A **semantics** specifies the meaning of sentences in the language. An **interpretation** specifies:

- what objects (individuals) are in the world
- the correspondence between symbols in the computer and objects & relations in world
  - constants denote individuals
  - predicate symbols denote relations
An **interpretation** is a triple $I = \langle D, \phi, \pi \rangle$, where

- $D$, the **domain**, is a nonempty set. Elements of $D$ are **individuals**.
- $\phi$ is a mapping that assigns to each constant an element of $D$. Constant $c$ **denotes** individual $\phi(c)$.
- $\pi$ is a mapping that assigns to each $n$-ary predicate symbol a relation: a function from $D^n$ into $\{\text{TRUE, FALSE}\}$. 
Example Interpretation

Constants:  *phone*, *pencil*, *telephone*.

Predicate Symbol:  *noisy* (unary), *left_of* (binary).

\[ D = \{ \text{\ding{101}}, \text{\ding{102}}, \text{\ding{103}} \}. \]

\[ \phi(p\text{hone}) = \text{\ding{102}}, \phi(p\text{encil}) = \text{\ding{103}}, \phi(t\text{elephone}) = \text{\ding{102}}. \]

\[ \pi(\text{noisy}): \begin{array}{c|c|c}
\langle \text{<} \rangle & \text{FALSE} & \langle \text{\textcircled{\textbardbl}} \rangle & \text{TRUE} \\
\end{array} \]

\[ \pi(\text{left_of}): \]

\[ \begin{array}{c|c|c|c}
\langle \text{<} \rangle & \text{FALSE} & \langle \text{<}, \text{\textcircled{\textbardbl}} \rangle & \text{TRUE} \\
\langle \text{\textcircled{\textbardbl}}, \text{<} \rangle & \text{FALSE} & \langle \text{\textcircled{\textbardbl}}, \text{\textcircled{\textbardbl}} \rangle & \text{FALSE} \\
\langle \text{\textcircled{\textbardbl}}, \text{\textcircled{\textbardbl}} \rangle & \text{FALSE} & \langle \text{\textcircled{\textbardbl}}, \text{\textcircled{\textbardbl}} \rangle & \text{TRUE} \end{array} \]
Important points to note

• The domain $D$ can contain real objects. (e.g., a person, a room, a course). $D$ can’t necessarily be stored in a computer.

• $\pi(p)$ specifies whether the relation denoted by the $n$-ary predicate symbol $p$ is true or false for each $n$-tuple of individuals.

• If predicate symbol $p$ has no arguments, then $\pi(p)$ is either $TRUE$ or $FALSE$. 
A constant $c$ **denotes in $I$** the individual $\phi(c)$.

Ground (variable-free) atom $p(t_1, \ldots, t_n)$ is

- **true in interpretation $I$** if $\pi(p)(\langle \phi(t_1), \ldots, \phi(t_n) \rangle) = TRUE$ in interpretation $I$ and
- **false** otherwise.

Ground clause $h \leftarrow b_1 \land \ldots \land b_m$ is **false in interpretation $I$** if $h$ is false in $I$ and each $b_i$ is true in $I$, and is **true in interpretation $I$** otherwise.
Example Truths

In the interpretation given before, which of the following are true?

\[\text{noisy(phone)}\]
\[\text{noisy(telephone)}\]
\[\text{noisy(pencil)}\]
\[\text{left_of(phone, pencil)}\]
\[\text{left_of(phone, telephone)}\]
\[\text{noisy(phone)} \leftarrow \text{left_of(phone, telephone)}\]
\[\text{noisy(pencil)} \leftarrow \text{left_of(phone, telephone)}\]
\[\text{noisy(pencil)} \leftarrow \text{left_of(phone, pencil)}\]
\[\text{noisy(phone)} \leftarrow \text{noisy(telephone)} \land \text{noisy(pencil)}\]
In the interpretation given before, which of following are true?

\[
\begin{align*}
&\text{noisy} (\text{phone}) & \text{true} \\
&\text{noisy} (\text{telephone}) & \text{true} \\
&\text{noisy} (\text{pencil}) & \text{false} \\
&\text{left}_\text{of} (\text{phone}, \text{pencil}) & \text{true} \\
&\text{left}_\text{of} (\text{phone}, \text{telephone}) & \text{false} \\
&\text{noisy} (\text{phone}) \leftarrow \text{left}_\text{of} (\text{phone}, \text{telephone}) & \text{true} \\
&\text{noisy} (\text{pencil}) \leftarrow \text{left}_\text{of} (\text{phone}, \text{telephone}) & \text{true} \\
&\text{noisy} (\text{pencil}) \leftarrow \text{left}_\text{of} (\text{phone}, \text{pencil}) & \text{false} \\
&\text{noisy} (\text{phone}) \leftarrow \text{noisy} (\text{telephone}) \land \text{noisy} (\text{pencil}) & \text{true}
\end{align*}
\]
A knowledge base, $KB$, is true in interpretation $I$ if and only if every clause in $KB$ is true in $I$.

A **model** of a set of clauses is an interpretation in which all the clauses are true.

If $KB$ is a set of clauses and $g$ is a conjunction of atoms, $g$ is a **logical consequence** of $KB$, written $KB \models g$, if $g$ is true in every model of $KB$.

That is, $KB \models g$ if there is no interpretation in which $KB$ is true and $g$ is false.
User’s view of Semantics

1. Choose a task domain: **intended interpretation.**
2. Associate constants with individuals you want to name.
3. For each relation you want to represent, associate a predicate symbol in the language.
4. Tell the system clauses that are true in the intended interpretation: **axiomatizing the domain.**
5. Ask questions about the intended interpretation.
6. If $KB \models g$, then $g$ must be true in the intended interpretation.
The computer doesn’t have access to the intended interpretation.

All it knows is the knowledge base.

The computer can determine if a formula is a logical consequence of KB.

If $KB \models g$ then $g$ must be true in the intended interpretation.

If $KB \not\models g$ then there is a model of $KB$ in which $g$ is false. This could be the intended interpretation.
in(kim,r123).
part_of(r123,cs_building).
in(X,Y) ←
    part_of(Z,Y) \land
    in(X,Z).

\(\text{in}(\text{kim}, \text{cs\_building})\)