**Exercise 11.1.** 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
"0.0001"^xsd:double
wikibase:geoPrecision
"13.7368"^xsd:double
```

**Hint:** Refer to the RDF Dump Format description\(^1\) for details on the encoding.

**Exercise 11.2.** 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 playground\(^2\) to test ShEx validation.

**Exercise 11.3.** Wikidata Property Constraints\(^3\) are a mechanism to specify how properties should be used on Wikidata. As an example, an Inverse Constraint\(^4\) 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 Wikidata Query Service\(^5\) to find statements violating an Inverse Constraint:

- write a SPARQL query to find all Inverse Constraints and the related properties, and
- extend this to find statements violating these constraints.

**Hint:** To avoid exceeding the available memory, use LIMIT/OFFSET to restrict the query to 5 constraints at a time. You may also need to disable the query optimiser (using `hint:Query hint:optimizer "None"`) and manually enforce the join order to prevent this query from timing out.

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\(^1\)https://www.mediawiki.org/wiki/Wikibase/Indexing/RDF_Dump_Format#Globe_coordinate
\(^2\)http://rdfsphere.weso.es/validate
\(^3\)https://www.wikidata.org/wiki/Help:Property_constraints_portal
\(^4\)https://www.wikidata.org/wiki/Help:Property_constraints_portal/Inverse
\(^5\)https://query.wikidata.org
Exercise 11.4. 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\textsuperscript{5} 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

- 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.