10 – Database implementation - MySQL

ASE230 – Server-Side Programming

Nicholas Caporusso

Objectives

- Create and query a database using MySQL

Agenda

1. Introduction to PHPMyAdmin
2. Database creation and manipulation
3. Tools for manipulating data
4. Exporting and importing data
5. Working with users and privileges
6. Managing databases and tables

Introduction to PHPMyAdmin

PhpMyAdmin

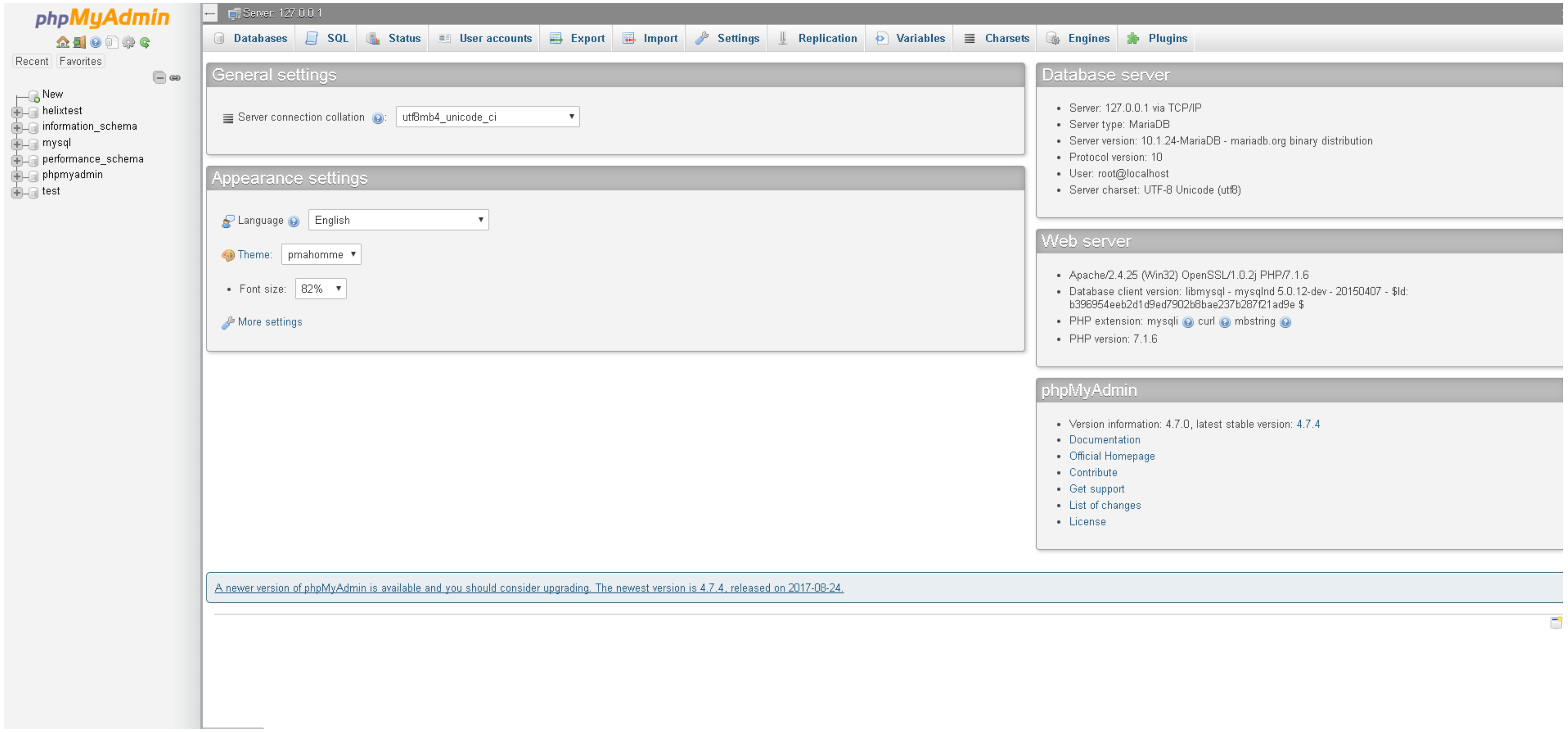
- myPhpAdmin: A popular web interface to MySQL that comes bundled with XAMPP and LAMP

- The default URL:
  - http://localhost/phpmyadmin

- Make sure you enabled MySQL from XAMPP panel!!

- Note: On new MySQL installations the single user account defined is “root” and the password is blank or “”.

The main interface



General settings

Server connection collation: utf8mb4_unicode_ci

Appearance settings

Language: English

Theme: pmahomme

- Font size: 82%

More settings

Database server

- Server: 127.0.0.1 via TCP/IP
- Server type: MariaDB
- Server version: 10.1.24-MariaDB - mariadb.org binary distribution
- Protocol version: 10
- User: root@localhost
- Server charset: UTF-8 Unicode (utf8)

Web server

- Apache/2.4.25 (Win32) OpenSSL/1.0.2j PHP/7.1.6
- Database client version: libmysql - mysqlnd 5.0.12-dev - 20150407 - $Id: b396954eeb2d1d9ed7902b8bae237b287f21ad9e $
- PHP extension: mysqli curl mbstring
- PHP version: 7.1.6

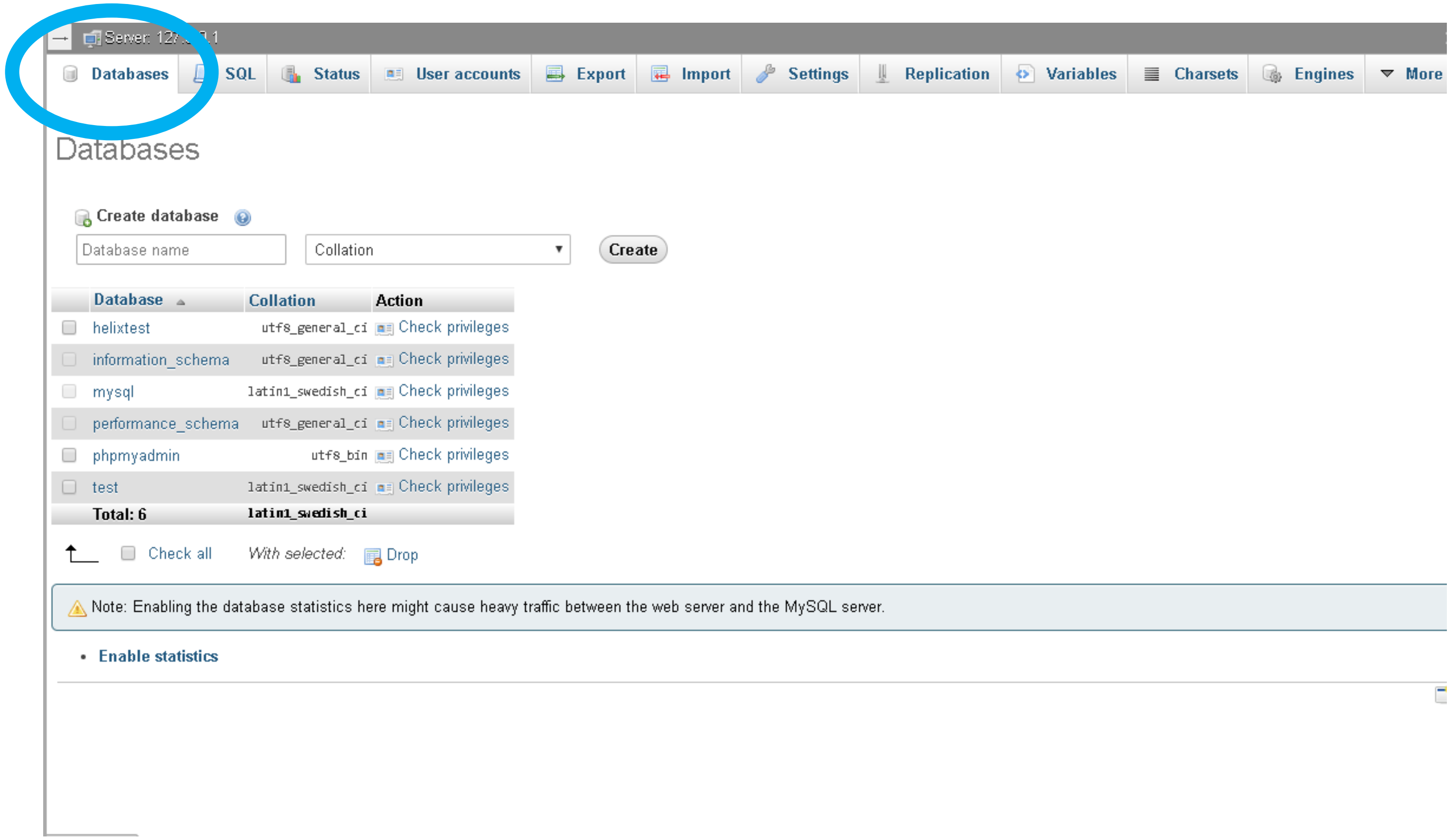
phpMyAdmin

- Version information: 4.7.0, latest stable version: 4.7.4
- Documentation
- Official Homepage
- Contribute
- Get support
- List of changes
- License

A newer version of phpMyAdmin is available and you should consider upgrading. The newest version is 4.7.4, released on 2017-08-24.

Database creation and manipulation

Listing your databases



Databases

Create database

Database name | Collation | Create

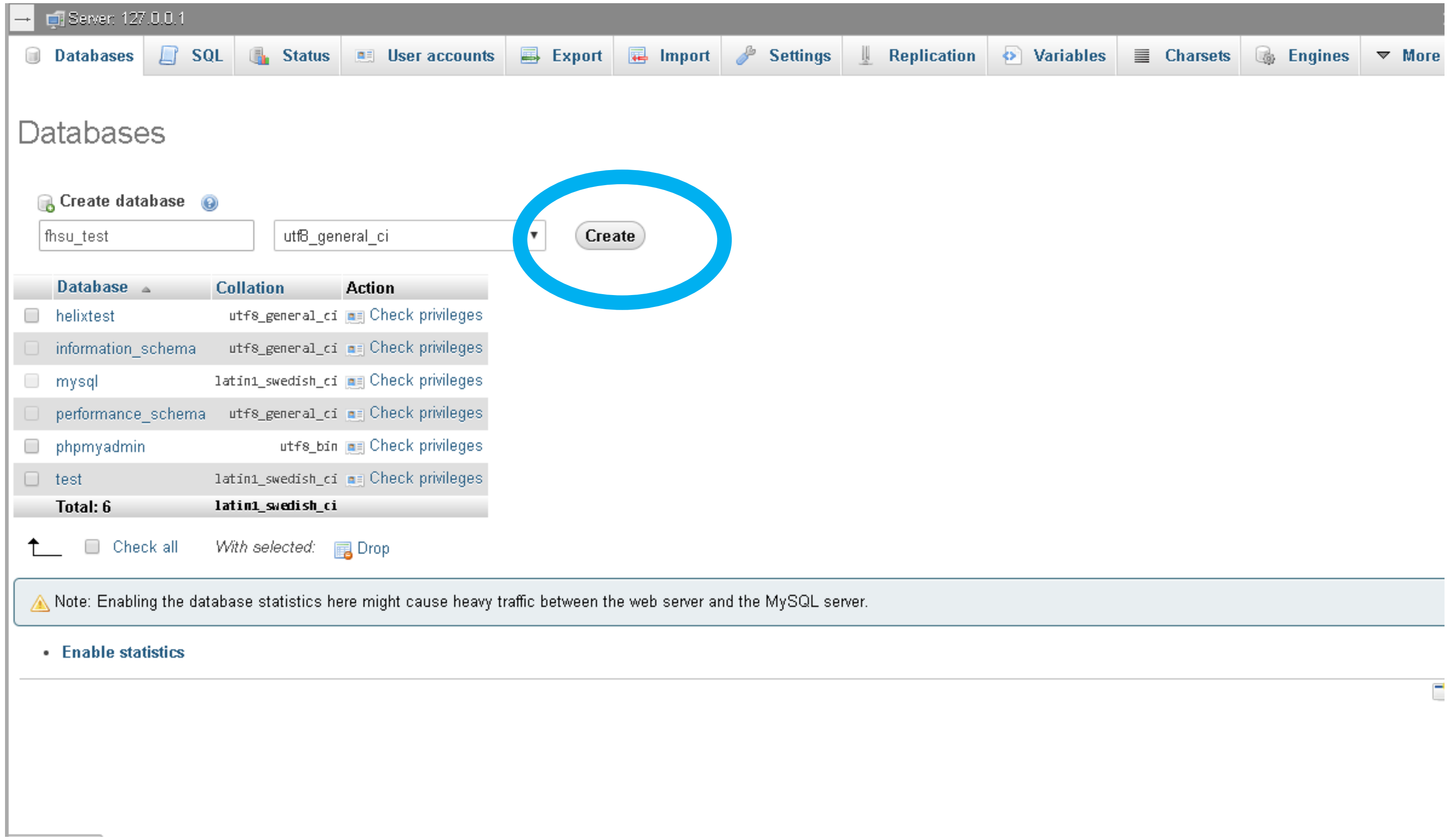
Database	Collation	Action
helixtest	utf8_general_ci	Check privileges
information_schema	utf8_general_ci	Check privileges
mysql	latin1_swedish_ci	Check privileges
performance_schema	utf8_general_ci	Check privileges
phpmyadmin	utf8_bin	Check privileges
test	latin1_swedish_ci	Check privileges
Total: 6	latin1_swedish_ci	

Check all *With selected:* Drop

Note: Enabling the database statistics here might cause heavy traffic between the web server and the MySQL server.

- **Enable statistics**

Create a new database



Databases

Create database

fhsu_test | utf8_general_ci | Create

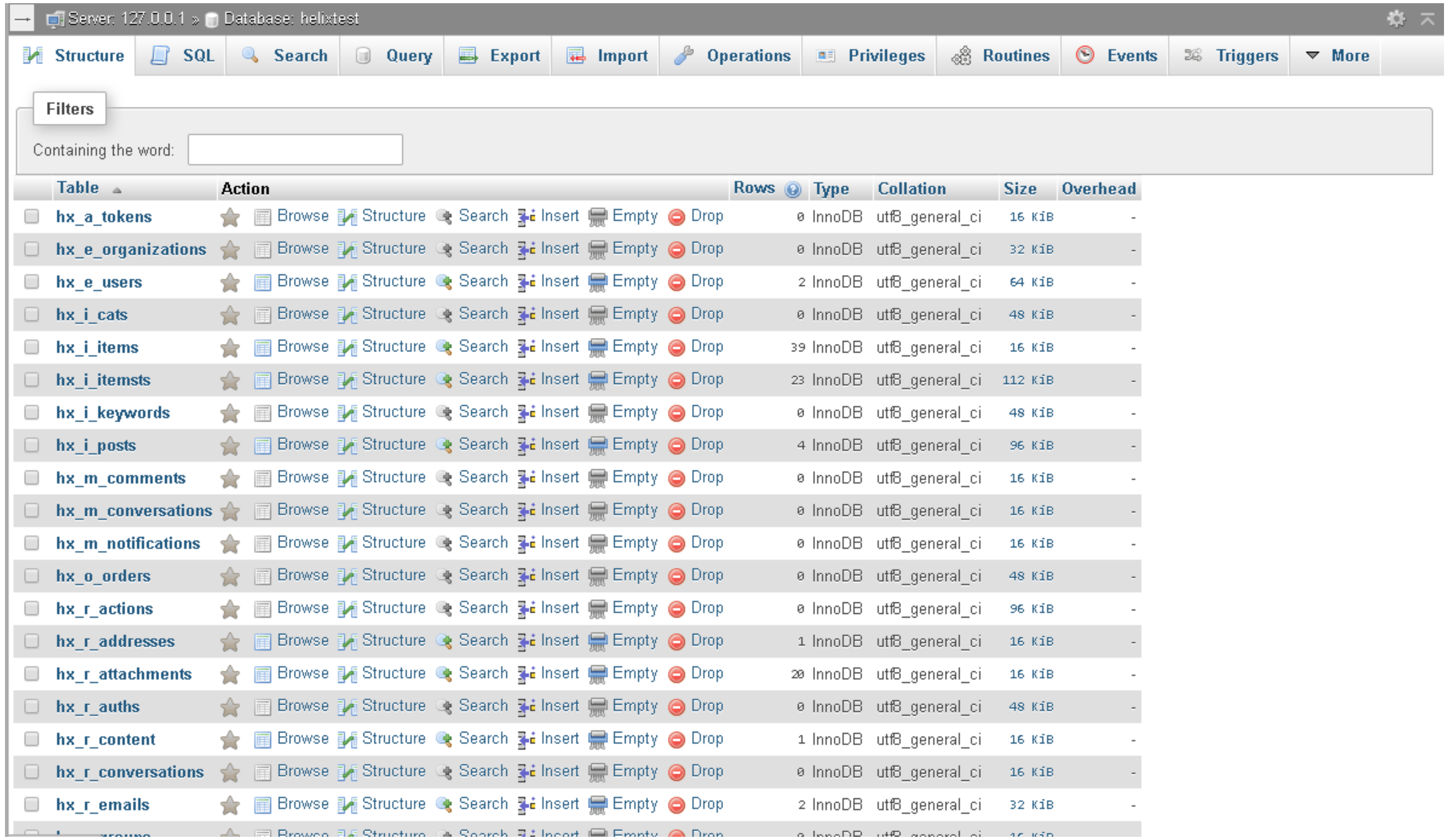
	Database	Collation	Action
☐	helixtest	utf8_general_ci	Check privileges
☐	information_schema	utf8_general_ci	Check privileges
☐	mysql	latin1_swedish_ci	Check privileges
☐	performance_schema	utf8_general_ci	Check privileges
☐	phpmyadmin	utf8_bin	Check privileges
☐	test	latin1_swedish_ci	Check privileges
	Total: 6	latin1_swedish_ci	

Check all *With selected:* Drop

Note: Enabling the database statistics here might cause heavy traffic between the web server and the MySQL server.

- **Enable statistics**

Listing all tables


Server: 127.0.0.1 » Database: helixtest

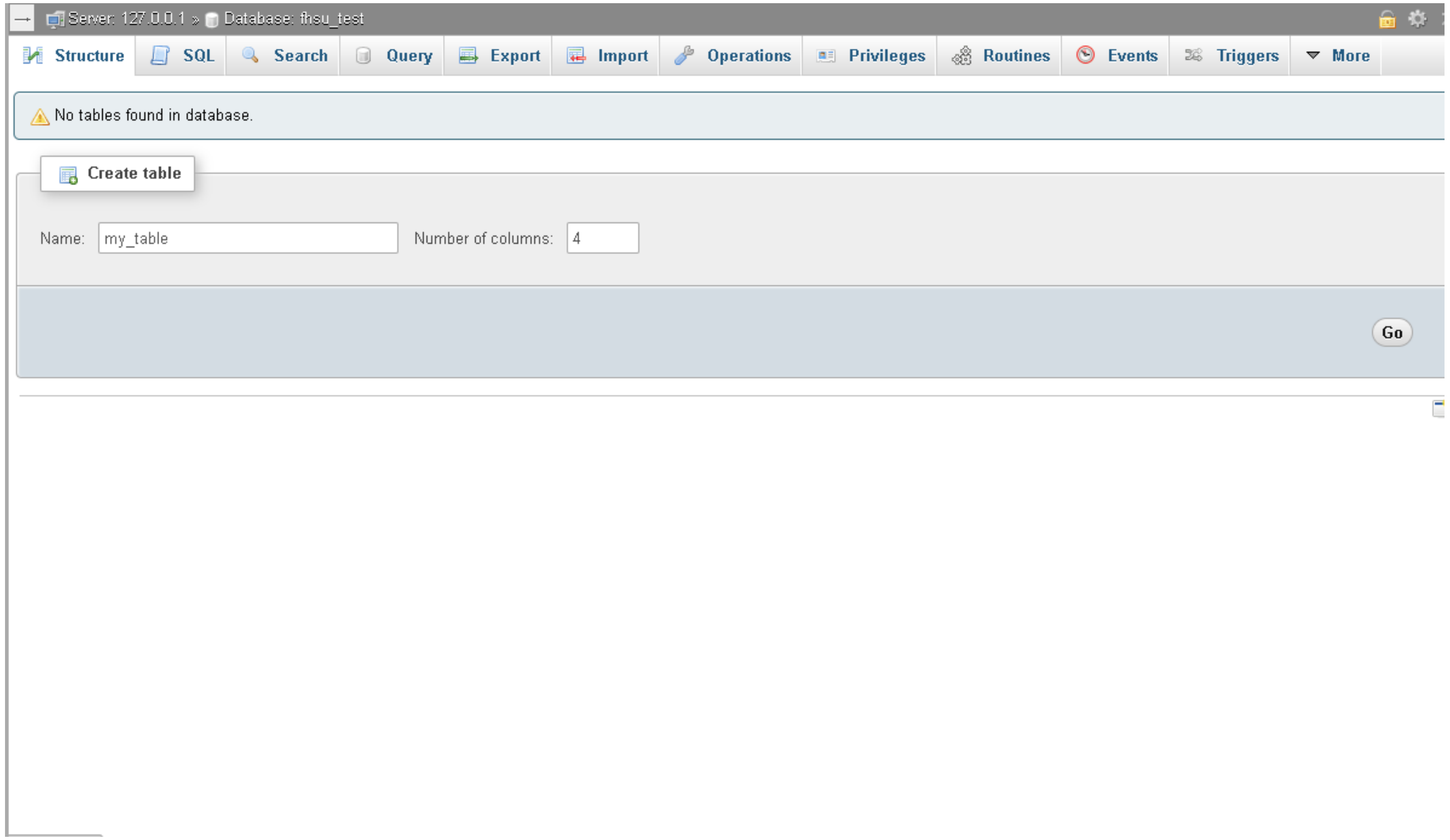
Structure | SQL | Search | Query | Export | Import | Operations | Privileges | Routines | Events | Triggers | More

Filters

Containing the word:

Table	Action	Rows	Type	Collation	Size	Overhead
hx_a_tokens	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	16 KiB	-
hx_e_organizations	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	32 KiB	-
hx_e_users	Browse Structure Search Insert Empty Drop	2	InnoDB	utf8_general_ci	64 KiB	-
hx_i_cats	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	48 KiB	-
hx_i_items	Browse Structure Search Insert Empty Drop	39	InnoDB	utf8_general_ci	16 KiB	-
hx_i_itemsts	Browse Structure Search Insert Empty Drop	23	InnoDB	utf8_general_ci	112 KiB	-
hx_i_keywords	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	48 KiB	-
hx_i_posts	Browse Structure Search Insert Empty Drop	4	InnoDB	utf8_general_ci	96 KiB	-
hx_m_comments	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	16 KiB	-
hx_m_conversations	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	16 KiB	-
hx_m_notifications	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	16 KiB	-
hx_o_orders	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	48 KiB	-
hx_r_actions	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	96 KiB	-
hx_r_addresses	Browse Structure Search Insert Empty Drop	1	InnoDB	utf8_general_ci	16 KiB	-
hx_r_attachments	Browse Structure Search Insert Empty Drop	20	InnoDB	utf8_general_ci	16 KiB	-
hx_r_auths	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	48 KiB	-
hx_r_content	Browse Structure Search Insert Empty Drop	1	InnoDB	utf8_general_ci	16 KiB	-
hx_r_conversations	Browse Structure Search Insert Empty Drop	0	InnoDB	utf8_general_ci	16 KiB	-
hx_r_emails	Browse Structure Search Insert Empty Drop	2	InnoDB	utf8_general_ci	32 KiB	-

Creating a new table (1/2)



No tables found in database.

Name: my_table   Number of columns: 4

Creating a new table (2/2)

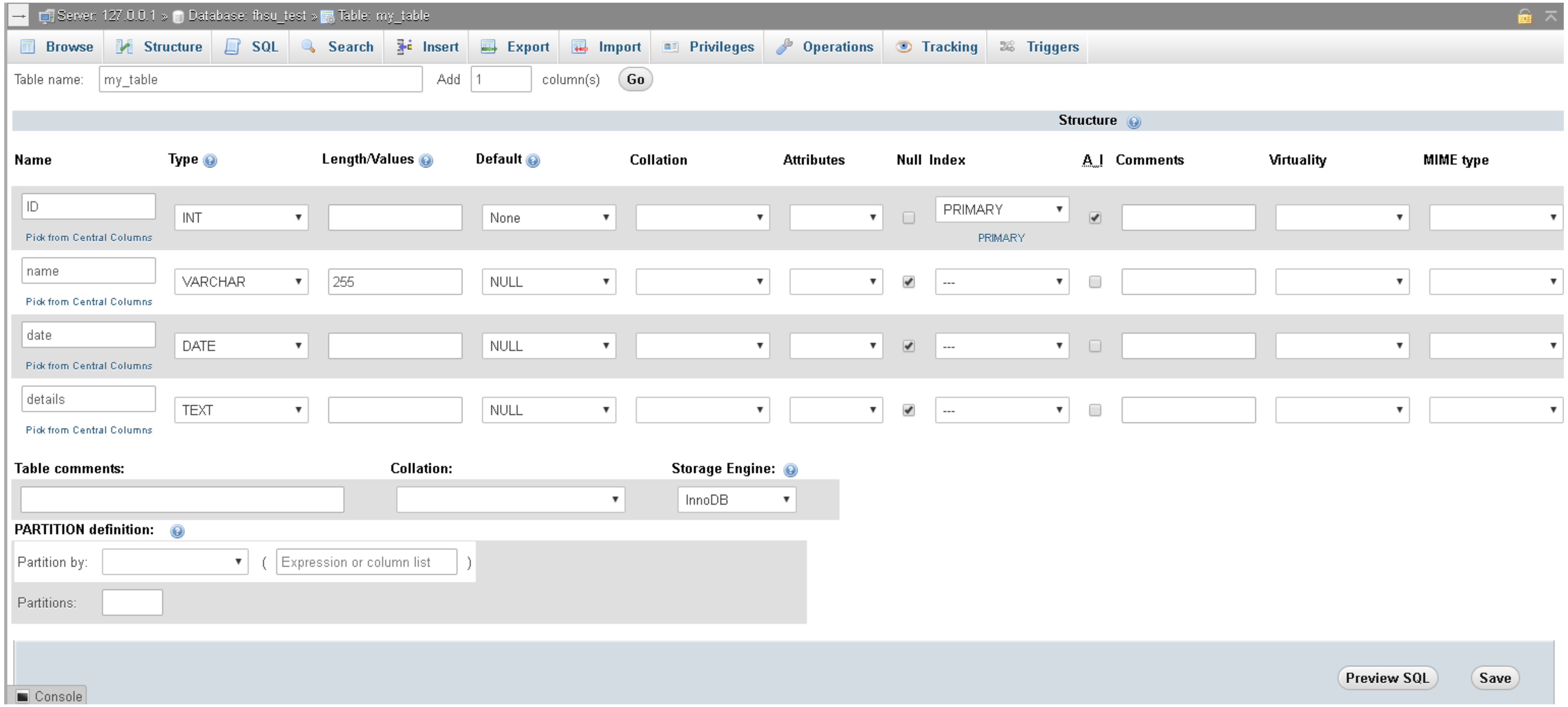

Server: 127.0.0.1 » Database: fhsu_test » Table: my_table

Table name: my_table Add 1 column(s) Go

Structure

Name	Type	Length/Values	Default	Collation	Attributes	Null	Index	A_I	Comments	Virtuality	MIME type
ID	INT		None			☐	PRIMARY	✓			
name	VARCHAR	255	NULL			✓	---	☐			
date	DATE		NULL			✓	---	☐			
details	TEXT		NULL			✓	---	☐			

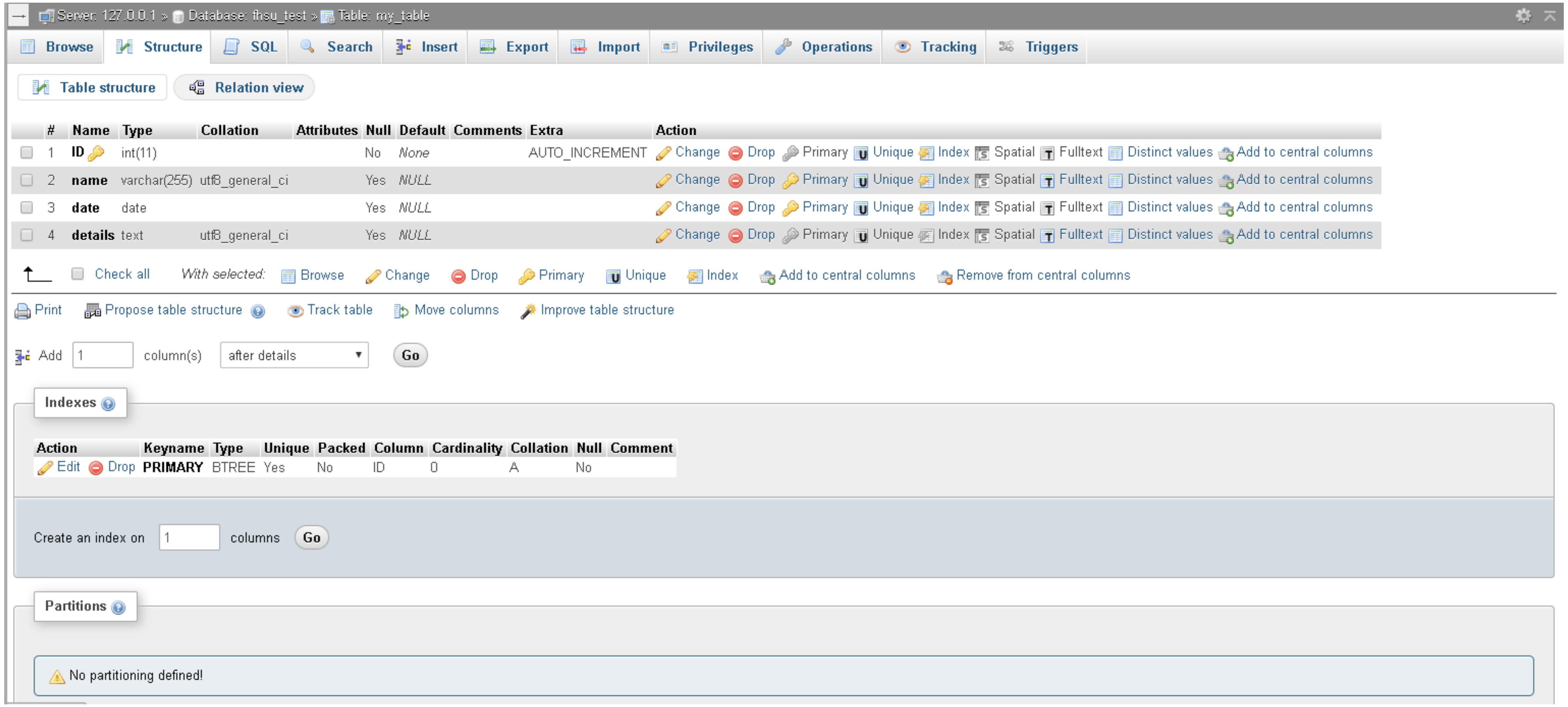
Table comments: Collation: Storage Engine: InnoDB

PARTITION definition:

Partition by: (Expression or column list)

Partitions:

Table structure



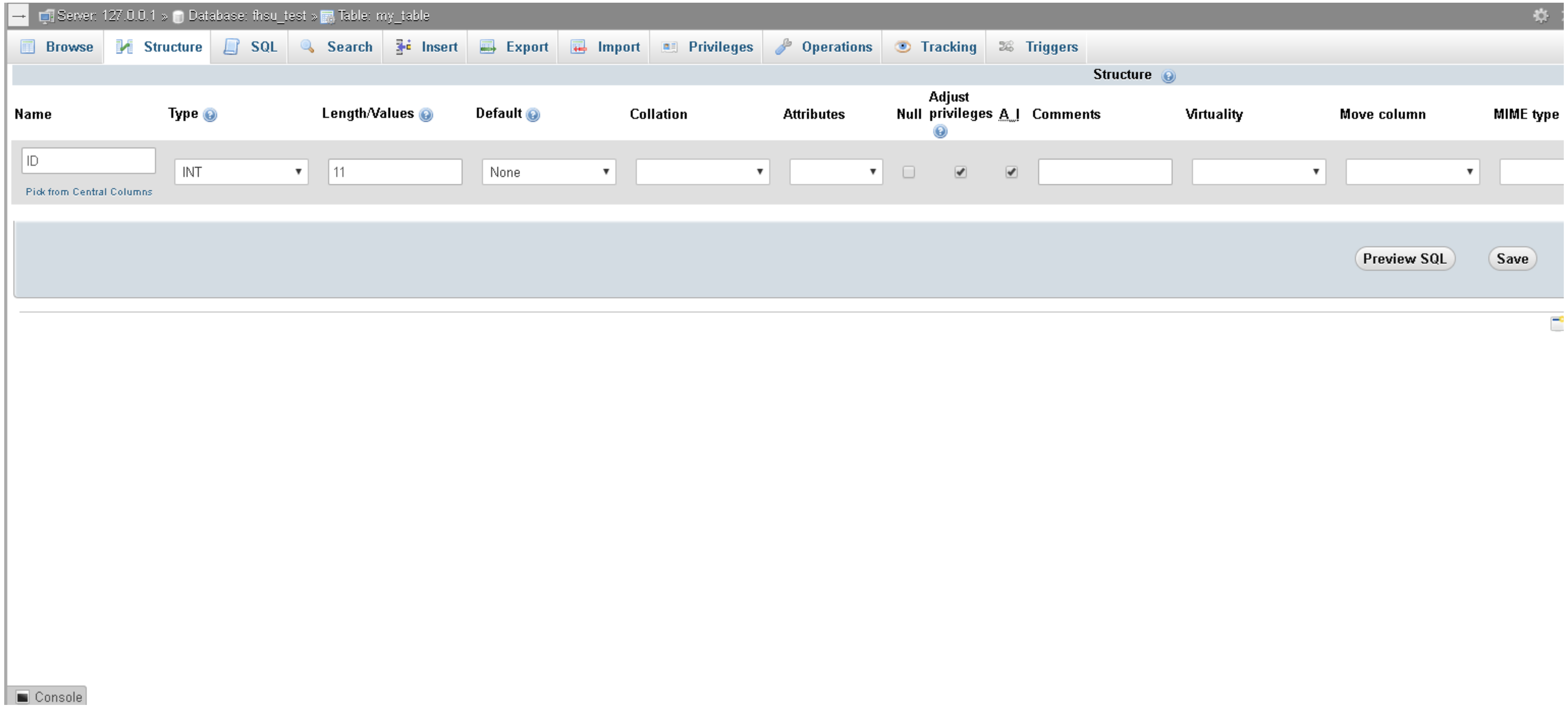
#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	ID	int(11)			No	*None*		AUTO_INCREMENT	Change Drop Primary Unique Index Spatial Fulltext Distinct values Add to central columns
2	**name**	varchar(255)	utf8_general_ci		Yes	*NULL*			Change Drop Primary Unique Index Spatial Fulltext Distinct values Add to central columns
3	**date**	date			Yes	*NULL*			Change Drop Primary Unique Index Spatial Fulltext Distinct values Add to central columns
4	**details**	text	utf8_general_ci		Yes	*NULL*			Change Drop Primary Unique Index Spatial Fulltext Distinct values Add to central columns

Check all
With selected: Browse Change Drop Primary Unique Index Add to central columns Remove from central columns
Print
Propose table structure
Track table
Move columns
Improve table structure
Add 1 column(s) after details Go
Indexes

Action	Keyname	Type	Unique	Packed	Column	Cardinality	Collation	Null	Comment
Edit Drop	**PRIMARY**	BTREE	Yes	No	ID	0	A	No	

No partitioning defined!

Modifying a field



Server: 127.0.0.1 » Database: fhsu_test » Table: my_table

Browse | Structure | SQL | Search | Insert | Export | Import | Privileges | Operations | Tracking | Triggers

Structure

Name	Type	Length/Values	Default	Collation	Attributes	Null	Adjust privileges	A_I	Comments	Virtuality	Move column	MIME type
ID	INT	11	None			☐	✓	✓				

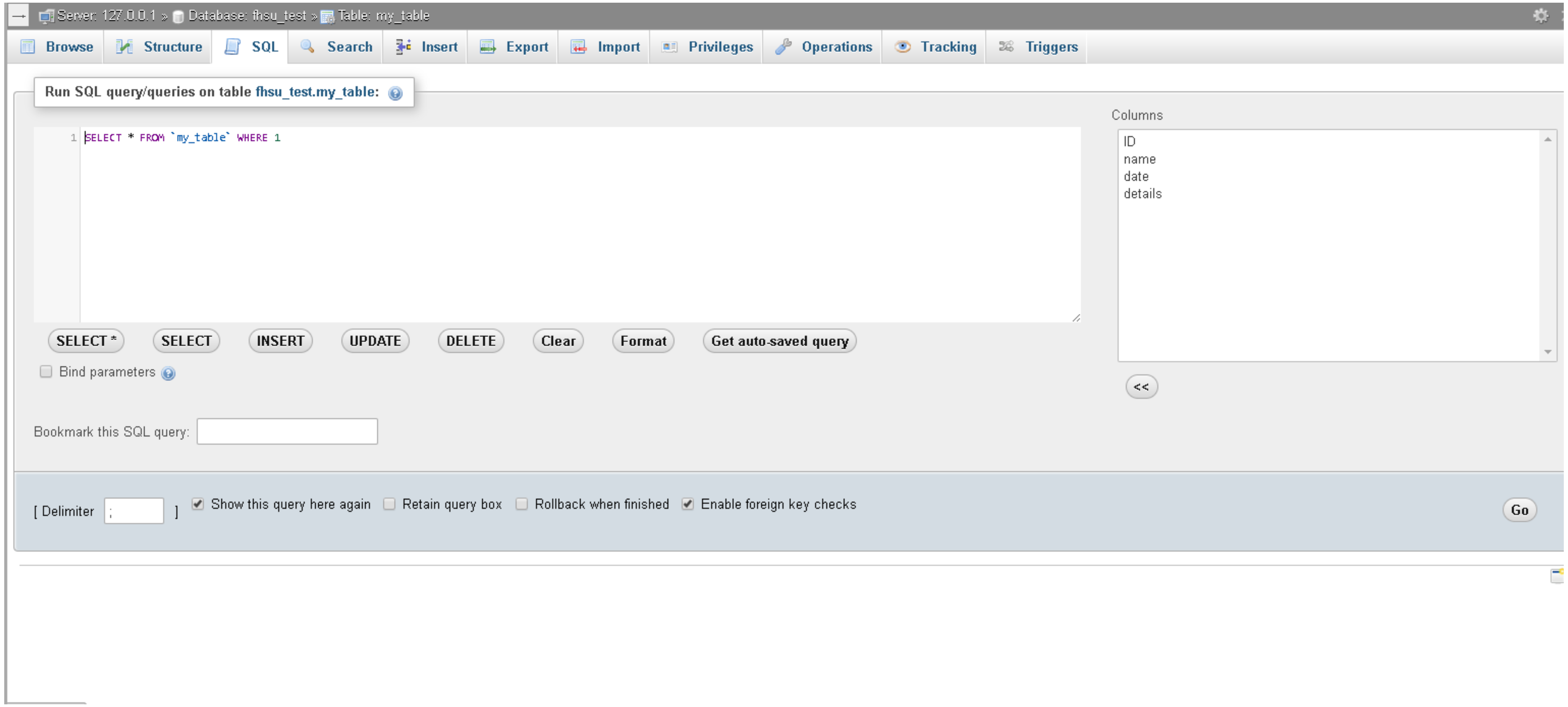
Pick from Central Columns

Preview SQL | Save

Console

Tools for manipulating data

The SQL window



```
SELECT * FROM `my_table` WHERE 1
```

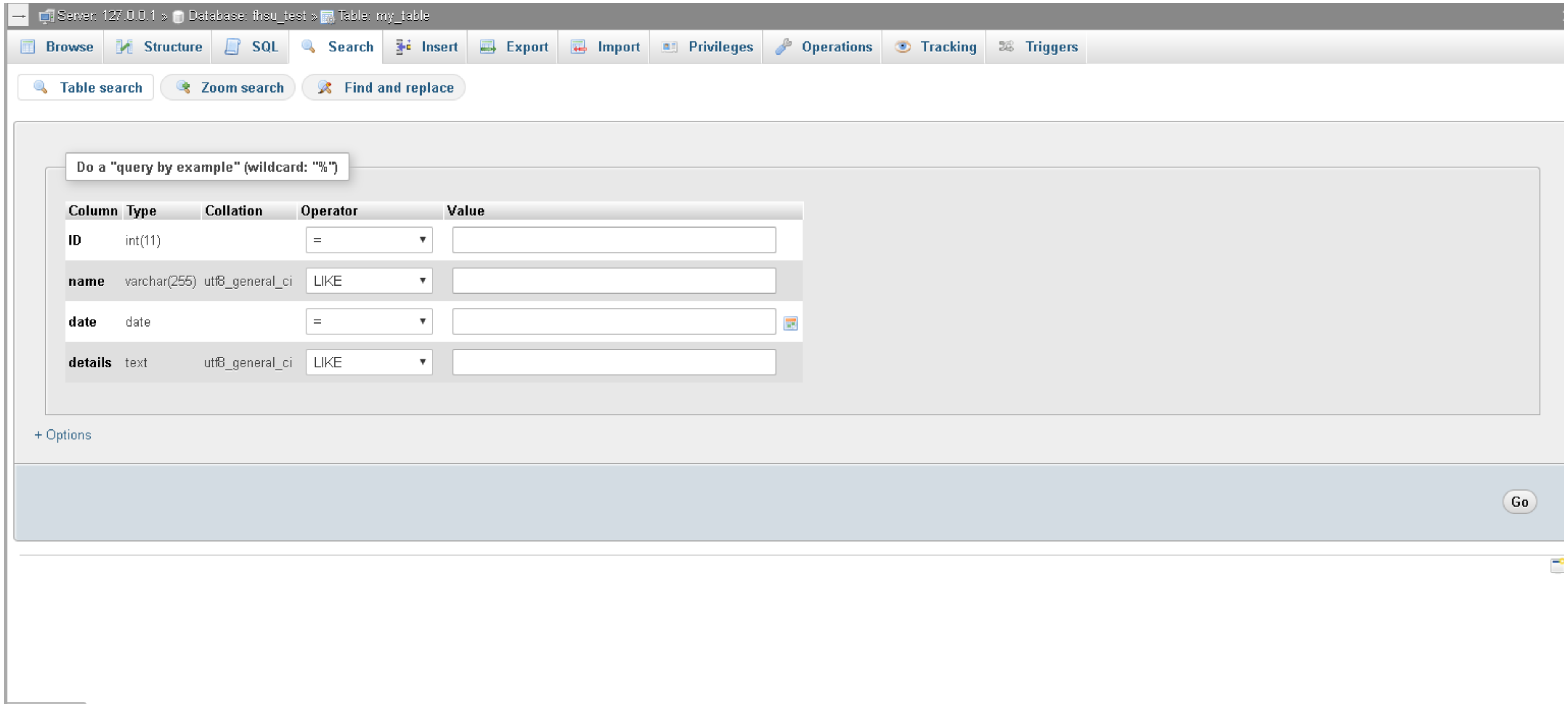
Columns: ID, name, date, details

☐ Bind parameters

Bookmark this SQL query:

[Delimiter ;] ☑ Show this query here again ☐ Retain query box ☐ Rollback when finished ☑ Enable foreign key checks

The search window

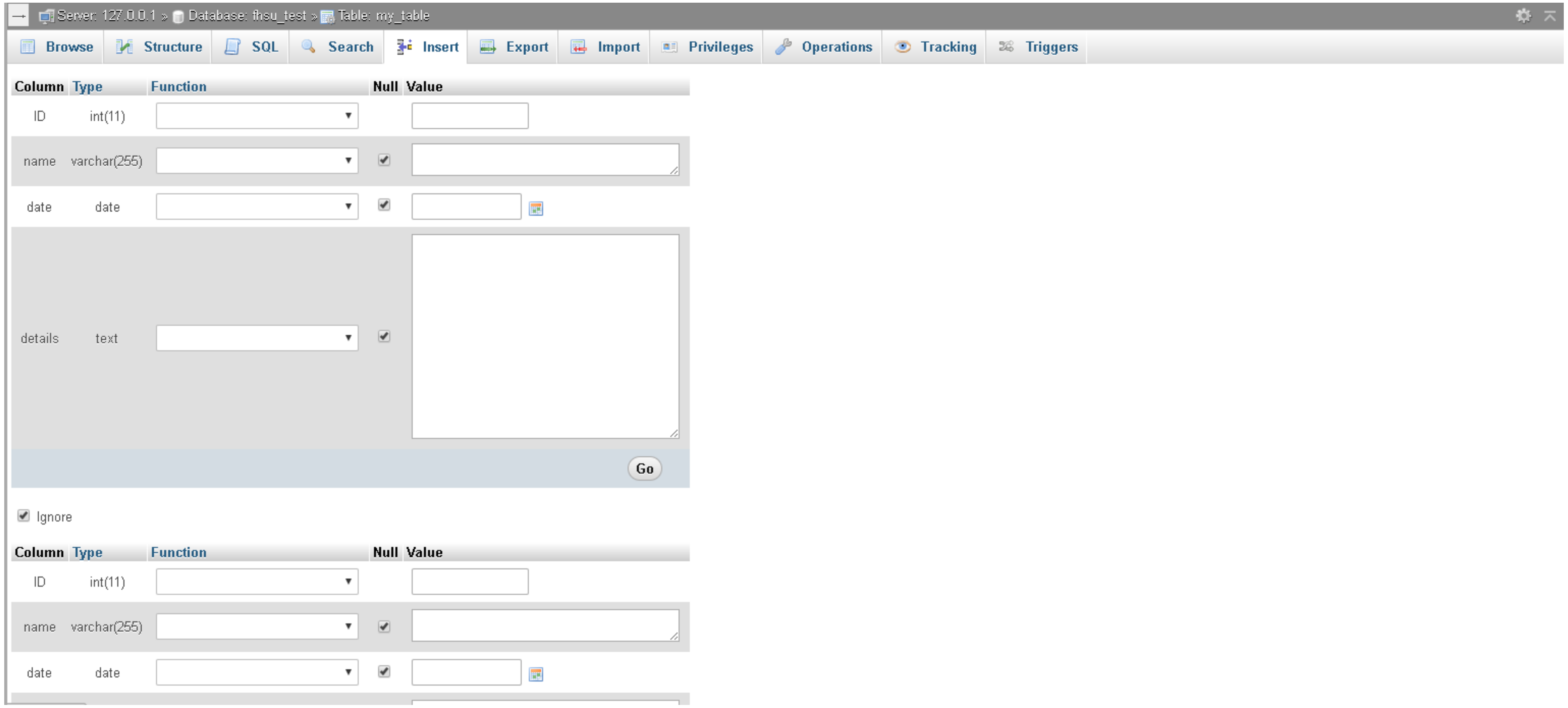


Server: 127.0.0.1 » Database: fhsu_test » Table: my_table

Do a "query by example" (wildcard: "%")

Column	Type	Collation	Operator	Value
ID	int(11)		=	
name	varchar(255)	utf8_general_ci	LIKE	
date	date		=	
details	text	utf8_general_ci	LIKE	

Inserting a new record



Server: 127.0.0.1 » Database: fhsu_test » Table: my_table

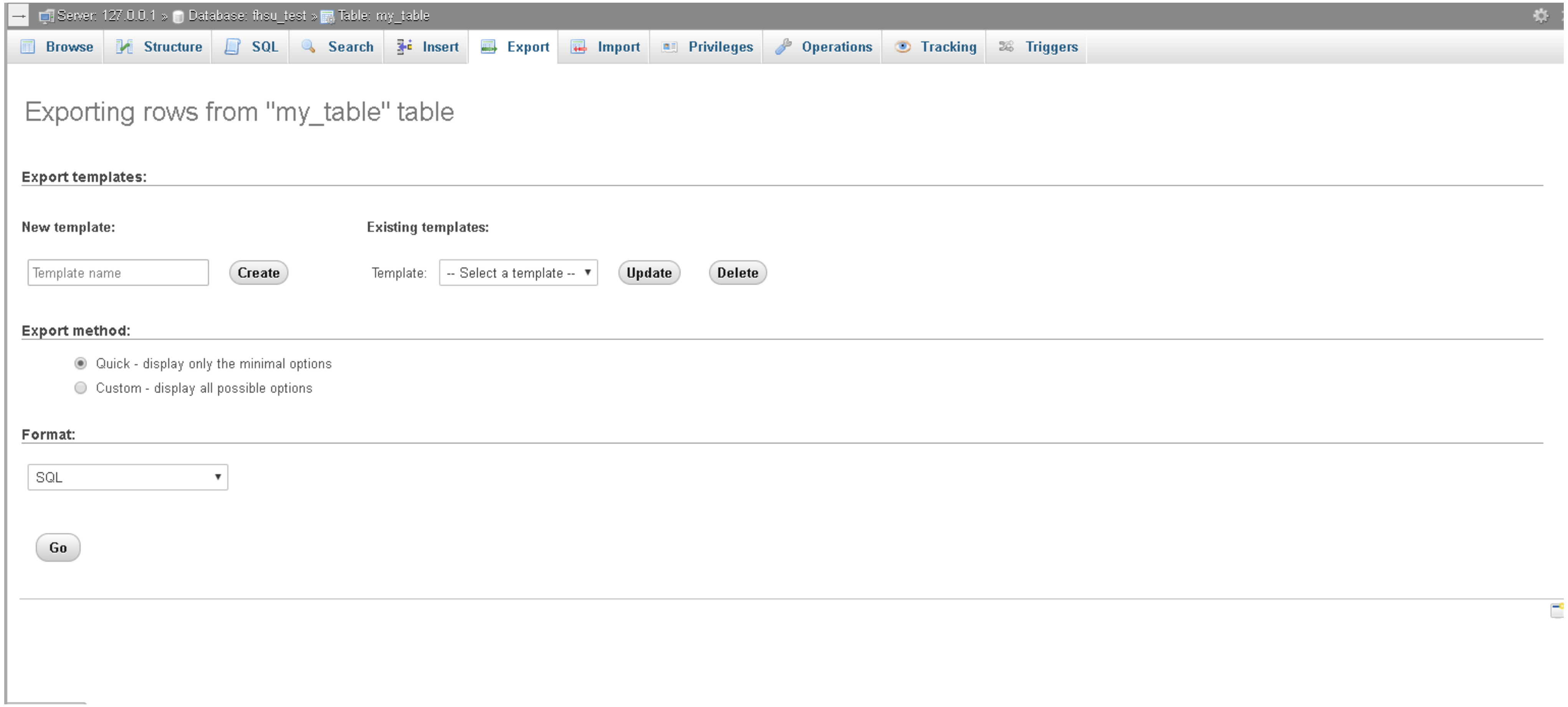
Column	Type	Function	Null	Value
ID	int(11)			
name	varchar(255)		✓	
date	date		✓	
details	text		✓	

✓ Ignore

Column	Type	Function	Null	Value
ID	int(11)			
name	varchar(255)		✓	
date	date		✓	

Exporting and importing data

Exporting data



Exporting rows from "my_table" table

Export templates:

New template:

Template name

Create

Existing templates:

Template: -- Select a template --

Update

Delete

Export method:

[✓ Quick - display only the minimal options]

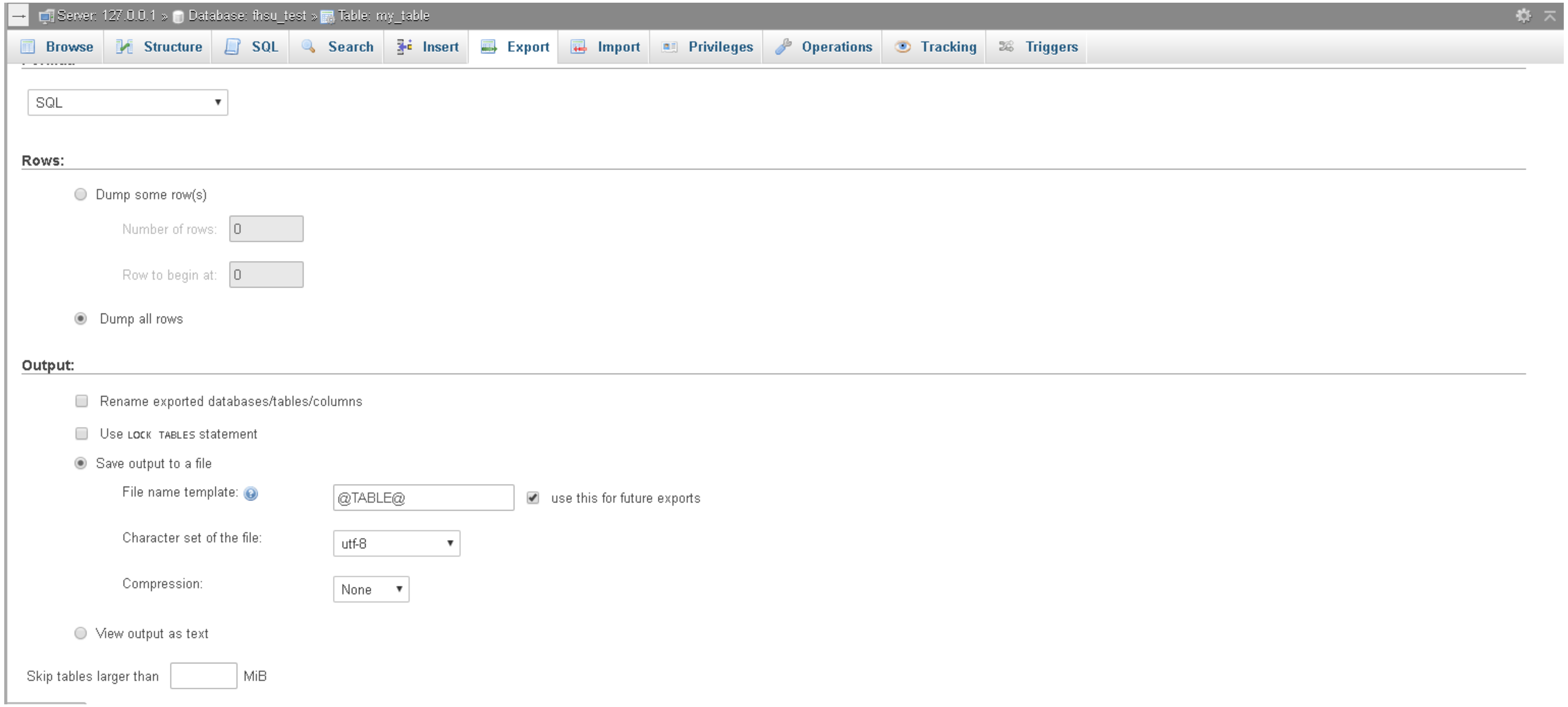
Custom - display all possible options

Format:

SQL

Go

Options for exporting data (1/3)



SQL

Rows:

○ Dump some row(s)

Number of rows: 0

Row to begin at: 0

● Dump all rows

Output:

☐ Rename exported databases/tables/columns

☐ Use LOCK TABLES statement

● Save output to a file

File name template: @TABLE@ ☑ use this for future exports

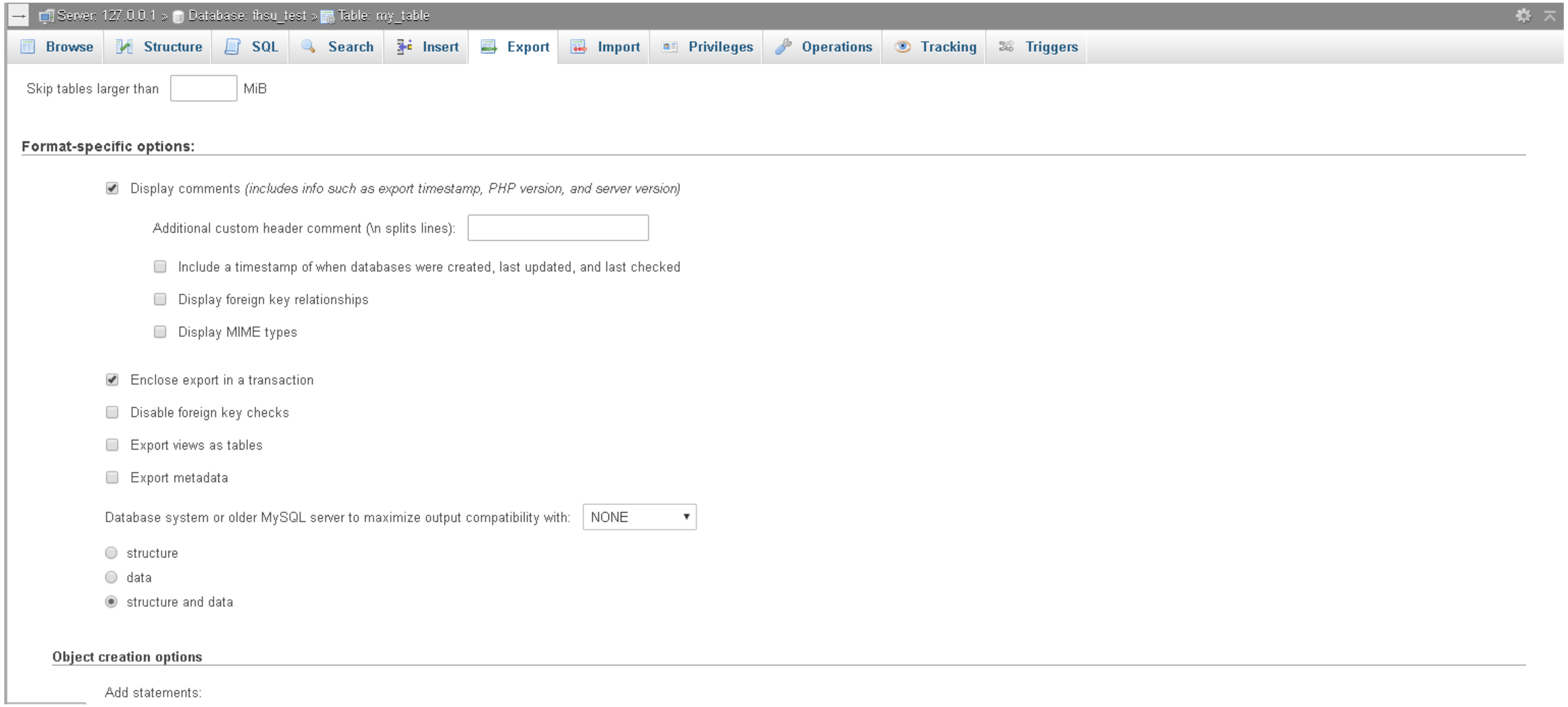
Character set of the file: utf-8

Compression: None

○ View output as text

Skip tables larger than MiB

Options for exporting data (2/3)



Server: 127.0.0.1 » Database: fhsu_test » Table: my_table

Skip tables larger than [ ] MiB

Format-specific options:

- [x] Display comments *(includes info such as export timestamp, PHP version, and server version)*
  - Additional custom header comment (\n splits lines): [ ]
  - [ ] Include a timestamp of when databases were created, last updated, and last checked
  - [ ] Display foreign key relationships
  - [ ] Display MIME types
- [x] Enclose export in a transaction
- [ ] Disable foreign key checks
- [ ] Export views as tables
- [ ] Export metadata

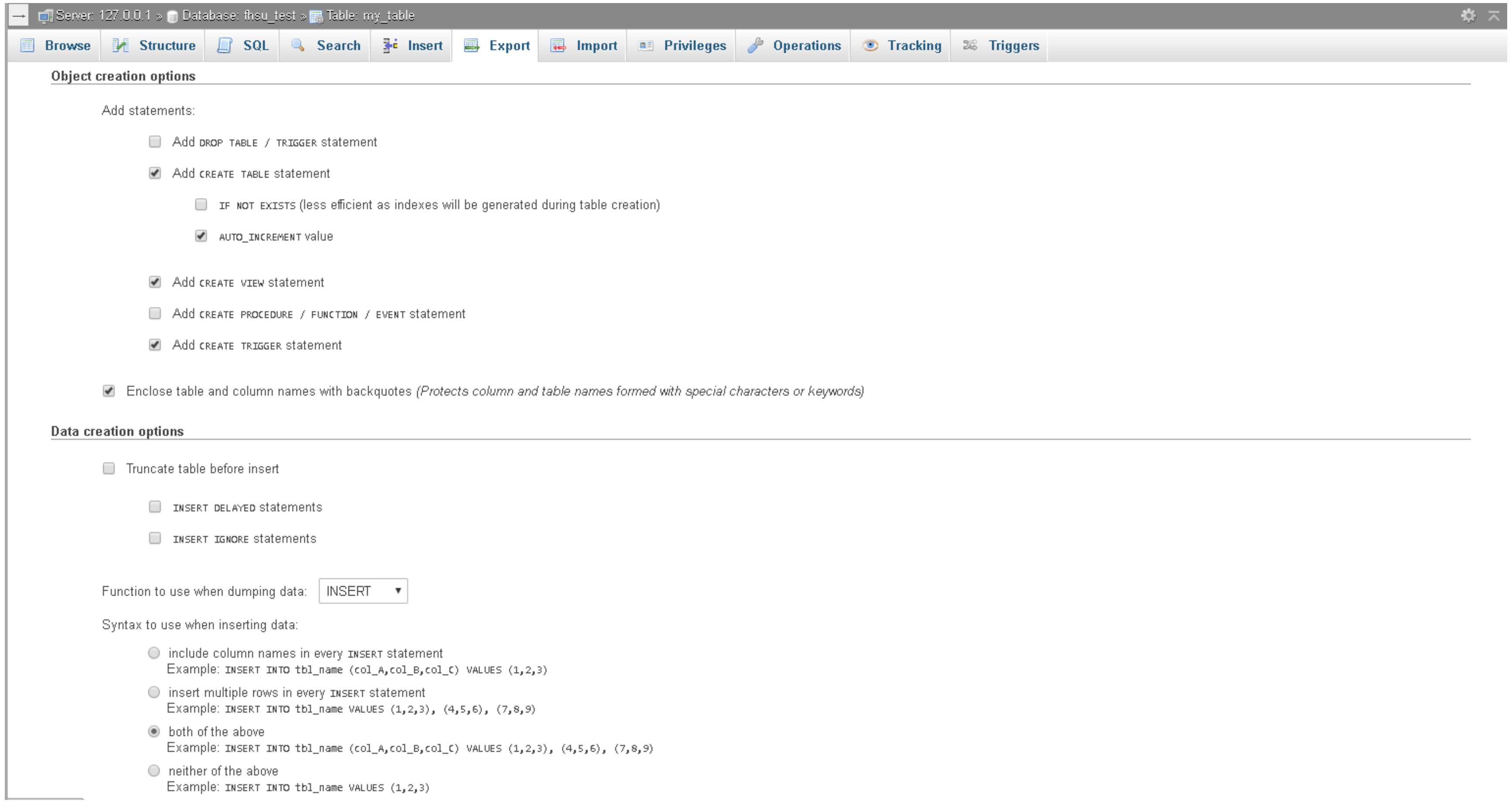
Database system or older MySQL server to maximize output compatibility with: NONE

- ○ structure
- ○ data
- ● structure and data

Object creation options

Add statements:

Options for exporting data (3/3)



Server: 127.0.0.1 » Database: fhsu_test » Table: my_table

Browse | Structure | SQL | Search | Insert | Export | Import | Privileges | Operations | Tracking | Triggers

Object creation options

Add statements:

- ☐ Add DROP TABLE / TRIGGER statement
- ✓ Add CREATE TABLE statement
  - ☐ IF NOT EXISTS (less efficient as indexes will be generated during table creation)
  - ✓ AUTO_INCREMENT value
- ✓ Add CREATE VIEW statement
- ☐ Add CREATE PROCEDURE / FUNCTION / EVENT statement
- ✓ Add CREATE TRIGGER statement

✓ Enclose table and column names with backquotes *(Protects column and table names formed with special characters or keywords)*

Data creation options

☐ Truncate table before insert

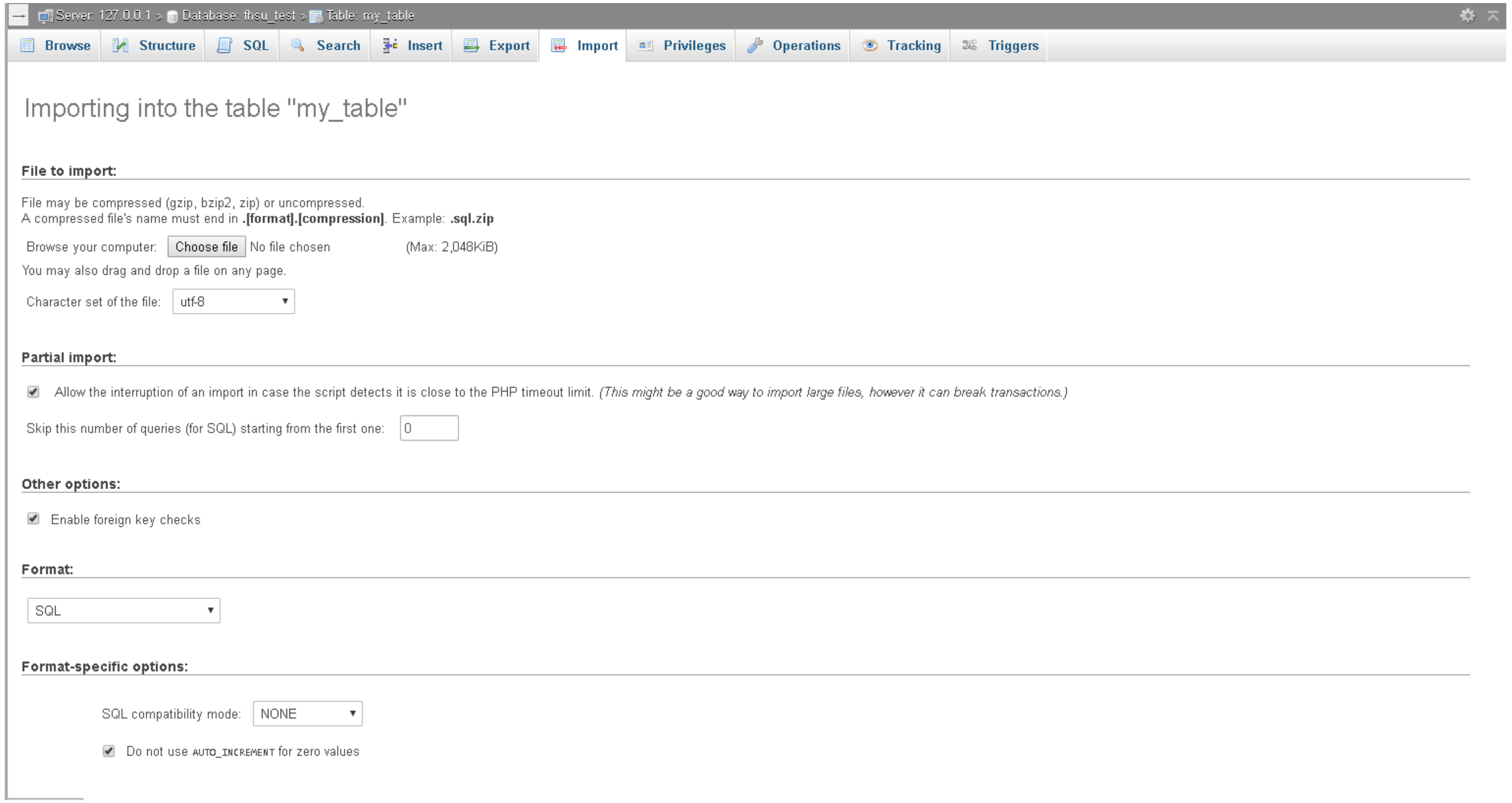
- ☐ INSERT DELAYED statements
- ☐ INSERT IGNORE statements

Function to use when dumping data: INSERT

Syntax to use when inserting data:

- ○ include column names in every INSERT statement
  Example: `INSERT INTO tbl_name (col_A,col_B,col_C) VALUES (1,2,3)`
- ○ insert multiple rows in every INSERT statement
  Example: `INSERT INTO tbl_name VALUES (1,2,3), (4,5,6), (7,8,9)`
- ● both of the above
  Example: `INSERT INTO tbl_name (col_A,col_B,col_C) VALUES (1,2,3), (4,5,6), (7,8,9)`
- ○ neither of the above
  Example: `INSERT INTO tbl_name VALUES (1,2,3)`

Importing data



Importing into the table "my_table"

File to import:

File may be compressed (gzip, bzip2, zip) or uncompressed.
A compressed file's name must end in **.[format].[compression]**. Example: **.sql.zip**

Browse your computer: Choose file No file chosen (Max: 2,048KiB)

You may also drag and drop a file on any page.

Character set of the file: utf-8

Partial import:

☑ Allow the interruption of an import in case the script detects it is close to the PHP timeout limit. *(This might be a good way to import large files, however it can break transactions.)*

Skip this number of queries (for SQL) starting from the first one: 0

Other options:

☑ Enable foreign key checks

Format:

SQL

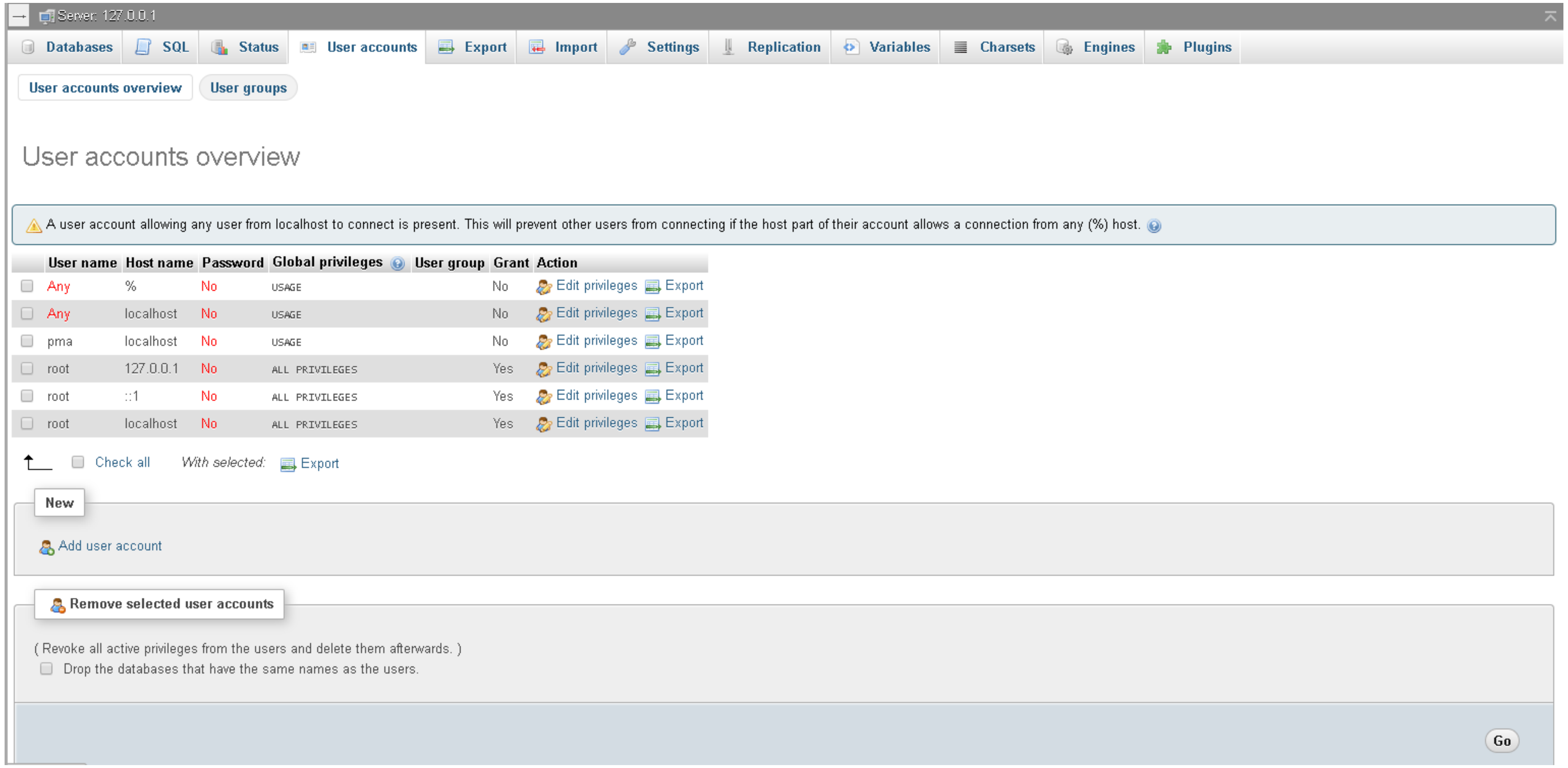
Format-specific options:

SQL compatibility mode: NONE

☑ Do not use AUTO_INCREMENT for zero values

Working with users and privileges

Listing users



User accounts overview

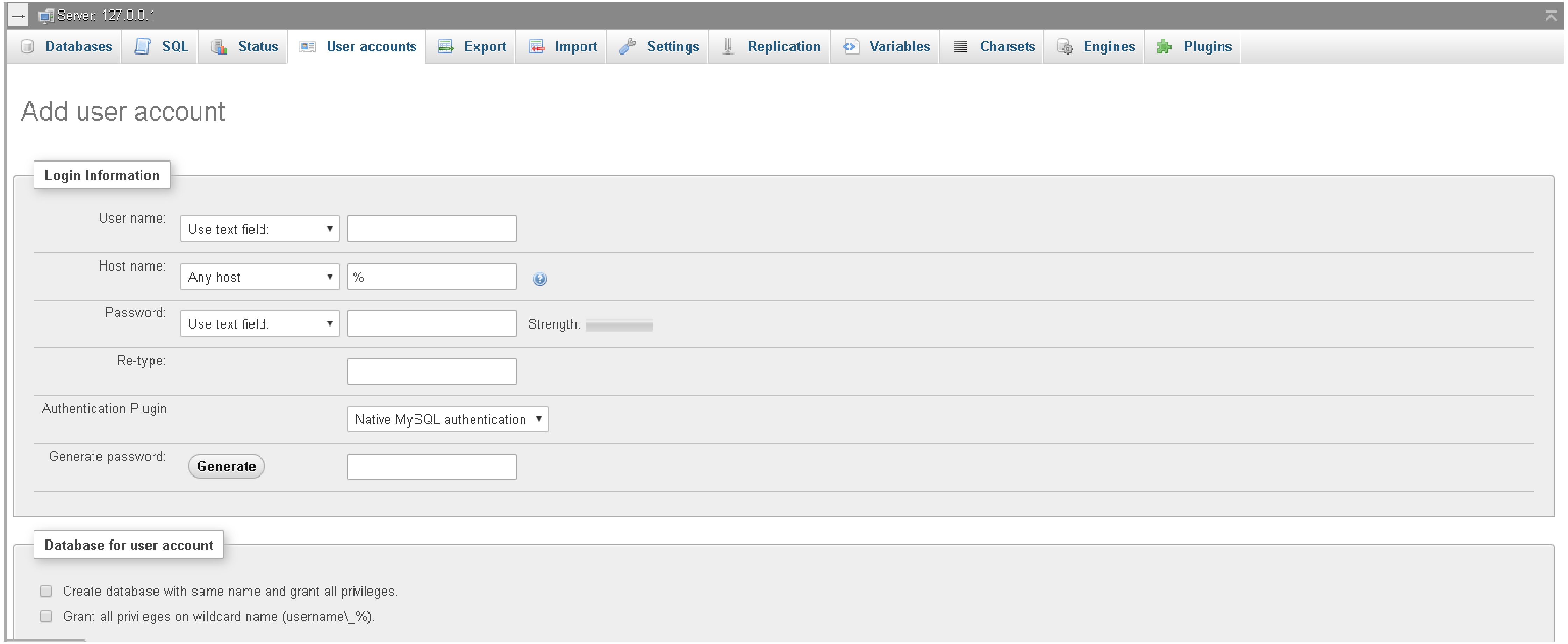
A user account allowing any user from localhost to connect is present. This will prevent other users from connecting if the host part of their account allows a connection from any (%) host.

	User name	Host name	Password	Global privileges	User group	Grant	Action
☐	Any	%	No	USAGE		No	Edit privileges Export
☐	Any	localhost	No	USAGE		No	Edit privileges Export
☐	pma	localhost	No	USAGE		No	Edit privileges Export
☐	root	127.0.0.1	No	ALL PRIVILEGES		Yes	Edit privileges Export
☐	root	::1	No	ALL PRIVILEGES		Yes	Edit privileges Export
☐	root	localhost	No	ALL PRIVILEGES		Yes	Edit privileges Export

(Revoke all active privileges from the users and delete them afterwards.)

☐ Drop the databases that have the same names as the users.

Adding a new user (1/2)



Add user account

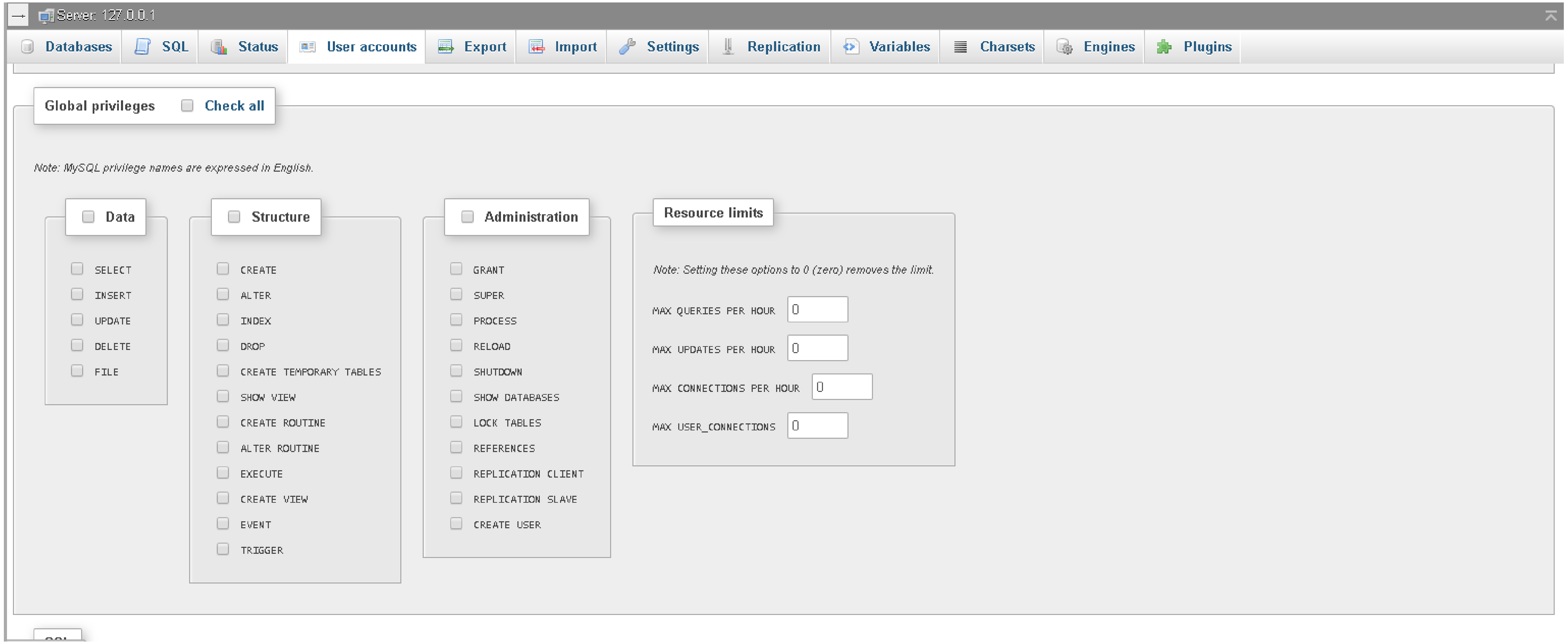
Login Information

User name:	Use text field:	
Host name:	Any host	%
Password:	Use text field:	Strength:
Re-type:		
Authentication Plugin		Native MySQL authentication
Generate password:	Generate	

Database for user account

- [ ] Create database with same name and grant all privileges.
- [ ] Grant all privileges on wildcard name (username_%).

Adding a new user (2/2)



Global privileges ☐ Check all

Note: MySQL privilege names are expressed in English.

☐ Data

☐ SELECT
☐ INSERT
☐ UPDATE
☐ DELETE
☐ FILE

☐ Structure

☐ CREATE
☐ ALTER
☐ INDEX
☐ DROP
☐ CREATE TEMPORARY TABLES
☐ SHOW VIEW
☐ CREATE ROUTINE
☐ ALTER ROUTINE
☐ EXECUTE
☐ CREATE VIEW
☐ EVENT
☐ TRIGGER

☐ Administration

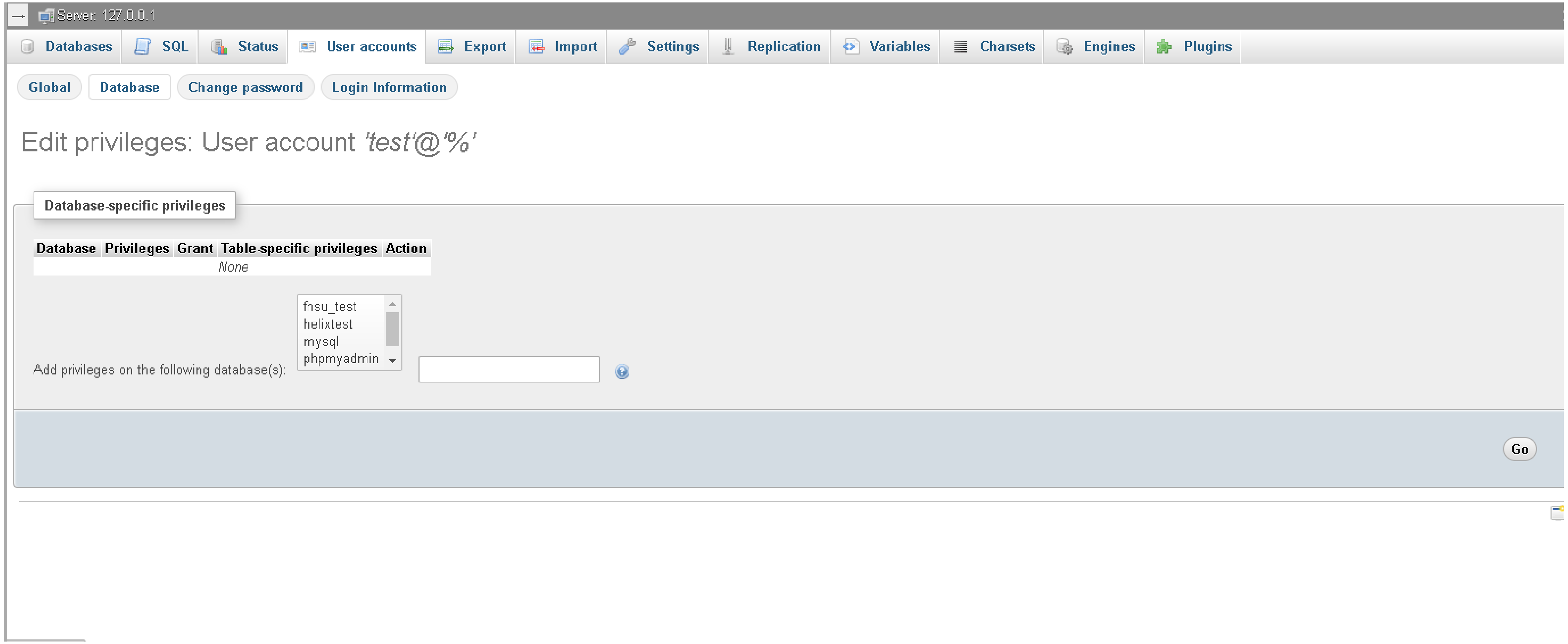
☐ GRANT
☐ SUPER
☐ PROCESS
☐ RELOAD
☐ SHUTDOWN
☐ SHOW DATABASES
☐ LOCK TABLES
☐ REFERENCES
☐ REPLICATION CLIENT
☐ REPLICATION SLAVE
☐ CREATE USER

Resource limits

Note: Setting these options to 0 (zero) removes the limit.

MAX QUERIES PER HOUR	0
MAX UPDATES PER HOUR	0
MAX CONNECTIONS PER HOUR	0
MAX USER_CONNECTIONS	0

Assigning a user to a database (1/2)



Edit privileges: User account *'test'@'%'*

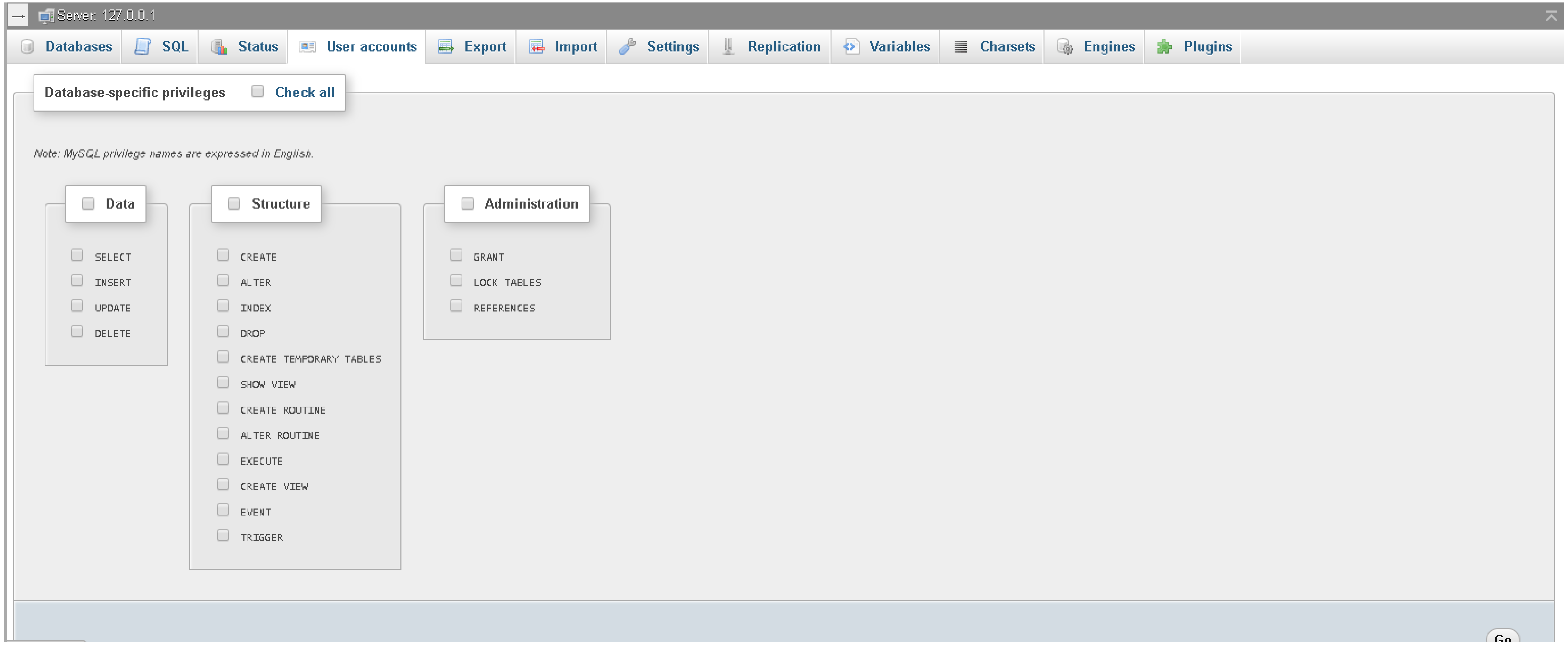
Database-specific privileges

Database	Privileges	Grant	Table-specific privileges	Action
None				

Add privileges on the following database(s):

```
fhsu_test
helixtest
mysql
phpmyadmin
```

Assigning a user to a database (2/2)



Database-specific privileges ☐ Check all

Note: MySQL privilege names are expressed in English.

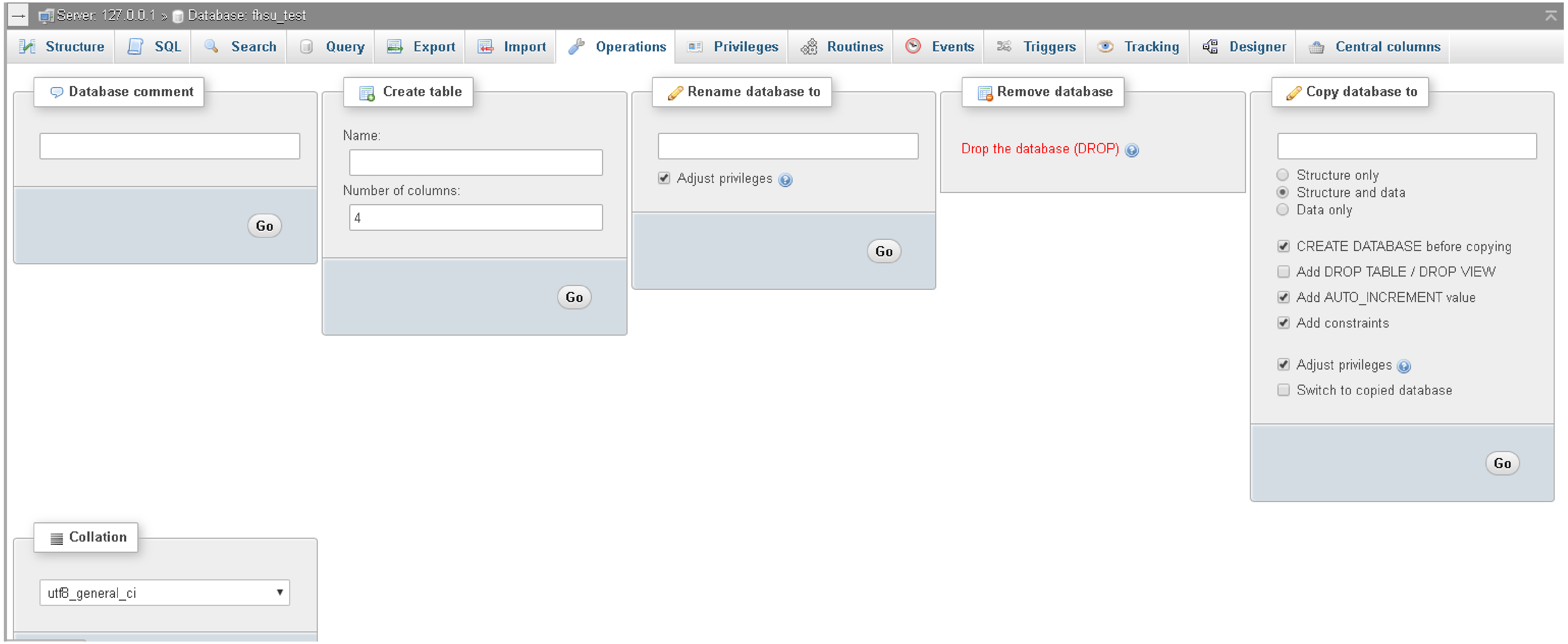
☐ Data
- ☐ SELECT
- ☐ INSERT
- ☐ UPDATE
- ☐ DELETE

☐ Structure
- ☐ CREATE
- ☐ ALTER
- ☐ INDEX
- ☐ DROP
- ☐ CREATE TEMPORARY TABLES
- ☐ SHOW VIEW
- ☐ CREATE ROUTINE
- ☐ ALTER ROUTINE
- ☐ EXECUTE
- ☐ CREATE VIEW
- ☐ EVENT
- ☐ TRIGGER

☐ Administration
- ☐ GRANT
- ☐ LOCK TABLES
- ☐ REFERENCES

Managing databases and tables

Executing operations on a database


Server: 127.0.0.1 » Database: fhsu_test

Database comment

Go

Create table

Name:

Number of columns: 4

Go

Rename database to

☑ Adjust privileges

Go

Remove database

Drop the database (DROP)

Copy database to

○ Structure only
● Structure and data
○ Data only

☑ CREATE DATABASE before copying
☐ Add DROP TABLE / DROP VIEW
☑ Add AUTO_INCREMENT value
☑ Add constraints

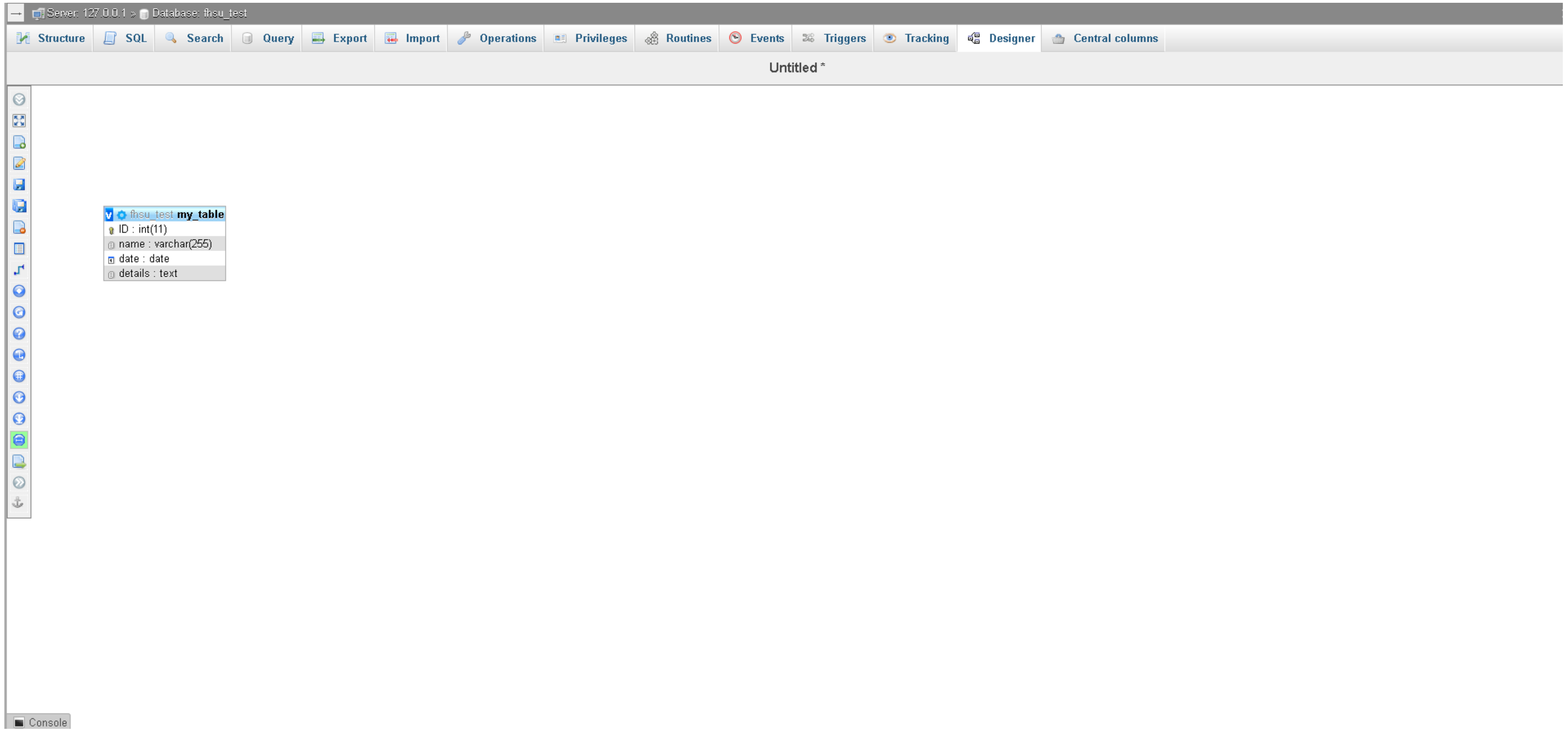
☑ Adjust privileges
☐ Switch to copied database

Go

Collation

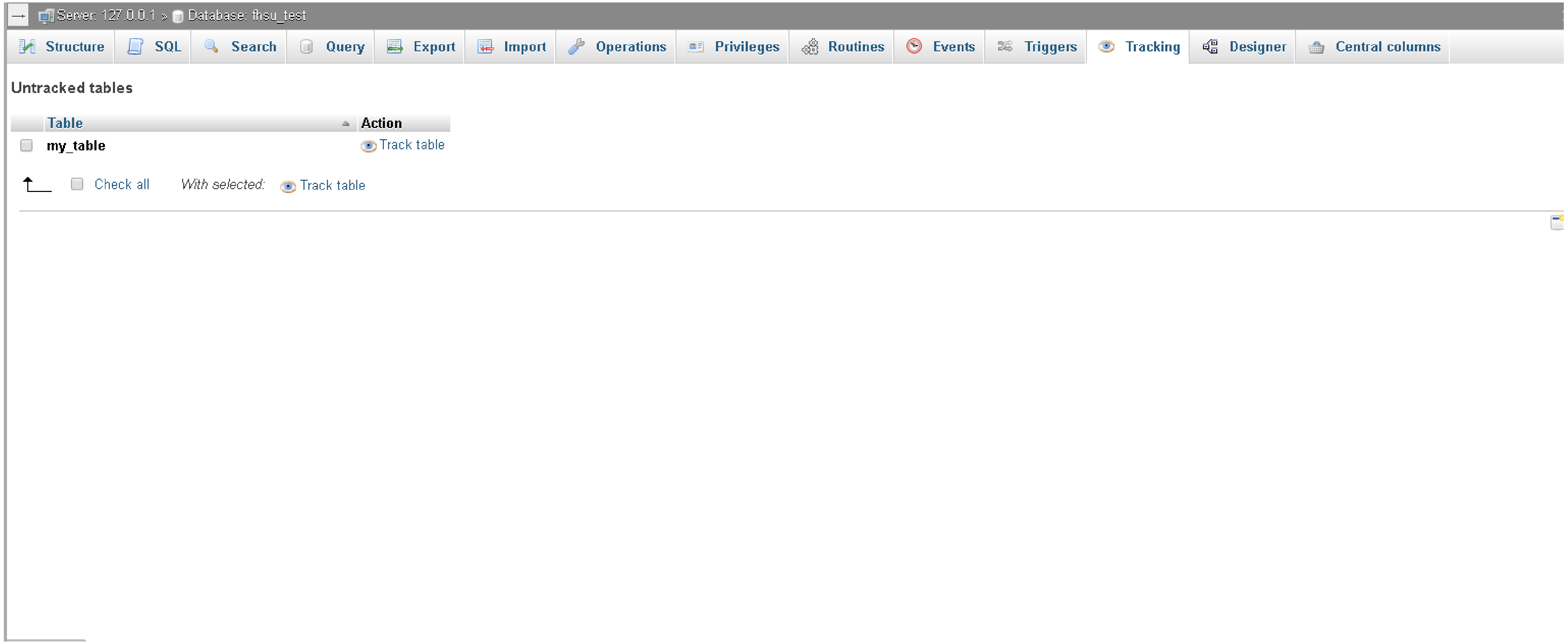
utf8_general_ci

Visual editor



fhsu_test my_table
ID : int(11)
name : varchar(255)
date : date
details : text

Tracking table versions (1/2)



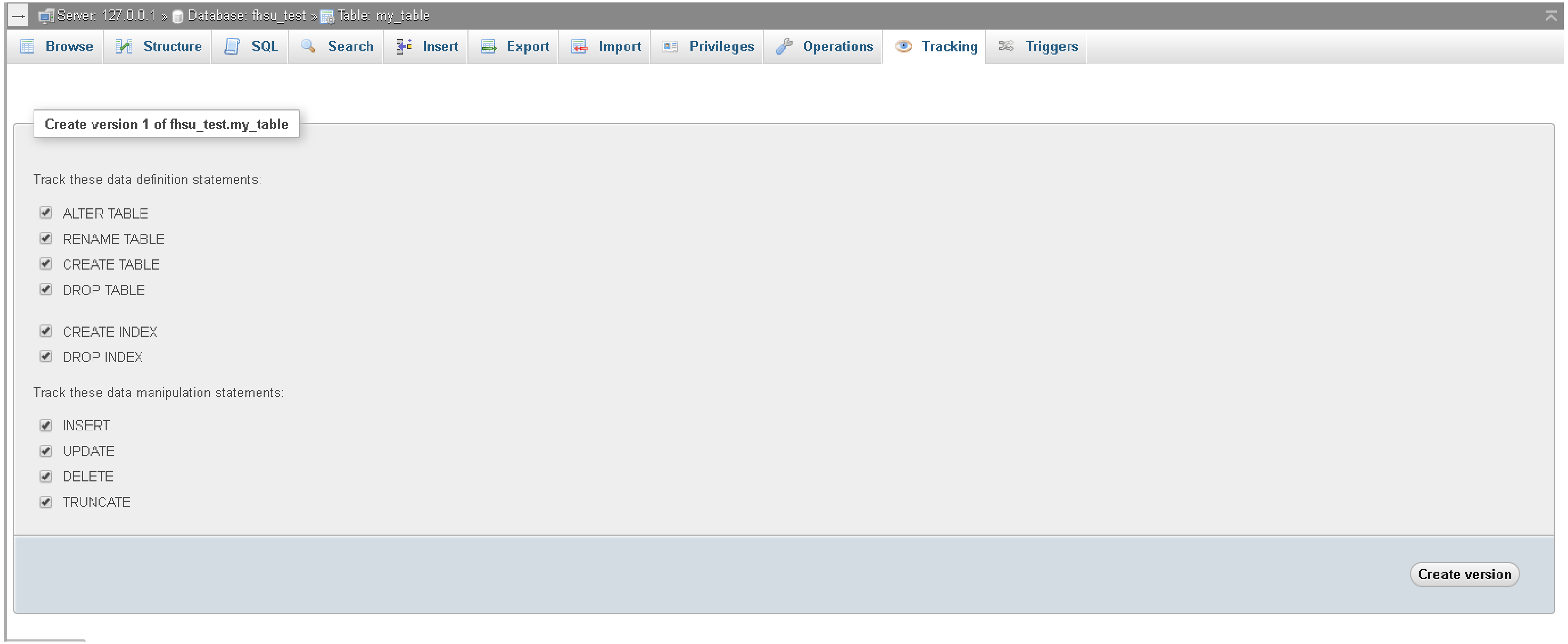
Server: 127.0.0.1 » Database: fhsu_test

Untracked tables

Table	Action
my_table	Track table

Check all   *With selected:*   Track table

Tracking table versions (2/2)



Server: 127.0.0.1 » Database: fhsu_test » Table: my_table

Create version 1 of fhsu_test.my_table

Track these data definition statements:

- [✓] ALTER TABLE
- [✓] RENAME TABLE
- [✓] CREATE TABLE
- [✓] DROP TABLE
- [✓] CREATE INDEX
- [✓] DROP INDEX

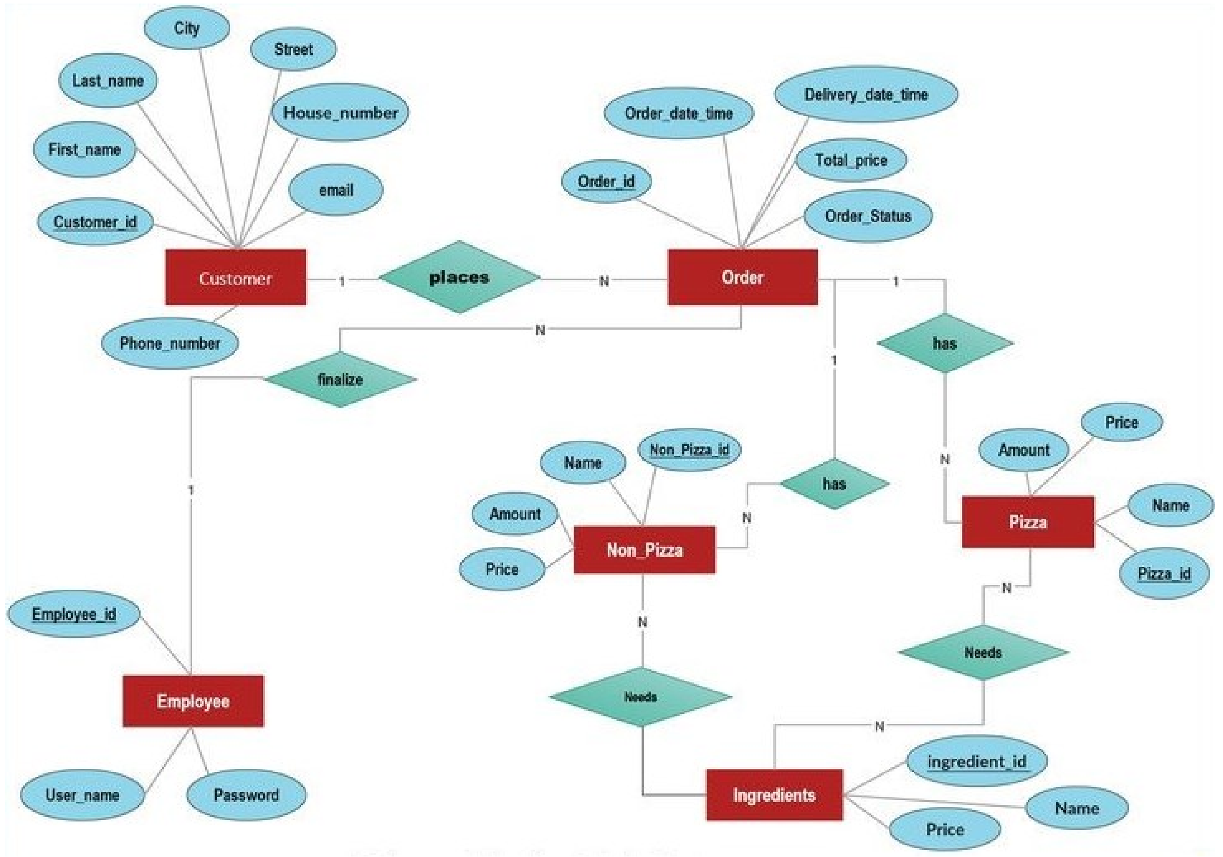
Track these data manipulation statements:

- [✓] INSERT
- [✓] UPDATE
- [✓] DELETE
- [✓] TRUNCATE

Wrap-up

In-class exercise

- Implement the structure of the ER shown in the picture



Agenda

1. Database and table creation
2. Modifying table structure
3. CRUD operations

Database and table creation

The Structured Query Language

- Rise to dominance due in part to its powerful and flexible query language
- Structured Query Language (SQL) allows the user to specify what must be done without specifying how it must be done
- SQL-based relational database application involves:
  - User interface
  - A set of tables stored in the database
  - SQL engine

SQL and MySQL

- MySQL uses Structured Query Language (SQL)
- SQL is language for retrieving, updating, deleting, information from a database
- Relational databases use a model that define data according to relationships
- Other databases: Oracle, Informix, DB2 (IBM) Access (Microsoft), SQL Server, PostgreSQL

Why a database?

- powerful: can search it, filter data, combine data from multiple sources
- fast: can search/filter a database very quickly compared to a file
- big: scale well up to very large data sizes
- safe: built-in mechanisms for failure recovery (e.g. transactions)
- multi-user: concurrency features let many users view/edit data at same time
- abstract: provides layer of abstraction between stored data and app(s)
  - many database programs understand the same SQL commands

Example tables (1/4): The Simpsons' school

id	name	email
123	Bart	bart@fox.com
456	Milhouse	milhouse@fox.com
888	Lisa	lisa@fox.com
404	Ralph	ralph@fox.com

students

id	name
1234	Krabappel
5678	Hoover
9012	Stepp

teachers

id	name	teacher_id
10001	Computer Science 142	1234
10002	Computer Science 143	5678
10003	Computer Science 190M	9012
10004	Informatics 100	1234

courses

student_id	course_id	grade
123	10001	B-
123	10002	C
456	10001	B+
888	10002	A+
888	10003	A+
404	10004	D+

grades

Example tables (2/4): The world

code	name	continent	independence_year	population	gnp	head_of_state	...
AFG	Afghanistan	Asia	1919	22720000	5976.0	Mohammad Omar	...
NLD	Netherlands	Europe	1581	15864000	371362.0	Beatrix	...
...	...	...	...	...	...	...	...

countries (Other columns: region, surface_area, life_expectancy, gnp_old, local_name, government_form, capital, code2)

id	name	country_code	district	population
3793	New York	USA	New York	8008278
1	Los Angeles	USA	California	3694820
...	...	...	...	...

cities

country_code	language	official	percentage
AFG	Pashto	T	52.4
NLD	Dutch	T	95.6
...	...	...	...

languages

Example tables (3/4): IMDB

id	first_name	last_name	gender
433259	William	Shatner	M
797926	Britney	Spears	F
831289	Sigourney	Weaver	F
...			

actors

id	name	year	rank
112290	Fight Club	1999	8.5
209658	Meet the Parents	2000	7
210511	Memento	2000	8.7
...			

movies

actor_id	movie_id	role
433259	313398	Capt. James T. Kirk
433259	407323	Sgt. T.J. Hooker
797926	342189	Herself
...		

roles

movie_id	genre
209658	Comedy
313398	Action
313398	Sci-Fi
...	

movies_genres

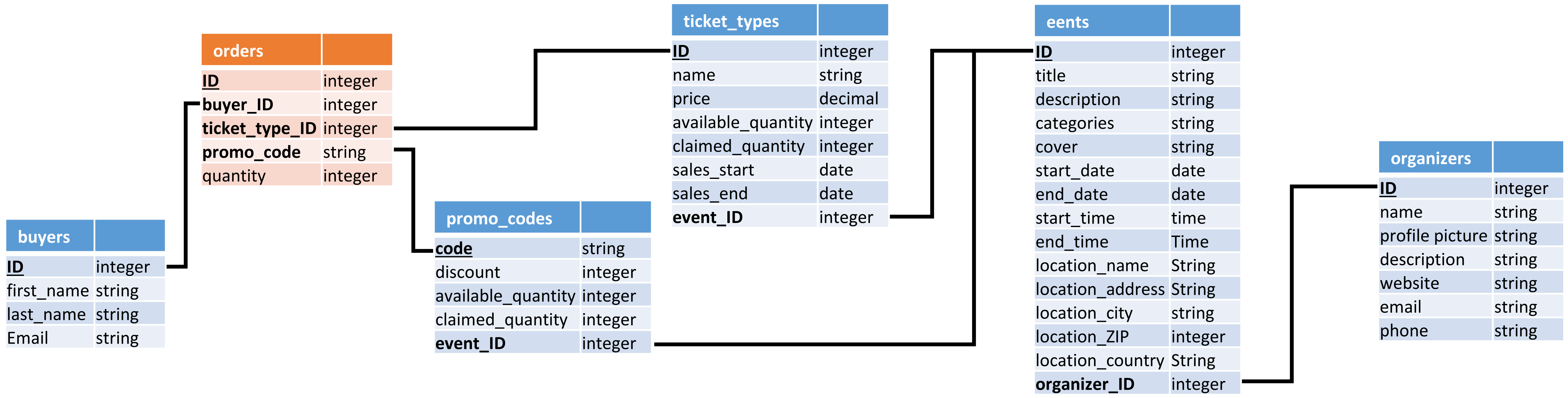
id	first_name	last_name
24758	David	Fincher
66965	Jay	Roach
72723	William	Shatner
...		

directors

director_id	movie_id
24758	112290
66965	209658
72723	313398
...	

movies_directors

Example tables (4/4): Eventbrite



orders	
ID	integer
buyer_ID	integer
ticket_type_ID	integer
promo_code	string
quantity	integer

buyers	
ID	integer
first_name	string
last_name	string
Email	string

promo_codes	
code	string
discount	integer
available_quantity	integer
claimed_quantity	integer
event_ID	integer

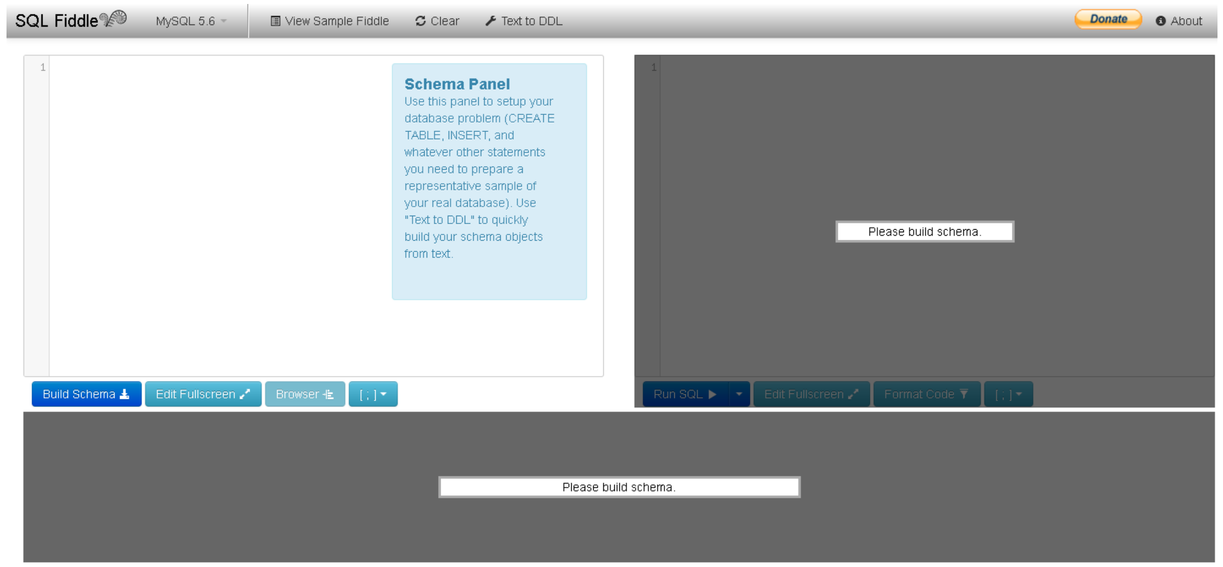
ticket_types	
ID	integer
name	string
price	decimal
available_quantity	integer
claimed_quantity	integer
sales_start	date
sales_end	date
event_ID	integer

eents	
ID	integer
title	string
description	string
categories	string
cover	string
start_date	date
end_date	date
start_time	time
end_time	Time
location_name	String
location_address	String
location_city	string
location_ZIP	integer
location_country	String
organizer_ID	integer

organizers	
ID	integer
name	string
profile picture	string
description	string
website	string
email	string
phone	string

Testing with SQLfiddle

Schema editor (left side)

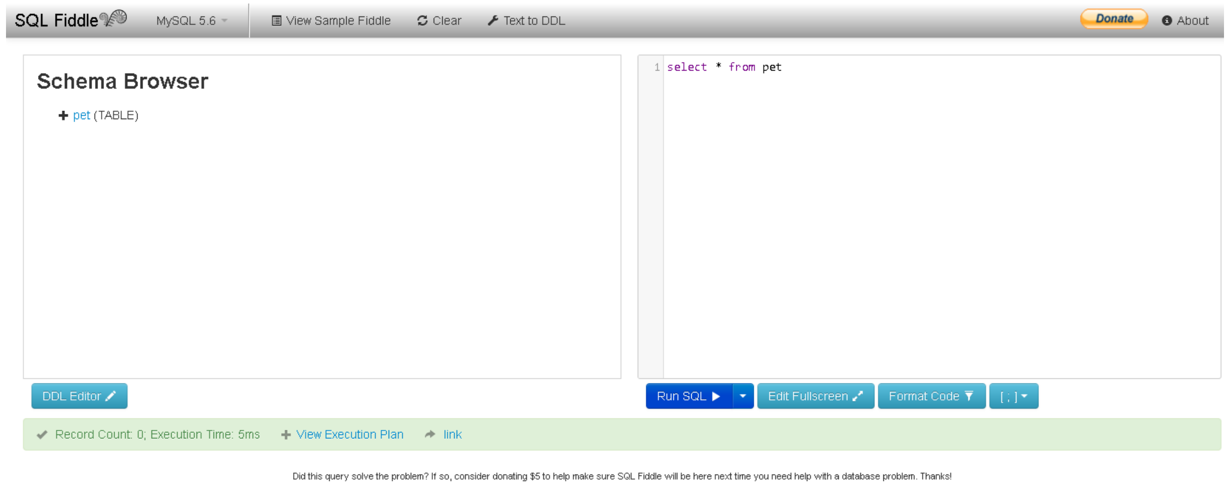


Schema Panel
Use this panel to setup your database problem (CREATE TABLE, INSERT, and whatever other statements you need to prepare a representative sample of your real database). Use "Text to DDL" to quickly build your schema objects from text.

Please build schema.

Please build schema.

SQL Browser (right side)



Schema Browser
pet (TABLE)

```
select * from pet
```

Record Count: 0; Execution Time: 5ms   View Execution Plan   link

Did this query solve the problem? If so, consider donating $5 to help make sure SQL Fiddle will be here next time you need help with a database problem. Thanks!

Comments in MySQL

- MySQL permits syntax for three different comments.

```
/*
 * Multi-line comment
 * and /* nested comments
 *        are legal */
 */


 # Shell-like comment


-- Standard SQL comment
```

Creating a database

- The command CREATE DATABASE can be utilized to create a new database

- The command USE can be utilized to choose the database we want to use, after we created it

```
Syntax:
CREATE DATABASE dbName;


Example:
CREATE DATABASE carddb;
USE carddb;
```

Creating a table

- When we create a table, we want to define the columns of the table, so that we can use them later
- Columns are in parentheses, separated by commas

```
CREATE TABLE tblName (
  colName1 dataType1
  [colAttr1 ...]
  [, colName2 dataType2]
  [, colAttr2 ...]
  [, tblAttr1, ...] );
```

Anatomy of table creation

- When we create a column, we specify
  - name of the column
  - data type
  - if it supports null values
  - if it supports automatic operations (e.g., auto increment)

- When we create a table, we also specify its keys, if any

```
CREATE TABLE notecard (
    # id INT NOT NULL AUTO_INCREMENT,
    id /* column name */
    INT /* column data type */
    NOT NULL /* data can’t be null */
    AUTO_INCREMENT, /* next integer */
    name VARCHAR(50), /* 50 chr max */
    content TEXT, /* unlimited char */
    creation TIMESTAMP DEFAULT NOW(),
    category_id INT, /* foreign key */
    PRIMARY KEY(id) ); /* index */
```

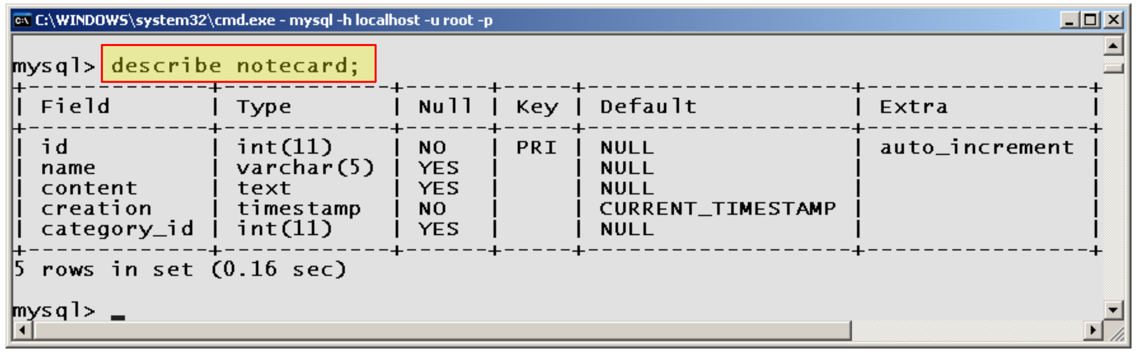
An example

- The table posts will contain blog posts
  - Id will be the unique identifier
  - Content will be the text of the post
  - Date will be the creation date
  - Topic is a foreign key which references a category id
  - Post_by is a foreign key which references an author

```
CREATE TABLE posts (
   post_id INT(8) NOT NULL AUTO_INCREMENT,
   post_content TEXT NOT NULL,
   post_date DATETIME NOT NULL,
   post_topic INT(8) NOT NULL,
   post_by INT(8) NOT NULL,
   PRIMARY KEY (post_id)
) TYPE=INNODB;
```

Viewing the table structure

- The describe command displays the column name, column type, and other attributes regarding a table



```
C:\WINDOWS\system32\cmd.exe - mysql -h localhost -u root -p

mysql> describe notecard;
+-------------+------------+------+-----+-------------------+----------------+
| Field       | Type       | Null | Key | Default           | Extra          |
+-------------+------------+------+-----+-------------------+----------------+
| id          | int(11)    | NO   | PRI | NULL              | auto_increment |
| name        | varchar(5) | YES  |     | NULL              |                |
| content     | text       | YES  |     | NULL              |                |
| creation    | timestamp  | NO   |     | CURRENT_TIMESTAMP |                |
| category_id | int(11)    | YES  |     | NULL              |                |
+-------------+------------+------+-----+-------------------+----------------+
5 rows in set (0.16 sec)

mysql> _
```

```
Syntax:
DESCRIBE tableName;
```

Modifying table structure

Renaming a table

- We can modify the structure of the table, e.g., to rename it, using the command ALTER

```
Syntax:

ALTER TABLE oldTable

   RENAME newTable;


Example:

ALTER TABLE notecard
   RENAME recipe;
```

Renaming a column

- The command ALTER also supports changing the data type of a field

```
Syntax:
ALTER TABLE tableName
    CHANGE oldColNam
    newColNam newColType;

Example:
ALTER TABLE author
    CHANGE penname
    pseudonym varchar(25);
```

Modifying a column data type

- Warning: Changing the data type of a column in a table that contains values could cause a loss of data!

```
Syntax:
ALTER TABLE tableName
   MODIFY colName colType;

Example:
ALTER TABLE book
   MODIFY author
      varchar(25);
```

Adding a column

- We can add columns using the command ALTER and the attributes of the column

```
Syntax:
ALTER TABLE tblName
   ADD colName1 colType1
   FIRST|AFTER colName2;

Example:
ALTER TABLE book
   ADD pseudonym
      varchar(25)
         AFTER id;
```

Changing the column order

- The command ALTER is also used for changing the order of columns

```
Syntax:
ALTER TABLE tblName
   MODIFY colNam1 colType
   FIRST|AFTER colNam2;

Example:
ALTER TABLE book
   MODIFY pseudonym
      varchar(25)
         AFTER author;
```

Removing a column

- Pitfall: Dropping a column also removes the data stored in the column!
- Note: There is no “undo” on dropped columns.

```
Syntax:
ALTER TABLE tableName
    DROP columnName;

Example:
ALTER TABLE book
    DROP pseudonym;
```

Removing a table

- Pitfall: Dropping a table also removes the data stored in the table!
- Note: There is no “undo” on dropped tables.

```
Syntax:
DROP TABLE tableName;


Example:
DROP TABLE book;
```

CRUD operations

CRUD operations

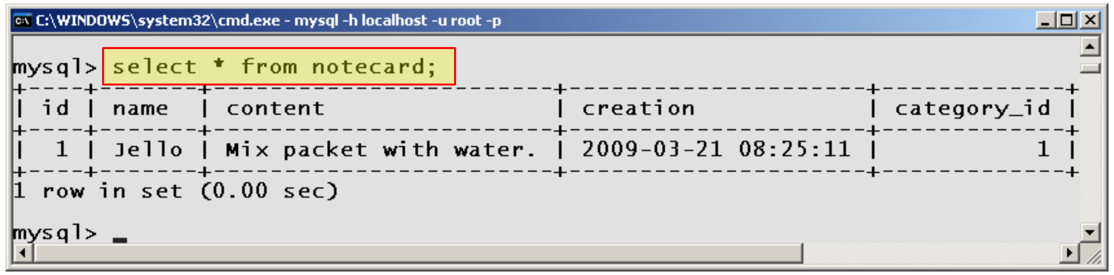
- The acronym CRUD represents the most common SQL operations performed on a database.

- The following are the most often used SQL data commands:
  - SELECT: Querying data in a database
  - INSERT: Adding data to tables
  - UPDATE: Modifying existing table data
  - DELETE: Removing rows from tables

Letter	Operation	MySQL Statement
C	Create	INSERT
R	Retrieve	SELECT
U	Update	UPDATE
D	Destroy	DELETE

Querying table data: SELECT

- SELECT: Used for extracting data contained in a table.
- The asterisk (*) can be used as a wildcard to specify all the columns in a query.



C:\WINDOWS\system32\cmd.exe - mysql -h localhost -u root -p

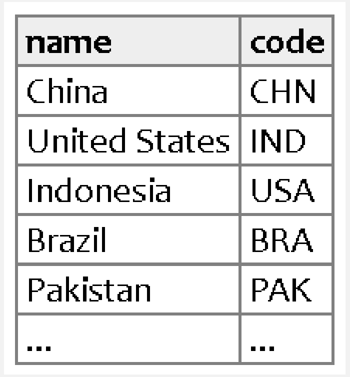
```
mysql> select * from notecard;
+----+-------+-------------------------+---------------------+-------------+
| id | name  | content                 | creation            | category_id |
+----+-------+-------------------------+---------------------+-------------+
|  1 | Jello | Mix packet with water.  | 2009-03-21 08:25:11 |           1 |
+----+-------+-------------------------+---------------------+-------------+
1 row in set (0.00 sec)

mysql> _
```

```
Syntax:
SELECT column1 [, ...]
   FROM table1 [, ...]
   [WHERE clause]
   # no [SANTA clause]
   [ ORDER BY clause [ASC|DESC] ]
   [LIMIT n];


Example:
SELECT * FROM recipe LIMIT 1;
```

SELECT explained

- the SELECT statement searches a database and returns a set of results
  - the column name(s) written after SELECT filter which parts of the rows are returned
  - table and column names are case-sensitive
  - SELECT * FROM table; keeps all columns

```
SELECT name, code FROM countries;
```



name	code
China	CHN
United States	IND
Indonesia	USA
Brazil	BRA
Pakistan	PAK
...	...

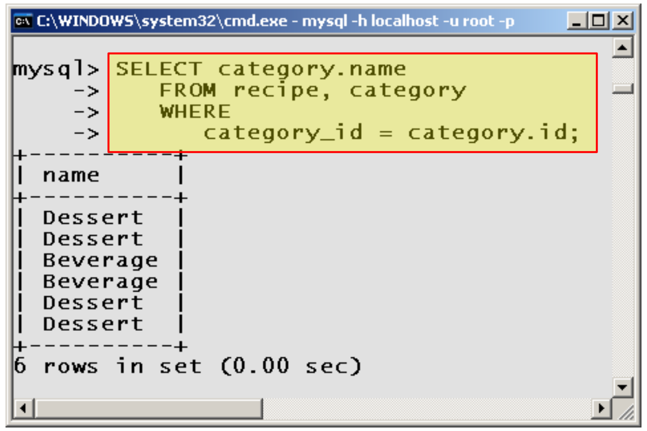
SELECT: examples

```
/* display all columns and all rows */
SELECT * FROM recipe;

/* column names specified */
SELECT name, content
   FROM recipe;

/* specify matching row(s) */
SELECT * FROM recipe
   WHERE name = "Jello";

/* sort according to name */
SELECT * FROM recipe ORDER BY name;

/* obtain most recent recipe */
SELECT id FROM recipe ORDER BY creation
   DESC LIMIT 1;
```

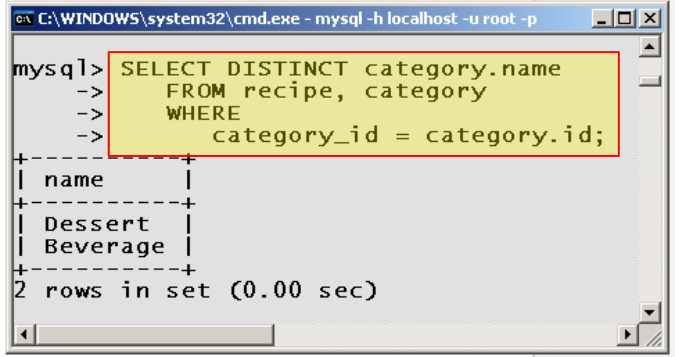
Selecting unique values only

- A select statement may result in duplicate row values.
- Unique rows can be obtained by using the DISTINCT key word.

```
Syntax:
SELECT DISTINCT col1 [, ...]
   FROM tbl1 [, ...]
   [WHERE condition]
   [ORDER BY col1 [, ...]
   [LIMIT n];
```


C:\WINDOWS\system32\cmd.exe - mysql -h localhost -u root -p

```
mysql> SELECT category.name
    ->   FROM recipe, category
    ->   WHERE
    ->     category_id = category.id;
+----------+
| name     |
+----------+
| Dessert  |
| Dessert  |
| Beverage |
| Beverage |
| Dessert  |
| Dessert  |
+----------+
6 rows in set (0.00 sec)
```


C:\WINDOWS\system32\cmd.exe - mysql -h localhost -u root -p

```
mysql> SELECT DISTINCT category.name
    ->   FROM recipe, category
    ->   WHERE
    ->     category_id = category.id;
+----------+
| name     |
+----------+
| Dessert  |
| Beverage |
+----------+
2 rows in set (0.00 sec)
```

SELECT DISTINCT explained

SELECT language FROM languages;

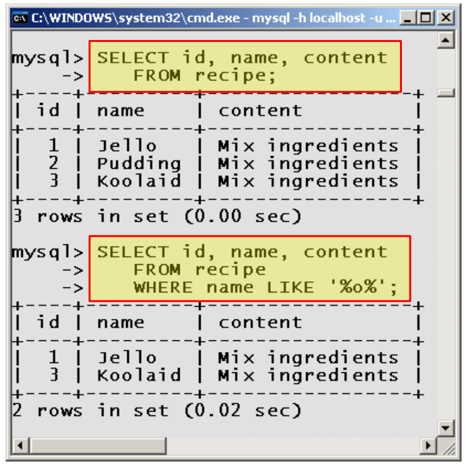
language
Dutch
English
English
Papiamento
Spanish
Spanish
Spanish
...

SELECT DISTINCT language FROM languages;

language
Dutch
English
Papiamento
Spanish
...

Searching with the % wildcard

- Searching records in a database often involves matching part of string in a field
- wildcard % matches zero or more characters and is used with keyword "LIKE".

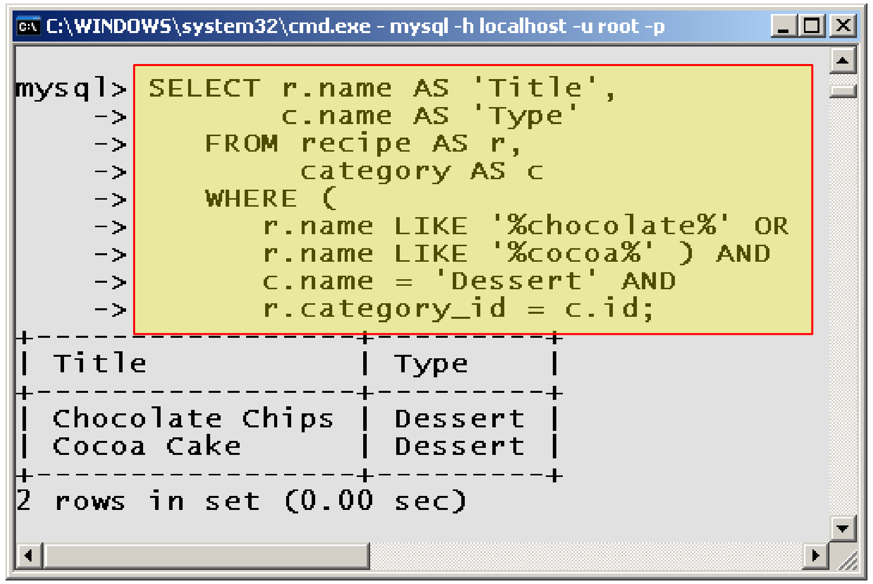


```
C:\WINDOWS\system32\cmd.exe - mysql -h localhost -u ...
mysql> SELECT id, name, content
    ->    FROM recipe;
+----+---------+-----------------+
| id | name    | content         |
+----+---------+-----------------+
|  1 | Jello   | Mix ingredients |
|  2 | Pudding | Mix ingredients |
|  3 | Koolaid | Mix ingredients |
+----+---------+-----------------+
3 rows in set (0.00 sec)

mysql> SELECT id, name, content
    ->    FROM recipe
    ->    WHERE name LIKE '%o%';
+----+---------+-----------------+
| id | name    | content         |
+----+---------+-----------------+
|  1 | Jello   | Mix ingredients |
|  3 | Koolaid | Mix ingredients |
+----+---------+-----------------+
2 rows in set (0.02 sec)
```

```
Example:
SELECT *
   FROM recipe WHERE
   (content LIKE "%rubarb%" AND
   content LIKE "%strawberr%");
```

Logical operators

- The keywords AND, OR and NOT can be used in the WHERE clause to combine multiple statements

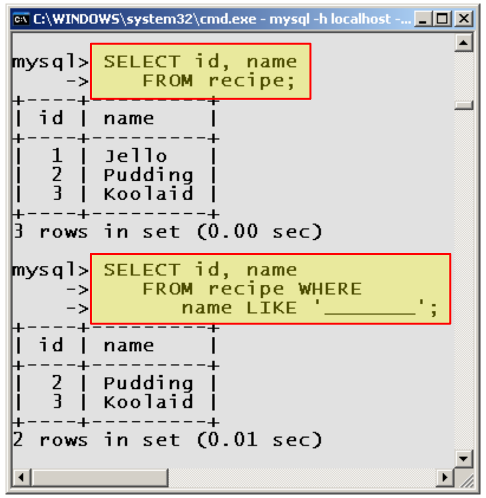


```
C:\WINDOWS\system32\cmd.exe - mysql -h localhost -u root -p

mysql> SELECT r.name AS 'Title',
    ->        c.name AS 'Type'
    ->   FROM recipe AS r,
    ->        category AS c
    ->   WHERE (
    ->      r.name LIKE '%chocolate%' OR
    ->      r.name LIKE '%cocoa%' ) AND
    ->      c.name = 'Dessert' AND
    ->      r.category_id = c.id;
+-----------------+---------+
| Title           | Type    |
+-----------------+---------+
| Chocolate Chips | Dessert |
| Cocoa Cake      | Dessert |
+-----------------+---------+
2 rows in set (0.00 sec)
```

```
Examples:
SELECT r.name AS 'Title',
       c.name AS 'Type'
   FROM recipe AS r,
        category AS c
   WHERE (
      r.name LIKE '%chocolate%' OR
      r.name LIKE '%cocoa%' ) AND
      c.name = "Dessert" AND
      r.category_id = c.id;
```

Searching with the _ wildcard

- Searching records in a database often involves matching part of string in a field
- Wildcard _ matches exactly one character and is used with keyword “LIKE”.


C:\WINDOWS\system32\cmd.exe - mysql -h localhost -...

```
mysql> SELECT id, name
    ->    FROM recipe;
+----+---------+
| id | name    |
+----+---------+
|  1 | Jello   |
|  2 | Pudding |
|  3 | Koolaid |
+----+---------+
3 rows in set (0.00 sec)

mysql> SELECT id, name
    ->    FROM recipe WHERE
    ->       name LIKE '_______';
+----+---------+
| id | name    |
+----+---------+
|  2 | Pudding |
|  3 | Koolaid |
+----+---------+
2 rows in set (0.01 sec)
```

```
Example:
SELECT id, name
   FROM recipe WHERE
      name LIKE '_______'; # 7
```

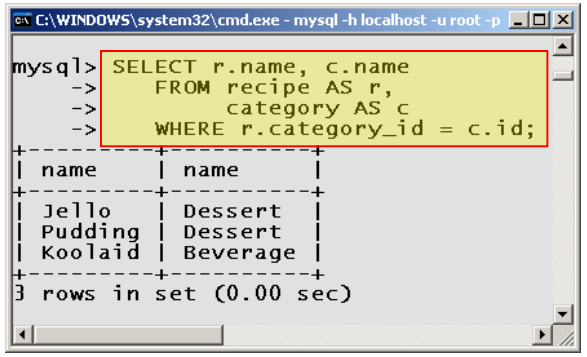
Table aliases

- A table alias is an alternative name (often abbreviated) which references a table.
  - Note: in the example “r” alias for table “recipe”, “c” alias for table “category”

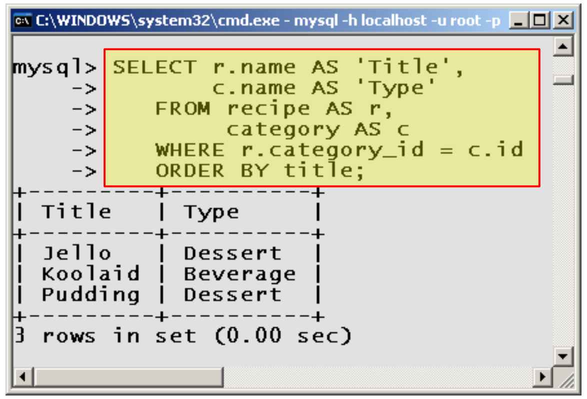
```
Table Alias Example:
SELECT *
   FROM recipe AS r,
        category AS c
   WHERE r.category_id = c.id;
```

Column aliases

- A column alias is an alternative abbreviated name of which to reference a column
  - Note: in the example, “Title” alias for column “recipe.name”, “Type” alias for column “category.name”



```
C:\WINDOWS\system32\cmd.exe - mysql -h localhost -u root -p
mysql> SELECT r.name, c.name
    ->    FROM recipe AS r,
    ->         category AS c
    ->    WHERE r.category_id = c.id;
+---------+----------+
| name    | name     |
+---------+----------+
| Jello   | Dessert  |
| Pudding | Dessert  |
| Koolaid | Beverage |
+---------+----------+
3 rows in set (0.00 sec)
```



```
C:\WINDOWS\system32\cmd.exe - mysql -h localhost -u root -p
mysql> SELECT r.name AS 'Title',
    ->        c.name AS 'Type'
    ->    FROM recipe AS r,
    ->         category AS c
    ->    WHERE r.category_id = c.id
    ->    ORDER BY title;
+---------+----------+
| Title   | Type     |
+---------+----------+
| Jello   | Dessert  |
| Koolaid | Beverage |
| Pudding | Dessert  |
+---------+----------+
3 rows in set (0.00 sec)
```

```
Column Alias Example:
SELECT r.name AS 'Title',
       c.name AS 'Type'
   FROM recipe AS r,
        category AS c
   WHERE r.category_id = c.id
   ORDER BY 'Title';
```

NKU

Adding new data: INSERT

- Used for creating a new row of data in a table
- The order of the column names must match the order of the values

```
Syntax:
INSERT INTO table
  [(column1, ... )]
   VALUES (value1, ...);

Example:
INSERT INTO notecard
   # COLUMNS
     ( name,
       content,
       category_id )
   VALUES
     ( "Pudding",     # name
       "Add milk.",   # content
       2 );           # category_id
```

INSERT: omitting columns

- Column names can be omitted:
    - Values must be specified in the order which the columns were created.
    - No columns can be skipped.
    - Every column must have a value or NULL

- Don’t do this

```
Example without columns:

INSERT INTO recipe

   VALUES (

     NULL,          # id

     "Jello",       # name

     "Add water",   # content

     NULL,          # creation

     2 );           # category_id
```

INSERT: rules

- If columns are not specified, values must be in the same order in which they were defined (via CREATE command)
- Numeric values should not be quoted
- String values must be quoted
- Date and time values should be quoted
- SQL functions should not be quoted.
- NULL should never be quoted.
- If a value is not specified, the value inserted is NULL, unless a default column value has been defined or column attribute is AUTO_INCREMENT.
- Quoting a column name is optional.

How to get the last inserted ID

- There are many solutions.
- However, some of them are prone to some serious errors
- Always use last_insert_ID()

```
Worst Solution:
SELECT COUNT(id) FROM RECIPE;


Poor Solution:
SELECT MAX(id) FROM RECIPE;


Good Solution:
SELECT id FROM recipe ORDER BY
   creation DESC LIMIT 1;


Best Solution:
SELECT LAST_INSERT_ID();
```

Updating table data: UPDATE

- Used for modifying existing table data
- Pitfall
  - Failing to specify the WHERE or LIMIT clause modifies all the records in the table!
- Note
  - There is no "undo" on inadvertently modified data.

```
Syntax:
UPDATE tableName
    SET colName = newValue
    [WHERE colName = const]
    [LIMIT n];
```

UPDATE: examples

```
/* modify column 'content' on all rows */
UPDATE recipe
   SET content = "Mix ingredients";

/* replace "Drink" with "Beverage" (1st match) */
UPDATE category
   SET name = "Beverage"
   WHERE name = "Drink“
   LIMIT 1;

/* modify via unique id (most common) */
UPDATE recipe
   SET content = "Stir ingredients";
   WHERE id = 1;
```

Deleting data: DELETE

- Used for removing row(s) in a table
- Pitfall:
  - Failing to specify the WHERE or LIMIT clause deletes all the records in the table!
- Note:
  - There is no “undo” on deleted data

```
Syntax:
DELETE FROM tableName
   [WHERE colName = const]
   [LIMIT n];
```

DELETE: examples

```
/* delete all rows (you sure?) */
DELETE FROM book;

/* delete the first match */
DELETE FROM book
   WHERE lastName = "Wesley"
   LIMIT 1;

/* delete books having more than 30 pages*/
DELETE FROM book
   WHERE num_pages > 30;

/* delete via id (most common) */
DELETE FROM book
   WHERE id = 1;
```

Wrap-up

In-class exercise

- Implement the database of a movie website similar to IMDB
  - movies
  - actors
  - directors
- Design queries to insert dummy data in the database and to modify the rating of a movie

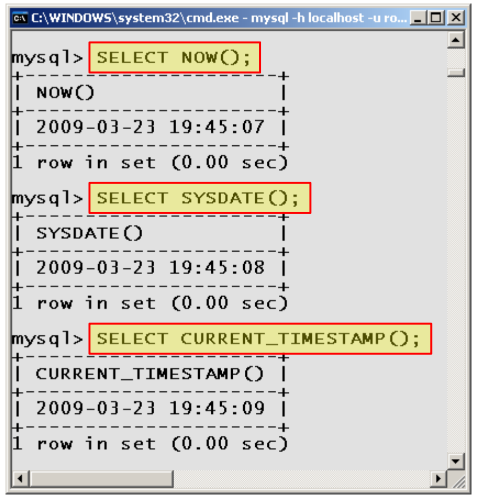
Agenda

1. Date and time functions
2. Extracting data using conditions
3. Extracting data from multiple tables
4. Indexes
5. Performance considerations

Date and time functions

Date and time functions

- There are three functions that return the current time and date:
  - NOW()
  - SYSDATE()
  - CURRENT_TIMESTAMP()



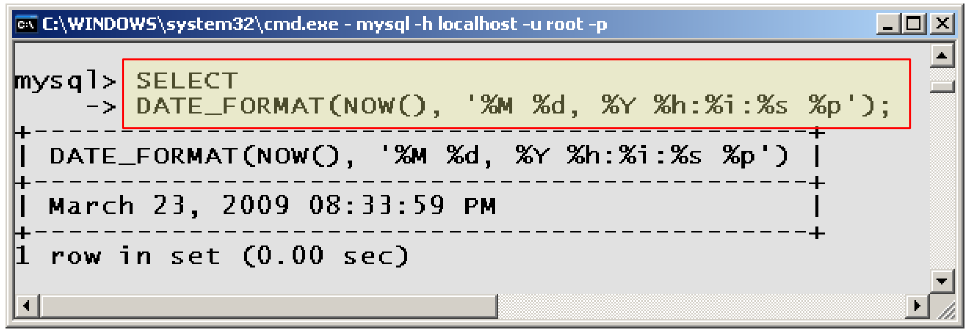
C:\WINDOWS\system32\cmd.exe - mysql -h localhost -u ro...

```
mysql> SELECT NOW();
+---------------------+
| NOW()               |
+---------------------+
| 2009-03-23 19:45:07 |
+---------------------+
1 row in set (0.00 sec)

mysql> SELECT SYSDATE();
+---------------------+
| SYSDATE()           |
+---------------------+
| 2009-03-23 19:45:08 |
+---------------------+
1 row in set (0.00 sec)

mysql> SELECT CURRENT_TIMESTAMP();
+---------------------+
| CURRENT_TIMESTAMP() |
+---------------------+
| 2009-03-23 19:45:09 |
+---------------------+
1 row in set (0.00 sec)
```

```
Example:

SELECT NOW();

SELECT SYSDATE();

SELECT CURRENT_TIMESTAMP();
```

Date format function

- SQL has one command to display the date in the format specified
  - DATE_FORMAT()



C:\WINDOWS\system32\cmd.exe - mysql -h localhost -u root -p

```
mysql> SELECT
    -> DATE_FORMAT(NOW(), '%M %d, %Y %h:%i:%s %p');
+-------------------------------------------------+
| DATE_FORMAT(NOW(), '%M %d, %Y %h:%i:%s %p') |
+-------------------------------------------------+
| March 23, 2009 08:33:59 PM                      |
+-------------------------------------------------+
1 row in set (0.00 sec)
```

```
Example:

SELECT

DATE_FORMAT(

NOW(), '%M %d, %Y %h:%i:%s %p');
```

Date format specifier characters (1/2)

Specifier	Description
`%a`	Abbreviated weekday name (Sun..Sat)
`%b`	Abbreviated month name (Jan..Dec)
`%c`	Month, numeric (0..12)
`%D`	Day of the month with English suffix (1st, 2nd, 3rd, …)
`%d`	Day of the month, numeric (00..31)
`%e`	Day of the month, numeric (0..31)
`%f`	Microseconds (000000..999999)
`%H`	Hour (00..23)
`%h`	Hour (01..12)
`%I`	Hour (01..12)

Specifier	Description
`%i`	Minutes, numeric (00..59)
`%j`	Day of year (001..366)
`%k`	Hour (0..23)
`%l`	Hour (1..12)
`%M`	Month name (January..December)
`%m`	Month, numeric (00..12)
`%p`	AM or PM
`%r`	Time, 12-hour (hh:mm:ss with AM or PM)
`%S`	Seconds (00..59)
`%s`	Seconds (00..59)

NKU

Date format specifier characters (1/2)

Specifier	Description
`%T`	Time, 24-hour (hh:mm:ss)
`%U`	Week (00..53), where Sunday is the first day of the week
`%V`	Week (01..53), where Sunday is the first day of the week; used with %X
`%W`	Weekday name (Sunday..Saturday)
`%w`	Day of the week (0=Sunday..6=Saturday)
`%X`	Year for week where Sunday is first day of week, numeric, four digits; used with %V
`%Y`	Year, numeric, four digits
`%y`	Year, numeric (two digits)
`%%`	A literal “%” character

Minimum and maximum value

- Finding the minimum and maximum value
  - MIN(): Finds the minimum value for a column
  - MAX(): Finds the maximum value for a column

- Note: in the example “Poor” and “Rich” are aliases for “MIN(salary)” and “MAX(salary)”

```
Example:
SELECT MIN(salary) AS Poor,
       MAX(salary) AS Rich
    FROM paystub;
```

Counting values

- COUNT() Finds the number of data rows
- Note: in the example "total" is an alias for "COUNT(id)"

```
Example:
SELECT COUNT(id) AS total
   FROM recipe;
```

Getting the sum of values

- SUM(): Finds the total value of a column
- Note: in the example “Total is an alias for “SUM(salary)”

```
Example:
SELECT SUM(salary)
        AS Total
    FROM paystub;
```

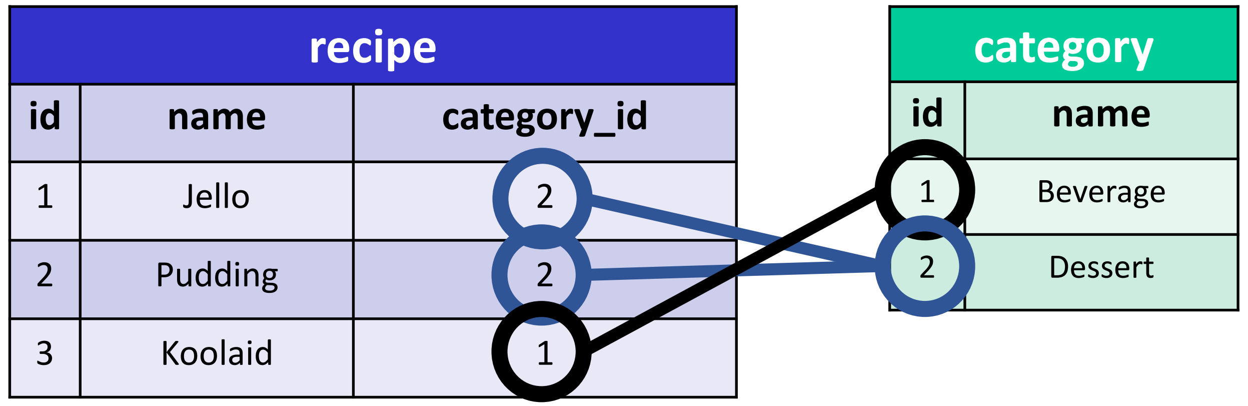
Getting the average of values

- AVG(): Finds the average value for a column
- Note: in the example “Average” is an alias for “AVG(salary)”.

```
Example:
SELECT AVG(salary)
    AS Average
    FROM paystub;
```

Tables with foreign keys

- Often multiple tables are combined to obtain the information required.



recipe

id	name	category_id
1	Jello	2
2	Pudding	2
3	Koolaid	1

category

id	name
1	Beverage
2	Dessert

- The tables are "joined" via the where clause.

Extracting data using conditions

The WHERE clause

- The WHERE clause filters out rows based on their columns' data values
- in large databases, it's critical to use a WHERE clause to reduce the result set size
  - suggestion: when trying to write a query, think of the FROM part first, then the WHERE part, and lastly the SELECT part

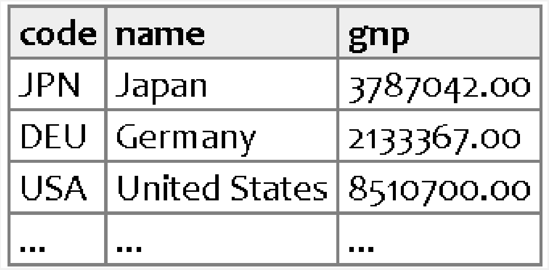
```
SELECT name, population FROM cities WHERE
country_code = "FSM";
```

name	population
Weno	22000
Palikir	8600

Using operators

- The WHERE portion of a SELECT statement can use the following operators:
  - =, >, >=, <, <=
  - <> : not equal
  - BETWEEN min AND max
  - LIKE pattern
  - IN (value, value, ..., value)

```
SELECT name, gnp FROM countries WHERE gnp >
2000000;
```



code	name	gnp
JPN	Japan	3787042.00
DEU	Germany	2133367.00
USA	United States	8510700.00
...	...	...

Using multiple clauses

- Multiple WHERE conditions can be combined using AND and OR
- When combining several clauses, you can conveniently use parentheses to group clauses

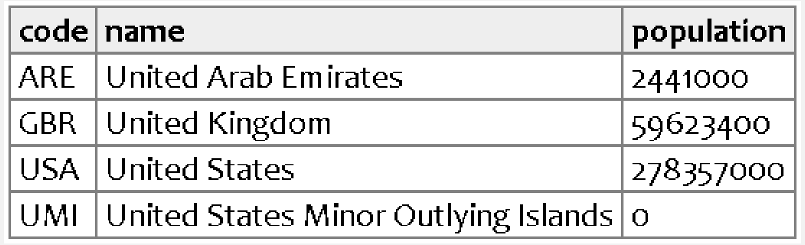
```
SELECT * FROM cities WHERE code = 'USA' AND
population >= 2000000;
```

id	name	country_code	district	population
3793	New York	USA	New York	8008278
3794	Los Angeles	USA	California	3694820
3795	Chicago	USA	Illinois	2896016
...	...	...	...	...

Using LIKE

- How to use LIKE
  - LIKE 'text%' searches for text that starts with a given prefix
  - LIKE '%text' searches for text that ends with a given suffix
  - LIKE '%text%' searches for text that contains a given substring

```
SELECT code, name, population FROM countries
WHERE name LIKE 'United%';
```



code	name	population
ARE	United Arab Emirates	2441000
GBR	United Kingdom	59623400
USA	United States	278357000
UMI	United States Minor Outlying Islands	0

Ordering results

- You can write ASC or DESC to sort in ascending (default) or descending order:
  - SELECT * FROM countries ORDER BY population DESC;
- can specify multiple orderings in decreasing order of significance:
  - SELECT * FROM countries ORDER BY population DESC, gnp;

```
SELECT code, name, population FROM countries

WHERE name LIKE 'United%' ORDER BY
population;
```

code	name	population
UMI	United States Minor Outlying Islands	0
ARE	United Arab Emirates	2441000
GBR	United Kingdom	59623400
USA	United States	278357000

Limiting the number of results

- can be used to get the top-N of a given category (ORDER BY and LIMIT)
- also useful as a sanity check to make sure your query doesn't return thousands of rows

```
SELECT name FROM cities WHERE name LIKE 'K%'
LIMIT 5;
```

name
Kabul
Khulna
Kingston upon Hull
Koudougou
Kafr al-Dawwar

Extracting data from multiple tables

Example of related tables

- **primary key**: a column guaranteed to be unique for each record (e.g. Lisa Simpson's ID 888)
- **foreign key**: a column in table A storing a primary key value from table B
  - (e.g. records in grades with student_id of 888 are Lisa's grades)
- **normalizing**: splitting tables to improve structure / redundancy (linked by unique IDs)

id	name	email
123	Bart	bart@fox.com
456	Milhouse	milhouse@fox.com
888	Lisa	lisa@fox.com
404	Ralph	ralph@fox.com

students

id	name	teacher_id
10001	Computer Science 142	1234
10002	Computer Science 143	5678
10003	Computer Science 190M	9012
10004	Informatics 100	1234

courses

student_id	course_id	grade
123	10001	B-
123	10002	C
456	10001	B+
888	10002	A+
888	10003	A+
404	10004	D+

grades

id	name
1234	Krabappel
5678	Hoover
9012	Stepp

teachers

Querying multi-table databases

- When we have larger datasets spread across multiple tables, we need queries that can answer high-level questions such as:
  - What courses has Bart taken and gotten a B- or better?
  - What courses have been taken by both Bart and Lisa?
  - Who are all the teachers Bart has had?
  - How many total students has Ms. Krabappel taught, and what are their names?

- To do this, we'll have to join data from several tables in our SQL queries.

Joining with ON clauses

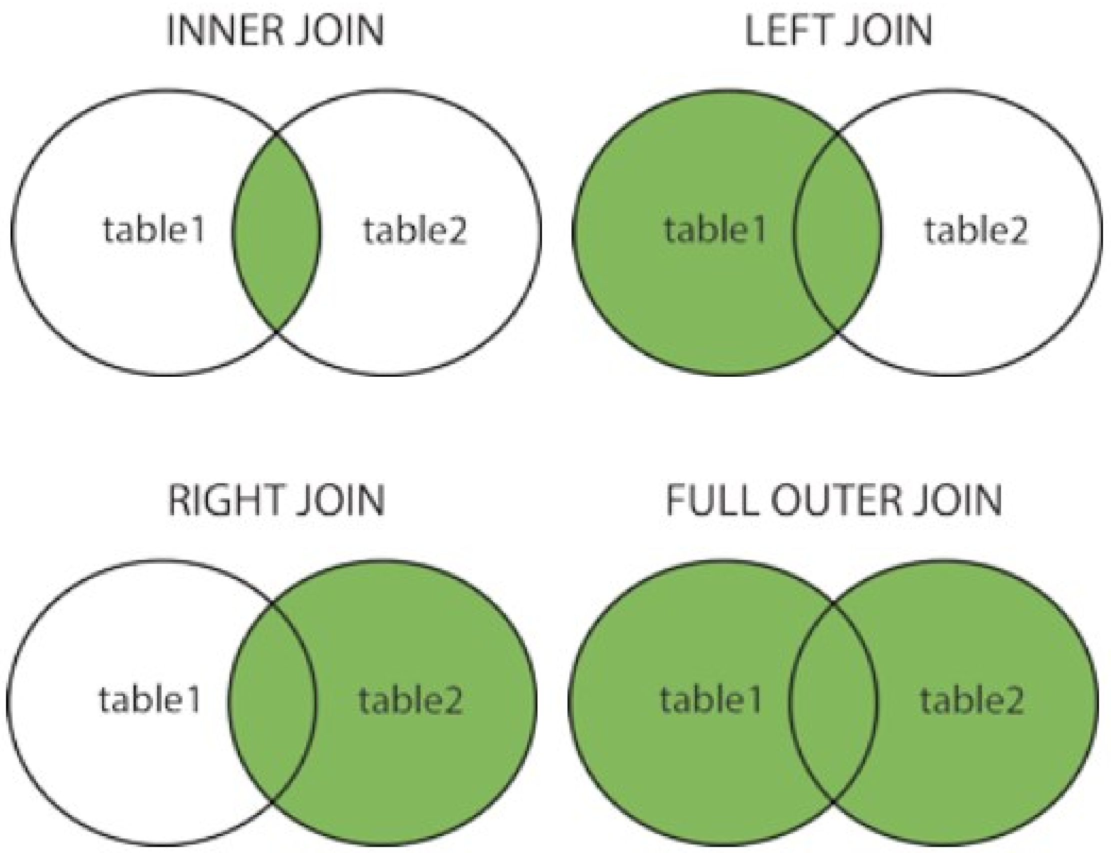
- join: combines records from two or more tables if they satisfy certain conditions
- the ON clause specifies which records from each table are matched
- the rows are often linked by their key columns (id)

```
SELECT *
FROM students
JOIN grades ON id = student_id;
```

id	name	email	student_id	course_id	grade
123	Bart	bart@fox.com	123	10001	B-
123	Bart	bart@fox.com	123	10002	C
404	Ralph	ralph@fox.com	404	10004	D+
456	Milhouse	milhouse@fox.com	456	10001	B+
888	Lisa	lisa@fox.com	888	10002	A+
888	Lisa	lisa@fox.com	888	10003	A+

Different types of joins

- **(INNER) JOIN**: Returns records that have matching values in both tables
- **LEFT (OUTER) JOIN**: Return all records from the left table, and the matched records from the right table
- **RIGHT (OUTER) JOIN**: Return all records from the right table, and the matched records from the left table
- **FULL (OUTER) JOIN**: Return all records when there is a match in either left or right table



Filtering columns in a join

- You can select individual columns
- The notation **table.column** can be used to disambiguate column names:
  - SELECT * FROM students JOIN grades ON students.id = grades.student_id;

```
SELECT name, course_id, grade
FROM students
JOIN grades ON id = student_id;
```

name	course_id	grade
Bart	10001	B-
Bart	10002	C
Ralph	10004	D+
Milhouse	10001	B+
Lisa	10002	A+
Lisa	10003	A+

Using conditions

- FROM / JOIN glue the proper tables together, and WHERE filters the results
- what goes in the ON clause, and what goes in WHERE?
  - ON directly links columns of the joined tables
  - WHERE sets additional constraints such as particular values (123, 'Bart')

```
SELECT name, course_id, grade
FROM students
JOIN grades ON id = student_id
WHERE name = 'Bart';
```

name	course_id	grade
Bart	10001	B-
Bart	10002	C

Using table aliases

- You can give names to tables, like a variable name in Java
- to specify all columns from a table, write table.*
- (grade column sorts alphabetically, so grades C or better are ones <= it)

```
SELECT s.name, g.*
FROM students s
JOIN grades g ON s.id = g.student_id
WHERE g.grade <= 'C';
```

name	student_id	course_id	grade
Bart	123	10001	B-
Bart	123	10002	C
Milhouse	456	10001	B+
Lisa	888	10002	A+
Lisa	888	10003	A+

Multi-way joins

- More than 2 tables can be joined, as shown above
- What does the above query represent?
    - The names of all courses in which Bart has gotten a B- or better.

```
SELECT c.name
FROM courses c
JOIN grades g ON g.course_id = c.id
JOIN students bart ON g.student_id = bart.id
WHERE bart.name = 'Bart' AND g.grade <= 'B-';
```

name
Computer Science 142

Indexes

Indexes

- Mechanism that enables a database to locate a record in row rapidly (e.g. table of contents or textbook index)

- Best Practice Don’ts:
  1. Don’t index every column
  2. Indexing uses extra storage space
  3. Additional time is required to create indexed columns during data insert
  4. Too many indexes increase search time to locate record

- Don’t index primary keys, they are already indexed

Indexes: which column?

- As a best practice, columns which are the most utilized as conditions in queries should be indexed:
    1. Columns in a WHERE clause
    2. Columns in an ORDER BY clause
    3. Columns in MIN and MAX clauses

```
//e.g., WHERE
SELECT * FROM authors
   WHERE author = 'Max Lucado';
// author should be indexed

//e.g., in an ORDER BY clause
SELECT * FROM contacts
   ORDER BY author;
// author should be indexed

//e.g., in MIN and MAX clauses
SELECT MAX(elevation) FROM mountain;
// elevation should be indexed
```

Creating an index

- Indexes can be defined
  - While creating the table
  - On existing tables

```
// e.g., while creating the table
CREATE TABLE employee (
   id INT NOT NULL
      AUTO_INCREMENT,  // id
   name VARCHAR(11),
   INDEX name_ix(name) );

// e.g., in an existing table
CREATE INDEX name_ix ON
   employee(name);
```

Unique values and indexes

- Indexes can have the unique keyword

- Unique indexes can be defined
  - While creating the table
  - On existing tables

```
// e.g., Unique Index upon table creation:
CREATE TABLE employee (
   id INT NOT NULL
      AUTO_INCREMENT,
   ss_number VARCHAR(11),
   UNIQUE ss_uq(ss_number) );

// e.g., Unique Index for an existing table:
CREATE UNIQUE INDEX ss_uq ON
   employee(ss_number);
```

Multiple column indexes

- Unlike primary keys, an index can be applied to multiple columns.
- Multi-column unique key, for example, could assure that the combination of two columns is unique.

location	
city	**state**
Manhattan	KS
Manhattan	NY

```
Example:

CREATE UNIQUE INDEX state_uq ON
location(city, state);
```

Performance considerations

Performances

```
SELECT *
FROM author
WHERE name = 'John MacArthur';
```

Without index

id	select_type	table	type	possible_keys	key	key_len	ref	rows	Extra
1	SIMPLE	author	ALL	NULL	NULL	NULL	NULL	7	Using where

With index

id	select_type	table	type	possible_keys	key	key_len	ref	rows	Extra
1	SIMPLE	author	const	name_uq	name_uq	42	const	1	

Explanation:

- type: ALL means every record is scanned to determine match.
- possible_keys: NULL means no index defined.
- key: NULL means no key is used by query.
- rows: Number of rows searched for query (there are 7 records in the database).