This document contains extra practice in formalising natural language. The second page contains the FOL formalisation and the third page has the DL variant, where possible.

1 Natural language sentences

1. All lions are animals
2. Each professor teaches at least course
3. All humans eat some fruit and cheese
4. Animals are either herbivores or carnivores
5. The sister of one’s mother is one’s aunt
6. Something can’t be both pap and pizza
7. If a person works for a company, then that person is an employee
8. Anything that manages something is a manager, and vice versa.
9. All flies have exactly two eyes as part
10. Anything has at most one life
11. The participation relation is defined by relating physical objects to processes
12. Having something as part is the inverse of being part of something
13. connection is symmetric (if one thing is connected to something else, that other thing is also connected to the one thing)
14. A vehicle can be either motorised or not, but not both
15. Several snails are slow
16. Each patient is registered at some hospital on a certain weekday
17. All students are at some time in their life not a student
2 Answers — FOL

Note: there may be more than one solution; only one is given. Also note that a problem of natural language is that it can be imprecise.

1. $\forall x (\text{Lion}(x) \rightarrow \text{Animal}(x))$
2. $\forall x (\text{Professor}(x) \rightarrow \exists y (\text{teaches}(x, y) \land \text{Course}(y)))$
3. $\forall x (\text{Human}(x) \rightarrow \exists y, z (\text{eat}(x, y) \land \text{Fruit}(y) \land \text{eat}(x, z) \land \text{Cheese}(z)))$ (note: twice the ‘eat’, with $y$ and $z$, not “fruit($y$) \land cheese($y$)”, for that refers to the objects that are both, which don’t exist)
4. $\forall x (\text{Animal}(x) \rightarrow \text{Herbivore}(x) \lor \text{Carnivore}(x))$
5. $\forall x, y, z (\text{hasmother}(x, y) \land \text{hassister}(y, z) \rightarrow \text{hasaunt}(x, z))$ (or with $\leftrightarrow$ and/or with the composition operator $\circ$)
6. $\forall x (\text{Pap}(x) \rightarrow \neg \text{Pizza}(x))$
7. $\forall x \exists y ((\text{Person}(x) \land \text{worksfor}(x, y) \land \text{Company}(y) \rightarrow \text{Employee}(x)))$
8. $\forall x, y (\text{manages}(x, y) \leftrightarrow \text{Manager}(x))$
9. $\forall x (\text{Fly}(x) \rightarrow \exists^2 y (\text{haspart}(x, y) \land \text{Eye}(y)))$ (note: this is shorthand notation...)
10. $\forall x, y, z (\text{life}(x, y) \land \text{life}(x, z) \rightarrow y = z)$
11. $\forall x, y (\text{participation}(x, y) \rightarrow \text{PhysicalObject}(x) \land \text{Process}(y))$
12. $\forall x, y (\text{hasPart}(x, y) \rightarrow \text{partOf}^-(x, y))$
13. $\forall x, y (\text{connection}(x, y) \rightarrow \text{connection}(y, x))$
14. Vehicles: combine the pattern for the ‘or’ from 4 with the disjoints of 6, for the vehicles.
15. $\exists x (\text{Snail}(x) \land \text{slow}(x))$ but not this is suboptimal (recall the apple & green; similar story here)
16. $\forall x (\text{Patient}(x) \rightarrow \exists y, z (\text{registration}(x, y, z) \land \text{Hospital}(y) \land \text{Weekday}(z)))$
17. Note: this requires either a temporal ‘extension’ or necessity (beyond the current scope). Let’s take temporal, for which we introduce a notions of time, $t$, that quantifies over time points only (for simplicity, and linear time): $\forall x, t (\text{Student}(x, t) \rightarrow \exists t' \neq t (\neg \text{Student}(x, t'))$
3 Answers — DL

Note: there may be more than one solution; only one if given. Also note that these axioms are agnostic about particular fragments, and we don’t consider datatypes.

1. Lion ⊑ Animal
2. Professor ⊑ ∃teaches.Course
3. Human ⊑ ∃eat.Fruit ∩ ∃eat.Cheese
4. Animal ⊑ Herbivore ⊔ Carnivore
5. hasMother ◦ hasSister ⊑ aunt (or with ≡, i.e., that the notion of ‘aunt’ is defined by it)
6. Pap ⊑ ¬Pizza (or with ‘bottom’: Pap ∩ Pizza ⊑ ⊥)
7. Person ∩ ∃worksFor.Company ⊑ Employee
8. ∀manages.⊤≡ Manager
9. Fly ⊑ = 2 hasPart.Eye
10. lazy option: Func(life), less lazy, as part of another axiom, ≤ 1 life or ≤ 1 life.⊤
11. lazy option: Participation ⊑ PhysicalObject × Process, and in full: ∃participation ⊑ PhysicalObject and ∃participation− ⊑ Process
12. hasPart ⊑ partOf−
13. lazy option (in SROIQ): Sym(connection)
14. Vehicles: combine the ‘or’ from 4 with the disjoints of 6.
15. Not easily represented in DLs (rework it with some subtype of snails for which it always holds)
16. This can be represented in the DLR family of Description Logics, but not in most DLs and not in OWL either (which has only binaries—we’ll return to this in the second part of the module)
17. This can be represented in several temporal description logics, using temporal operators, alike Student ⊑ ◦∗¬Student with the diamond-shape the temporal counterpart of ∃ and with *, this reads as ‘sometime’. More about this can be found in the ‘advanced topics’.