Foundations of Logic Programming
Tutorial 3 (on November 24th)

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Exercise 3.1:
Consider the following program P:

```
double(0,0).
double(s(X),s(s(Y))) :- double(X,Y).
```

a) Give the Herbrand universe HU_F and the Herbrand base $HB_{\Pi,F}$ determined by P.

b) Give two models of P.

c) Consider the following interpretations I_1 and I_2. For each case specify whether the given interpretation satisfies P or not. Justify your answer.

- $I_1 : D_{I_1} = \mathbb{N}, 0_{I_1} = 1, s(t)_{I_1} = 2 \times t_{I_1}, double_{I_1} = \{(a, a^2) \mid a \geq 1\}$
- $I_2 : D_{I_2} = \mathbb{N}, 0_{I_2} = 0, s(t)_{I_2} = (2 \times t_{I_2}) + 1,$
  $double_{I_2} = \{(0, 0)\} \cup \{(a, a^2 - a + 1 \mid a \geq 1)\}$

Exercise 3.2:
Consider the following program which specifies the descendant relation which is the relation of being a child of, or a child of a child of, or a child of a child of a child of, ...

```
descend(X,Y) :- child(X,Y).
descend(X,Y) :- child(X,Z), descend(Z,Y).
```

With the input database

```
child(anne, bridget).
child(bridget, caroline).
child(caroline, donna).
child(donna, emily).
```

Give the search tree for the query: `?- descend(anne, donna).`

Exercise 3.3:
Consider the program from Exercise 3.2. What happens if we change the order of the rules and goals. What is the result of the queries `?- descend(X,Y).`, `?- descend(anne,emily).` and `?- descend(anne,bridget).`

a)
```
descend(X,Y) :- child(X,Z), descend(Z,Y).
descend(X,Y) :- child(X,Y).
```

b)
```
descend(X,Y) :- descend(Z,Y), child(X,Z).
descend(X,Y) :- child(X,Y).
```

c)
```
descend(X,Y) :- child(X,Y).
descend(X,Y) :- descend(Z,Y), child(X,Z).
```

Exercise 3.4:
Consider the following program for addition.

```
add(0,Y,Y).
add(s(X),Y,s(Z)) :- add(X,Y,Z).
```

Give the search tree and instantiations for the querie:
`?- add(s(s(s(0))), s(s(0)), R).`