Exercise 12.1. The following extract from Wikidata shows how geographic coordinates are encoded. Develop a SHACL schema that validates statement values for geographic coordinates in Wikidata.

```
"51.0282"^^xsd:double
```

```
wikibase:geoLatitude
```

```
wd:Q2
```

```
wikibase:geoGlobe
```

```
wdv:0...4
```

```
wikibase:geoLongitude
```

```
"0.001"^^xsd:double
```

```
wikibase:geoPrecision
```

```
"13.7368"^^xsd:double
```

**Hint:** Refer to the RDF Dump Format description¹ for details on the encoding.

Exercise 12.2. Show that deciding whether a given RDF graph is valid with respect to some fixed ShEx schema is NP-hard by reducing from 3-colourability.

**Hint:** You can use the RDF Shape playground² to test ShEx validation.

Exercise 12.3. Wikidata Property Constraints³ are a mechanism to specify how properties should be used on Wikidata. As an example, an Inverse Constraint⁴ specifies that every statement for a given property must have a matching statement in the reverse direction using some other property (e.g., every “mother” statement must have a matching “child” statement).

Use the VLog4j client¹ and the Wikidata Query Service⁵ to find statements violating an Inverse Constraint:

- write a SPARQL query to find all Inverse Constraints and the related properties,
- write a SPARQL query that finds violating statements for a given pair of forward and inverse properties,
- write a rules program that combines these two SPARQL data sources to obtain all statements violating Inverse Constraints.

² [http://rdfshape.weso.es/validate](http://rdfshape.weso.es/validate)
⁵ [https://query.wikidata.org](https://query.wikidata.org)
Hint: Finding all violations for all inverse constraints might take a long time. For testing, limit your queries to, e.g., 10 pairs of properties. To achieve that for VLog4j data sources, note that you can nest a subquery inside a graph pattern.

Exercise 12.4. Participants and winners of sports tournaments are modelled in Wikidata using properties P1334 ("participant of") and P2522 ("victory").

Write a program that, using the Wikidata Query Service, extracts the subgraph of Wikidata where there is an edge from vertex $w$ to vertex $v$ if $v$ is a participant of some tournament with winner $w$, and produces as output two files containing

- the graph in METIS graph format (cf. Exercise sheet 1), and

- a dictionary mapping every vertex ID to the English label of the corresponding Wikidata item (with each line being of the form $n$, "l", where $n$ is the vertex ID and $l$ is the item label), respectively.