Logical Reasoning

Introduction to Formal Logic

Why Study Logic?

1. [Source]
2.

Introduction to Logical Concepts

Logic is the study of rational argumentation

Rational

Something we have good grounds to show is likely true

Argumentation

1. Central term of all logic
2. A set of sentences such that one sentence, the conclusion, is claimed to follow from the other sentences, the premises
3. Have two parts
    a. Conclusion
    b. Premises

Conclusion

1. The point of the argument
2. The thing that is being argued for
    a. That we are trying to convince ourselves or others of
3. Arguments
    a. What we give in order to provide legitimate reasons to believe the conclusion
4. Every argument has one and only one conclusion

Premises

1. The reasons to be believe the conclusion
2. The grounds that are being proposed to support rational belief in conclusion
3. There can be many number of premises to one conclusion

When you approach an argument

Find the conclusion

1. The thing that is established by the argument
2. Use indicator words
    a. Certain words we use to point out conclusions
        i. Therefore
        ii. Thus
        iii. Hence
        iv. So
        v. Ergo

    b. Not every use of these words indicates a conclusion
        i. Indicate premises: “because”, “since”, & “given that”
3. Inserting your own indicator words
    a. “Therefore”
        i. Look at a passage and determine if “therefore” can be naturally inserted in a way that maintains the meaning of the passage
            1. That is an argument
        ii. What immediately follows “therefore”
            1. This is a conclusion
    b. “Because”
        i. If you can insert “because” into a passage without changing ht meaning
            1. This is an argument
        ii. What comes right after “because”
            1. This is a premise

Set out the premises

Types of arguments

Deductive

1. If its conclusion is no broader than its premises
    a. We are arguing from broad to narrow
2. If the conclusion only refers to that which is mentioned in the premises
3. Deductive inferences are “non-ampliative”
    a. The conclusion is contained within the contents of the premises
4. Ex: “All men are mortal. Socrates is a man. Therefore, Socrates is mortal”
    a. Premises
        i. All men being mortal
    b. Conclusion
        i. One of these men being mortal
    c. Deduction moves from broad to narrow
5. Because the content of a deductive argument is already contained in the premises
    a. In a successful deductive argument, the conclusion will be absolutely certain

Inductive

1. Ampliative
    a. They do have a conclusion that is broader than the premises
    b. We are arguing from narrow to broad
2. Ex: “The sun has risen every other morning, so the sun will rise tomorrow as well”
    a. Notice that the premises contains a lot of data
        i. But the conclusion is not about one of those days
        ii. It is about a day outside of the data set

    b. We are using factors about millions of other days to expand our reasonable belief to one new one
        i. We have a collection of data and the day in the conclusion is not one of them
        ii. It is a further instance not contained in the content of the premises
    c. Just because the sun has always risen, there is no guarantee that it will do so again
    d. Successful inductive arguments, because they are ampliative, only give us high probability, not absolute certainty
    e. Conclusion lies outside the scope of the premises
        i. There is a risk that even a very good inductive argument might have a false conclusion
        ii. While deductive certainty is great, most real-life cases restrict user to high probability of induction
3. The conclusion outruns the premises, we have no guarantees about the degree of belief into the conclusion

Criteria for acceptable arguments

1. Sound argument
    a. An argument that is both valid and well-grounded
    b. A sound argument gives us good reason to believe its conclusion
2. Validity
    a. Looks at the structural elements of the argument
    b. Its study is called formal logic
        i. It is an examination of the form of arguments
    c. Validity for deductive and inductive arguments are completely different matters, and we need different tools
3. Well-groundedness
    a. Looks at the acceptability of the argument other than the form
        i. Its study is called informal logic
    b. We begin to build a complete account of the ways we determine what arguments give us good reason to believe their conclusion

Validity

1. An argument is valid if and only if, assuming the truth of the premisses for the sake of argument, the conclusion follows from them
2. We are assuming the premises are true for the sake of argument
    a. Maybe they are true; maybe they are false
        i. We don't care
    b. Validity does not concern the content of the premises
3. All we are looking at is whether the premises, if true, would lead you to the conclusion

4. Validity is not about the content of the argument
    a. But about the form of the argument
5. Validity looks at the skeleton of the argument and determines if it strong enough to support the weight of the conclusion

Well-groundedness

1. Well-groundedness justifies our ability to make a huge assumption about the truth of the premises in the first criterion, validity
2. Argument is well-grounded
    a. If and only if all of its premises are true
3. Maybe the conclusion is true, or maybe it's false, but what is important for us in evaluating the well-groundedness of an argument is
    a. The truth of falsity of the premises

Informal Logic and Fallacies

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Fallacies of Faulty Authority

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Fallacies of Cause and Effect

1. Post-hoc
    a. Post hoc: Just because it happened after, doesn't mean it happened because of it
    b. Making correlation between two events based on time order is not enough, we need a mechanism for that
    c. Neglect of a common cause: by taking correlation to mean causation
    d. Because we see B when we often see A, then A causes B
    e. We wrongly assert that A caused B or B caused A when there could be C that could cause them both.
2. Causal oversimplification: to take one factor of an event and elevate it and it alone as the cause is an error of causal oversimplification

Fallacies of Irrelevance

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Inductive Reasoning

1. Conclusions do move beyond the scope of the premises to give us a rational belief about something we have not yet observed
2. Induction is ampliative
    a. In that it amplifies our rational beliefs
    b. It takes us from narrow to broad
3. They give us new knowledge about the world
    a. They take what we already know and give us logical permission to believe new things that we did not know before
4. Deduction only rearranges our previous knowledge into new forms we may or may not have considered
    a. But induction actually generates completely novel beliefs about the world
5. The best we can get from induction is likely truth
    a. If you have a good inductive argument, the conclusion is probably true
        i. It's not "definitely true" but "probably true" is enough for rational beliefs

Inductive Arguments

Inductive Analogy

1. Used when we want to apply what we've learned from all other instances in the past to one in the present or future
2. Form
    a. P1 has property A
    b. P2 has property A
    c. P3 has property A
    d. ...
    e. Pn has property A
    f. I have only seen n instances of P
    g. Therefore, P(n + 1) has the property A
3. " I have seen some number n different Ps"
    a. "And every one of them has the property A"
    b. "Therefore, I believe that the next P i see will also have the property A"

Universal Generalization

1. Stronger inductive inference
2. Form
    a. P1 has property A
    b. P2 has property A
    c. P3 has property A
    d. ...

    e. Pn has property A
    f. I have only seen n instances of P
    g. Therefore, all Ps have the property A
3. Makes a broader claim, saying something about all members of the observed population

Statistical Generation

1. Form
    a. X percent of all observed Ps have the property A
    b. Therefore, X percent of all Ps have the property A
2. Generalizing over the entire set of Ps from some limited sample of Ps
    a. But are not attributing the property to all of them, but to some percentage
    b. Either an explicit percentage or a vaguer amount of the population

Inductive Fallacies

Exaggerated accuracy

1. -

Induction in Polls and Science

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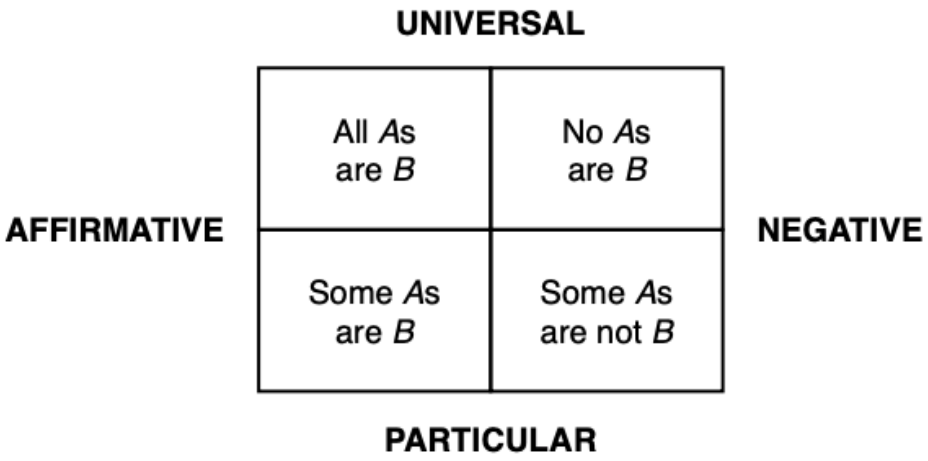
Introduction to Formal Logic

1. Examines what propositions necessarily follow from what other propositions because of their forms
2. Propositions need to be expressed as declarative sentences
    a. They have a specific form and contain:
        i. Subjects
            1. What the sentence is about
        ii. Predicates
            1. What we are asserting about the subject
3. A sentence is true if and only if
    a. The subject does have the property asserted by the predicate
    b. It is false if the subject does not

Categorical sentences



Universal affirmative (All As are B)

1. All people have noses

Universal negative (No As are B)

1. No circles have angles

Particular affirmative (Some As are B)

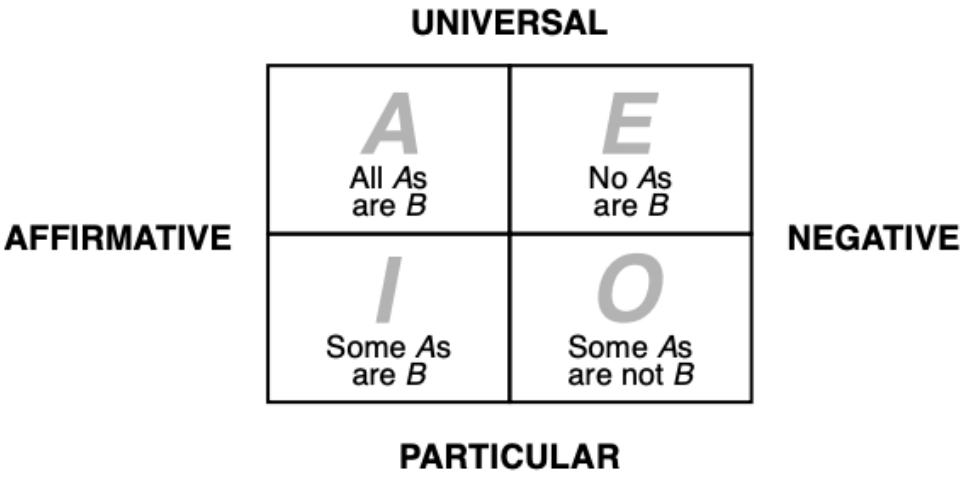
1. Some people are blonde

Particular negative (Some As are not B)

1. Some wines are not expensive

Types of sentences

Opposite corners are negations of each other



A sentences

1. Universal affirmative sentences

E sentences

1. Universal negations

I sentences

1. Particular affirmatives

O sentences

1. Particular negative

Square of opposition

Opposite corners are negations of each other

Contradictories

1. Sentences on opposite corners
2. One and only one can be true at a time
3. A sentence is only true if and only if the O sentence is false
4. A and O sentences will always have different truth-values
    a. All Boy Scouts are boys
        i. if and only if it is not true that some Boy Scouts are not boys
    b. If it is false that all Boy Scouts are boys
        i. Then there must be some Boy Scout that isn't a boy

Contraries

1. Sentences that cannot both be true, but they can both be false
2. A and E sentences
    a. It is false that all paintings use the color blue
    b. It is false that no paintings use the color blue

Subcontraries

1. They can both be true, but they cannot both be false
2. I and O sentences
    a. It is true that some people are having a birthday today and some people aren't
3. If it is false that some As are B, then it must be true that some As are not B
4. The word "some" means at least one, maybe all
    a. By using the word "some" we are not saying that only some, but not all
    b. It might be simultaneously true that all people have mothers and that some people have mothers
5. The world "all" is slightly more complex
    a. It means that every member of the category
    b. A sentence
        i. All unicorns have a horn

Viewpoints

Hypothetical viewpoint

1. "All unicorns have a horn" is true
    a. Because it means that all unicorns, if there are any, (and there might not be), have a horn
2. Just because an A sentence is true
    a. Does not mean that the corresponding I sentence will be true
3. "All griffins have the body of a lion" is true
    a. But that does not mean that some griffins do
    b. Because the word "some" means that there is at least one
        i. And the griffin is a mystical beast. There aren't any

Existential viewpoint

1. "All unicorns have a horn" is false
    a. Because it now means that they are unicorns and all of them have a horn
2. A sentences imply I sentences
3. E sentences imply O sentences
4. "If no square has five sides, then some squares do not have five sides"

5. As long as we know the subject exists, then if the predicate holds for all, it must hold for some
6. With untrue subjects
    a. We can have true A sentences
        i. And false I sentence
    b. We can have a true E sentence
        i. And false O sentence

Categorical Syllogisms

1. An argument with two premises
    a. A type of argument that is the key to reasoning
2. Categorical sentence as a conclusion

Categorical sentence as a conclusion

1. Has a subject
    a. Called the minor term (S)
2. Has a predicate
    a. The major term (P)

Two categorical sentences as premises

1. Has a Middle term (M)
    a. A term that appears in both premises but not in the conclusion
2. Minor Premise
    a. The premise with the minor term (S) and the middle term (M)
3. Major Premise
    a. The premise with the major term (P) and the middle term (M)
    b. (Always written first)
4. Example
    a. All humans are mortal (Major Premise)
        i. “Mortal” is the predicate
        ii. “Human” is the middle term
    b. All Greeks are human (Minor Premise)
        i. “Greeks” is the subject
        ii. “Human” is the middle term
    c. Therefore, all Greeks are mortal (Conclusion)
        i. “Greek” is minor term
        ii. “Mortal” is the major term

Truth-Functional Logic

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Truth Tables

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Truth Tables and Validity

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Natural Deduction

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Logical Proofs with Equivalences

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Conditional and Indirect Proofs

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First-Order Predicate Logic

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Validity in First-Order Predicate Logic

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Demonstrating Invalidity

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Relational Logic

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Introducing Logical Identity

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Logic and Mathematics

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Proof and Paradox

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Modal Logic

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Three-Valued and Fuzzy Logic

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