1 | What is Logic?

Dfn **1.1.** *Logic: the study of arguments or inference or reasoning. Informal logic studies reasoning in ordinary languages (e.g. English). Formal logic studies reasoning in formal (symbolic) languages (e.g. Calculus)*

Some Examples of Reasoning

- **E.g. 1**: Show / Prove that Socrates is mortal
  1. All men are mortal
  2. Socrates is a man
  3. So, Socrates is mortal
- **E.g. 2**: Show / Prove that no one has freewill
  1. Everything that happens in the universe is governed by scientific laws
  2. Scientific laws require that everything that happens is necessary and could not have been otherwise
  3. a person acts freely only if they could have done otherwise
  4. So, no one acts freely
- **E.g. 3**: Former Secretary of Defense, Donald Rumsfeld, was once asked during a press hearing to comment on the view that there was no tie between officials in Baghdad and Al Qaeda. He had this to say in response.

  > Reports that say that something hasn't happened are always interesting to me, because as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns - the ones we don't know we don't know.[1]

[1] Source: BBC News "Rum remark wins Rumsfeld an award" - http://news.bbc.co.uk/2/hi/3254852.stm

- **E.g. 4**: Mathematical Proofs (e.g. $c^2 = a^2 + b^2$, proof for the existence of God)

1	$p \to \Box p$	Anselm: perfection cannot exist contingently
2	$\neg\Box\neg p$	Anselm: perfection is not impossible
3	$\Box p \to p$	Modal axiom
4	$\Box p \wedge \neg\Box p$	Principle of Excluded Middle
5	$\neg\Box p \to \Box\neg\Box p$	Becker's postulate instance
6	$\Box p \wedge \Box\neg\Box p$	4, 5 substitution
7	$\Box\neg\Box p \to \Box\neg p$	1 modal modus tollens
8	$\Box p \wedge \Box\neg p$	6, 7 substitution
9	$\Box p$	8, 2 disjunctive syllogism
10	p	9, 3 modus ponens

- **E.g. 5** Visual Arguments: Even though arguments are usually implicit, they do not have to be written or spoken.

Figure 1: An Advertisement for the US Military.

2 | Why Study Logic?

1. Taking the GRE/LSAT? reasoning portions on tests are logic tests
2. Continuing with Philosophy? Understanding logic is a requirement for any field in analytic philosophy, except for ethics and political philosophy
3. Continuing with Computer Science, Linguists, Mathematics? Good foundation for formal work and use of proofs. (See also PHIL3030 - Symbolic Logic)
4. Studying logic helps improve reasoning abilities

3 | How to Study Logic?

1. Attend all the lectures
2. Memorize definitions! Pay attention to the nuances of definitions.
3. Do all the assigned homework exercises; more if necessary
4. Seek help right away if you are not clear on the material
5. Do not fall behind!
6. You can omit historical notes in the readings. They are, however, recommended for philosophy majors and the curious.

4 | The Structure of an Argument (Ch 1.1)

Dfn **4.1.** *Statement: a declarative sentence that expresses a fact (in the actual world); It is either true or false.*

- *Warning about Terminology: in this course, 'sentence', 'statement' and 'proposition' will be used interchangeably*

Dfn **4.2.** *Argument: a group of statements (the premise) which are claimed to provide support for, or reasons to believe, another statement (the conclusion).*

Dfn **4.3.** *Inference (narrow): the reasoning process expressed by an argument*

1. All men are mortal ← Premise
2. Socrates is a man ← Premise
   ———————
3. So, Socrates is mortal ← Conclusion

Ths **4.4.** *The premises support the conclusion.*
Ths **4.5.** *The premises are reasons for the conclusion*
Ths **4.6.** *The premises and conclusion are statements that are true or false*
Ths **4.7.** *Premises and conclusion can often be identified by indicator words:*

Premise Indicators	*Conclusion Indicators*
since	*therefore*
because	*so*
for	*entails*
given that	*hence*
for the reason that	*consequently*
owing to	*it follows that*
due to	*as a result*

Examples

- **Ex. I.I.6**: "The fact that there was never a land bridge between Australia and mainland Asia is evidenced by the fact that the animal species in the two areas are very different. Asian placental mammals and Australian marsupial mammals have not been in contact in the last several million years."
- **Ex. I.I.17**: An ant releases a chemical when it dies, and its fellows then carry it away to the compost heap. Apparently the communication is highly effective; a healthy ant painted with the death chemical will be dragged to the funeral heap again and again.

5 | Deduction and Induction (Ch 1.3)

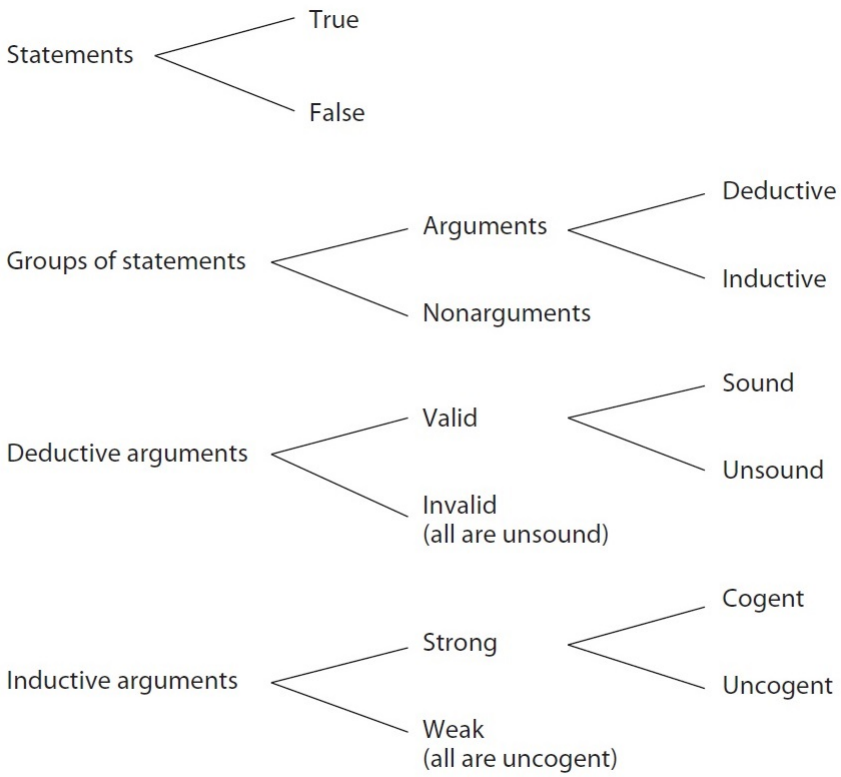

Figure 2: Arguments Categorized

- Anything said by a speaker fall under one of three categories: i) deductive argument, ii) inductive argument or iii) not an argument. The last category includes exclamations, questions, expressions of emotion, and other forms of speech where the speaker is not attempting provide reasons for the conclusion. If a speaker is attempting to provide reasons, then they will either give a deductive or an inductive argument.

Dfn **5.1.** *Deductive Argument: an argument where it is impossible that the conclusion be false given that the premises are true.*
Dfn **5.2.** *Inductive Argument: an argument where it is improbable for the conclusion to be false given that the premises are true.*

- Note that each definition can be reworded:
  (Deductive) an argument such that **assuming** that the premises are true the conclusion **necessarily** true.
  (Inductive) an argument such that **assuming that** the premises are true, the conclusion is **probably** true.
- **E.g.** Deductive Argument
  1. All entertainers are extroverts
  2. David Letterman is an entertainer
     ———————
  3. Therefore, David Letterman is an extrovert
- **E.g.** Inductive Argument
  1. The vast majority of entertainers are extroverts
  2. David Letterman is an entertainer
     ———————
  3. Therefore, David Letterman is an extrovert

How do we recognize a deductive or inductive argument?

- **Test 1**: Does the argument claim that the conclusion is necessarily the case or only probably the case: deductive if necessary, inductive if probable.
- **Test 2**: Does the argument fit into common deductive **forms**? If it does, then it is a deductive argument.

Kinds of Arguments Arguments are diverse. Here is a list of some common kinds.

- **Arguments by Definition**
  1. Claudio doesn't tell the truth.
  2. 'mendacious' means not telling the truth.
  3. Therefore, Claudio is mendacious
- **Categorical Syllogism** A set of three statements placing objects/persons into categories/groups.
  1. All cats are mammals.
  2. All mammals are animals
  3. Therefore, all cats are animals
- **Disjunctive Syllogism**: Either —— or ——. statement paired with two other statements in which one alternative is eliminated and we are left with the remaining alternative.
  1. Either we pay the rent or we will be evicted
  2. We did not pay the rent
  3. Therefore, we will be evicted
- **Argument from Analogy**:
  1. Fish, animals and humans are all created by a being.
  2. So, there must be someone who created the universe
- **Generalization**
  1. one orange in the crate is tasty.
  2. So, all oranges in the crate are tasty.

- **Argument from Authority**
  1. Scientists say that global temperatures are rising
  2. So, global temperatures are rising.

6 | Validity, Truth, Soundness and Cogency (Ch 1.4)

Dfn **6.1.** *Valid argument = it is impossible for the conclusion to be false given that the premises are true. Invalid otherwise.*
Dfn **6.2.** *Sound argument = true premises, valid argument. Both conditions must be met for an argument to be sound. Unsound otherwise.*
Ths **6.3.** *Whether or not an argument is valid can't be determined simply by looking at truth values of the premises and conclusion. One has to determine whether the links between the premises and conclusion is necessary.*
Ths **6.4.** *The only impossible combination in a valid argument is: true premises and a false conclusion.*
Ths **6.5.** *a set of sentences is either an argument or its is not (e.g. a set of questions). If it is an argument then it must purport to be a deductive argument or an inductive argument. If the argument purports to be deductive then it could be valid or invalid. If a valid argument has true premises then it is sound. If an argument purports to be inductive then it could be strong or weak. If it is strong and the premises are true then the argument is cogent.*

Examples of Deductive Arguments Here are some examples of deductive arguments classifies by the truth of the premises.

Properties	Valid	Invalid
True Premises True Conclusion	Ex 1	Ex4
True Premises False Conclusion	None	Ex5
False Premises True Conclusion	Ex2	Ex6
False Premises False Conclusion	Ex3	Ex7

- **E.g. 1**: True Premises, True Conclusion
  1. All wines are beverages
  2. Chardonnay is a wine
  3. So, Chardonnay is a beverage. **sound**
- **E.g. 2**: False Premises, True Conclusion
  1. All wines are soft drinks
  2. Ginger ale is a wine
  3. So, Ginger ale is a soft drink. **unsound**
- **E.g. 3**: False Premises, False Conclusion
  1. All wines are whiskeys
  2. Ginger ale is a wine
  3. So, ginger ale is a whiskey. **unsound**
- **E.g. 4**: True Premises, True Conclusion
  1. All wines are beverages
  2. Chardonnay is a beverage
  3. So, chardonnay is a wine. **unsound**
- **E.g. 5**: True Premises, False Conclusion
  1. All wines are beverages
  2. Ginger ale is a beverage
  3. So, Ginger ale is a wine. **unsound**
- **E.g. 6**: False Premises, True Conclusion
  1. All wines are whiskeys
  2. Chardonnay is a whiskey
  3. So, Chardonnay is a wine. **unsound**
- **E.g. 7**: False Premises, False Conclusion
  1. All wines are whiskeys
  2. Ginger ale is a whiskey
  3. So, Ginger ale is a wine. **unsound**

Dfn **6.6.** *Strong Inductive Argument = improbable that the conclusion is false given that the premises are true. Weak inductive otherwise.*
Dfn **6.7.** *Cogent Argument = strong argument with all true premises. Not cogent otherwise.*

- Strong inductive arguments have a probability of 51% or greater.
- Conclusion Indicator words for Inductive arguments: improbable/probable, implausible, likely, reasonably

Properties	Strong	Weak
True Premises Probably True Conclusion	Ex 1	Ex4
True Premises Probably False Conclusion	None	Ex5
False Premises Probably True Conclusion	Ex2	Ex6
False Premises Probably False Conclusion	Ex3	Ex7

- **E.g. 1**: (Strong): True Premise, Probably true conclusion
  1. All previous US Presidents were older than 40
  2. Therefore, probably the next US president will be older than 40. **cogent**
- **E.g. 2**: (Strong): False Premise, Probably True Conclusion
  1. All previous U.S. presidents were TV debaters
  2. Therefore, probably the next US president will be a TV debates, **uncogent**
- **E.g. 3**: (Strong): False Premises, Probably True Conclusion
  1. All previous US presidents died in office
  2. So, probably the next US president will dies in office. **uncogent**
- **E.g. 4**: (Weak): True Premises, Probably True Conclusion
  1. A few US presidents were lawyers
  2. So, probably the next US president will be older than 40. **uncogent**
- **E.g. 5**: (Weak): True Premises, Probably False Conclusion
  1. A few US presidents were unmarried
  2. Therefore, probably the next US president will be unmarried. **uncogent**
- **E.g. 6** : (Weak): False Premise, Probably True Conclusion
  1. A few US presents were dentists
  2. Therefore, probably the next US president will be a TV debater. **uncogent**
- **E.g. 7:** False Premise, Probably False Conclusion
  1. A few US presents were dentists
  2. Therefore, probably the next US president will be a dentist. **uncogent**

7 | Argument Forms: Proving Invalidity (Ch. 1.5)

To determine whether an argument is invalid follow **the counter-example method**

1. Identify premises and the conclusion of the argument.
2. Identify the logical form of the argument i.e. symbolize argument
3. Attempt to find a substitution instance that yields an invalid argument
4. If an invalid substitution instance is found, then the original argument is invalid; If an invalid substitution instance is not found, then no conclusion can be drawn.

Note on what the method yields: The counter-example method cannot be used to show that an argument is valid. We simply do not conclude anything, if we cannot find an invalid substitution instance.

Note on Step 3: It is easier if you begin by substituting terms in the conclusion by choosing two terms that make it false, and then proceed to try to find appropriate terms that make all premises true.

The following logical patterns will aid symbolization step:

1. All …are …(dots typically stand for terms ('dogs') or phrases ("US Presidents"))
2. Some …are …(typically stand for terms ('dogs') or phrases ("US Presidents"))
3. Some …are not …(dots typically stand for terms ('dogs') or phrase ("US Presidents"))
4. Not …(dots typically, but not always, stand for a sentence)
5. If …then …(dots typically stand for a sentence)
6. Either …or …(dots typically, but not always, stand for a sentence)
7. …and …(dots typically, but not always, stand for a sentence)
8. Note that "Some" as used in logic means "at least one" - there is no upper bound just a lower bound i.e. there can't be none and there has to be one or more.

- **E.g. 1**: Since all dogs are fast, and cats are fast, so all turtles are fast.
  - **Step 1**: Identify premises and the conclusion
    1. All dogs are fast
    2. All cats are fast
    3. So, All turtles are fast
  - **Step 2**: Identify the logical form i.e. symbolize argument
    1. All D are F
    2. All C are F
    3. So, All T are F
  - **Step 3**: Find a substitution instance that yields an invalid argument
    Example: the idea is to start from the conclusion of the symbolized argument, and pick F and T so that the conclusion is false. In this case we chose **'F' = fake** and **'T' = teeth**, so the conclusion, "All teeth are fake" is false because for us, in this world, most teeth are not fake. We can then choose D and C so that both premises turn out to be true. If we choose **'D' = dentures**, and **'C' = toupees**, we get the following argument with true premises and a false conclusion.
    1. All dentures are fake
    2. All toupees are fake.
    3. So, All teeth are fake
  - **Step 4**: Since we found a substitution instance, we can definitely conclude that the original argument is **invalid**.
- **E.g. 2**: "All daises are plants, since all daises are flowers and all flowers are plants."
  - **Step 1**: Identify premises and the conclusion
    1. All daisies are flowers.
    2. All flowers are plants.
    3. Therefore, all daisies are plants
  - **Step 2**: Identify the logical form i.e. symbolize argument
    1. All D are F
    2. All F are P
    3. All D are P
  - **Step 3**: Find a substitution instance that yields an invalid argument
    For instance, if we choose **D** — "dogs'; **P** — "puddles", this choice yields a false conclusion: "All dogs are puddles". The statement is false "in this world", because, of course, some dogs are not puddles. Now, we need to choose a meaning for the term **F** so that the premises turn out true. But, there is no way to do that. Try it out: let's say **F** means "animals", so the first premise is true — All dogs are animals — but now the second premise says "All animals are puddles", is false.
  - **Step 4**: What does this show about the argument we started with? In this case, since we did not find an invalid substitution instance, nothing is shown. In particular, we cannot conclude, via this method, that the original argument is valid.
- **E.g. 3**: Alexander the Great died from typhoid fever, then he became infected in India. Alexander the Great did not die from typhoid fever. Therefore, he was not infected in India.
  - **Step 1**: Identify the premises and conclusion
    1. if Alexander the Great died from typhoid fever then he became infected in India.
    2. Alexander the Great did not die from typhoid fever
    3. So, he was not infected in India.

- **Step 2**: Identify logical form i.e. symbolize argument ** The sentence "Alexander the Great **did not** die from typhoid fever" is translated as "It is not the case that Alexander the Great died from typhoid fever" or NOT A, where A — Alexander the Great died from typhoid fever.
  1. if A then B
  2. Not A
  3. So, Not B
- **Step 3**: Find substitution instance that yields invalid argument (False conclusion, True premises)
  B — Abe Lincoln was shot; so the conclusion now reads "it is not the case that Abe Lincoln was shot", which for us in this world is false, because Abe Lincoln was shot. Now we need a reading of "A" that makes both premises true. So, Let's say 'A' – "George Belic shot Abe Lincoln". That clearly makes premise 2 true; George Belic did not shot Abe Lincoln is true. And, premise 1 also turns out to be true: if George Belic shot Abe Lincoln then Abe Lincoln was shot. So, with our choice of "A" and "B" we have found a substitution instance that has true premises and a false conclusion. **Step 4**: Since we found a substitution instance for the symbolized argument, we can conclude that the original argument about Alexander the Great is **invalid**.
- **E.g. 4**: No patrons of fast-food restaurants are health-food addicts. Consequently, no patrons of fast-food restaurants are connoisseurs of fine desserts, since no connoisseurs of fine desserts are health-food addicts.
  Step 2: Form of Argument
  1. No P are H
  2. No C are H
  3. No P are C

  Step 3: Substitution Instance
  1. No dogs are fish. (T)
  2. No mammals are fish. (T)
  3. No dogs are mammals. (F)

  The argument is invalid.

- **E.g. 5**: All diabetes victims are either insulin takers or glucose eliminators. Accordingly, some diabetes victims are glucose eliminators, since some diabetes victims are insulin takers. (Ex. 1.5.II.9)
  - Step 2: Form
    1. All D are I or G
    2. Some D are Is
    3. So, Some D are Gs
  - Step 3: Substitution Instance