'YYYY-MM-DD' e.g. '1975-05-17'
   - Times: 'hh:mm:ss[.f] ' e.g. '15:00:00'
   - Timestamp: 'YYYY-MM-DD hh:mm:ss[.f]' e.g. '1975-05-17 15:00:00'

6) Two single quotes `''` are used to represent (escape) a single quote character in a character constant. e.g. `'Master''s'`.

SQL Identifiers

Identifiers are used to identify objects in the database such as tables, views, and columns.

- The identifier is the name of the database object.

An SQL identifier (name) must follow these rules:

- only contain upper or lower case characters, digits, and underscore ("_") character
- be no longer than 128 characters
  - DB vendors may impose stricter limits than this.
- must start with a letter (or underscore)
- cannot contain spaces
- Note: Quoted or ***delimited identifiers*** enclosed in double quotes allow support for spaces and other characters. E.g. `"select"`

Database Identifier Question

Question: Select ***one*** valid identifier.

A) `23test`

B) `'fred'`

C) `test_!`

D) `field_`

E) `from`

Delimited Database Identifiers

Question: **True or False:** `"from"` can be used as a valid identifier according to the SQL standard (including the double quotes).

A) True

B) False

SQL Data Types

In the relational model, each attribute has an associated *domain* of values.

In SQL, each column (attribute) has a ***data type*** that limits the values that it may store. The standard SQL data types are similar to their programming language equivalents.

The database will perform (implicit) data type conversion when necessary.

Explicit data type conversion using functions such as `CAST` and `CONVERT`.

SQL Data Types (2)

Data Type	Description
BOOLEAN	TRUE or FALSE
CHAR	Fixed length string (padded with blanks) e.g. CHAR(10)
VARCHAR	Variable length string e.g. VARCHAR(50)
BIT	Bit string e.g. BIT(4) can store '0101'
NUMERIC or DECIMAL	Exact numeric data type e.g. NUMERIC(7,2) has a precision (max. digits) of 7 and scale of 2 (# of decimals) e.g. 12345.67
INTEGER	Integer data only
SMALLINT	Smaller space than INTEGER
FLOAT or REAL	Approximate numeric data types.
DOUBLE PRECISION	Precision dependent on implementation.
DATE	Stores YEAR, MONTH, DAY
TIME	Stores HOUR, MINUTE, SECOND
DATETIME or TIMESTAMP	Stores date and time data.
INTERVAL	Time interval.
CHARACTER LARGE OBJECT	Stores a character array (e.g. for a document)
BINARY LARGE OBJECT	Stores a binary array (e.g. for a picture, movie)

Example Database - workson

emp

eno	ename	bdate	title	salary	supereno	dno
E1	J. Doe	1975-01-05	EE	30000	E2	null
E2	M. Smith	1966-06-04	SA	50000	E5	D3
E3	A. Lee	1966-07-05	ME	40000	E7	D2
E4	J. Miller	1950-09-01	PR	20000	E6	D3
E5	B. Casey	1971-12-25	SA	50000	E8	D3
E6	L. Chu	1965-11-30	EE	30000	E7	D2
E7	R. Davis	1977-09-08	ME	40000	E8	D1
E8	J. Jones	1972-10-11	SA	50000	null	D1

workson

eno	pno	resp	hours
E1	P1	Manager	12
E2	P1	Analyst	24
E2	P2	Analyst	6
E3	P3	Consultant	10
E3	P4	Engineer	48
E4	P2	Programmer	18
E5	P2	Manager	24
E6	P4	Manager	48
E7	P3	Engineer	36

proj

pno	pname	budget	dno
P1	Instruments	150000	D1
P2	DB Develop	135000	D2
P3	Budget	250000	D3
P4	Maintenance	310000	D2
P5	CAD/CAM	500000	D2

dept

dno	dname	mgreno
D1	Management	E8
D2	Consulting	E7
D3	Accounting	E5
D4	Development	null

SQL CREATE TABLE

The **CREATE TABLE** command is used to create a table in the database. A table consists of a table name and a set of fields with their names and data types.

Example:

```
CREATE TABLE emp (
    eno         CHAR(5),
    ename       VARCHAR(30) NOT NULL,
    bdate       DATE,
    title       CHAR(2),
    salary      DECIMAL(9,2),
    supereno    CHAR(5),
    dno         CHAR(5),
    PRIMARY KEY (eno)
)
```

field must always have a value

Data Types:

CHAR(5) – always 5 chars long
VARCHAR(30) – up to 30 chars long
DECIMAL(9,2) – e.g. 1234567.99
DATE – e.g. 1998/01/18

SQL Constraints

Constraints are specified in `CREATE` and `ALTER TABLE` statements.

Types of constraints:

- 1) **Required data** - To specify that a column must always have a data value (cannot be `NULL`) specify `NOT NULL` after the column definition.
  - e.g. `eno CHAR(5) NOT NULL`
  - If a field is `UNIQUE` or a `PRIMARY KEY`, `NOT NULL` is not necessary.
- 2) **Domain constraints** - Verify that the value of a column is in a given domain using `CHECK`.
  - e.g. `title CHAR(2) CHECK (title IN (NULL,'EE','SA','PR','ME'))`
  - Forces the title to be either `NULL` or one of 4 defined values.
  - Can also be performed using user-defined types (domains).

SQL Constraints - Entity Integrity

Entity Integrity constraint - The primary key of a table must contain a unique, non-null value for each row. The primary key is specified using the `PRIMARY KEY` clause.

- e.g. `PRIMARY KEY (eno)` (for emp relation)
- e.g. `PRIMARY KEY (eno,pno)` (for workson relation)
- It is also possible to use `PRIMARY KEY` right after defining the attribute in the `CREATE TABLE` statement.

There can only be one primary key per relation, other candidate keys can be specified using `UNIQUE`:

- e.g. `UNIQUE (ename)`

SQL Constraints - Referential Integrity

Referential integrity constraint - Defines a foreign key that references the primary key of another table.

- If a foreign key contains a value that is not `NULL`, that value must be present in some tuple in the relation containing the referenced primary key.

Example: `workson` contains two foreign keys:

- `workson.eno` references `emp.eno`
- `workson.pno` references `proj.pno`

Specify foreign keys using `FOREIGN KEY` syntax:

```
FOREIGN KEY (eno) REFERENCES emp(eno)
```

SQL Referential Integrity Example

The `CREATE TABLE` command for the `workson` relation:

```
CREATE TABLE workson (
    eno       CHAR(5),
    pno       CHAR(5),
    resp      VARCHAR(20),
    hours     SMALLINT,
    PRIMARY KEY (eno,pno),
    FOREIGN KEY (eno) REFERENCES emp(eno),
    FOREIGN KEY (pno) REFERENCES proj(pno)
);
```

SQL Referential Integrity and Updates

When you try to `INSERT` or `UPDATE` a **row in a relation containing a foreign key** (e.g. `workson`) that operation is rejected if it violates referential integrity.

When you `UPDATE` or `DELETE` a **row in the primary key relation** (e.g. `emp` or `proj`), you have the option on what happens to the values in the foreign key relation (`workson`):

- 1) `CASCADE` - Delete (update) values in foreign key relation when primary key relation has rows deleted (updated).
- 2) `SET NULL` - Set foreign key fields to `NULL` when corresponding primary key relation row is deleted.
- 3) `SET DEFAULT` - Set foreign key values to their default value (if defined).
- 4) `NO ACTION` - Reject the request.

SQL Referential Integrity Example (2)

```
CREATE TABLE workson (
    eno    CHAR(5),
    pno    CHAR(5),
    resp   VARCHAR(20),
    hours  SMALLINT,
    PRIMARY KEY (eno,pno),
    FOREIGN KEY (eno) REFERENCES emp(eno)
                              ON DELETE NO ACTION
                              ON UPDATE CASCADE,
    FOREIGN KEY (pno) REFERENCES proj(pno)
                              ON DELETE NO ACTION
                              ON UPDATE CASCADE
);
```

Enforcing Referential Integrity Question

Question: Select ***one*** true statement.

Entity integrity

A) `SET NULL` can be used for the `workson.eno` foreign key.

B) `ON UPDATE CASCADE` will modify all rows in the primary key table when a value is modified in the foreign key table.

Reverse

C) `SET DEFAULT` cannot be used for the `workson.eno` foreign key. (Assume a default value was specified for `eno` field).

D) If a primary key row is deleted and it is referenced by a foreign key row, `NO ACTION` will generate an error to the user.

SQL CREATE TABLE Full Syntax

Full syntax of `CREATE TABLE` statement:

```
CREATE TABLE tableName (
  { attrName attrType  [NOT NULL] [UNIQUE] [PRIMARY KEY]
     [DEFAULT value] [CHECK (condition)] [, ...] }
   [PRIMARY KEY (colList) [, ...]]
   {[FOREIGN KEY (colList) REFERENCES tbl [(colList)]
     [ON UPDATE action]
     [ON DELETE action] [, ...] ] }
   {[CHECK (condition)] }
);
```

Creating the Example Database

```
CREATE TABLE emp (
    eno         CHAR(5),
    ename       VARCHAR(30) NOT NULL,
    bdate       DATE,
    title       CHAR(2),
    salary      CHAR(5),
    supereno    CHAR(5),
    dno         CHAR(5),
    PRIMARY KEY (eno),
    FOREIGN KEY (supereno) REFERENCES emp(eno)
            ON DELETE SET NULL ON UPDATE CASCADE,
    FOREIGN KEY (dno) REFERENCES dept(dno)
            ON DELETE SET NULL ON UPDATE CASCADE
);
```

Creating the Example Database (2)

```
CREATE TABLE workson (
    eno     CHAR(5),
    pno     CHAR(5),
    resp    VARCHAR(20),
    hours   SMALLINT,
    PRIMARY KEY (eno,pno),
    FOREIGN KEY (eno) REFERENCES emp(eno)
                   ON DELETE NO ACTION ON UPDATE CASCADE,
    FOREIGN KEY (pno) REFERENCES proj(pno)
                   ON DELETE NO ACTION ON UPDATE CASCADE
);
```

Question:

Write `CREATE TABLE` statements to build the `proj` and `dept` relations:

- `dept(dno, dname, mgreno)`
- `proj(pno, pname, budget, dno)`

Creating Schemas

A ***schema*** is a collection of database objects (tables, views, domains, etc.) usually associated with a single user.

Creating a schema: (User `Joe` creates the schema)

```
CREATE SCHEMA employeeSchema AUTHORIZATION Joe;
```

Dropping a schema:

```
DROP SCHEMA employeeSchema;
```

ALTER TABLE

The **ALTER TABLE** command can be used to change an existing table. This is useful when the table already contains data and you want to add or remove a column or constraint.

- DB vendors may support only parts of `ALTER TABLE` or may allow additional changes including changing the data type of a column.

General form:

```
ALTER TABLE tableName
    [ADD [COLUMN] colName dataType [NOT NULL] [UNIQUE]
        [DEFAULT value] [CHECK (condition)] ]
     [DROP [COLUMN] colName [RESTRICT | CASCADE]
     [ADD [CONSTRAINT [constraintName]] constraintDef]
     [DROP CONSTRAINT constraintName [RESTRICT | CASCADE]]
     [ALTER [COLUMN] SET DEFAULT defValue]
     [ALTER [COLUMN] DROP DEFAULT]
```

ALTER TABLE Examples

Add column `location` to `dept` relation:

```
ALTER TABLE dept
  ADD location VARCHAR(50);
```

Add field `SSN` to `Emp` relation:

```
ALTER TABLE emp
  ADD SSN CHAR(10);
```

Indicate that `SSN` is `UNIQUE` in `emp`:

```
ALTER TABLE emp
  ADD CONSTRAINT ssnConst UNIQUE(SSN);
```

DROP TABLE

The command **DROP TABLE** is used to delete the table definition and all data from the database:

```
DROP TABLE tableName [RESTRICT | CASCADE]
```

Example: `DROP TABLE emp;`

- Note: The database does not confirm if you really want to drop the table and delete its data. The effect of the command is immediate.
- RESTRICT will not drop object if it is used. CASCADE will drop object even if it is used.

Question: What would be the effect of the command:

```
DROP TABLE emp CASCADE;
```

Indexes

Indexes are used to speed up access to the rows of a table based on the values of certain attributes.

- An index will often significantly improve the performance of a query, however they represent an overhead as they must be updated every time the table is updated.

The general syntax for creating and dropping indexes is:

```
CREATE [UNIQUE] INDEX indexName
    ON  tableName (colName [ASC|DESC] [,...])

DROP INDEX indexName;
```

- `UNIQUE` means that each value in the index is unique.
- `ASC/DESC` specifies the sorted order of index.

Indexes Example

Creating an index on `eno` and `pno` in `workson` is useful as it will speed up joins with the `emp` and `proj` tables respectively.

- Index is not `UNIQUE` as `eno` (`pno`) can occur many times in `WorksOn`.

```
CREATE INDEX idxEno ON workson (eno);
CREATE INDEX idxPno ON workson (pno);
```

Most DBMSs will put an index on the primary key, but if they did not, this is what it would like for `workson`:

```
CREATE UNIQUE INDEX idxPK ON workson (eno,pno);
```

`CREATE TABLE` Question

Question: How many of the following statements are **TRUE**?

1) Each field in the `CREATE TABLE` statement is separated by a comma.

2) The data type for a field is optional.

3) You can create two tables in a database with the same name (in the same schema).

4) A table will not be dropped (with `DROP TABLE`) if it contains data.

A) 0 **B)** 1 **C)** 2 **D)** 3 **E)** 4

Connecting to MySQL – Command Line

1) Install Docker Desktop by following lab instructions.

2) Start Docker Desktop. Start container by running:
   - `docker-compose up -d`

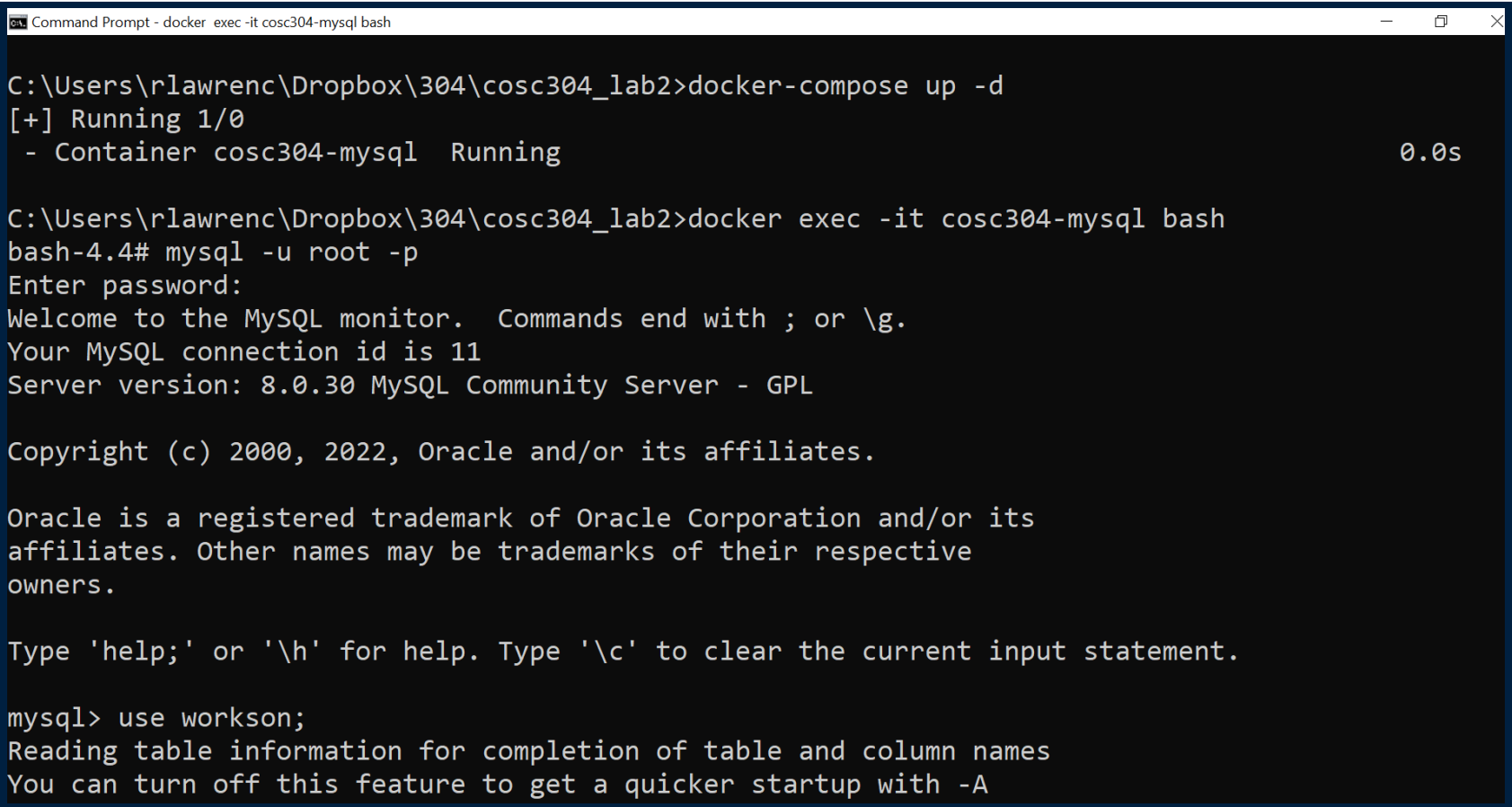
3) Connect to the container by running this command in shell:
   - `docker exec -it cosc304-mysql bash`

4) Connect to MySQL with: `mysql –u root -p`
   - See password in `docker-compose.yml` file.

4) Use `workson` database or `mydb`.

5) Run SQL commands.

Connecting to MySQL – Command Line (2)



Connecting to MySQL – GUI using SQuirreL

1) SQuirreL SQL is a GUI for SQL querying of multiple databases. Download at: **http://squirrel-sql.sourceforge.net/**

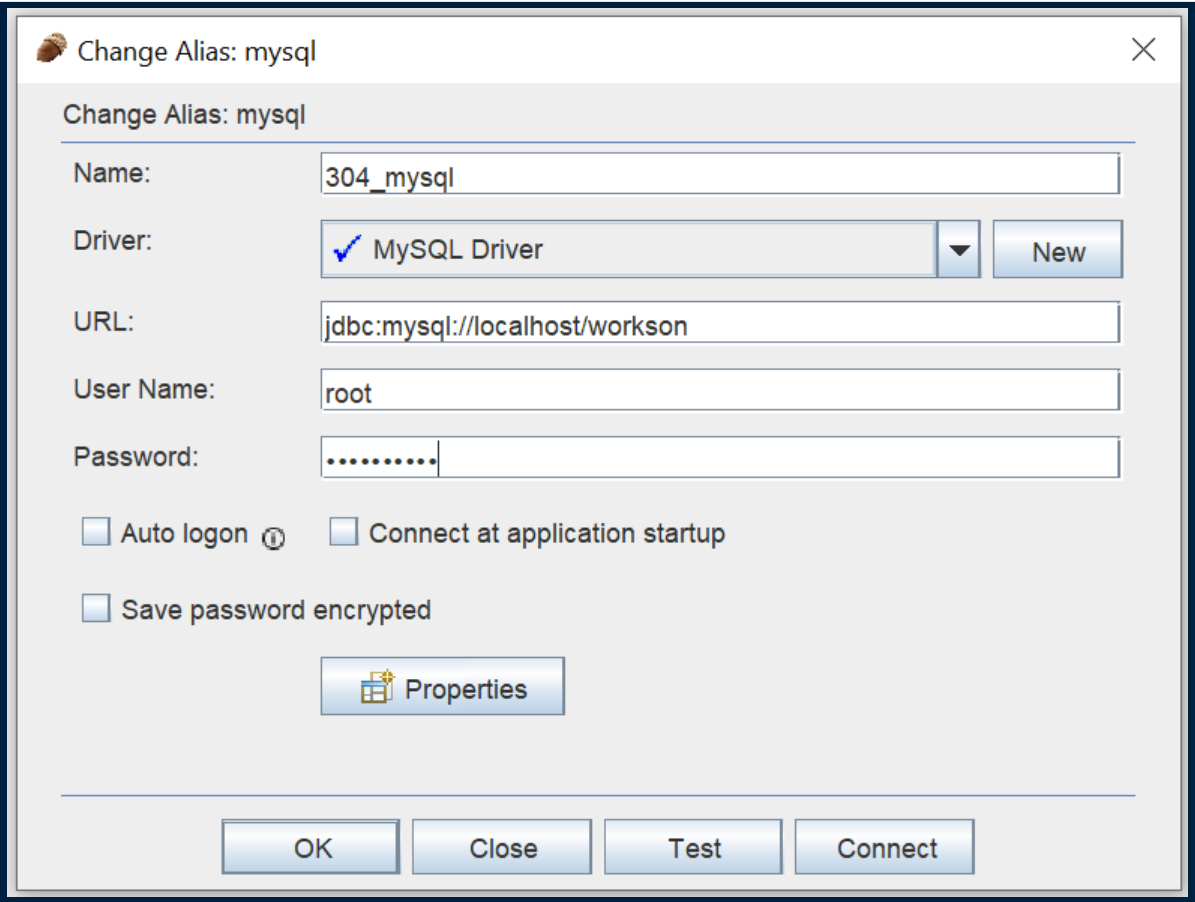
2) Install Java. Install SQuirreL.

3) Download the MySQL JDBC driver and put in lib folder of SQuirreL.

4) Create an alias to connect to SQuirreL.

5) Connect and run queries.

Connecting to MySQL – GUI using SQuirreL (2)



Try it: CREATE TABLE

Question: Create a table called `mydata` that has three fields:

- `num` – that will store a number (use `int` as data type)
- `message` – that will store a string up to 50 characters (`varchar` data type)
- `amount` – that stores a decimal number with 8 total digits and 2 decimal digits (`decimal` data type)

Connect to the sample MySQL database or use the web site **https://www.db-fiddle.com/** to try your table creation.

Adding Data using INSERT

Insert a row using the INSERT command:

```
INSERT INTO emp VALUES ('E9','S. Smith','1975-03-05',
                        'SA',60000,'E8','D1')
```

Fields: eno, ename, bdate, title, salary, supereno, dno

If you do not give values for all fields in the order they are in the table, you must list the fields you are providing data for:

```
INSERT INTO emp(eno, ename, salary)
       VALUES ('E9','S. Smith',60000)
```

Note: If any columns are omitted from the list, they are set to NULL.

INSERT Multiple Rows

INSERT statement extended by many databases to take multiple rows:

```
INSERT INTO tableName [(column list)]
VALUES (data value list) [, (values) ]*
```

Example:

```
INSERT INTO emp (eno, ename) VALUES
    ('E10', 'Fred'), ('E11', 'Jane'), ('E12', 'Joe')
```

INSERT rows from SELECT

Insert multiple rows that are the result of a SELECT statement:

```
INSERT INTO tableName [(column list)]
  SELECT ...
```

Example: Add rows to a temporary table that contains only employees with title ='EE'.

```
INSERT INTO tmpTable
    SELECT eno, ename
    FROM emp
    WHERE title = 'EE'
```

Try it: INSERT

Question: Using the `mydata` table insert three rows:

- `(1, 'Hello', 99.45)`
- `(2, 'Goodbye', 55.99)`
- `(3, 'No Amount')`

Connect to the sample MySQL database or use the web site **https://www.db-fiddle.com/** to try.

UPDATE Statement

Updating existing rows using the `UPDATE` statement. Examples:

- 1) Increase all employee salaries by 10%.

```
UPDATE emp SET salary = salary*1.10;
```

- 2) Increase salary of employee E2 to $1 million and change his name:

```
UPDATE emp SET salary = 1000000, name='Rich Guy'
WHERE eno = 'E2';
```

Notes:

- May change (`SET`) more than one value at a time. Separate by commas.
- Use `WHERE` to filter only the rows to update.

Try it: UPDATE

Question: Using the `mydata` table and the three rows previously inserted do these updates:

- Update all `amount` fields to be `99.99`.
- Update the `num` field and set it to 10 for the record with `num = 1`.
- Update the `message` field to `'Changed'` for the record with `num = 2`.

Connect to the sample MySQL database or use the web site **https://www.db-fiddle.com/** to try.

DELETE Statement

Rows are deleted using the `DELETE` statement. Examples:

- 1) Fire everyone in the company.

```
DELETE FROM emp;
```

- 2) Fire everyone making over $35,000.

```
DELETE FROM emp
WHERE salary > 35000;
```

Try it: DELETE

Question: Using the `mydata` table and the three rows previously inserted do these deletes:

- Delete the row with `num = 1`.
- Delete the row(s) with `message > 'C'`.
- Delete all rows.

Connect to the sample MySQL database or use the web site **https://www.db-fiddle.com/** to try your DELETE statements.

INSERT Question

Question: How many of the following statements are **TRUE**?

1) You must always specify the fields being inserted with `INSERT` statement.

2) If you list the fields, the fields must be in the same order as the table.

3) If you do not provide a value for a number field, it will default to 1.

4) Number data items are enclosed in single quotes.

A) 0 **B)** 1 **C)** 2 **D)** 3 **E)** 4

UPDATE Question

Question: How many of the following statements are **TRUE**?

1) You may update more than one row at a time.
2) If the `UPDATE` has no `WHERE` clause, it updates all rows.
3) You may update zero or more rows using a`UPDATE` statement.
4) `UPDATE` may change more than one data value (column) in a row.

A) 0 **B)** 1 **C)** 2 **D)** 3 **E)** 4

DELETE Question

Question: How many of the following statements are **TRUE**?

1) A `DELETE` with no `WHERE` clause will delete all rows.
2) The `DELETE` keyword is case-sensitive.
3) It is possible to `DELETE` zero or more rows using a `WHERE` clause.
4) A `DELETE` statement may delete zero rows when executed.

A) 0 **B)** 1 **C)** 2 **D)** 3 **E)** 4

Practice Questions

Relational database schema:

```
emp (eno, ename, bdate, title, salary, supereno, dno)
proj (pno, pname, budget, dno)
dept (dno, dname, mgreno)
workson (eno, pno, resp, hours)
```

1) Insert a department with number `'D5'`, name `'Useless'`, and no manager.
2) Insert a `workson` record with `eno='E1'` and `pno='P3'`.
3) Delete all records from `emp`.
4) Delete only the records in `workson` with more than 20 hours.
5) Update all employees to give them a 20% pay cut.
6) Update the projects for `dno='D3'` to increase their budget by 10%.

Conclusion

SQL is the standard query language for databases.

SQL contains a data definition language that allows you to `CREATE`, `ALTER`, and `DROP` database objects such as tables, indexes, schemas, and views. `CREATE TABLE` creates a table.

Constraints are used to preserve the integrity of the database:

- `CHECK` can be used to validate attribute values.
- **Entity Integrity constraint** - The primary key of a table must contain a unique, non-null value for each row.
- **Referential integrity constraint** - Defines a foreign key that references a unique key of another table.

`INSERT`, `DELETE`, and `UPDATE` commands modify the data stored within the database.

Objectives

- Recognize valid and invalid identifiers.
- Explain the key types of constraints and how to enforce them: required (not null) data, domain constraints, entity integrity, referential integrity.
- Write a `CREATE TABLE` statement given a high-level description.
- List what `ALTER TABLE` can and cannot do.
- Remove a table using `DROP TABLE`.
- Create an index on fields of a table.
- Explain how an index helps improve query time.
- Write `INSERT`, `DELETE`, and `UPDATE` commands.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