PMS 509 Knowledge Technologies
Homework II
Due on December 22, 2017.

1. "Translate" the following Greek sentences into $\mathcal{ALCQO}$. If you think that the given sentence cannot be translated into $\mathcal{ALCQO}$, then you should give a translation into first-order logic (remember: $\mathcal{ALCQO}$, like all DLs we studied, is a subset of first-order logic).

   (α′) Η Ελένη είναι όμορφη.

   (β′) Ο Γιάννης είναι όμορφος και πλούσιος.

   (γ′) Ο Πέτρος είναι μυώδης και πλούσιος.

   (δ′) Ο Τίμος είναι μυώδης και ευγενικός.

   (ε′) Σε όλους τους άνδρες αρέσουν οι όμορφες γυναίκες.

   (ϛ′) Όλοι οι πλούσιοι είναι ευτυχισμένοι.

   (ζ′) Όλοι οι άνδρες που τους αρέσει μια γυναίκα, στην οποία αρέσουν, είναι ευτυχισμένοι.

   (η′) Όλες οι γυναίκες που τους αρέσει ένας άνδρας, στον οποίο αρέσουν, είναι ευτυχισμένες.

   (ϑ′) Στην Κατερίνα αρέσουν όλοι οι άνδρες, στους οποίους η ίδια αρέσει.

   (ι′) Στην Ελένη αρέσουν όλοι οι άνδρες που είναι ευγενικοί και πλούσιοι ή μυώδεις και όμορφοι.

   (ια′) Ο Κωστάκης, ο Γιωργάκης και η Ντορούλα είναι μέλη του πολιτικού κόμματος ΔΝΤ.

   (ιβ′) Κάθε μέλος του κόμματος ΔΝΤ που δεν είναι δεξιός, είναι φιλελεύθερος.

   (ιγ′) Στους δεξιούς δεν αρέσει ο σοσιαλισμός.

   (ιδ′) Σ′ όποιον δεν αρέσει ο καπιταλισμός, δεν είναι φιλελεύθερος.

   (ιε′) Στον Κωστάκη δεν αρέσει ό,τι αρέσει στον Γιωργάκη, και του αρέσει ό,τι δεν αρέσει στον Γιωργάκη.

   (ιϛ′) Στο Γιωργάκη αρέσει ο σοσιαλισμός και ο καπιταλισμός.

   (ιζ′) Υπάρχει ένα μέλος του ΔΝΤ που είναι φιλελεύθερος αλλά δεν είναι δεξιός.

   (ιη′) Δίποδο είναι ένα ζώο με ακριβώς δύο πόδια.

   (ιϑ′) Τρίγωνο είναι ένα πολύγωνο που έχει ακριβώς τρεις γωνίες και ακριβώς τρεις πλευρές που είναι ευθύγραμμα τμήματα.

   (κ′) Ορθογώνιο τρίγωνο είναι ένα τρίγωνο που μία από τις γωνίες του είναι ορθή.

2. Which of the following expressions are syntactically correct in $\mathcal{ALCQ}$ and which ones are incorrect?

   (a) $\texttt{Person} \sqcap \texttt{hasChild}$

   (b) $\exists \texttt{hasChild}. \equiv \texttt{Person}$

   (c) $\exists \texttt{hasChild}.(\geq 1)$

   (d) $\texttt{hasChild} \sqsubseteq \texttt{hasBaby}$

   (e) $\texttt{hasChild}(\texttt{ANNA})$

   (f) $\texttt{Person} \equiv \exists \texttt{hasChild}.\bot$

3. Consider the following English sentences:

   (a) Wolfgang is a person.

   (b) Wolfgang has two distinct pets: Alexis and Yanis (with one "n").

   (c) Alexis and Yanis are animals.

   (d) An animal lover is a person which has at least three pets that are animals.

   (e) Wolfgang is an animal lover.

   (f) Wolfgang is not an animal lover.

   Now answer the following questions:

   (a) Give an $\mathcal{ALCQ}$ knowledge base KB which formalizes the first four of the above sentences and two $\mathcal{ALCQ}$ formulas ϕ and ϕ' that formalize the fifth and sixth sentence.

   (b) Can you use tableau techniques to prove that $KB \models \phi$ and $KB \models \phi'$? For the case or cases where the entailment is not true, prove formally that this is the case.

   The description logic $\mathcal{ALCQ}$ has been covered in class. The tableau proof techniques for it have not been covered in class but are covered in the following paper we have in the readings: "Franz Baader. Description Logics. In Reasoning Web: Semantic Technologies for Information Systems, 5th International Summer School 2009, volume 5689 of Lecture Notes in Computer Science, pages 1-39. Springer-Verlag, 2009." It is available from `http://lat.inf.tu-dresden.de/research/papers.html`.

4. Consider the following English sentences:

   (a) Every person is happy if all his children are successful.

   (b) All beautiful persons are successful.

   (c) Every person is beautiful if one of his/her parents is beautiful, otherwise he/she is ugly.

   (d) Aphrodite is a parent of Eros.

   (e) Aphrodite is beautiful.

   (f) Eros is successful.

   (g) Every beautiful person is happy.

   (h) Every parent is happy if he/she has no children.

   Now answer the following questions:

   (a) Write an OWL 2 ontology which encodes sentences (a)-(e) above.

   (b) Now formalize the sentences (f)-(h) as OWL 2 axioms. Which ones of these axioms are entailed by the previous ontology? You do not need to give detailed proofs; only explain why the corresponding entailment relation holds or does not hold and how you can use Protege to show this.

5. Consider the following English sentences:

   (a) Konstantina, Stella and Roi are members of the club Psiloritis.

   (b) Every member of the club Psiloritis who is not a skier is a mountain climber.

(c) Mountain climbers do not like rain.

(d) If someone is a skier then he likes snow.

(e) Konstantina doesn't like anything that Stella likes.

(f) Stella likes rain and snow.

Now answer the following questions:

(a) Give an OWL 2 ontology which formalizes the above sentences.

(b) Explain what properties and class memberships or non-memberships hold for Konstantina, Stella and Roi as a result of the above sentences and your formalization in OWL 2. Use Protege to verify your claims i.e., discuss what Protege will do with your ontology and how you have verified your claims.

6. OpenStreeMap (OSM) is an open and free map service created by volunteers (`https://www.openstreetmap.org/`). In this exercise you will build an OWL 2 ontology for a part of OSM. In Homework 3 you will also be given data that populate such an ontology and you will query this data using GeoSPARQL. Finally, for your class project, we will introduce other data sources as well, and you will combine them with OSM and develop a small application using them.

   Please start by reading the following Web pages/documents:

   - `http://wiki.openstreetmap.org/wiki/`. Read the Beginners Guide and browse the Map Features documentation.
   - `http://download.geofabrik.de/osm-data-in-gis-formats-free.pdf`. This document describes OSM data using terminology from the area of Geographic Information Systems something that we also did in the lecture on linked geospatial data. This document will be used for understanding which OSM features should be covered by your ontology. Your ontology should cover **only** the following features of OSM:
     - Places (Section 4.1 of the document)
     - Natural Features (Section 4.3 of the document)
     - Waterways (Section 5.3 of the document)
     - Land use and land cover (Section 6.2 of the document)
     - Bodies of water (Section 6.3 of the document)

   After you have read the above documents and understood what the ontology will be about, start developing it using the ontology engineering principles we would have covered in the lectures.