

Knowledge Graphs 2021/22: Mock Exam

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2022-02-21

Task 1: a–b

RDF Literals I

Let the prefix `xsd` be defined as <http://www.w3.org/2001/XMLSchema#>. Which of the following three RDF literals describe the same value?

1 "2"^^xsd:integer

2 "2"^^xsd:float

3 "2.0"^^xsd:decimal

1 "2021-03-16T09:20:00"^^xsd:dateTime

2 "2021-03-16T09:20:00+01:00"^^xsd:dateTime

3 "2021-03-16T08:20:00Z"^^xsd:dateTime

Task 1: a–b

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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`

Task 1: a–b

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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

Task 1: c

RDF Literals II

Define the term “RDF graph”. You may use the terms “IRI”, “blank node”, “literal”, and “Unicode” in your definition.

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Solution

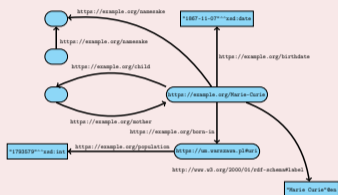
A **triple** is a 3-tuple of **subject**, **predicate**, and **object**, where

- ▶ subject is an IRI or a blank node,
- ▶ predicate is an IRI, and
- ▶ object is an IRI, a blank node, or a literal.

An **RDF graph** is a set of triples.

Task 2

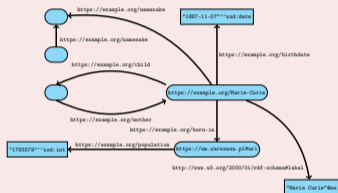
Turtle Serialisation



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.

Task 2

Turtle Serialisation



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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 .
  
```


Task 3: a

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.

Task 3: a

SPARQL Querying I



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

Solution

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

Task 3: b

SPARQL Querying II



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 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.

Task 3: b

SPARQL Querying II



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 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.

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)
```

Task 3: c

SPARQL Querying III



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 book series consisting only of books whose authors have died. Note that multiple authors may contribute books to a series.

Task 3: c

SPARQL Querying III



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 book series consisting only of books whose authors have died. Note that multiple authors may contribute books to a series.

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 [] . }
  }
}
```

Task 4: a

RDF Leanness I

Give a formal definition of a **lean RDF graph**. Briefly describe the intuitive significance of this notion.

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RDF Leanness I

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Solution

An **instance** $\sigma(G)$ of an RDF graph G is obtained by replacing some blank nodes by arbitrary RDF terms. An RDF graph G is lean if it does not have an instance $\sigma(G)$ with $\sigma(G) \subsetneq G$. Intuitively, lean graphs do not have internal redundancy.

Task 4: b

RDF Leanness II

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 []] .`

Task 4: b

RDF Leanness II

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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.

Task 5: a

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
```

Task 5: b

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"})
RETURN [ n IN nodes(p) | n.name ]
```

Task 5: b

Cypher Query Evaluation



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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"]

Task 6: a

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 $1 < 2 < 3 < \dots < n - 1 < n$ using facts

`first(1)` `next(1, 2)` `next(2, 3)` \dots `next($n - 1, n$)` `last(n)`

Write a Datalog program P such that $\langle P, \text{Result} \rangle$ 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.

Task 6: a

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Write a Datalog program P such that $\langle P, \text{Result} \rangle$ 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.

Solution

```

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

```


Task 6: b

Stratified Datalog

Give a stratification of the following Datalog program P .

```

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) .
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Task 6: b

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notSameFather(?x, ?y) :- ~sameFather(?x, ?y) .
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

Task 7

Complexity of Problems

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

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

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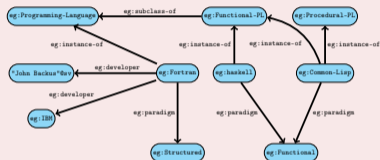
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Question 15

ShEx Evaluation

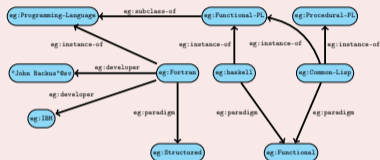


```
eg:programming-language {
  (eg:instance-of @<#programming_language> |
   eg:instance-of @<#subclass_of_programming_language>)+;
  eg:developer IRI*;
  eg:paradigm @<#Programming-paradigm>*;
  eg:publication-date LITERAL*;
} <#subclass_of_programming_language> {
  (eg:subclass-of @<#programming_language> ; 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.

Question 15

ShEx Evaluation



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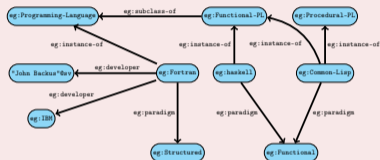
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Solution

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

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ShEx Evaluation



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```

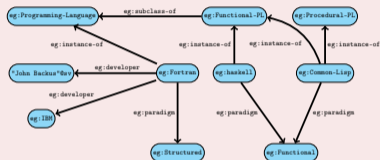
Validate the RDF graph according to this schema, i.e., apply the `eg:programming-language` shape to the nodes `eg:Fortran`, `eg:Common-Lisp`, and `eg:Haskell`. Which of the nodes is valid and which is invalid for the schema? Explain your answer in each case.

Solution

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

Question 15

ShEx Evaluation



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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.

Solution

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