Task 2 (3 marks)
Normalization of relational tables

(1) Consider the following relational schema in BCNF.

```
ROOM(bldg-number, room-number, room-area)
primary key = (bldg-number, room-number)
```

Add to a relational schema `ROOM` a **meaningful attribute** such that after addition the relational schema will be at most in 1NF and not in 2NF. Prove, that after addition of an attribute the relational schema is not in 2NF.

We add an attribute `total-floors` (total number of floors in a building) with FD:
`bldg-number` → `bldg-floors`

Functional dependencies:
`bldg-number, room-number` → `room-area, total-floors`
`bldg-number` → `total-floors`

Minimal key:
`(bldg-number, room-number)`

The highest valid normal form:
1NF, 2NF violated by a non-prime attribute `total-floors` functionally dependent on a subset of minimal key `bldg-number` → `total-floors`

(2) Consider the following relational schema in BCNF.

```
FLIGHT(flight-number, from-city, to-city)
primary key = (flight-number)
```

Add to a relational schema `FLIGHT` a **meaningful attribute** such that after addition the relational schema will be at most in 2NF and not in 3NF. Prove, that after addition of an attribute the relational schema is not in 3NF.

We add an attribute `from-city-population` (population of a city) with FDs:
`from-city` → `from-city-population,`

`FLIGHT(flight-number, from-city, to-city, from-city-population)`

Functional dependencies:
`flight-number` → `from-city, to-city`
`from-city` → `from-city-population`

Minimal key:
(flight-number)

The highest valid normal form:
2NF, 3NF violated by an attribute from-city-population being transitively dependent on a minimal key flight-number.

(3) Consider the following relational schema in BCNF.

ORDER(order-number, supplier)
primary key = (order-number)

Add to a relational schema RDER a **meaningful attribute** such that after addition the relational schema will be at most in 3NF and not in BCNF. Prove, that after addition of an attribute the relational schema is not in BCNF.

ORDER(order-number, supplier)
primary key = (order-number)

primary key contributes to FD order-number → supplier.

Hence, an attribute X that must be added in order to break BCNF must trigger FD supplier, X → order-number

Assume that X = date-time-when-supplier-works-on-order and assume that to implement an order a supplier can work on an order in more than one moment in time, for example on two different days or on the same day at a different time.

ORDER(order-number, supplier, date-time-when-supplier-works-on-order)

Functional dependencies:
order-number → supplier
supplier, date-time-when-supplier-works-on-order → order-number

minimal keys:
(supplier, date-time-when-supplier-works-on-order)
(order#, date-time-when-supplier-works-on-order)

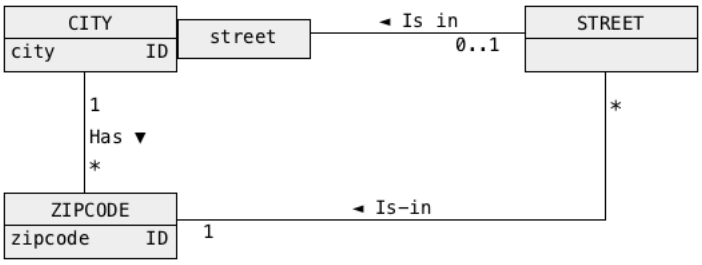
The highest valid normal form:
3NF, BCNF violated by FD order-number → supplier

Deliverables

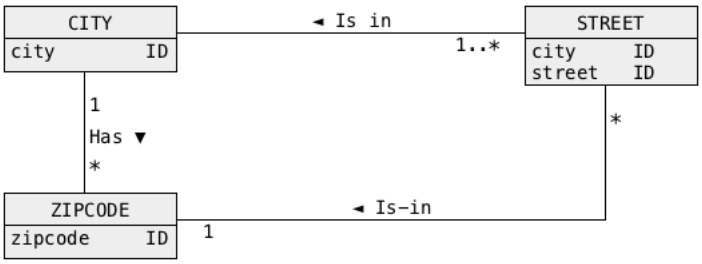
A file `solution2.pdf` with a report from denormalization of relational schemas (1), (2), and (3). For each one of the cases listed above provide a proof that after addition of a meaningful attribute a relational schema is in a required normal form.

The comments below are not the components of any of the solutions listed above and are not really required. The comments below attempt to provide more explanations on a nature of the relational designs where a relational schema is in 3NF and it is not in BCNF.

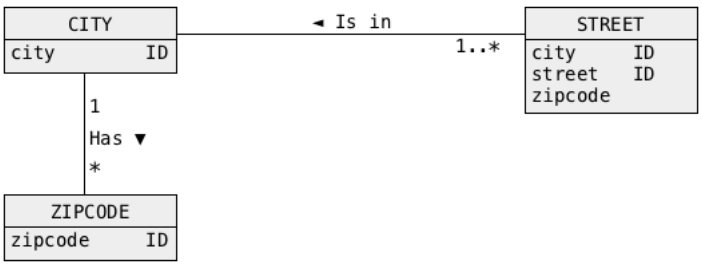
A conceptual schema whose logical design contributes to a relational schema `(city, street, zipcode)` in 3NF and not in BCNF is the following.



Elimination of qualification in a process of logical design provides the following conceptual schema.



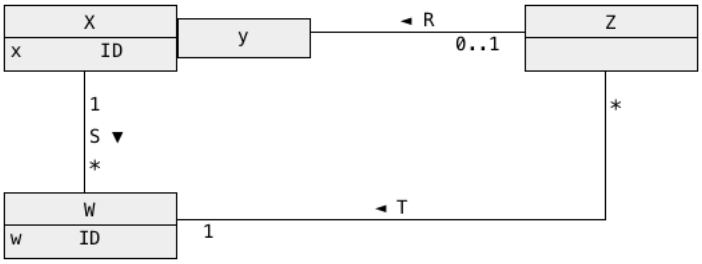
Next, implementation of an association `Is-in` between the classes `ZIPCODE` and `STREET` provides the following conceptual schema.



Transformation of a class `STREET` into a relational schema provides `(city, street, zipcode)` with FD indicated by an identifier `city, street -> zipcode`

An association `Has` contributes to the second FD `zipcode -> city`.

The conceptual schemas that lead to the relational schemes in 3NF and in BCNF must be consistent with the following template.



For example, the following conceptual schema are consistent with the template above.