Knowledge Graphs 2020/21: Mock Exam

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Questions 2–3

RDF Literals

Match up the RDF literals that describe the same value, where the prefix `xsd` is defined as `http://www.w3.org/2001/XMLSchema#`.

- `"2"^^xsd:integer`
- `"2"^^xsd:float`
- `"2021-03-16T09:20:00+01:00"^^xsd:dateTime`
- `"2021-03-16T08:20:00"^^xsd:dateTime`
- `"2.0"^^xsd:decimal`
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Solution

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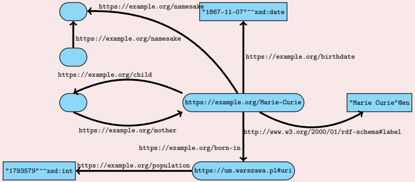
Solution

- `"2"^^xsd:integer` describes the same value as `"2.0"^^xsd:decimal`, since `xsd:integer` is a derived type of `xsd:decimal`
- `"2021-03-16T09:20:00+01:00"^^xsd:dateTime` and `"2021-03-16T08:20:00Z"^^xsd:dateTime` describe the same value in different time zones

Question 4

Turtle Serialisation



Use the Turtle format to encode this RDF graph, using the base IRI `https://example.org/` and the prefixes `xsd` (for `http://www.w3.org/2001/XMLSchema#`) and `rdfs` (for `http://www.w3.org/2000/01/rdf-schema#`). Take advantage of syntactic abbreviations wherever possible.

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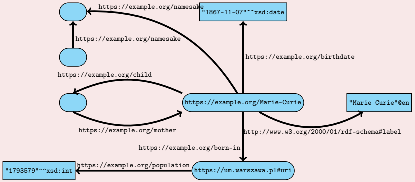

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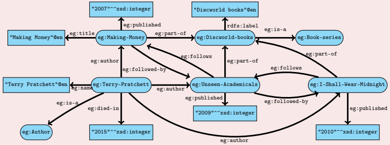
Solution

```
<Marie-Curie> <birthdate> "1867-11-07"^^xsd:date ;
              rdfs:label "Marie Curie"@en ;
              <born-in> <https://um.warszawa.pl#uri> ;
              <child> [ <mother> <Marie-Curie> ] ;
              <namesake> _:1 .
_:2 <namesake> _:1 .
<https://um.warszawa.pl#uri> <population> 1793579 .
```

Question 5

SPARQL Querying I



Consider an RDF graph describing authors and book series, using a schema as described by the image to the left (i.e., the image shows just a tiny portion of the whole graph, which contains information on many more book series, authors, and books).

Write a SPARQL query that finds all books belonging to the Discworld series.

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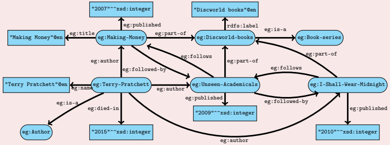

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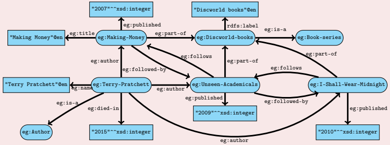
Solution

```
SELECT ?book WHERE {
  ?book eg:part-of eg:Discworld-books .
}
```

Question 6

SPARQL Querying II



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Write a SPARQL query that finds all authors of book series, ordered by the maximal number of books they contributed to any series. Note that multiple authors may contribute books to a series, and that authors may contribute books to multiple series.

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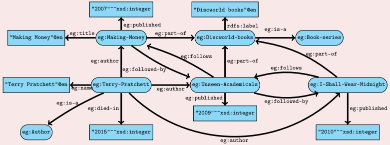

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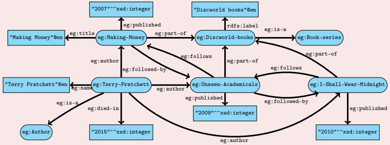
Solution

```
SELECT ?author (MAX(?contributions) AS ?books) WHERE {
  { SELECT ?author ?series (COUNT(?book) AS ?contributions) WHERE {
      ?series eg:is—a eg:Book—series .
      ?author eg:author ?book .
      ?book eg:part—of ?series .
  } GROUP BY ?author ?series }
} GROUP BY ?author
ORDER BY DESC(?books)
```

Question 7

SPARQL Querying III



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Write a SPARQL query that finds all book series consisting only of books whose authors have died. Note that multiple authors may contribute books to a series.

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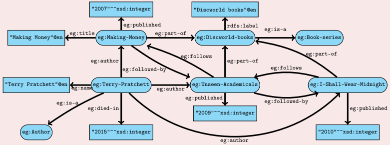

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Solution

```
SELECT ?series WHERE {
  ?series eg:is-a eg:Book-series .
  FILTER NOT EXISTS {
    ?book eg:part-of ?series ; ^eg:author ?author .
    FILTER NOT EXISTS { ?author eg:died-on [] . }
  }
}
```

Questions 8–9

RDF Leanness

Which of the following RDF graphs is not lean?

1.
```
eg:s   eg:p   eg:o  .
_:1    eg:p   _:1   .
```

2.
```
eg:s   eg:p   _:2   .
_:1    eg:p   eg:o  .
```

3.
```
eg:s   eg:p   eg:s .
_:1    eg:p   [ eg:p   [] ] .
```

4.
```
eg:s   eg:p   eg:o .
_:1    eg:p   [ eg:p   [] ] .
```

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```

3
```
eg:s   eg:p   eg:s  .
_:1    eg:p   [ eg:p   [] ] .
```

4
```
eg:s   eg:p   eg:o  .
_:1    eg:p   [ eg:p   [] ] .
```

Solution

Graph 3 is not lean: the instance mapping all blank nodes to `eg:s` maps to the only triple `eg:s eg:p eg:s`, which is a proper subset of the graph.

Question 10

Cypher Querying

Consider a property graph that uses the `HAS_CHILD` relationship type to model parent–child relationships. Write a Cypher query that finds persons and their great-grandparents.

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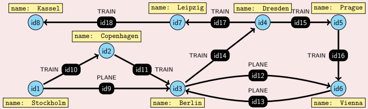
Solution

```
MATCH (person)<-[:HAS_CHILD*3]-(greatGrandparent)
RETURN person, greatGrandparent
```

Question 11

Cypher Query Evaluation



Which answers does the following Cypher query produce on this graph?

```
MATCH p = (s {name: "Stockholm"})—[:TRAIN∗]—(a)—[:PLANE∗1..]—>(b)—[:TRAIN∗0..]—(d {name: "Vienna"})
RETURN [ n IN nodes(p) | n.name ]
UNION ALL MATCH p = (s {name: "Stockholm"})—[:TRAIN∗]—(d {name: "Vienna"})
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```

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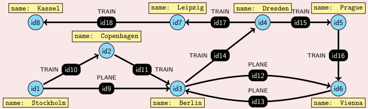

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RETURN [ n IN nodes(p) | n.name ]
UNION ALL MATCH p = (s {name: "Stockholm"})—[:TRAIN∗]—(d {name: "Vienna"})
RETURN [ n IN nodes(p) | n.name ]
```

Solution

- ["Stockholm", "Copenhagen", "Berlin", "Vienna"]
- ["Stockholm", "Copenhagen", "Berlin", "Dresden", "Prague", "Vienna", "Berlin", "Vienna"]
- ["Stockholm", "Copenhagen", "Berlin", "Vienna", "Berlin", "Dresden", "Prague", "Vienna"]
- ["Stockholm", "Copenhagen", "Berlin", "Dresden", "Prague", "Vienna"]

Question 12

Datalog Querying

Consider a schema consisting of two unary predicates `first` and `last`, and of a binary predicate `next`. Let D be a database of that schema, encoding a linear order of the form $1 < 2 < 3 < \cdots < n-1 < n$ using facts

$$\texttt{first}(1) \qquad \texttt{next}(1,2) \qquad \texttt{next}(2,3) \qquad \cdots \qquad \texttt{next}(n-1,n) \qquad \texttt{last}(n)$$

Write a Datalog program P such that $\langle P, \texttt{Result}\rangle$ derives `Result` over D iff the linear order encoded by D has even length. If D is not of the form described above, the behaviour of P is unspecified. Use Rulewerk syntax to format your answer.

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Solution

```
odd(?X)  :-  first (?X) .
odd(?Y)  :- next(?X, ?Y), even(?X) .
even(?Y) :- next(?X, ?Y), odd(?X) .
Result   :- even(?X), last (?X) .
```

Question 13

Stratified Datalog

Give a stratification of the following Datalog program P (in Rulewerk syntax)

```
mother(?x, ?y)          :- triple(?x, wdt:P25, ?y) .
father(?x, ?y)          :- triple(?x, wdt:P22, ?y) .
notSameMother(?x, ?y)   :- mother(?x, ?z),          ~mother(?y, ?z) .
sameFather(?x, ?y)      :- father(?x, ?z),           father(?y, ?z) .
notSameFather(?x, ?y)   :- ~sameFather(?x, ?y) .
halfSiblings(?x, ?y)    :- sameMother(?x, ?y),       notSameFather(?x, ?y) .
halfSiblings(?x, ?y)    :- sameFather(?x, ?y),       notSameMother(?x, ?y) .
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halfSiblings(?x, ?y)  :- sameMother(?x, ?y),    notSameFather(?x, ?y) .
halfSiblings(?x, ?y)  :- sameFather(?x, ?y),    notSameMother(?x, ?y) .
```

Solution

Using three strata, a possible stratification maps predicates as follows:

1. `triple`, `mother`, `father`, `sameFather`
2. `notSameMother`, `notSameFather`
3. `sameMother`, `halfSiblings`

Question 14

Complexity of Problems

- **given** a SPARQL query q, **decide** whether q has a match on the empty RDF graph
- **given** a database instance $\mathcal{I}$, **decide** whether a fixed Datalog query $\langle P, \mathtt{Result}\rangle$ derives `Result` on $\mathcal{I}$
- **given** a simple graph G, **decide** whether G has a 3-colouring
- **given** a database instance $\mathcal{I}$ and a Datalog query $\langle P, \mathtt{Result}\rangle$, **decide** whether $\langle P, \mathtt{Result}\rangle$ derives `Result` on $\mathcal{I}$

Sort the problems by their computational complexity, from the easiest (top) to the hardest (bottom). That is, every problem should provably be at most as hard as all the problems below it.

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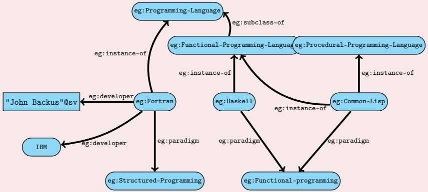
Solution

1. **given** a database instance $\mathcal{I}$, **decide** whether a fixed Datalog query $\langle P, \texttt{Result}\rangle$ derives Result on $\mathcal{I}$
2. **given** a simple graph G, **decide** whether G has a 3-colouring
3. **given** a SPARQL query q, **decide** whether q has a match on the empty RDF graph
4. **given** a database instance $\mathcal{I}$ and a Datalog query $\langle P, \texttt{Result}\rangle$, **decide** whether $\langle P, \texttt{Result}\rangle$ derives Result on $\mathcal{I}$

Question 15

ShEx Evaluation




```
eg:programming—language {
  (eg:instance—of @<#programming_language> |
   eg:instance—of @<#subclass_of_programming_language>)+;
  eg:developer IRI*;
  eg:paradigm @<#Programming—paradigm>*;
  eg:publication—date LITERAL*;
} <#subclass_of_programming_language> {
  (eg:subclass—of @<#programming_language> ; eg:subclass—of IRI *) |
  (eg:subclass—of @<#subclass_of_programming_language>; eg:subclass—of IRI *)
} <#programming_language> [ eg:Programming—Language ]
<#Programming_paradigm> [ eg:Functional—Programming
eg:Structured—Programming ]
```

Validate the RDF graph according to this schema, i.e., apply the `eg:programming-language` shape to the nodes `eg:Fortran`, `eg:Common-Lisp`, and `eg:Haskell`. Which of the nodes is valid and which is invalid for the schema? Explain your answer in each case.

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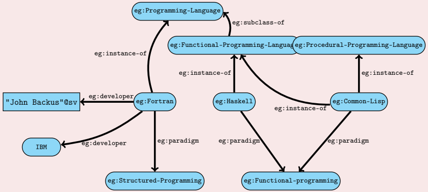
ShEx Evaluation

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Solution

- `eg:Fortran` is invalid, `"John Backus"@sv` is not an IRI

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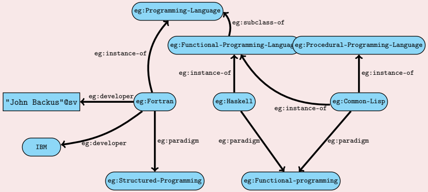


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Solution

- `eg:Common-Lisp` is invalid, `eg:Procedural-Programming-Language` is not a `eg:subclass-of` of `eg:Programming-Language`

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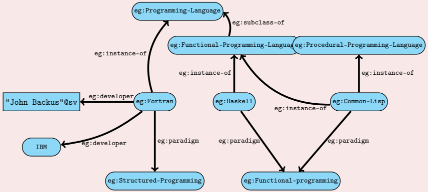

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Solution

- eg:Haskell is valid: both eg:paradigm and eg:instance-of comply with the schema