Relational data

- pandas
- SQLite

Two tables

Table: city		
name	population	established
'Copenhagen'	775033	800
'Aarhus'	273077	750
'Berlin'	3711930	1237
'Munich'	1464301	1158
'Reykjavik'	126100	874
'Washington D.C.'	693972	1790
'New Orleans'	343829	1718
'San Francisco'	884363	1776

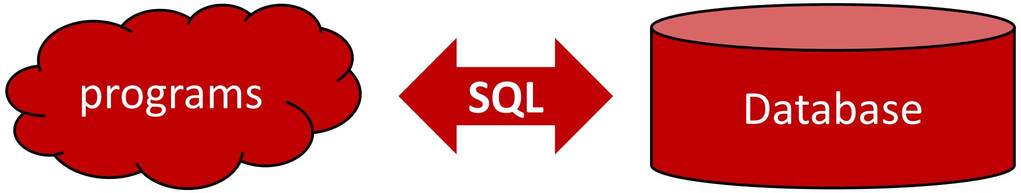
Table: country			
name	population	area	capital
'Denmark'	5748769	42931	'Copenhagen'
'Germany'	82800000	357168	'Berlin'
'USA'	325719178	9833520	'Washington, D.C.'
'Iceland'	334252	102775	'Reykjavik'

SQL

Table: country

name	population	area	capital
'Denmark'	5748769	42931	'Copenhagen'
'Germany'	82800000	357168	'Berlin'
'USA'	325719178	9833520	'Washington, D.C.'
'Iceland'	334252	102775	'Reykjavik'

- SQL = Structured Query **Language**
- **Database = collection of tables**
- ANSI and ISO standards since 1986 and 1987, respectively
- Widespread used SQL databases (can handle many tables/rows/users): Oracle, MySQL, Microsoft SQL Server, PostgreSQL and IBM DB2
- **SQLite** is a very lightweight version storing a database in one file
- SQLite is included in both iOS and Android mobil phones



programs

SQL

Database

The Course "Introduction to Databases" gives a more in-depth introduction to SQL (MySQL)

SQL examples

Table: country

name	population	area	capital
'Denmark'	5748769	42931	'Copenhagen'
'Germany'	82800000	357168	'Berlin'
'USA'	325719178	9833520	'Washington, D.C.'
'Iceland'	334252	102775	'Reykjavik'

- CREATE TABLE country (name, population, area, capital)
- INSERT INTO country VALUES ('Denmark', 5748769, 42931, 'Copenhagen')
- UPDATE country SET population=5748770 WHERE name='Denmark'
- SELECT name, capital FROM country WHERE population >= 1000000

  > [('Denmark', 'Copenhagen'), ('Germany', 'Berlin'), ('USA', 'Washington, D.C.')]
- SELECT * FROM country WHERE capital = 'Berlin'

  > [('Germany', 82800000, 357168, 'Berlin')]
- SELECT country.name, city.name, city.established FROM city, country WHERE city.name=country.capital AND city.population < 500000

  > ('Iceland', 'Reykjavik', 874), ('USA', 'Washington, D.C.', 1790)
- DELETE FROM country WHERE name = 'Germany'
- DROP TABLE country

www.w3schools.com/sql/

SQLite

sqlite-example.py

```python
import sqlite3
connection = sqlite3.connect('example.sqlite')  # creates file if necessary
c = connection.cursor()
countries = [('Denmark', 5748769, 42931, 'Copenhagen'),
             ('Germany', 82800000, 357168, 'Berlin'),
             ('USA', 325719178, 9833520, 'Washington, D.C.'),
             ('Iceland', 334252, 102775, 'Reykjavik')]
cities = [('Copenhagen', 775033, 800),
          ('Aarhus', 273077, 750),
          ('Berlin', 3711930, 1237),
          ('Munich', 1464301, 1158),
          ('Reykjavik', 126100, 874),
          ('Washington, D.C.', 693972, 1790),
          ('New Orleans', 343829, 1718),
          ('San Francisco', 884363, 1776)]
c.execute('CREATE TABLE country (name, population, area, capital)')
c.execute('CREATE TABLE city (name, population, established)')
c.executemany('INSERT INTO country VALUES (?,?,?,?)', countries)
c.executemany('INSERT INTO city VALUES (?,?,?)', cities)
connection.commit()  # make sure data is saved to database
connection.close()
```

docs.python.org/3/library/sqlite3.html

SQLite query examples

sqlite-example.py

```
for row in c.execute('SELECT * FROM city'):
    print(row)

for row in c.execute(
    '''SELECT country.name, city.name, city.established FROM city, country
       WHERE city.name=country.capital AND city.population < 700000'''):
    print(row)
```

Python shell

```
| ('Copenhagen', 775033, 800)
| ('Aarhus', 273077, 750)
| ('Berlin', 3711930, 1237)
| ('Munich', 1464301, 1158)
| ('Reykjavik', 126100, 874)
| ('Washington, D.C.', 693972, 1790)
| ('New Orleans', 343829, 1718)
| ('San Francisco', 884363, 1776)

| ('Iceland', 'Reykjavik', 874)
| ('USA', 'Washington, D.C.', 1790)
```

SQL injection

Right way

```
c.execute('INSERT INTO users VALUES (?)', (user,))
```

sqlite-example.py

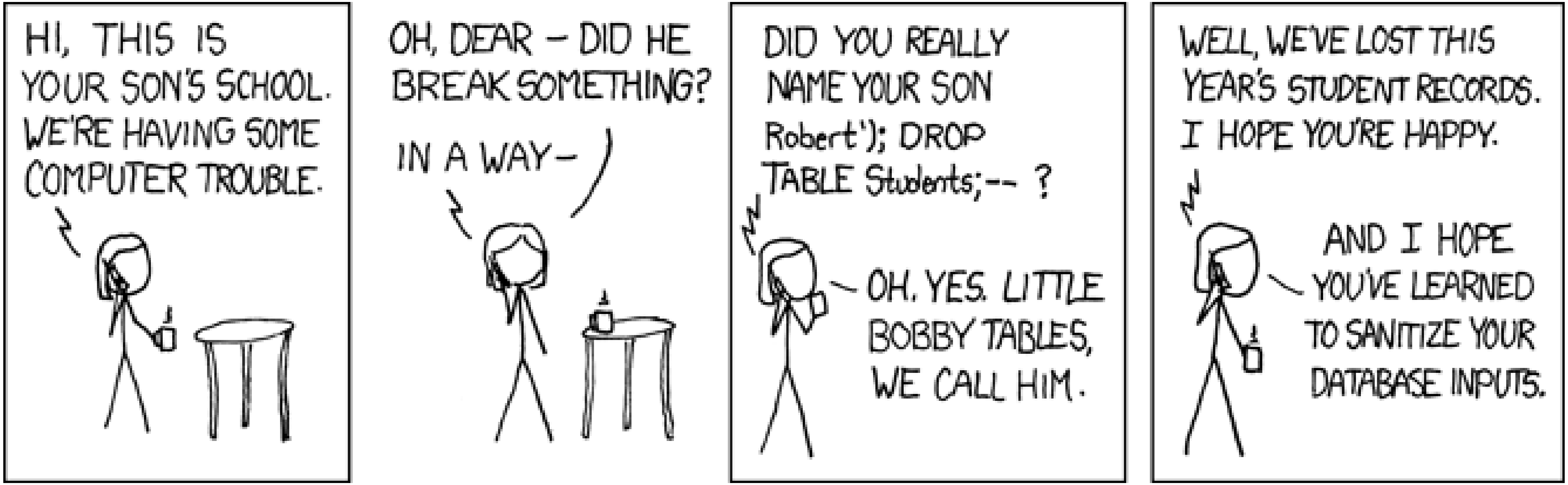
```
import sqlite3
connection = sqlite3.connect('users.sqlite')
c = connection.cursor()
c.execute('CREATE TABLE users (name)')
while True:
    user = input("New user: ")
    c.executescript('INSERT INTO users VALUES ("%s")' % user)
    connection.commit()
    print(list(c.execute('SELECT * FROM users')))
```

can execute a string containing several SQL statements

Insecure: NEVER use % on user input

Python shell

```
> New user: gerth
| [('gerth',)]
> New user: guido
| [('gerth',), ('guido',)]
> New user: evil"); DROP TABLE users; --
| sqlite3.OperationalError: no such table: users
```


HI, THIS IS YOUR SON'S SCHOOL. WE'RE HAVING SOME COMPUTER TROUBLE.
OH, DEAR – DID HE BREAK SOMETHING?
IN A WAY–
DID YOU REALLY NAME YOUR SON Robert'); DROP TABLE Students;-- ?
OH. YES. LITTLE BOBBY TABLES, WE CALL HIM.
WELL, WE'VE LOST THIS YEAR'S STUDENT RECORDS. I HOPE YOU'RE HAPPY.
AND I HOPE YOU'VE LEARNED TO SANITIZE YOUR DATABASE INPUTS.

xkcd.com/327/

Pandas

- Comprehensive Python library for data manipulation and analysis, in particular tables and time series
- Pandas **data frames** = tables
- Supports interaction with SQL, CSV, JSON, ...
- Integrates with Jupyter, numpy, matplotlib, ...

pandas.pydata.org

Reading tables

students.csv

```
Name,City
"Donald Duck","Copenhagen"
"Goofy","Aarhus"
"Mickey Mouse","Aarhus”
```

- Pandas provide functions for reading different data formats, e.g. SQLite and .csv files, into pandas.DataFrames

pandas-example.py

```
import pandas as pd
import sqlite3
connection = sqlite3.connect("example.sqlite")
countries = pd.read_sql_query("SELECT * FROM country", connection)
cities = pd.read_sql_query("SELECT * FROM city", connection)
students = pd.read_csv("students.csv")
students.to_sql('students', connection, if_exists='replace')
print(students)
```

Python shell

```
|             Name        City
| 0    Donald Duck  Copenhagen
| 1          Goofy      Aarhus
| 2   Mickey Mouse      Aarhus
```

Selecting columns and rows

Table: country

name	population	area	capital
'Denmark'	5748769	42931	'Copenhagen'
'Germany'	82800000	357168	'Berlin'
'USA'	325719178	9833520	'Washington, D.C.'
'Iceland'	334252	102775	'Reykjavik'

Python shell

```
> countries['name']  # select column
> countries.name  # same as above
> countries[['name', 'capital']]  # select multiple columns, note double-[]
> countries.head(2)  # first 2 rows
> countries[1:3]  # slicing rows, rows 1 and 2
> countries[::2]  # slicing rows, rows 0 and 2
> countries.at[1, 'area']  # indexing cell by (row, column name)
> cities[(cities['name']=='Berlin') | (cities['name']=='Munich')]  # select rows
> pd.DataFrame([[1,2], [3, 4], [5,6]], columns=['x', 'y'])  # create DF from list
> pd.DataFrame(np.random.random((3,2)), columns=['x', 'y'])  # from numpy
> ...
```

pandas.pydata.org/pandas-docs/stable/indexing.html

Merging and creating a new column

pandas-example.py

```
res = pd.merge(countries, cities, left_on="capital", right_on="name")

res.rename(columns={'name_x': 'country'})

res['%pop in capital'] = res['population_y'] / res['population_x']

res.sort_values('%pop in capital', ascending=False)

print(res[['country', '%pop in capital']])
```

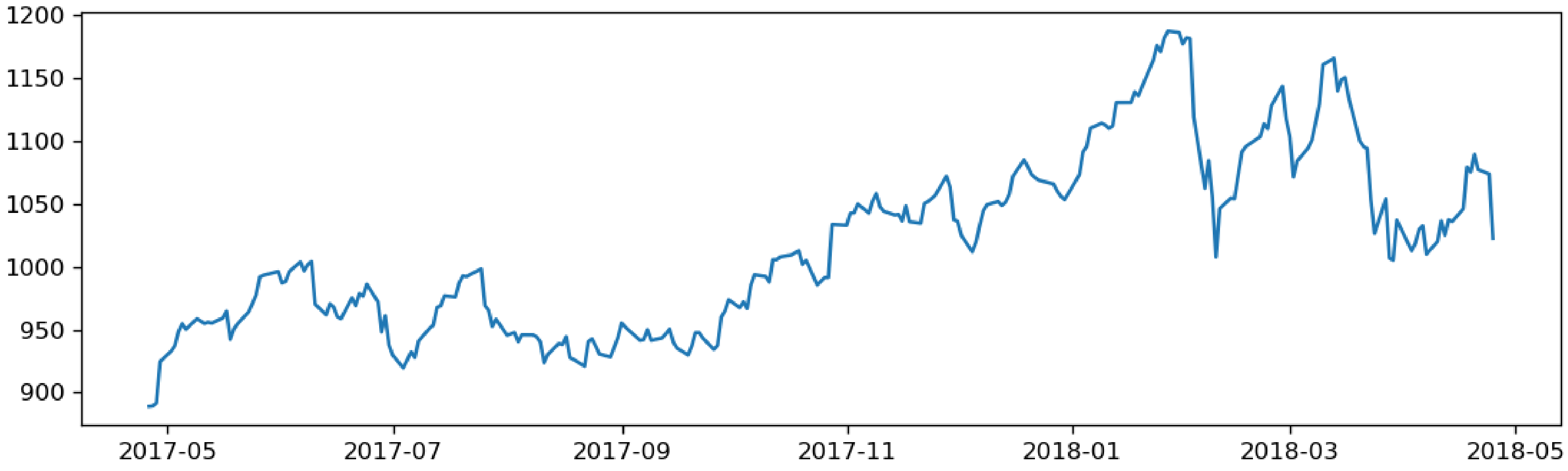
Python shell

```
|   country  %pop in capital
| 0 Denmark         0.134817
| 1 Germany         0.044830
| 2     USA         0.002131
| 3 Iceland         0.377260
```

Googlefinance > Pandas > Matplotlib

googlefinance-example.py

```
from googlefinance.client import get_price_data  # pip install googlefinance.client
param = {
    'q': "GOOGL", # Stock symbol (ex: "AAPL", "MSFT", "FB")
    'i': "86400", # Interval size in seconds ("86400" = 1 day intervals)
    'x': "NASD", # Stock exchange symbol on which stock is traded (ex: "NASD")
    'p': "1Y" # Period (Ex: "1Y" = 1 year)
}
df = get_price_data(param) # get price data (return pandas dataframe)
import matplotlib.pyplot as plt
plt.plot(df['Close'])
plt.show()
```



pypi.org/project/googlefinance.client