Assignment No. 13

Due: 13:15 on Thursday 2 April 2015 via email

There is no word limit/requirement for these exercises. Your responses may be in English, French, Spanish, German, Arabic, or any other language you are comfortable writing in. The grammar, spelling, and prescriptive conventions are not evaluated for the assignment. You do not need to edit, revise a number of times, or attend in any special way to form or language. You should just write in a way that is clear to you. You are welcome to use bullet points. You do not need to write complete sentences or in paragraph form complete with transitions.

Homework should be submitted by 15:15 on the day it is due. There is no late homework accepted. All written assignments must be typed using 12 pt Times New Roman or 11 pt Arial font with 1" margins. All assignments must be send in one of the following formats: .doc, .docx, .txt, .tex, .pdf, .rtf, .odt, .dot. Remember to cite all sources and use APA guidelines for the citations. Homework must also include your name, class, date, and assignment.

1 Predicate Logic – Expansion

For all sections below, translate the English prose statements into predicate-logic statements **only**.

For only **one** statement per section (although you may do this for all the statements for optional practice), declare the symbols used in your predicate-logic statements. You can use any symbol you want for the constants and predicates. It will be easiest and most clear if you use the first letter of the noun and the first letter of the predicate. For each statement make a set U and using extension notation, list the entities $u \in U$. Additionally, define the constant symbols and predicate symbols you introduce using denotation notation, set-builder notation, and extension notation.

Examples are shown in **red** for two of the statements in each of the required sections. The steps for completing the task are: 1) translate the English prose statement into a predicate-logic statement [*only* **each** *statement per section*]; 2) define a set U using extension notation which contains all the entities for the statement [*only for* **one** *statement per section*]; 3) define the entities in U by declaring the constant symbol, using denotation notation, using set-builder notation, and extension notation [*only for* **one** *statement per section*]; and 4) define the predicates in the predicate-logic statement by declaring the predicate letter and the number of number of arguments, using denotation notation, using set-builder notation, and extension notation [*only for* **one** *statement per section*].

Optional exercises and examples of them in **blue** are included to provide additional practice and extend the material beyond what was covered in lecture. Optional exercises are not necessarily an indication of what we will cover in the class, but merely provided for those wishing to explore the topic at greater depth and for their diversion.

1.1 Existential Quantification

- "Some students swim"
  - swim(some_student) $\rightarrow \exists x(S_i(x) \wedge S_j(x))$
  - $U = \{\emptyset\}$
  - $S_i(x) = [\![\text{student}]\!] = \{x : x \text{ is a student}\} = \{???\}$
  - $S_j(x) = [\![\text{swims}]\!] = \{x : x \text{ swims}\} = \{???\}$
- 'Some Mexicans are American'
  - american(some_mexican) $\rightarrow \exists x(A(x) \wedge M(x))$
  - $U = \{\emptyset\}$
  - $A(x) = [\![\text{American}]\!] = \{x : x \text{ is a American}\} = \{???\}$
  - $M(x) = [\![\text{Mexican}]\!] = \{x : x \text{ is a Mexican}\} = \{???\}$

- 'Sandra ate a banana'
  - eat(sandra,some_banana) $\rightarrow \exists x(E(s,x) \wedge B(x))$
  - $U = \{s\}$
  - $s = [\![\text{Sandra}]\!] = \{x : x \text{ is Sandra}\} = \{Sandra\}$
  - $B(x) = [\![\text{banana}]\!] = \{x : x \text{ is a banana}\} = \{???\}$
  - $E(x,y) = [\![\text{eat}]\!] = \{< x, y >: x \text{ eats } y\} = \{< s, ??? >\}$
- 'Bertha was cooking something'
  - cook(bertha,thing) $\rightarrow \exists x(C(b,x) \wedge T(x))$
  - $U = \{b\}$
  - $b = [\![\text{Bertha}]\!] = \{x : x \text{ is Bertha}\} = \{bertha\}$
  - $C(x,y) = [\![\text{cook}]\!] = \{< x, y >: x \text{ cooks } y\} = \{< b, ??? >\}$
  - $T(x) = [\![\text{thing}]\!] = \{x : x \text{ is a thing}\} = \{???\}$

1. 'Some Brooklyners are hipsters'
2. 'Some New Yorkers drive cars'
3. 'Graciela ate some burrito'
4. 'Antonia bought some house'

1.2 Universal Quantification

- "Every person is friendly"
  - friendly(every_person) $\rightarrow \forall x(P(x) \rightarrow F(x))$
  - $U = \{\emptyset\}$
  - $P(x) = [\![\text{person}]\!] = \{x : x \text{ is a person}\} = \{???\}$
  - $F(x) = [\![\text{friendly}]\!] = \{x : x \text{ is friendly}\} = \{???\}$
- "All Parisians in the room smoke cigarettes"
  - smoke(all_parisians_in_the_room,cigarettes) $\rightarrow \forall x(P(x) \rightarrow S(x,c))$
  - $U = \{c\}$
  - $c = [\![\text{cigarettes}]\!] = \{x : x \text{ is a cigarette}\} = \{cigarettes\}$
  - $P(x) = [\![\text{Parisian in the room}]\!] = \{x : x \text{ is a Parisian in the room}\} = \{???\}$
  - $S(x,y) = [\![\text{smoke}]\!] = \{< x, y >: x \text{ smokes } y\} = \{<???, c >\}$
- 'Sandra danced in all the clubs'
  - dance(sandra,all_clubs) $\rightarrow \forall x(C(x) \rightarrow D(s,x))$
  - $U = \{s\}$
  - $s = [\![\text{Sandra}]\!] = \{x : x \text{ is Sandra}\} = \{Sandra\}$
  - $C(x) = [\![\text{club}]\!] = \{x : x \text{ is a club}\} = \{???\}$
  - $D(x,y) = [\![\text{dance in}]\!] = \{< x, y >: x \text{ dances in } y\} = \{< s, ??? >\}$
- 'Pablo made all the money'
  - make(pablo,all_money) $\rightarrow \forall x(M_i(x) \rightarrow M_j(p,x))$

- $U = \{p\}$
- $p = [\![\text{Pablo}]\!] = \{x : x \text{ is Pablo}\} = \{pablo\}$
- $M_j(x) = [\![\text{money}]\!] = \{x : x \text{ is money}\} = \{???\}$
- $M_j(x, y) = [\![\text{make}]\!] = \{< x, y >: x \text{ makes } y\} = \{< p, ??? >\}$

1. 'All New Yorkers are rich'
2. 'All bodegas make heros'
3. 'Carlos lifted all the weights'
4. 'Jorge washed all the plates'

1.3 Quantification & Negation

- 'Not every person is friendly'
  - $\neg\forall x[P(x) \rightarrow F(x)]$ **or** $\exists x[P(x) \rightarrow \neg F(x)]$
  - $U = \{\emptyset\}$
  - $P(x) = [\![\text{person}]\!] = \{x : x \text{ is a person}\} = \{???\}$
  - $F(x) = [\![\text{friendly}]\!] = \{x : x \text{ is friendly}\} = \{???\}$
- 'Every person isn't friendly'
  - $\forall x[P(x) \rightarrow \neg F(x)]$ **or** $\neg\exists x[P(x) \rightarrow \neg F(x)]$
  - $U = \{\emptyset\}$
  - $P(x) = [\![\text{person}]\!] = \{x : x \text{ is a person}\} = \{???\}$
  - $F(x) = [\![\text{friendly}]\!] = \{x : x \text{ is friendly}\} = \{???\}$
- 'No Mexicans are Americans'
  - $\neg\exists x[A(x) \wedge M(x)]$ **or** $\forall x[M(x) \rightarrow \neg A(x)]$
  - $U = \{\emptyset\}$
  - $A(x) = [\![\text{American}]\!] = \{x : x \text{ is a American}\} = \{???\}$
  - $M(x) = [\![\text{Mexican}]\!] = \{x : x \text{ is a Mexican}\} = \{???\}$
- Some Mexicans aren't Americans'
  - $\exists x[(\neg A(x)) \wedge M(x)]$ **or** $\neg\forall x[M(x)) \rightarrow \neg A(x)]$
  - $U = \{\emptyset\}$
  - $A(x) = [\![\text{American}]\!] = \{x : x \text{ is a American}\} = \{???\}$
  - $M(x) = [\![\text{Mexican}]\!] = \{x : x \text{ is a Mexican}\} = \{???\}$

1. 'Not all New Yorkers are rich'
2. All New Yorkers aren't rich' **[Optional Exercise]**
3. 'No Brooklyners are hipsters'
4. 'Some Brooklyners aren't hipsters' **[Optional Exercise]**

1.4 Two Quantifiers [Optional Practice]

- All the artists are painting a mural
  - $\forall x \exists y[A(x) \rightarrow (P(x,y) \wedge M(y))]$ **or** $\exists x \forall y[A(x) \rightarrow (P(x,y) \wedge M(y))]$
  - $U = \{\emptyset\}$
  - $A(x) = [\![\text{artist}]\!] = \{x : x \text{ is an artist}\} = \{???\}$
  - $M(x) = [\![\text{mural}]\!] = \{x : x \text{ is a large scale painting on a wall}\} = \{???\}$
  - $P(x,y) = [\![\text{paint}]\!] = \{< x, y >: x \text{ applied oil- or water-based pigment emulsions to the surface of object } y\} = \{< ???, ??? >\}$
- All the girls kiss a boy
  - $\forall x \exists y[G(x) \rightarrow (K(x,y) \wedge B(y))]$ **or** $\exists x \forall y[G(x) \rightarrow (K(x,y) \wedge B(y))]$
  - $U = \{\emptyset\}$
  - $A(x) = [\![\text{girl}]\!] = \{x : x \text{ is a young human female}\} = \{???\}$
  - $B(x) = [\![\text{boy}]\!] = \{x : x \text{ is a young human male}\} = \{???\}$
  - $K(x,y) = [\![\text{kiss}]\!] = \{< x, y >: x \text{ touches } y \text{ with the lips slightly pursed and often making a smacking sound as a sign of affection or greeting}\} = \{< ???, ??? >\}$

1. All the girls are holding a balloon
2. All the flowers are in a vase
3. All the chefs are stirring a pot
4. All the stamps are on an envelope
5. All the soldiers are marching over a mountain