LOD

Basic Concepts

Solution **1.1**

$$\sqcap, \neg, \top, \equiv, \sqcup, \sqsubseteq, \bot, \models$$

Solution **1.2** 3 and 4 are not wffs in LOD.

Solution **1.3** Answer: a, c, d, e, f.

Solution **1.4** Answer: Yes, because it is acyclic and there are only definitions.

Solution **1.5** Answer: yes

Solution **1.6** By now you should be able to do it without help.

Solution **1.7** ANSWERS:

1. is true because the interpretation of $\top$ (top) is the entire domain and their difference is given precisely by the empty set that coincides with the interpretation of $\bot$ (bottom).
2. is false because by definition it must be $e \in \mathcal{I}(C)$.
3. is true because they correspond to their respective definitions
4. same as 3
5. same as 3

Translation

Solution **1.8**

- $\exists$studiesIn.Library
- Book
- $\exists$reads.Book
- $\forall$reads.ComicBook
- $\forall$friendsWith.($\exists$ studiesIn.Library)

Solution **1.9**

- Employee $\sqcap$ $\exists$worksAt.Library
- BlackTea $\sqcup$ GreenTea
- Person $\sqcap$ $\neg\exists$drinks.GreenTea
  (or Person $\sqcap$ $\forall$drinks.$\neg$GreenTea)
- $\forall$drinks.$\neg$BlackTea
  (or $\neg\exists$drinks.BlackTea)
- Person $\sqcap$ $\exists$drinks.GreenTea $\sqcap$ $\neg\exists$drinks.BlackTea
  (or Person $\sqcap$ $\exists$drinks.GreenTea $\sqcap$ $\forall$drinks.$\neg$BlackTea)

Solution **1.10**

- $\{Mario, Anna\}$
- $\{Toby, Gigi, Sara\}$
- $\{Anna\}$
- $\{Anna, Mario\}$
- $\emptyset$
- U
- $\{Mario, Anna\}$

Solution **1.11** ANSWER:

- D = <E, C, P>
- E = 0, . . . , 9
- C = A, B, C
- P = $\emptyset$
- T = $C \equiv A \sqcap B$

Note that: (a) we need to define the language and the interpretation functions; (b) we can define different languages and interpretations

Solution **1.12** ANSWER:

- D = <E, C, P >
- E = Fausto, Rui, Bisu, Italian, Chinese, Indian
- C = Employee, Professor, Student, Nationality
- P = hasNationality, hasSupervisor
- T = Professor $\sqsubseteq$ Employee; Student $\sqsubseteq$ Employee; Employee $\sqsubseteq \exists$hasNationality.Nationality $\sqcap \exists$hasSupervisor.Employee

Solution **1.13** ANSWER:

- Producer $\sqsubseteq$ Entity $\sqcap$ ($\exists$ProductType.$\top \sqcup \exists$Location.$\top \sqcup \exists$ProductValue.$\top \sqcup \exists$Transaction.Consumer)
- Consumer $\sqsubseteq$ Entity $\sqcap$ ($\exists$Gender.$\top \sqcup \exists$Age.$\top \sqcup \exists$AverageSpend.$\top$)

NOTE: in this ER diagram there is no cardinality, but in general we may have it. Consider also the implicit direction of arcs (from left to right).

Solution **1.14** ANSWER:

- D = <E, C, P>
- E = Alice, Bob, The Mona Lisa, Leonardo Da Vinci, La Joconde à Washington, 14 July 1990
- C = Entity, Person, Picture, File, Date
- P = isFriendOf, interestedIn, isAbout, wasCreatedBy, isBornOn

Solution **1.15** The theory T can be as follows:

- Person $\sqsubseteq$ Entity $\sqcap$ ($\exists$isFriendOf.Person$\sqcup \exists$interestedIn.Picture $\sqcup \exists$isBornOn.Date)
- Picture $\sqsubseteq$ Entity $\sqcap \exists$wasCreatedBy.Person
- File $\sqsubseteq$ Entity $\sqcap \exists$isAbout.Picture

Solution 1.16 **(Translate in $\mathcal{LOD}$).** The translation is pretty straightforward:

- Niente: $\bot$
- Tutto: $\top$
- Humans and vehicles: Human $\sqcap$ Vehicle
- Vehicles and not boats: Vehicle $\sqcap\neg$ Boat
- Wheels or engines and humans: (Wheel $\sqcup$ Engine) $\sqcap$ Human
- Adults or children: Adult $\sqcup$ Child

Solution 1.17 **(Translate in $\mathcal{LOD}$).** The translation of the concepts and role names is:

1. Vehicle $\sqcap \exists$ hasPart.Wheel $\sqcap \exists$ poweredBy.Engine
2. Vehicle $\sqcap \exists$ hasPart.Wheel $\sqcap \exists$ poweredBy.Human
3. Vehicle $\sqcap \exists$ travelsOn.Water
4. $\forall$ hasPart.$\neg$ Wheel
5. $\forall$ travelsOn.$\neg$ Water
6. Device $\sqcap \exists$ hasPart.Axle $\sqcap \exists$ capableOf.Rotation
7. Human $\sqcap \exists$ controls.Vehicle
8. Driver $\sqcap \exists$ controls.Car

Solution 1.18 **(Translate in $\mathcal{LOD}$).** The translation is:

1. Boat$\sqsubseteq \forall$hasPart.$\neg$Wheel
2. Car $\sqcup$ Bicycle $\sqsubseteq \forall$travelsOn.$\neg$Water
3. Driver $\sqcap\exists$controls.Car $\sqsubseteq$ Adult
4. Human $\sqsubseteq \neg$ Vehicle
5. Wheel $\sqcup$ Engine $\sqsubseteq \neg$ Human
6. Human $\sqsubseteq$ Adult $\sqcup$ Child
7. Adult $\sqsubseteq \neg$Child

Solution 1.19 **(Translate in $\mathcal{LOD}$).** The translation of the phrases is:

1. Car $\equiv$ Vehicle $\sqcap\exists$ hasPart.Wheel $\sqcap\exists$ poweredBy.Engine
2. Bicyle $\equiv$ Vehicle $\sqcap\exists$ hasPart.Wheel $\sqcap\exists$ poweredBy.Human
3. Boat $\equiv$ Vehicle $\sqcap\exists$ travelsOn.Water
4. Wheel $\equiv$ Device $\sqcap\exists$ hasPart.Axle $\sqcap\exists$ capableOf.Rotation
5. Driver $\equiv$ Human $\sqcap\exists$ controls.Vehicle

Solution 1.20

- Game $\sqcap \neg$Legal
- Lake $\sqsubseteq$ Location
- Lake $\sqsubseteq$ Location $\sqcap \exists$Madeof.Water
- Person $\sqsubseteq$ Male $\sqcup$ Female
- Male $\sqsubseteq \neg$ Female
- Person $\sqsubseteq \exists$hasBirthPlace.$\top$
- JavaProgramming $\sqsubseteq$ ProgrammingLanguage $\sqcap$ ComputerScience

Solution 1.21

- MasterStudent $\sqsubseteq$ Student
  - Unicorn $\sqsubseteq$ mythical $\sqcap$ horse $\sqcap \exists$has.Horn
  - PhDStudent $\sqsubseteq$ Student $\sqcap \exists$hasTask.Research

Solution **1.22** Answer:

- "Lion $\sqsubseteq$ Feline $\sqcap$ Large $\sqcap$ Gregarious $\sqcap$ Predatory $\sqcap \forall$livesIn.(Africa $\sqcup$ India) $\sqcap$ $\exists$livesIn.(Africa $\sqcup$ India)" and "MaleLion $\equiv$ Lion $\sqcap$ Male $\sqcap \forall$has.ShaggyMane $\sqcap \exists$has.ShaggyMane"
- "Penguin $\sqsubseteq$ Bird $\sqcap \neg$Fly $\sqcap \forall$livesIn.Antarctica $\sqcap \exists$livesIn.Antarctica $\sqcap \forall$has.WebbedFeet $\sqcap \exists$has.WebbedFeet"

Solution **1.23** ANSWERS:

- is true because all drivers drive a vehicle, and consequently there is an AND between the two conditions.
- is false because it is not the driver who is electric.
- is right because the formula in parentheses indicates an electric vehicle.
- is true for the same reason as (1) plus it is specified that they do NOT drink alcohol.
- is false because the correct translation requires the existential quantifier $\exists$ as in question (3).

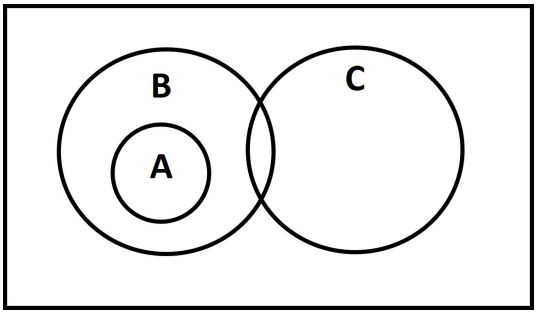
Solution **1.24** ANSWERS:

- is true (although not necessarily complete) where because the values of the attributes have not been specified we assign $\top$ as the space of possible values.
- is true because the universal quantifier tells us that the student is only enrolled in courses.
- is false because, given the text of the exercise, we are reading only the relation "enrolled" from "student" to "course", for this to be true, a relation from "course" to "student" should be defined.
- is false because it is not apparent from the diagram.

Solution **1.25**

$$\begin{aligned}\text{Event} \equiv\ & \text{Thing} \sqcap \\ & \forall\ \text{about.Thing} \sqcap \exists \text{about.Thing} \sqcap \\ & \forall\ \text{actor.Person} \sqcap \exists \text{actor.Person} \sqcap \\ & \forall \text{attendee.(Person} \sqcup \text{Organization)} \sqcap \exists \text{attendee.(Person} \sqcup \text{Organization)}\end{aligned}$$

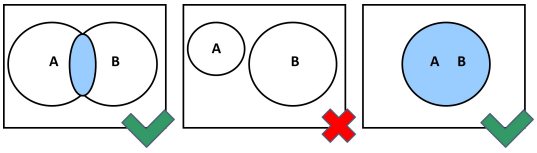
Solution **1.26**



Reasoning

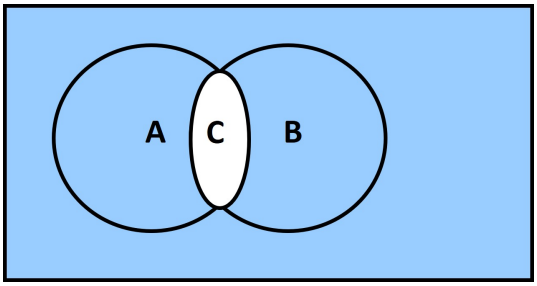
Entailment

Solution **1.27** ANSWER:

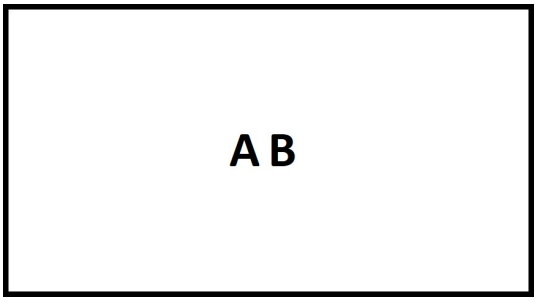


By using Venn Diagrams, we can easily observe that the fact that A and B are not empty does not imply that A ⊓ B is also not empty. Think to the case in which their extensions are disjoint.

Solution **1.28** ANSWER: Yes. A case is described below with a Venn Diagram.



Solution **1.29** ANSWER: No. In fact, we can find a counterexample in which I(A) = I(B) but the I(¬(A⊓B)) is empty.



Solution **1.30** Answer: We can restate the problem as follow: does T $\models$ Assistant $\sqsubseteq$ Undergraduate? We need to prove that this is true in all models (via the method of unfolding): Assistant $\equiv$ PhD $\sqcap$ Teach $\equiv$ Master $\sqcap$ Research $\sqcap$ Teach $\equiv$ Student $\sqcap \neg$ Undergraduate $\sqcap$ Research $\sqcap$ Teach. Answer is No. Assistants are actually students who are not undergraduate.

Solution **1.31** Answer: We can restate the problem as follow: does T $\models$ Bachelor $\sqcap$ Master $\sqsubseteq \bot$? We need to prove that this is true in all models (via the method of unfolding) Answer is obviously Yes because they contain two opposite constraints.

Unfolding

Solution **1.32** Answer: ColouredGuitar $\equiv$ Guitar $\sqcap \forall$hasSoundAmplification.withInputJack $\sqcap \exists$hasColour.String

Solution **1.33** Answer: No, because by unfolding all concepts I never obtain the same concept on the left and on the right of the equivalences.

Solution **1.34** Answer: Yes, because by unfolding it I get Female $\equiv \neg(\neg$Female) that is Female $\equiv$ Female.

Solution **1.35** Answer: a, b, c, e, f.