Introduction to Logic and Fallacies

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Version 20080921

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The purpose of this presentation is to provide a brief introduction to logic and logical fallacies.

This presentation is freely available from www.sticksandshadows.com. Contact the author at heafnerj@sticksandshadows.com.

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This presentation was created in conjunction with the LCTTA textbook project.

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Abstract

A set of common logical forms, fallacies, and persuasion tactics is presented.

I include an abstract.

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Arguments in General

Let's begin by looking at some of the basic properties of arguments.

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Deductive Argument

Provides **conclusive** support
Valid if it succeeds, **invalid** if it fails
Sound if valid and premises are true
Unsound if valid but premises are false

This is one type of argument. Validity and truth are not the same thing. An argument can be valid but the conclusion can be false. Validity has more to do with logical structure and form than with truth. Valid form and true premises must **always** lead to a true conclusion. There are no exceptions.

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Inductive Argument

Provides **probable** support
Strong if it succeeds, **weak** if it fails
Cogent if valid and premises are true
Not cogent if valid but premises are false

This is another type of argument. Note the contrast with deductive arguments. Inductive arguments do not provide conclusive support. Students have difficulty accepting that some arguments, especially in science, are simply not designed to give absolute conclusive support. In an inductive argument, having true premises does not guarantee that the conclusion is absolutely true. It only guarantees that the conclusion is probably true. Science makes **heavy** use of inductive arguments, much more so than nonscientists realize.

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Remember . . .

A valid argument with true premises will have a conclusion that is **always** true.

A strong argument with true premises will have a conclusion that is **probably** true.

False premises ruin the entire process!

These are three very important points to remember. Note that false premises can sometimes lead to a true conclusion even in a valid argument! Again, it's important to understand that valid deductive arguments lead to conclusions whose truth, or lack thereof, is absolute. On the other hand, inductive arguments

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Argument Forms

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Recognizing an argument's form is often the first step to understanding the argument and the first step in debunking an invalid argument.

Affirming the Antecedent
(modus ponens)

If P, then Q
P
Therefore Q

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For this form to be valid, knowing P to be true must be adequate grounds to conclude that Q is true (i.e. P is sufficient for Q). If this condition is not met, then modus ponens is not valid. If the premises are true, then the conclusion will always be true regardless of the content of the statements.

Affirming the Antecedent
(modus ponens)

If all shadows change according to Sun's position in the sky, then my shadow will change throughout the day. All shadows do change according to Sun's position in the sky. Therefore, my shadow will change throughout the day.

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In this example, P represents "all shadows change according to Sun's position in the sky" and Q represents "my shadow will change throughout the day." Knowing that **all** shadows change according to Sun's position in the sky is adequate grounds to conclude that **my** shadow will change throughout the day. Therefore, this is a perfectly valid logical form. If the premises are true (as they are here), then the conclusion must also be true. Proceed with caution if any of the premises are false!

Denying the Antecedent
(no Latin name)

If P, then Q
not P
Therefore not Q

This form occurs when knowing P to be true is **not** adequate grounds to conclude that Q is true (i.e. P is not sufficient for Q), but is treated as though it were. There may be some other condition R that allows us to adequately conclude that Q is true. If so, then we must explicitly account for R in a separate test and not in a test for P. This form constitutes a fallacy, even if the premises are true.

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Denying the Antecedent
(no Latin name)

If I have strep, then I have a sore throat. I do not have strep. Therefore, I do not have a sore throat.

In this example, P represents “I have strep” and Q represents “I have a sore throat.” Here, knowing P to be true is **not** adequate grounds to conclude that Q is true (i.e. P is not sufficient for Q). Having strep doesn’t mean you have a sore throat. That means that **not** having strep doesn’t mean you don’t have a sore throat **from some other cause**.

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Denying the Consequent
(modus tollens)

If P, then Q
not Q
Therefore not P

For this form to be valid, Q cannot be true unless P is also true (i.e. P is necessary for Q). If is condition is not met, then modus tollens is not valid. If the premises are true, then the conclusion will always be true regardless of the content of the statements. Note that this form should, strictly speaking, be articulated as If Q, then P because Q can only be true if P is also true. If both primses are true, however, it can be written either way but note there is a subtle difference. Modus tollens forms the basis of falsification. It allows us to rule out certain explanations that do not agree with observations.

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Denying the Consequent
(modus tollens)

If it is raining, then it is cloudy. It is not cloudy. Therefore, it is not raining.

In this example, P represents “it is raining” and Q represents “it is cloudy.” For it to be raining, it must also be cloudy. If we look outside and see clear skies, it cannot be raining. Therefore, this is a perfectly valid logical form and does not constitute a fallacy. If the premises are true (as they are here), then the conclusion must also be true. Proceed with caution if any of the premises are false!

16

Affirming the Consequent
(no Latin name)

If P, then Q
Q
Therefore P

This form occurs when Q can mistakenly be true even if P is not true (i.e. P is not necessary for Q but treated as though it is necessary for Q). There may be some other factor R which is necessary for Q but there is no mention of R. In other words, we may really have If P, then Q; If R then Q; Q; Therefore P. This does not take R into account. Note that if Q really is explained only by P, then there is no fallacy.

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Affirming the Consequent
(no Latin name)

If I have strep, then I have a sore throat. I have a sore throat. Therefore, I have strep.

In this example, P represents “I have strep” and Q represents “I have a sore throat.” However, Q can be the result of, for example, tonsillitis. Asserting you have a sore throat does not assert that you must have strep.

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Transposition and Sufficient/Necessary

If P, then Q
Therefore, if not Q, then not P

P sufficient for Q means Q necessary for P

This is the correct way to transform one expression into another. Note that the order of P and Q changes and both are negated. A common fallacy is to forget to change the order of P and Q upon transposition.

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Hypothetical Syllogism

If P, then Q
If Q, then R
Therefore, if P, then R

This form is always valid.

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Disjunctive Syllogism

Either P or Q
not P (or not Q)
Therefore, Q (or Therefore, P)

This form is always valid. Note that either disjunct can be denied.

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Shifting the Burden of Proof

Attempting to prove an argument by shifting the burden of proof onto the party defending the accepted explanation or claim when that burden actually lies with the challenger to that explanation or claim.

I prefer the name “burden of evidence” given that science deals more with evidence than proof. This is a special case of argumentum ad ignorantiam. A claim or argument is not true just because it has not been established as true. Science has an established framework of knowledge. When someone offers an idea or conclusion or argument that challenges the established framework, the challenger has the burden of evidence, not the party being challenged. Creationists are obligated to offer evidence that evolution is wrong. Biologists are under no such obligation to creationists.

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Shifting the Burden of Proof

I was abducted by aliens and taken aboard one of their spacecraft. Prove me wrong. You can't prove me wrong, therefore I must be right.

This example is typical of tactics used by some television interviewers.

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Appeal to Emotion
(many variations)

Attempting to prove an argument by evoking either positive or negative emotions.

Arguments that involve emotions are usually unreliable. Unfortunately, they are also usually very effective.

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Appeal to Emotion
(many variations)

We landscapers should be exempted from mandatory water conservation measures because if we can't water lawns, we'll go out of business.

Giving to our charity will make you feel so good about yourself!

25

The emotional appeal can be either positive or negative.

Appeal to the Past
(argumentum ad antiquitam)

Attempting to prove an argument by asserting that "that's the way it's always been" rather than by providing evidence.

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This fallacy is a favorite of pseudoscientists and antiscientists.

Appeal to the Past
(argumentum ad antiquitam)

Why change a system of teaching science that has served so many so well for so long?

27

This is a relevant, and frequently encountered, example.

Appeal to Novelty
(argumentum ad novitatem)

Attempting to prove an argument by asserting that something is better because it is new rather than by providing evidence.

28

This fallacy is a favorite of pseudoscientists and antiscientists.

Appeal to Novelty
(argumentum ad novitatem)

Mac OS X is better than Windows because OS X has a newer user interface and a better overall design.

29

This is a relevant, and frequently encountered, example.

Appeal to the People
(argumentum ad populum)

Attempting to prove an argument by citing that a large number of people accept it as true.

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This one is frequently seen, and is probably the most prevalent fallacy in our society. So many people, including government leaders, base decisions on what large numbers of people think. Large numbers of people can be, and often are, wrong. A majority of Americans think that evolution explains the creation of life; it does not (and never has).

Appeal to the People
(argumentum ad populum)

The majority of people in America do not accept evolution. How can this many people be wrong? Therefore, evolution must be erroneous.

This is a typical example.

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Appeal to Logic
(argumentum ad logicam)

Attempting to prove an argument by showing its conclusion to be true or false because it follows from one or more fallacies.

This one is potentially confusing because a fallacious argument can sometimes lead to true conclusions! Students tend to confuse this fallacy with reductio ad absurdum. The distinction, of course, is that argumentum ad logicam can lead to both true and false conclusions while reductio ad absurdum ALWAYS leads to an absurd conclusion.

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Appeal to Logic
(argumentum ad logicam)

Take the fraction 64/16. If you cancel out a 6 in both the numerator and denominator, you get 4/1, which is just 4. However, "canceling" out the 6 violates the rules of algebra, so the answer cannot possibly be correct.

This is a typical example. The process of getting the answer is flawed, but the conclusion is absolutely true! Many times, students only focus on the conclusion without paying sufficient attention to the process that got them there. In science, you must always pay attention to the process!

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Appeal to Ignorance
(argumentum ad ignorantiam)

Attempting to prove an argument by using the lack of evidence for the claim as evidence against the claim or attempting to prove an argument by using the lack of evidence against the claim as evidence for the claim.

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This fallacy is a favorite of pseudoscientists and antiscientists.

Appeal to Ignorance
(argumentum ad ignorantiam)

Life exists on other planets because we have no proof that life does not exist on other planets.

We cannot explain what happened before the Big Bang. Therefore, the Big Bang must be wrong.

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These are typical examples.

Argument by Repetition
(argumentum ad nauseum)

Attempting to prove an argument by asserting its truth repeatedly. The more often you say it, the truer it is.

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This fallacy is a favorite of pseudoscientists, antiscientists, and politicians. The general strategy is usually to belabor the point until no one any longer wants to contradict or discuss it. In these cases, it becomes an intimidation strategy. Note that argument by repetition is frequently used in classroom instruction!

Argument by Repetition
(argumentum ad nauseum)

9/11 changed everything, so we have to embrace this new law.

The American people want change, and I am the candidate of change. Therefore, you should vote for me.

These are typical examples.

37

Attacking the Person
(argumentum ad hominem)

Attempting to prove an argument by shifting the argument away from the evidence and toward the opponent's character by name calling or other such personal attack.

This is a favorite strategy of politicians. They use it to avoid answering real questions and to make some usually irrelevant accusation about their opponent. Note that this may be warranted if the question and the opponent's character are actually related. See the example in the next slide.

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Attacking the Person
(argumentum ad hominem)

Dr. Smith is an alcoholic so his research is suspect and unreliable.

This is a typical example. The speaker cannot counter a previously made argument and so attacks the opponent with something that is usually not related to the argument. However, this is not a fallacy if the attack is over something related to the issue being discussed.

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Appeal to Authority
(argumentum ad verecundiam)

Attempting to prove an argument by citing an authoritative source not relevant to the argument.

Appeal to authority is difficult to live with because it is necessary for promoting scientific ideas and under certain circumstances a fallacy. Appeal to authority can be valid if the authority is directly related to the issue being discussed. An astronomer is authoritative on the subject of eclipses, but not on issues in biology. Using an appeal to an astronomer on a biological question is fallacious. Still, an astronomical statement is not correct only because an astronomer says so. In that sense, we still have a fallacy. There must be supporting evidence.

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Appeal to Authority
(argumentum ad verecundiam)

My explanation for eclipses is correct because I found it on the Internet.

Almost all commercial endorsements!

This is a typical example.

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Appeal to Force
(argumentum ad baculum)

Attempting to prove an argument by threatening the opponent.

This is another favorite of religious groups, who threaten violence to all who do not accept their ways. The violence may be overt or covert. One may also threaten dire consequences.

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Appeal to Force
(argumentum ad baculum)

Do your homework or the next test will be so hard no one will pass.

This is a typical example.

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Hasty Generalization
(secundum quid)

Attempting to prove an argument by extending knowledge of an individual to all such individuals.

This is a frequently used fallacy.

44

Hasty Generalization
(secundum quid)

Carl Sagan was an astronomer and atheist, so all astronomers are atheists.

This is a typical example.

45

False Dilemma (Either-Or)
(bifurcation)

Attempting to prove an argument by giving only two alternatives when there are actually other alternatives.

In my experience, this fallacy causes many false alarms. In some cases, there may legitimately be only two alternative in an argument. It is only when there are more than two but only two are presented that we have a fallacy.

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False Dilemma (Either-Or)
(bifurcation)

I will make either an A or an F on the next test.

If you're not for me, you're against me.

These are typical examples.

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Circular Reasoning
(circulus in demonstrando)

Attempting to prove an argument by using the argument as its own supporting evidence, thereby always making it appear correct.

This fallacy should be easy to detect, but many people either do not recognize it when they see it or think they see it when some other fallacy is present.

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Circular Reasoning
(circulus in demonstrando)

This course is the best one at CVCC because it has the best instructor. CVCC attracted the best instructor because it has the best reputation. It has the best reputation because it offers this course.

This is a typical example.

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Slippery Slope
(camel's nose)

Attempting to prove an argument by warning that an initial action will lead step by step to extreme consequences.

This is usually easy to detect. The term "camel's nose" comes from the assumption that if a camel sticks its nose through the doors of a tent, the rest of the camel will inevitably follow.

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Slippery Slope
(camel's nose)

If we negotiate with terrorists, then government acknowledges terrorists have power, terrorism will be recognized as a legitimate political force, and terrorism will become more widespread as a means to gain power and to influence other governments.

This is a typical example

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Reduction to the Absurd
(reductio ad absurdum)

Attempting to prove an argument by warning that an initial action will lead step by step to absurd consequences.

This is also called “proof by contradiction,” in which an initial assumption is carried through to its logical end and we see if absurd consequences arise. If so, the initial assumption was incorrect. Used this way, reductio ad absurdum is a valid reasoning method.

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Reduction to the Absurd
(reductio ad absurdum)

A computer scientist claims to have developed a chess program that will always win regardless of who it plays.

This is a typical example. If the program plays itself, both programs must win, but there can only be one winner in a chess game. The result that there are two winners is absurd.

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Loaded Question
(plurium interrogationum)

A tactic to distract from an argument by asking an opponent a question that has a presupposition which the opponent would like to deny, but which the opponent would be accepting by responding in any earnest way.

Also asking for a simple answer to a question that does not have a simple answer.

This is a difficult attack to counter, but it can be done. If someone asks you about beating your spouse, you could say you don’t have a spouse. That kills the presupposition and may expose the attack to the audience. Another example is the question, “What is the meaning of life?”, which presupposes that life actually has or must have a meaning. That’s a fallacy. Another example of this fallacy is the question, “Why are you so angry?”. This is used frequently by television interviewers who do not agree with the guest to change the subject away from the actual topic to the guest’s character, which borders on an ad hominem attack.

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Loaded Question
(plurium interrogationum)

Why are you so angry?

This example is used frequently by television interviewers who do not agree with the guest to change the subject away from the actual topic to the guest's character, which borders on an ad hominem attack.

55

Loaded Question
(plurium interrogationum)

Why can't spacecraft travel at light speed?

This example is frequently seen in introductory astronomy and physics courses. It is not a trivial question, but usually students expect a trivial answer and get frustrated when not given one. The answer "It just can't." is more of an appeal to empty authority than anything. The answer "Einstein's equations say so." also smacks of appeal to authority, but more dangerously conveys no reasoning at all. Sometimes simple sounding questions have answers that require a chain of reasoning. Without that chain of reasoning for context, the answer will have little meaning to the student, but students have been conditioned to not have to reason to get answers. This is as much a social problem as an instructional problem.

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Wishful Thinking

Attempting to prove an argument by simply believing, or wishing for, the desired outcome.

This one crops up a lot in science. No spacecraft will ever travel at light speed no matter how hard we wish for that to be possible. The answer is complex in that it requires understanding how the question (of spacecraft traveling at light speed) fits into the framework defined by the laws of nature.

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Wishful Thinking

It would be so cool if space travel at warp speed were to someday be possible, therefore someday it will be possible.

This is a commonly used example, especially by students in introductory science courses.

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Feigning or Taking Offense

A tactic to distract from an argument by pretending to be offended by something your opponent said or did.

This tactic is used unchallenged by politicians and religious groups to discredit other people. It almost always works and almost always guarantees the person(s) pretending to be offended a free pass to say or not say anything. In my personal opinion, all “offense” is taken by choice and should be ignored at all costs. I can’t think of a single situation in which offense is genuine.

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Feigning or Taking Offense

I can’t learn anything about science because it conflicts with my religious beliefs and offends me and members of my religious order.

This is a frequently seen example.

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What do they all have in common?

EVIDENCE!

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All fallacies and distraction/intimidation tactics work to ignore evidence. All fallacies and distraction/intimidation tactics can be stopped cold by supporting arguments with evidence.

CAUTION!

- Logic doesn't govern Nature!
- Correct logic alone doesn't ensure correct answers!
- Logic doesn't govern human behavior!

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Like any tool, logic must be used correctly and appropriately. 1) Just because something is logically impossible, it necessarily physically impossible. Just because something is logically possible, it isn't necessarily physically possible. 2) Every individual step in a logical argument must be correct for the entire process to be correct. Additionally, rules from other disciplines must also be used correctly. 3) Bob wants to speak to whomever is in charge. Linda is in charge. Therefore, Bob wants to speak to Linda. Well, what if Bob really doesn't want to speak to Linda? What if he is avoiding her because she verbally abused him yesterday?

Thank you!

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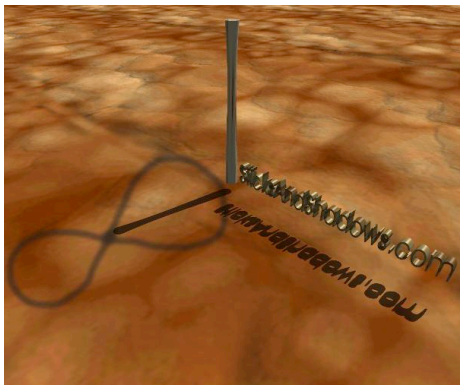

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