Logic Book Part 1

by Skylar Ruloff

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Introduction

This book is meant to be an easy introduction to logic. The goal of writing this book is to make it more accessible (monetarily and cognitively) than standard textbooks on logic. I wrote this to help people to learn how to think for themselves. Logic is not taught (or even offered in some cases) in schools so I hope this will allow everyone to learn logic easily and affordably.

This book was originally started as a podcast series on the Americans Against Tyranny podcast. Just to note, all definitions were taken from *The Power of Logic* by Frances Howard-Snyder, Daniel Howard-Snyder, and Ryan Wasserman.

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I Validity and Soundness

In this chapter I'll be going over how to tell the difference from good and not-so-good arguments. We will cover some of the basic components of an argument and how to tell if it is valid or sound. This chapter covers the very basics of logic, so expect a bunch of definitions. Don't worry though. Most of them are common sense, so you shouldn't have to work too hard to memorize them. Let's get started!

So, what is logic? **Logic** is the study of methods for evaluating whether the premises of an argument adequately support its conclusion.

So, what is an argument? No, it's not a screaming match between two people. An **Argument** is a set of statements where some of the statements, called the premises, are intended to support another, called the conclusion.

Oh no! More words to learn! But first, let's take a look at an example argument:

Every ebook can be downloaded.
This book is an ebook.
So, This book can be downloaded.

So let's take a look at statements now. A **Statement** is a declarative sentence that is either true or false.

Here are some examples of statements:

All cars have wheels.

Some books are made of paper.
No cars can fly.

All of these statements (or any statement) may be true or false.

Here are some examples of things that are not statements:

Look at that car! (This is a command).
Can you pick up that book? (This is a question).
We should go for a drive. (This is a proposal).

Now let's go over the parts of an argument. An argument is made up of statements. These statements can either be premises or conclusions. Here is an example:

1 If pigs can fly, then I can dance on the moon.
2 Pigs can fly.
3 So, I can dance on the moon.

Lines 1 and 2 are the premises. Line 3 in the conclusion. The premises will build up your argument to the conclusion.

Now, let's go over some basic types of arguments. These are not arguments forms, they will be covered later.

Let's cover deductive vs. inductive arguments first. A **Deductive Argument** is one in which the premises are intended to guarantee the conclusion. This means that as long as the premises are true statements, then the conclusion is intended to be true as well.

An **Inductive Argument** is one in which the premises are intended to make the conclusion probable, without guaranteeing it. This means that if the premises are true then the conclusion will most likely be true, but not necessarily.

Let's look at some examples of these:

All humans like chocolate.
Bob is a human.
So, Bob likes chocolate.

This is a deductive argument. The argument intends to guarantee to prove that Bob likes chocolate.

Most humans like chocolate.
Bob is a human.
So, Bob likes chocolate.

This is an inductive argument. Bob most likely likes chocolate, but not necessarily.

For our purposes, we will mostly discuss deductive arguments. These are obviously better at actually proving something compared to the inductive arguments.

Now let's compare valid and invalid arguments. A **Valid Argument** is one in which it is necessary that, if the premises are true, then the conclusion is true. This can be tricky to understand at first. A valid argument doesn't necessarily have true premises and a true conclusion. It

says that *if* the form of the argument is that all the premises are true then the conclusion *must* be true.

An **Invalid Argument** is one in which it is not necessary that, if the premises are true, then the conclusion is true. An invalid argument could have true or false premises and a true or false conclusion. The issue is not with the truth value, but with the validity. The form is so that the truth of the premises doesn't guarantee the truth of the conclusion.

Now let's take a look at a table full of examples:

	Valid Argument	**Invalid Argument**
True Premises, True Conclusion	If poodles are dogs, then they have fur. Poodles are dogs. So, poodles have fur.	Some people work on television. Oprah is a person. Hence, Oprah works on television.
False Premises, False Conclusion	All birds are leprechauns. All leprechauns are turtles. So, all birds ares turtles.	All planets are squares. Balloons are squares. So, balloons are planets.
False Premises, True Conclusion	All tires are people. All people are rubber. Therefore, all tires are rubber.	My mom is a pineapple. Turtles can fly. So, grass is green.

	Valid Argument	Invalid Argument
True Premises, False Conclusion	Not possible. See definition of valid argument.	All bikes have tires. All cars have tires. So, all bikes are cars.
Unknown Truth Value	If Brichiorisis is Kjoiri, then Ghjkds is Dfver. Brichiorisis is Kjoiri. So, Ghjkds is Dfver.	Some Knarknar are Bleepblop. Tkusk is Knarknar. So, Tkusk is Bleepblop.

Now let's discuss sound and unsound arguments. A **Sound Argument** is a valid argument in which all of the premises are true. Because all the premises are true and it is valid, the conclusion must also be true. Here's an example:

All poodles are dogs.
All dogs are mammals.
So, all dogs are mammals.

An **Unsound Argument** is one that either is invalid or has at least one false premise. Let's look at examples of these:

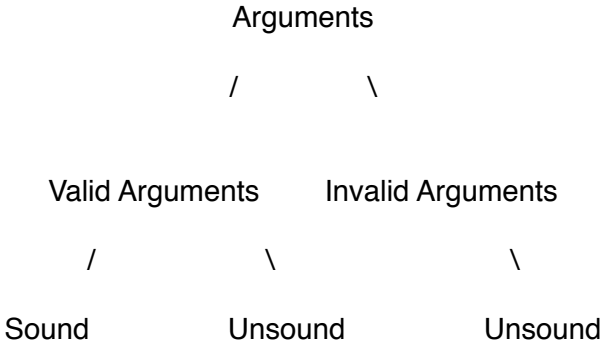
All poodles are mammals.
All cats are mammals.
So, all poodles are cats.

This one is unsound because it is invalid.

All poodles are mammals.
All mammals are trees.
Therefore, all poodles are trees.

This one is unsound because it has a false premise.

Here is a visual to show the relationship between valid and sound arguments:



All arguments can be either valid or invalid. All invalid arguments are unsound. Valid arguments with at least one false premise are unsound. Valid arguments with all true premises are sound.

II Argument Forms

Hey, you made it through the first chapter! Congratulations. Now let's talk about those argument forms I briefly mentioned in the first chapter. An **Argument Form** is a pattern of reasoning. All that really means is that there is a set 'formula' for each of these forms. This may seem weird and not make much sense, so let's just take a look at some of these forms.

The first, and most basic, is **Modus Ponens**. Here is the form:

If A, then B.
A.
So, B.

Or,

If Bob has lots of money, then Bob is rich.
Bob has lots of money.
So, Bob is rich.

The next thing we need to talk about has a very long name, but is a really simple concept. The **Substitution Instance of an Argument Form** is an argument that results from uniformly replacing the variables in that form with statements (or terms). All this means is that the argument form uses things like 'A' and 'B,' and then 'A' and 'B' are replaced by something else. Above, I replaced 'A' with 'Bob has lots of money.' Then I replaced 'B' with 'Bob is rich.'

A **Valid Argument Form** is one in which every substitution instance is a valid argument. That means that as long as the premises are true, the conclusion must also be true. Modus Ponens and all the other forms we will cover in this chapter are all valid argument forms.

The next definition can be tough to understand. I'll try my best to explain it, but just remember that it's not super important. A **Formally Valid Argument** is one that is valid in virtue of its form. Modus Ponens is a formally valid argument.

All Philosophers are nerds. So, no squares are circles.

This is not a formally valid argument. Like I said, this part gets weird, but hang in there. So the conclusion is true, so in a way it is valid, but not by it's form. This is one of the more obscure things I've found in logic and I don't expect it will ever be useful knowledge. Anyway, let's just move on!

Now we'll go over conditional statements. A **Conditional Statement** is an if-then statement. Think of the first line in modus ponens. "If blah blah blah, then blah blah blah." The 'if' part is the **antecedent** and the 'then' part is the **consequent**. Side note: If you see 'Only if,' this introduces the consequent.

It is also important to know that all conditional statements are hypothetical. Think of the example from above for modus ponens. "If Bob has lots of money, then Bob is rich." Bob may have lots of money, but maybe

not. Who knows? But, if he does have lots of money, then he is rich.

Now let's look at another argument form. Here is the form for **Modus Tollens**:
If A, then B.
Not B.
So, not A.

Or,

If Bob is on television, then he is famous.
Bob is not famous.
So, Bob is not on television.

The most important thing to remember, and the one most people mess up, is that you deny B (the consequent). Many people will try to deny A (the antecedent) instead. We will talk about formal fallacies later, but for now just remember to deny the consequent.

Negation is the denial of a statement. This is just like step 2 in modus tollens. Just think of, "It is not the case that blah blah blah."

Alright, we are done with boring definitions in this chapter. The rest is just argument forms. Remember, all of these forms are valid argument forms. So, if you use all true premises, then your conclusion will be true. First up is **Hypothetical Syllogism**:

If A, then B.
If B, then C.
So, if A, then C.

Or,

If I eat donuts all day, then I will get fat.
If I get fat, then I will be unhealthy.
So, if I eat donuts all day, then I will be unhealthy.

Alright, I lied. One more definition. A **Disjunction** is an either-or statement. “Either A or B.” The parts, ‘A’ and ‘B,’ are called disjuncts. A disjunction can be inclusive or exclusive, meaning “Either A or B (or both),” or Either A or B (but not both).” If it is not specified, it is assumed to be inclusive.

The next argument form is **Disjunctive Syllogism**:

Either A or B
Not A.
So, B

Or,

Either A or B
Not B.
So, A

Or,
Either Tom likes cookies or Tom likes ice cream.
Tom doesn’t like cookies.
So, Tom likes ice cream.

Remember that the ‘or’ is inclusive by default. So Tom could like 1. cookies, 2. ice cream, or 3. both. Since he doesn’t like cookies (option 1) we can also say he

doesn't like both (option 3), which only leaves one option: ice cream.

Here's the last one, **Constructive Dilemma**:

Either A or B
If A, then C.
If B, then D.
So, Either C or D.

Or,

Either Soviet Russia has a nuclear bomb, or Soviet Russia doesn't have a nuclear bomb.
If Soviet Russia has a nuclear bomb, then the United States can not attack.
If Soviet Russia doesn't have a nuclear bomb, then the United States can attack.
So, either he United States can not attack or the United States can attack.

III Counterexamples and Categorical Statements

In this chapter we will be covering a few topics including counterexamples, invalidity, and categorical statements. We will be going over some basic formal fallacies. These fallacies will look like some of the argument forms we went over in the last chapter, but the form will be a little off. Let's jump right in with covering the invalid argument form. An **Invalid Argument Form** is one that has some invalid substitution instances. This might not make any sense, but I'll try to explain it. Let's look back at modus tollens:

If A, then B.
Not B.
So, not A.

If we mix up the different parts of the argument, we could get the **Fallacy of Denying the Antecedent**:

If A, then B.
Not A.
So, not B.

This fallacy is an example of an invalid argument form. If someone said, "Hey, you suck!" that is not a good argument. It is just attacking someone and is a fallacy. However, these two fallacies are very different. The one we are focusing on now is a fallacy because of its form. Let's look at an example:

If it is snowing, then it is cold.
It isn't snowing.
So, it isn't cold.

This is the fallacy of denying the antecedent. Obviously it could be cold while not snowing. Now let's take at look at counterexamples.

A **Counterexample** to an argument form is a substitution instance in which the premises are true and the conclusion is false. If you can show that the conclusion is false with all true premises, then you show that the form is invalid. Let's take it one step further.

A **Good Counterexample** to an argument form is a substitution instance in which the premises are well-known truths and the conclusion is a well know falsehood.

Let's say someone says,

If God exists, then life exists.
Life exists.
So, God exists.

This is a fallacy we will cover soon. For now, let's see how we can come up with a good counterexample. We want to have true premises and a false conclusion, using the same form used above.

If Donald Trump is a horse, then he is a mammal (All true).
Donald Trump is a mammal (Still true).
So, Donald Trump is a horse (Very false).

This is an example of **Affirming the Consequent**. As you probably noticed, it is very similar to modus ponens, but the consequent is affirmed, rather than the antecedent. Here is the form for affirming the consequent:

If A, then B.
B.
So, A.

Let's go through some more counterexamples now.

Here is a bad argument:
Bob was a mechanic and Bob went to the Bahamas.
Bill is a mechanic.
So, Bill went to the Bahamas.

Here is the form:
A and B.
C.
So, D.

Here are some counterexamples:
Tony was a mechanic and tony is now long dead.
Bill is a mechanic.
So, Bill is now long dead.

Or,

Toes are on feet and birds can fly.
Pillows are for sleeping.
So, electricity is made of string cheese.

Let's look at one more:

Bad argument,
If abortion causes harm, then it is wrong.
If abortion causes harm, then it should be illegal.
So, if abortion is wrong, then it should be illegal.

Form:
If A, then B.
If A, then C.
So, if B, then C.

Counterexample:
If Bob is a husky, then he is a mammal.
If Bob is a husky, then he is a dog.
So, if Bob is a mammal, then he is a dog.

Now let's dive into categorical statements. A **Categorical Statement** is a statement that relates two classes or categories, where a class is a set or collection of things. Here are some examples:

All dogs are mammals.

Some people are fat.

Most planes have wings.

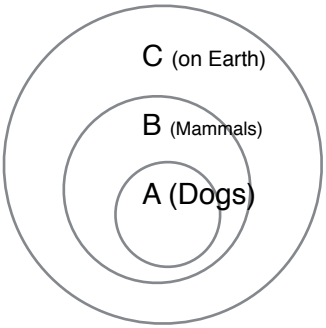
A **Term** is word or phrase that stands for a class of things. All that means is that when I say 'dogs,' it stands for all the dogs in the world.

Let's take a look at an example of an argument using categorical statements:

All dogs are mammals.
All mammals are on Earth.
So, all dogs are on Earth.

Form:
All A are B.
All B are C.
So, all A are C.

By far, the easiest way to figure out these is with Venn Diagrams. Here's what the above form would look like:



Now let's look at a slightly more tricky one:

All toucans are birds.
Some cats are not birds.
So, some cats are not toucans.

This may seem ridiculous, but let's go over it.

Form:
All A are B.
Some C are not B.
So, some C are not A.

Does it still seem crazy? Let's learn what the word some means. Some only means at least 1. So, by 'Some cats are not toucans,' I mean 'At least one cat is not a toucan.' This may take minute to soak in, but think about it. If I held up a cat and said, "Is this a toucan?" You would say, "No." So there is at least one cat that is not a toucan, aka, some cats are not toucans.

IV Strength and Cogency

So far we have largely focused on deductive arguments, which intend to guarantee the truth of the conclusion. Inductive arguments are meant to make the conclusion probable without actually guaranteeing its truth. This may sound quite pointless. Why bother only making it probable if you can guarantee it? Well, that's the point. This is useful for when you can't guarantee something.

Let's start by looking at strong and weak arguments. A **Strong Argument** is one in which it is probable (but not necessary) that, if the premises are true, then the conclusion is true. This is similar, but not the same as a valid argument. A valid argument says that is *necessary* that if the premises are true, then the conclusion is true. A strong argument is *probable (but not necessary)*. These two can be seen as closely related, but do not confuse them. Valid is deductive, strong is inductive.

A **Weak Argument** is one in which it is not probable that, if the premises are true, then the conclusion is true. Read this definition carefully. It is almost exactly the same as the strong argument, but it is *not* probable.

Here's an example of both:

95% of all Americans wear underwear.
Chris is an American.
So, Chris wears underwear.

3% of all birds can speak.
Tweety is a bird.
So, Tweety can speak.

The first example is a strong argument. There is a chance that Chris is part of the 5% that don't wear underwear, but there is a strong chance that he does. Because he probably wears underwear, we can say this is a strong argument.

The second example is a weak argument. There is only a 3% chance that Tweety speaks, so this argument is a weak argument.

Some arguments won't be this simple. These were easy because they listed percentages. Here's some examples of inductive arguments without percentages:

Dr. Thompson of the Harvard Medical Research Team says that eating sandals will cause cancer.

Joe Schmoe says that aliens are abducting people and doing experiments on them.

The first example comes from a Doctor working with a very important and likely fictional medical team. He makes a statement on something that he's been studying for years. Maybe there isn't enough evidence to guarantee his statement, but it is probable. So, we can call this a strong argument.

The second argument comes from Joe Schmoe. He is making bold claims with no evidence. We can call this a weak argument for obvious reasons.

Now let's look at cogency. A **Cogent Argument** is a strong argument in which all of the premises are true.

This is different from a sound argument. A sound argument is a *valid* argument with all true premises. A cogent argument is a *strong* argument with all true premises.

An **Uncogent Argument** is one that is either weak of strong with at least on false premise.

Let's go over how an argument can be uncogent:

It's strong with at least one false premise.
It's weak with all true premises.
It's weak and has at least one false premise.

The only way for an argument to be cogent is to be strong and have all true premises. Anything else (as far as inductive arguments go) is uncogent.

Now let's go over some examples:

All or nearly all basketballs are round.
The NBA uses basketballs.
So, during the next NBA game they will use a round ball.

This is a cogent argument. The premises are true and the argument is strong. Certainly there is a small chance that there is some strange new form of basketball with a square ball. Or there is a chance that before the next game someone will invent something new. However, this is extremely unlikely.

Now let's see some uncogent arguments:

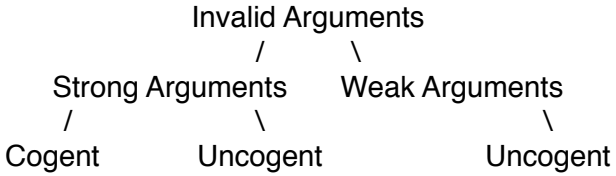
Most people are robots.
John is a person.
So, John is a robot.

According to TheOnion, turtles can fly.
So, my turtle can probably fly.

A few dogs are exactly the same.
Bob's poodle is 10 pounds.
So, my Saint Bernard is 10 pounds.

The first argument is strong, but is uncogent because it has a false premise (People are not robots). The second argument has a true premise, but is uncogent because it is weak (TheOnion is a satirical news source). The third is weak and has a false premise. It is weak because only a few dogs are exactly the same and it has a false premise (Bob has a pomeranian, not a poodle).

Here is a visual to show the relationship between strong and weak arguments:



All inductive arguments can be either strong or weak. All weak arguments are uncogent. Strong arguments with at least one false premise are uncogent. Strong arguments with all true premises are cogent.

References

Howard-Snyder, Frances, Daniel Howard-Snyder, and Ryan Wasserman. The Power of Logic. Fifth ed. New York: McGraw-Hill Higher Education, 2013. Print.