**Chapter 10**

Representation Knowledge Using Rules

**The chapter consist of Short type Questions &Answers , Descriptive Question & Answer and MCQs & answers**

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[A university has asked you to write a program to help them determine whether or not to accept students who have applied for admission. There are 3 basic pathways for a student to be accepted. If a student is returning to the university after a time away and is in good academic standing with no outstanding fees, they are accepted. Students who submit a complete application and are qualified are also accepted. Students are qualified if they have high SAT scores as well as good high-school transcripts. The university also has a legacy program, wherein children of former graduates are qualified (though these student must still submit a complete application). For brevity, let’s only talk about 3 individuals: Sam is a former graduate and Chris is his son. Chris has good high-school transcripts and he submitted a complete application. Laura is a returning student in good academic standing. 16](file:///C:\0.%20RNDas_WORKING%20FOLDER\D%20Drive%20Data%20from%20Desktop%20PC\0.%20RNDas_WILEY\Intelligent%20System\AI_RESOURCES\AI_Students'%20Resources\AI_App%20B_Testing\Chapter_10.docx#_Toc14902960)

[A) Give the knowledge base representing this problem, using unary predicates accepted, returning, goodStanding, clearBalance, appComplete, qualified, legacyStudent, highSAT, goodHS, and graduate, as well as the binary predicate child. The university admissions officials should be able to provide queries such as accepted(chris) and get a true or false answer. 16](file:///C:\0.%20RNDas_WORKING%20FOLDER\D%20Drive%20Data%20from%20Desktop%20PC\0.%20RNDas_WILEY\Intelligent%20System\AI_RESOURCES\AI_Students'%20Resources\AI_App%20B_Testing\Chapter_10.docx#_Toc14902961)

[B) Show the top-down derivation of the query accepted(chris) applied to your KB. 16](file:///C:\0.%20RNDas_WORKING%20FOLDER\D%20Drive%20Data%20from%20Desktop%20PC\0.%20RNDas_WILEY\Intelligent%20System\AI_RESOURCES\AI_Students'%20Resources\AI_App%20B_Testing\Chapter_10.docx#_Toc14902962)

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# Short type Questions &Answers

## Why logic is used in artificial intelligence?

Logic is widely used in computer science, and particularly in Artificial Intelligence. Logic is widely used as a representational method for Artificial Intelligence. Unlike some other representations, logic allows us to easily reason about negatives (such as, “this book is not red”) and disjunctions (“or”—such as, “He’s either a soldier or a sailor”).

Logic is also often used as a representational method for communicating concepts and theories within the Artificial Intelligence community. In addition, logic is used to represent language in systems that are able to understand and analyze human language. As we will see, one of the main weaknesses of traditional logic is its inability to deal with uncertainty. Logical statements must be expressed in terms of truth or falsehood—it is not possible to reason, in classical logic, about possibilities.

## What is an atom? Give the definition and an example.

Answer: An atom is a symbol starting with a lower case letter. Example: ai \_is \_fun

## What is a body? Give the definition and an example.

Answer: A body is an atom or is of the form b1 ∧ b2 where b1 and b2 are bodies. Example: students\_ are \_motivated ∧ ai \_is \_fun

## What is a definite clause? Give the definition and an example.

Answer: A definite clause is an atom or is a rule of the form h ← b where h is an atom and b is a body. (Read this as h if b.) Example:

students\_ are \_successful ← ai\_ is\_ fun ∧ students\_ are\_ motivated

## What is a knowledge case? Give the definition and an example.

Answer: A knowledge base is a set of definite clauses.

Example:

ai\_ is\_ fun \_students\_ are\_ motivated

students\_ are \_successful ← ai \_is\_ fun ∧ students\_ are\_ motivated

What is an interpretation of a knowledge base KB? Give the definition and an example. Answer: An interpretation I is an assignment of truth values to each atom in each clause of the knowledge base. For the knowledge base above, one interpretation is:

ai\_ is\_ fun = true

students\_ are\_ motivated = false

students\_ are \_successful = true (Note that there’s nothing in the definition of an interpretation that says clauses have to be true under the interpretation; that part is captured by a model; see below)

## What is a model of a knowledge base KB?

Answer: A model of a set of clauses is an interpretation in which all the clauses are true. For the knowledge base above, the only model is:

ai\_ is\_ fun = true

students\_ are\_ motivated = true

students \_are \_successful = true

## What is syntax

The syntax of propositional logic is simple. The symbols of propositional logic are the logical constants True and False, proposition symbols such as P and Q, the logical connectives∧, ∨, ⌐, →, ↔ and parentheses (). All sentences are made by putting these symbols together using the following rules:

* The logical constants True and False are sentences themselves.
* A propositional symbol such as P or Q is a sentence itself
* Wrapping parentheses around a sentence yields a sentence, for example (P∧ Q)

## Define semantic

The semantic of propositional logic is also quite straight forward. We define it by specifying the interpretation of the proposition symbols and constants and specifying the meanings of the logical connectives. A proposition symbol can mean whatever you want. That is, its interpretation can be any arbitrary fact.

## Draw the Truth tables for the 5 logical connectives

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| A | B | ⌐A | A∧ B | A∨B | A→B | A↔B |
| False | False | True | False | False | True | True |
| False | True | True | False | True | True | False |
| True | False | False | False | True | False | False |
| True | True | False | True | True | True | True |

Truth tables for the 5 logical connectives

## Write first-order predicate logic for “All kings are persons”

“All kings are persons”, is written in first-order predicate logic as

∀x king(x) 🡪 Person(x)

## • Given a knowledge base KB and a conjunction of atoms g, what is meant by KB |= g?

Answer: g is a logical consequence of KB, that is, it is true in every model of KB

## • Given a proof procedure P, a knowledge base KB and a conjunction of atoms g, what is meant by KB `P g?

Answer: g can be derived from KB by means of the proof procedure P.

## • Define what it means for a proof procedure to be sound.

Answer: KB ` g implies that KB |= g

## • Define what it means for a proof procedure to be complete.

Answer: KB |= g implies that KB ` g

## • What is the key idea of the bottom-up proof procedure?

Answer: You search forward from the given knowledge base, iteratively expanding the set of atoms implied by the knowledge base KB.

## • How do you know when you have completed a successful derivation using the bottom-up proof procedure?

Answer: If the set of atoms implied by KB is a superset of the atoms in g, the derivation is succesful. • How can the bottom-up proof procedure show that there is no successful derivation?

Answer: If the procedure finishes and the set of atoms implied by KB is not a superset of g, then there exists no successful derivation.

## • What is the key idea of the top-down proof procedure?

Answer: You search backward from the query to see if it can be derived from the knowledge base.

## • How do you know when you have completed a successful derivation using the top-down proof procedure?

Answer: You obtain the answer clause yes ← with an empty body.

## • Give an example of an admissible heuristic for top-down search.

Answer: The number of atoms in the clause, since it will take at least that many resolution steps, i.e. it won’t overestimate.

# Descriptive Question & Answer

## Write a short note on Resolution

Resolution is a procedure used in proving that arguments which are expressible in predicate logic are correct.

Resolution is a procedure that produces proofs by refutation or contradiction.

Resolution lead to refute a theorem-proving technique for sentences in propositional logic and first-order logic.

Resolution is a rule of inference.

Resolution is a computerized theorem prover.

Resolution is so far only defined for Propositional Logic. The strategy is that the Resolution techniques of Propositional logic be adopted in Predicate Logic.

## Consider the following inference: Given the rules and facts,

## R1: If X is a close relative of Y and Y is a close relative of Z then X is acquainted with Z.  R2: If X is a parent of Y, then X is a close relative of Y.  R3: If X is married to Y, then X is a close relative of Y.  F1: Sam is a parent of Mike.  F2: Mike is married to Alice.

## Infer that Sam is acquainted with Alice.

## Explain how Datalog can carry out the inference. You may use either backward or forward chaining.

A. Express rules R1-R3 and facts F1,F2 in the Datalog representation using the following primitives:

c(X,Y) --- X is a close relative of Y.   
p(X,Y) --- X is a parent of Y.   
m(X,Y) --- X is married to Y.   
a(X,Y) --- X is acquainted with Y.   
sam, mike, alice : Constants.

**Answer:**

R1: a(X,Z) :- c(X,Y),c(Y,Z).

R2: c(X,Y) :- p(X,Y).

R3: c(X,Y) :- m(X,Y).

F1: p(sam,mike),

F2. m(mike,alice).

B. Explain how Datalog can carry out the inference. You may use either backward or forward chaining.

**Answer:**In backward chaining you start with the goal G0 ?- a(sam,alice), and proceed as follows:

G0 ?- a(sam,alice) matches R1 giving G1

G1 ?- c(sam,Y1), c(Y1,alice) generates first G2

G2 ?- c(sam,Y1) matches R2 giving G3

G3 ?- p(sam,Y1) matches F1 with Y1=mike. G3 succeeds.

G2 succeeds

G1 generates G4:

G4 ?- c(mike,alice) matches R2 giving G5

G5 ?- p(mike,alice) fails. Return to G4

G4 matches R3 giving G6

G6 ?- m(mike,alice) matches F2. G6 succeeds.

G4 succeeds

G1 succeeds

G0 succeeds.

## What are Issues in Knowledge Representation

The fundamental goal of Knowledge Representation is to facilitate inferencing (conclusions) from knowledge.

The issues that arise while using KR techniques are many. Some of these are explained below.

Important Attributes :

Any attribute of objects so basic that they occur in almost every problem domain ?

Relationship among attributes:

Any important relationship that exists among object attributes ?

Choosing Granularity :

At what level of detail should the knowledge be represented ?

Set of objects :

How sets of objects be represented ?

Finding Right structure :

Given a large amount of knowledge stored, how can relevant parts be accessed ?

**Important Attributes**:

There are attributes that are of general significance.

There are two attributes **"instance"** and **"isa"**, that are of general importance. These attributes are important because they support *property* *inheritance*.

**Relationship among Attributes***: (Ref. Example- Fig. Inheritable KR*)

The attributes to describe objects are themselves entities they represent.

The relationship between the attributes of an object, independent of specific knowledge they encode, may hold properties like:

*Inverses, existence in an isa hiera hy, techniques for reasoning about values and single valued attributes*.

◊ **Inverses :**

This is about *consistency check*, while a value is added to one attribute. The entities are related to each other in many different ways. The figure shows attributes *(isa, instance, and team)*, each with a directed arrow, originating at the object being described and terminating either at the object or its value.

There are two ways of realizing this:

first, represent two relationships in a *single representation*; e.g., a logical representation, ***team(Pee-Wee-Reese, Brooklyn–Dodgers)***, that can be interpreted as a statement about Pee-Wee-Reese or Brooklyn–Dodger.

second, use attributes that focus on a *single entity but use them in*

*pairs*, one the inverse of the other; for e.g., one,

***Dodgers***, and the other,***team = Pee-Wee-Reese, . . . .***

This second approach is followed in semantic net and frame-based systems, accompanied by a knowledge acquisition tool that guarantees the consistency of inverse slot by checking, each time a value is added to one attribute then the corresponding value is added to the inverse.

**◊ Existence in an "isa" hiera** **hy :**

This is about *generalization-specialization*, like, classes of objects and specialized subsets of those classes. There are attributes and specialization of attributes.

Example: the attribute *"height*" is a specialization of general attribute

*"physical-size"*which is, in turn, a specialization of*"physical-attribute*".These generalization-specialization relationships for attributes are important because they support inheritance.

**Techniques for reasoning about values :**

This is about *reasoning values of attributes* not given explicitly. Several kinds of information are used in reasoning, like,

height : must be in a unit of length,

age : of person can not be greater than the age of person's parents.

The values are often specified when a knowledge base is created.

**Single valued attributes :**

This is about a *specific attribute* that is guaranteed to take a unique value.

Example : A baseball player can at time have only a single height and be a member of only one team. KR systems take different approaches to provide support for single valued attributes.

**Choosing Granularity**

What level should the knowledge be represented and what are the primitives ?

 Should there be a small number or should there be a large number of low-level primitives or High-level facts.

 High-level facts may not be adequate for inference while Low-level primitives may require a lot of storage.

**Example of Granularity**:

Suppose we are interested in following facts

**John spotted Sue.**

This could be represented as

**Spotted (agent(John), object (Sue))**

Such a representation would make it easy to answer questions such are

**Who spotted Sue ?**

Suppose we want to know

**Did John see Sue ?**

Given only one fact, we cannot discover that answer.

We can add other facts, such as

**Spotted (x , y)**→                   **saw (x , y)**

We can now infer the answer to the question.

Set of Objects KR - issues

Certain  properties  of  objects  that  are  true  as member of  a set  but not as  individual;

Example : Consider the assertion made in the sentences

"there are more sheep than people in Australia", and "*English* speakers can be found all over the world."

To describe these facts, the only way is to attach assertion to the sets representingpeople, sheep, and English**.**

The  reason to represent sets of objects is :

If a property is true for all or most elements of a set, then it is more efficient to associate it once with the set

rather than to associate it explicitly with every elements of the set . This is done in different ways :

in logical representation through the use of *universal quantifier*,  and

in hiera hical structure where node represent sets, the *inheritancepropagate*set level assertion down to individual.

Example: assert **large (elephant)**;

Remember to make clear distinction between,

whether we are asserting some property of the set itself,

means, **the set of elephants is large**,         or

asserting some property that holds for individual elements of the set , means, **any thing that is an elephant is large**.

There are three ways in which sets may be represented :

Name, as in the example – Ref Fig. Inheritable KR, the node - Baseball-Player and the predicates as Ball and Batter in logical representation.

Extensional definition is to list the numbers,  and

In tensional definition is to provide a rule, that returns true or

false depending on whether the object is in the set or not.

**Finding Right Structure**

Access to right structure for describing a particular situation.

It requires, selecting an initial structure and then revising the choice. While doing so, it is necessary to solve following problems :

how to perform an initial selection of the most appropriate structure.

how to fill in appropriate details from the current situations.

how to find a better structure if the one chosen initially turns out not to be appropriate.

what to do if none of the available structures is appropriate.

when to create and remember a new structure.

There is no good, general purpose method for solving all these problems. Some knowledge representation techniques solve some of them.

## Which of the following rules are syntactically invalid in propositional definitive clause logic, and why?

## 1. bikeCrashed ← cycledDrunk

## 2. goByBus ∨ goByCar ← bikeBroke

## 3. goByBus ← ¬haveGas ∨ bikeBroke

1. bikeCrashed ← cycledDrunk Answer: Syntactically valid.

2. goByBus ∨ goByCar ← bikeBroke Answer: Syntactically invalid: the head of a clause has to be an atom.

3. goByBus ← ¬haveGas ∨ bikeBroke Answer: Syntactically invalid: atoms in a clause’s body can only be connected by a ∧, and you can’t have negation, either.

## A university has asked you to write a program to help them determine whether or not to accept students who have applied for admission. There are 3 basic pathways for a student to be accepted. If a student is returning to the university after a time away and is in good academic standing with no outstanding fees, they are accepted. Students who submit a complete application and are qualified are also accepted. Students are qualified if they have high SAT scores as well as good high-school transcripts. The university also has a legacy program, wherein children of former graduates are qualified (though these student must still submit a complete application). For brevity, let’s only talk about 3 individuals: Sam is a former graduate and Chris is his son. Chris has good high-school transcripts and he submitted a complete application. Laura is a returning student in good academic standing.

## A) Give the knowledge base representing this problem, using unary predicates accepted, returning, goodStanding, clearBalance, appComplete, qualified, legacyStudent, highSAT, goodHS, and graduate, as well as the binary predicate child. The university admissions officials should be able to provide queries such as accepted(chris) and get a true or false answer.

## B) Show the top-down derivation of the query accepted(chris) applied to your KB.

## C) Show one of the failing top-down derivations of the query accepted(laura) applied to your KB.

Answer

A) Answer:

Here is a sample KB.

% file: school.pl

accepted(Student) <- returning(Student) & goodStanding(Student) & clearBalance(Student). accepted(Student) <- appComplete(Student) & qualified(Student).

qualified(Student) <- legacyStudent(Student).

qualified(Student) <- highSAT(Student) & goodHS(Student).

legacyStudent(Student) <- child(Student, Parent) & graduate(Parent).

goodHS(chris).

graduate(sam).

child(chris, sam).

appComplete(chris).

returning(laura).

goodStanding(laura).

B) Answer:

yes ← [accepted(chris)].

yes ← [appComplete(chris), qualified(chris)].

yes ← [qualified(chris)].

yes ← [legacyStudent(chris)].

yes ← [child(chris, Parent), graduate(Parent)].

yes ← [graduate(sam)].

yes.

“yes” - proven

C) Answer:

yes ← [accepted(laura)].

yes ← [returning(laura), goodStanding(laura), clearBalance(laura).

yes ← [goodStanding(laura), clearBalance(laura).

yes ← [clearBalance(laura). no choice, fail

# MCQs & answers

**1.** Translate the following statement into FOL. “For every *a*, if *a* is a philosopher, then *a* is a scholar”

(a) ∀*a* philosopher(*a*) scholar(*a*)

(b) ∃*a* philosopher(*a*) scholar(*a*)

(c) All of the above

(d) None of the above

**2.** The statement comprising the limitations of FOL is/are \_\_\_\_\_\_\_\_\_\_\_\_\_.

(a) Expressiveness

(b) Formalising natural languages

(c) Many-sorted logic

(d) All of the above

**3.** First-order logic is also known as \_\_\_\_\_\_\_\_\_\_\_.

(a) First-order predicate calculus

(b) Quantification theory

(c) Lower order calculus

(d) All of the above

**4.** Which is created by using single propositional symbol?

(a) Complex sentences

(b) Atomic sentences

(c) Composition sentences

(d) None of the above

**5.** Which is used to construct the complex sentences?

(a) Symbols

(b) Connectives

(c) Logical connectives

(d) All of the above

**6.** How many proposition symbols are there in AI?

(a) 1

(b) 2

(c) 3

(d) 4

**7.** How many logical connectives are there in AI?

(a) 2

(b) 3

(c) 4

(d) 5

**8.** Which is used to compute the truth of any sentence?

(a) Semantics of propositional logic

(b) Alpha-beta pruning

(c) First-order logic

(d) Both semantics of propositional logic and alpha-beta pruning

**Answers**

**1. (a) 2. (d) 3. (d) 4. (b) 5. (c) 6. (b) 7. (d) 8. (a)**