

Introduction to Logic: Problems and solutions

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Part I
Informal Logic

One task we logicians are interested in is that of analyzing the notion of proof to make it as rigorous as any other notion in mathematics.

ldots...

Raymond Smullyan, *The Lady or the Tiger?* , 1982

Chapter 1

Theory of Argumentation

1.1 Lecture 1: Identification of Arguments

1.2 Lecture 2: Non-arguments

1.2.1 Identify arguments from the following passages

1. If you want to find a good job, you should work hard. You do want to find a good job. So you should work hard.
2. Once upon a time there was a prince and a princess. They lived happily together and one day they decided to have a baby. But the baby grew up to be a nasty and cruel person and they regret it very much.
3. Cutting the interest rate will have no effect on the stock market this time round as people have been expecting a rate cut all along. This factor has already been reflected in the market.
4. For a long time, astronomers suspected that Europa, one of Jupiter's many moons, might harbor a watery ocean beneath its ice-covered surface. They were right. Now the technique used earlier this year to demonstrate the existence of the European ocean has been employed to detect an ocean on another Jovian satellite, Ganymede, according to work announced at the recent American Geo-physical Union meeting in San Francisco. The Economist 16.12.2000
5. Scientific discoveries are continually debunking religious myths. Further, science provides the only hope for solving the many problems faced by humankind. Hence, science provides a more accurate view of human life than does religion.
6. India's wait for an Olympic gold medal in an individual event is finally over! Shooter Abhinav Bindra fired his way to victory in the 10-meter air rifle event on Monday, giving India her first gold medal in Beijing 2008 Olympics. Bindra's triumph gives India her first Olympic gold medal ever in an individual event and a gold medal in any Olympic event after 28 years.
7. It is wrong for society to kill a murderer. This follows for the reason that if a murderer is wrong in killing his victim, then society is also wrong in killing the murderer. And a murderer is wrong in killing his victim.

8. Since particle like behavior and wave like behavior are the only properties that we ascribe to light, and since these properties now are recognized to belong not to light itself, but to our interaction with light, ... it appears that light has no properties independent of us! To say that something has no properties is the same as saying that it does not exist. The next step in this logic is inescapable. Without us, light does not exist. [Gary Zukav, *The Dancing Wu Li Masters* (New York: Bantam Books, 1979), p. 95]
9. The earth is getting warmer. Why? There are many reasons, but here are two important ones. First, the burning of coal, oil, and natural gas has greatly increased the carbon dioxide in the atmosphere. And carbon dioxide retains heat. Second, chlorofluorocarbons, which are used in air conditioners and refrigerators, have attacked the ozone layer, thus leaving the earth exposed to ultraviolet rays from the sun.
10. If inflation is receding, the government's economic policies are sound. Inflation is indeed receding. Therefore, the government's economic policies are sound.
11. If I were you, I would accept the fact that we are not free. In fact, you would be wise to stop treating others with the respect that real freedom would require and simply approach others as stimulus and response machines, to be manipulated for your own gain.
12. Make sure that you follow the guidelines to live a ethical life. 1. Begin each day with a prayer. 2. Work hard. 3. Love your family. 4. Make light of your troubles. 5. Follow the Golden Rule. 6. Read from the scriptures. 7. Show kindness. 8. Read worthwhile books. 9. Be clean and pure. 10. Have charity in your heart. 11. Be obedient and respectful. 12. End the day in prayer. These twelve rules, the "Quaker Dozen," were written long ago in a family Bible. But I believe they still fit today's problems. (Adapted from Olive Ireland Theen, "Grandfather's Quaker Dozen," in William Nichol, ed., *A New Treasury of Words to Live By*, 1959)[Statement of Belief/Opinion]
13. item Although you usually cannot eliminate the personal feelings that are influencing your perceptions, you can become aware of them and try to compensate for their bias. For instance, if you are asked to evaluate a group of people, one of whom is a good friend, you should try to keep these personal feelings in mind in order to make your evaluation as accurate as possible (John Chaffee, *The Thinker's Way*, 1998)

Answers

1. 1. Argument; Modus Ponens (MP).
2. 2. Non-Argument, Non Inferential, and is a chronological description of facts composed of statements but no premise or conclusion.
3. 3. Argument: The conclusion is that this time, cutting interest rate will have no effect on the stock market.
4. Not an argument. A Report
5. Argument; Conclusion: Science provides a more accurate view.....
6. Non-Argument; Report.
7. Argument; Conclusion: it is wrong for society kill a murderer.

8. Argument
9. Argument
10. Non-Argument: Explanation.
11. Argument
12. Non- Argument: A piece of Advice.
13. Non-Argument; Statement of belief.
14. Non- Argument: Example or Illustration

1.3 Lecture 3: Types of Arguments: Deductive vs Inductive

1.4 Lecture 4:Nature and Scope of Deductive and Inductive Arguments

1.4.1 Is the following argument best classified as deductive or inductive?

1. If inflation is receding, the government's economic policies are sound. Inflation is indeed receding. Therefore, the government's economic policies are sound.
2. Most of the crows observed so far have been black. Therefore, probably the next crow we see will be black.
3. When a lighted match is slowly dunked into water, the flame is snuffed out. But gasoline is a liquid, just like water. Therefore, when a lighted match is slowly dunked into gasoline, the flame will be snuffed out.
4. This figure is a Euclidean triangle. Therefore, the sum of its angles is equal to two right angles.
5. When a cook cant recall the ingredients in a recipe, it is appropriate that she refresh her memory by consulting the recipe book. Similarly, when a student cant recall the answers during a final exam, it is appropriate that she refresh her memory by consulting the textbook.
6. By accident Karina baked her cake two hours longer than she should have. Therefore, they have probably been ruined.
7. Based on a survey of 2200 randomly selected likely voters, 56.2% indicate that they will vote for the incumbent in the upcoming election. Therefore, approximately 56% of the votes in the upcoming election will be for the incumbent.
8. All reptiles ever examined are cold-blooded. Dinosaurs resemble reptiles in many ways. So dinosaurs were cold blooded.
9. On a National Geographic map, no two adjacent nations appear shaded with the same color. Brazil is shaded green on this map, and it is a National Geographic map. Only two nations in South America are not adjacent to Brazil. So at most three South American nations on this map are shaded green.

Answers

1. Deductive Argument; Modus Ponens.
2. Inductive: Conclusion probably follows from the premises.
3. Inductive, Weak Analogy
4. Deductive; True by definition.
5. Inductive, Strong
6. Inductive argument.
7. Inductive Argument
8. Deductive Argument.
9. Deductive Argument

1.5 Lecture 5: Truth, Validity and Soundness

1.6 Lecture 6: Strength of Inductive arguments, Counter example method

1.6.1 Construct counter examples for the following invalid arguments

1. 1. If Ravi is a philosopher, then Ravi is wise ($A \rightarrow B$)
2. Ravi is not a philosopher. $\neg A$
So, 3. Ravi is not wise. $\neg B$
2. All who seek public office are noble. Some who seek public office are not wise persons.
So, some wise persons are not noble.

Answers:

1. 1. If lemons are red, then lemons have a color.
2. Lemons have a color.
So, 3. Lemons are red.
2. All Cats are Animals. Some animals are not four-legged. Some four legged-species are not animals.

1.6.2 Evaluate the following Deductive and Inductive Arguments

1. Some professors wear glasses. Mr. Einstein wears glasses. Therefore, Mr. Einstein is a professor.
2. The overwhelming majority of mutations are not beneficial to an organisms survival. So the odds are that no mutation is going to give an organism super powers.
3. When a lighted match is slowly dunked into water, the flame is snuffed out. But gasoline is a liquid, just like water. Therefore, when a lighted match is slowly dunked into gasoline, the flame will be snuffed out.

4. No book in English begins numbering its pages on a left-hand page. This is a book in English, therefore it will begin its numbering on a right-hand page
5. It usually takes 2-3 days for a delivery to ship from the warehouse to your door via most major shipping services. You ordered on Tuesday morning, so it is safe to assume your package will arrive Thursday or Friday.
6. All math teachers are over 7 feet tall. Mr. Damodhar. is a math teacher. Therefore, Mr. Damodhar is over 7 feet tall.
7. No one who can afford health insurance is unemployed. All politicians can afford health insurance. Therefore, no politician is unemployed.
8. Just as a football player does not become great without pain, so too with a pianist. I will bet every great football player has at one time or another torn muscles, ligaments, or tendons; many have broken something; surely all have come away from practice bruised. So you want to be great? You want to be a concert pianist one day, a virtuoso? Then I want to see you hurt! I want to see you bleed, I want to see sprained or crushed fingers!
9. Roses are red and beautiful. Einstein was a genius. Therefore, if roses are red and beautiful, Einstein was a genius.
10. If you know that you are not real, then you are not real. If you know that you are not real, then you are real. So, you cannot know that you are not real.
11. Most of the logic quizzes in the course have been very easy so far. The teacher announced that the next quiz will be extremely difficult. Therefore, the next quiz will be very easy as well.

1.6.3 Answers

1. Invalid;
2. Inductive Argument, Strong, Cogent
3. Inductive Argument (analogy), Weak, Uncogent.
4. Valid, Sound
5. Inductive, Strong.
6. Valid, Unsound; the first premise is false.
7. Valid, Sound.
8. Weak analogy, Uncogent.
9. Valid, Unsound
10. Strong, Uncogent.

1.7 Lecture 7: Toulmin's Model of Argumentation

1.7.1 Identify claim, support, warrant, rebuttal in the following arguments

1. Universities should reinstate affirmative action admissions policies. Affirmative action provides equal access to education [Claim] policies. Affirmative action provides equal access to education for all ethnic groups.(Support) Equality of access is a basic American Value [Warrant]
2. It is Monday already, and last Thursday was Thanksgiving[Grounds]. By law, Thanksgiving can never fall before November 23rd[Warrant]. So. there are less than thirty days left[Claim] to do our Christmas shopping. Moreover, the date of Thanksgiving is established by Act of Congress [Backup] .[Toulmin, pp27]
3. In the following argument, identify the *claim, data(Grounds), rebuttal, warrant, qualifiers* using Toulmin's model.*The weather will be clearing and cooler by tomorrow morning. The accumulated experience of meteorologists in the North Temperature zone indicates that, in these latitudes, passage of a cold front is normally followed by clearing, cooler weather. Only this evening the wind has veered around (turned aside from a course) from SW toward NW; the rain has nearly stopped; there are local breaks in the clouds- all signs indicating the passage of a cold front. Unless some unusually complex frontal system is involved, chances are, it will be clearing and cooler by the morning.*

Chapter 2

Fallacies

2.1 Lecture 8: Identification of Formal and Informal Fallacies

2.1.1 Determine whether the fallacies committed by the following arguments are formal fallacies or informal fallacies.

1. If Rasputin was really mad, then he deceived Czar Nicholas II. Rasputin was not really mad. Therefore, he did not deceive Czar Nicholas II.
2. Everything that runs has feet. The Columbia River runs very swiftly. Therefore, the Columbia River has feet.
3. All people who believe we create our own reality are people who lack social responsibility. All people governed by selfish motives are people who lack social responsibility. Therefore, all people who believe we create our own reality are people governed by selfish motives.
4. The ship of state is like a ship at sea. No sailor is ever allowed to protest orders from the captain. For the same reason, no citizen should ever be allowed to protest presidential policies.
5. Renowned violinist Pinchas Zukerman has said, "When it comes to vodka, Smirnoff plays second fiddle to none." We must therefore conclude that Smirnoff is the best vodka available.
6. If the Chinese government systematically kills its unwanted orphans, then the Chinese government is immoral. The Chinese government is indeed immoral. Therefore, the Chinese government systematically kills its unwanted orphans.
7. Sarah Jessica Parker, Ben Affleck, and Julia Roberts are Democrats. Therefore, it must be the case that all Hollywood stars are Democrats.
8. Congresswoman Michele Bachmann argues in favor of drilling for oil in the Arctic National Wildlife Refuge. But consider this. Bachmann is a total moron, a complete idiot who would not recognize an oil well if she bumped into one. Clearly her arguments are ridiculous.
9. If plastic guns are sold to the public, then terrorists will carry them aboard airliners undetected. If plastic guns are sold to the public, then airline hijackings will increase.

Therefore, if terrorists carry plastic guns aboard airliners undetected, then airline hijackings will increase

Answers

1. Formal fallacy.
2. Informal fallacy.
3. Formal fallacy.
4. Informal Fallacy
5. Informal fallacy.
6. Formal fallacy.
7. Informal Fallacy
8. Informal fallacy.
9. Formal fallacy

Source: Patrick Hurley, Concise Introduction to Logic, 11th Edition pp 121

2.2 Lecture 9: Informal Fallacies: Fallacies of relevance

1. The position open in the accounting department should be given to Frank Thompson. Frank has six hungry children to feed, and his wife desperately needs an operation to save her eyesight.
2. Erica Evans, who takes orders at the local Taco Bell, argues persuasively in favor of increasing the minimum wage. But this is exactly what you would expect. Erica is paid the minimum wage, and if the minimum wage is increased, then her own salary will go up. Obviously Erica's arguments are worthless.
3. The school board argues that our schools are in desperate need of repair. But the real reason our students are falling behind is that they spend too much time with their computers. Becoming educated means a lot more than learning how to point and click. The school board should send a letter to the parents urging them to monitor their kids' computer time.
4. Whoever thrusts a knife into another person should be arrested. But surgeons do precisely this when operating. Therefore, surgeons should be arrested.
5. You should read Irving Stone's latest novel right away. It is sold over a million copies, and practically everyone in the Manhattan cocktail circuit is talking about it.
6. Friedrich Nietzsche's philosophy is not worth the paper it's printed on. Nietzsche was an immoral reprobate who went completely insane from syphilis before he died.
7. Surely you welcome the opportunity to join our protective organization. Think of all the money you will lose from broken windows, overturned trucks, and damaged merchandise in the event of your not joining.

8. Senator Barrow advocates increased Social Security benefits for the poor. It is regrettable that the senator finds it necessary to advocate socialism. Socialism defeats initiative, takes away promised rewards, and leads directly to inefficiency and big government. It was tried for years in Eastern Europe, and it failed miserably. Clearly, socialism is no good.
9. Something is seriously wrong with high school education these days. After ten years of decline, SAT scores are still extremely low, and high school graduates are practically incapable of reading and writing. The obvious conclusion is that we should close the schools.
10. The editors of the Daily Register have accused our company of being one of the city's worst water polluters. But the Daily Register is responsible for much more pollution than we are. After all, they own the Western Paper Company, and that company discharges tons of chemical residue into the city's river every day.
11. If 20 percent of adult Americans are functionally illiterate, then it's no wonder that morons get elected to public office. In fact, 20 percent of adult Americans are functionally illiterate. Therefore, it's no wonder that morons get elected to public office.
12. Ladies and gentlemen, today the lines of battle have been drawn. When the din of clashing armor has finally died away, the Republican party will emerge victorious! We are the true party of the American people! We embody the values that all real Americans hold sacred! We cherish and protect our founding fathers' vision that gave birth to the Constitution! We stand for decency and righteousness; for self-determination and the liberty to conduct our affairs as each of us freely chooses! In the coming election, victory will be ours, so help us God!
13. We've all heard the argument that too much television is the reason our students can't read and write. Yet many of today's TV shows are excellent. *Grey's Anatomy* unveils the personal lives of interns at an urban hospital, *Gossip Girl* explores the world of privileged teenagers at an elite private school, and *American Idol* uncovers hidden musical talent. Today's TV is just great!
14. Surely architect Norris is not responsible for the collapse of the Central Bank Tower. Norris has had nothing but trouble lately. His daughter eloped with a child molester, his son committed suicide, and his alcoholic wife recently left for Las Vegas with his retirement savings.
15. The First Amendment to the Constitution prevents the government from interfering with the free exercise of religion. The liturgical practice of the Religion of Internal Enlightenment involves human sacrifice. Therefore, it would be wrong for the government to interfere with this religious practice.

Source: Patrick Hurley (11ed), pp 133-134

Answers

1. Appeal to pity.
2. Adhominem Circumstantial
3. Red Herring

4. Accident
5. Ad Populaum.
6. Ad Hominem , Abusive
7. Appeal to force.
8. Strawmen
9. Ignoratio Elenchi
10. Tu quoque (you, too).
11. It is not fallacy. This is Modus ponens.
12. Ad Populum.
13. Red herring.
14. Appeal to pity
15. Fallacy of Accident.

2.3 Lecture 10: Fallacies of Weak Induction and Fallacies arising out of ambiguity in Language

2.3.1 Identify the fallacies of weak induction committed by the following arguments, giving a brief explanation for your answer. If no fallacy is committed, write no fallacy.

1. If a car breaks down on the freeway, a passing mechanic is not obligated to render emergency road service. For similar reasons, if a person suffers a heart attack on the street, a passing physician is not obligated to render emergency medical assistance.
2. There must be something to psychical research. Three famous physicists Oliver Lodge, James Jeans, and Arthur Stanley Eddington took it seriously.
3. The accumulation of pressure in a society is similar to the buildup of pressure in a boiler. If the pressure in a boiler increases beyond a critical point, the boiler will explode. Accordingly, if a government represses its people beyond a certain point, the people will rise up in revolt.
4. A few minutes after Governor Harrison finished his speech on television, a devastating earthquake struck southern Alaska. For the safety of the people up there, it is imperative that Governor Harrison make no more speeches.
5. Lester Brown, universally respected author of the yearly State of the World report, has said that the destruction of tropical rain forests is one of the ten most serious worldwide problems. Th us, it must be the case that this is indeed a very serious problem.
6. The abstinence only policy for birth control just doesnt work. After all, it didnt work for Jamie Lynn Spears, and it didnt work for Bristol Palin, either.

7. Probably no life exists on Venus. Teams of scientists have conducted exhaustive studies of the planet's surface and atmosphere, and no living organisms have been found.
8. We don't dare let the animal rights activists get their foot in the door. If they sell us on the idea that dogs, cats, and dolphins have rights, next it will be chickens and cows. That means no more chicken Kiev or prime rib. Next it will be worms and insects. That will lead to the decimation of our agricultural industry. The starvation of the human race will follow close behind.
9. No one has proved conclusively that America's nuclear power plants constitute a danger to people living in their immediate vicinity. Therefore, it is perfectly safe to continue to build nuclear power plants near large metropolitan centers.
10. There are more churches in New York City than in any other city in the nation, and more crimes are committed in New York City than anywhere else. So, if we are to eliminate crime, we must abolish the churches.

Answers:

1. Weak Analogy
2. Appeal to Unqualified Authority.
3. No fallacy
4. False Cause
5. Appeal to unqualified authority.
6. Hasty Generalization.
7. No Fallacy
8. Slippery Slope
9. Appeal to Ignorance
10. False Cause.

Source: Patrick Hurley (11Ed)- pp 149–150

Lecture 11: Fallacies arise out of ambiguity

Source: Patrick Hurley (11Ed)- pp 170–171

2.3.2 Identify the fallacies of presumption, ambiguity, and grammatical analogy committed by the following arguments, giving a brief explanation for your answer. If no fallacy is committed, write no fallacy.

1. Either we require forced sterilization of Third World peoples or the world population will explode and all of us will die. We certainly don't want to die, so we must require forced sterilization.
2. Every sentence in this paragraph is well written. Therefore, the paragraph is well written.

3. An athlete is a human being. Therefore, a good athlete is a good human being.
4. James said that he saw a picture of a beautiful girl stashed in Stephens locker. We can only conclude that Stephen has broken the rules, because girls are not allowed in the locker room.
5. Why is it so difficult for you to reach a decision?
6. Water will quench ones thirst. Water is composed of hydrogen and oxygen. Therefore, hydrogen will quench ones thirst, and so will oxygen.
7. People who lack humility have no sense of beauty, because everyone who has a sense of beauty also has humility.
8. Butane is combustible. Therefore, it burns.
9. Twenty years ago, Kung Fong, the great sumo wrestler, could have yanked up one of the fir trees in the new municipal arboretum with a single pull. Therefore, since Mr. Fong is as strong today as he was then, he could just as easily pull up one of those trees today.
10. If Thomas gives Marie a ring, then Thomas and Marie will be engaged. Thomas did give Marie a ring. In fact, he phoned her just the other night. Therefore, Thomas and Marie are engaged

Answers to 2.4.1

1. False Dichotomy
2. Fallacy of composition
3. Equivocation
4. Amphiboly
5. Complex Question
6. Fallacy of division
7. Begging Question
8. Begging the Question
9. Suppressed Evidence
10. Equivocation

Part II
Traditional Logic

Chapter 3

Syllogistic Logic

3.1 Lecture 11: Introduction and motivation for Syllogistic Logic

3.1.1 Name the form of each of the following categorical statements (A , E , I , or O). Identify the subject and predicate terms in each case. Then state the quantity (universal or particular) and quality (affirmative or negative).

Source: Frances Howard- Snyder (et..al), Power of Logic(4th Edition), pp 201-202

1. All hungry cannibals are dangerous people.
2. No Ohioans are Texans.
3. Some diamonds are not valuable objects.
4. No green vegetables are minerals.
5. Some outlaws are heroes.
6. All equilateral triangles are geometrical figures.
7. Some poems are not sonnets.

Answers:

1. A, hungry cannibals, dangerous people, universal, affirmative
2. E, Ohioans, Texans, universal, negative
3. O, diamonds, valuable objects, particular, negative
4. E, green vegetables, minerals, universal, negative
5. I, outlaws, heroes, particular, affirmative
6. A, equilateral triangles, geometrical figures, universal, affirmative.
7. O, poems, sonnets, particular, negative

3.1.2 Give the names of the logical relations that hold between the following pairs of corresponding categorical statements

Source: Power of Logic (4Ed), pp. 208

1. All roses are red flowers./No roses are red flowers.
2. All souls are immortal substances./Some souls are immortal substances.
3. Some people are jerks./Some people are not jerks.
4. No Apaches are Shawnees./Some Apaches are Shawnees.
5. No emeralds are plants./Some emeralds are not plants.
6. Some people who believe in ghosts are smart people./Some people who believe in ghosts are not smart people.
7. Some radical skeptics are profoundly miserable people./All radical skeptics are profoundly miserable people.
8. No truths are statements worth dying for./All truths are statements worth dying for.
9. All atoms are physical objects./Some atoms are not physical objects.
10. Some odd numbers are numbers that can be divided by 2 (without remainder)./Some odd numbers are not numbers that can be divided by 2 (without remainder).
11. Some gems are not amethysts./Some gems are amethysts.
12. All liars are harmful people./ No liars are harmful people.
13. Some leaders are followers./Some leaders are not followers.
14. All positive whole numbers between 4 and 6 are odd numbers./No positive whole numbers between 4 and 6 are odd numbers.
15. Some dinosaurs are not rational animals./No dinosaurs are rational animals

Answers for 3.1.2

1. Contraries A, E are contraries (Square of opposition)
2. Superaltern/subaltern
3. Subcontraries
4. Contradictories
5. Superaltern/subaltern Subcontraries
6. Subaltern/superaltern
7. Contraries
8. Contradictories
9. None. *Some odd numbers are numbers that can be divided by 2 (without remainder)* is necessarily false; hence, it cannot be true (subcontraries can both be true).

10. Subcontraries
11. Contraries
12. . Subcontraries
13. None. All positive whole numbers between 4 and 6 are odd numbers is a necessary truth; hence, it cannot be false (contraries can both be false).
14. Subaltern/superaltern

3.2 Lecture 12: Aristotle theory of Syllogisms-1

3.2.1 Specify the mood and figure of the following forms. Then use the list of valid forms provided in this section to determine whether the forms are valid.

1. . 1. Some P are M.
2. All S are M.
So, 3. Some S are P.
2. . 1. Some M are P.
2. Some M are S.
So, 3. Some S are P.
3. . 1. All P are M.
2. No M are S.
So, 3. No S are P.
4. . 1. No M are P.
2. Some M are not S.
So, 3. Some S are P.
5. 1. No M are P.
2. All S are M.
So, 3. No S are P.
6. . 1. No P are M.
2. All M are S.
So, 3. No S are P.
7. . 1. All P are M.
2. Some S are M.
So, 3. Some S are P.
8. . 1. Some P are not M.
2. Some S are not M.
So, 3. Some S are not P.

3.2.1 Answers

1. Second figure: IAI (not valid)
2. Third figure: III (not valid)
3. Fourth figure: AEE (valid)
4. . Third figure: EOI (not valid)
5. First figure: EAE (valid)
6. Fourth figure: EAE (not valid)
7. Second figure: AII (not valid)
8. Second figure: OOO (not valid)

3.3 Lecture 13: Aristotle theory of Syllogism-2: Rules for Validity of Syllogism

3.3.1 Summary of Rules for Determining the Validity of Categorical Syllogisms

1. Rule 1: A valid standard-form categorical syllogism must contain exactly three terms, and each term must be used with the same meaning throughout the argument.
2. Rule 2: In a valid standard-form categorical syllogism, the middle term must be distributed in at least one premise.
3. Rule 3: In a valid standard-form categorical syllogism, a term must be distributed in the premises if it is distributed in the conclusion.
4. Rule 4: In a valid standard-form categorical syllogism, the number of negative premises must be equal to the number of negative conclusions.
5. Rule 5: No valid standard-form categorical syllogism with a particular conclusion can have two universal premises.

Source: Snyder, *Power of Logic* (4 Ed), pp- 272

3.3.2 Apply the five rules set forth in this section to determine whether the following forms are valid. It may be useful first to determine the mood and figure of each argument form.pp 273

1. No P are M. No M are S. So, no S are P.
2. All M are P. No S are M. So, no S are P.
3. All M are P. All M are S. So, all S are P.
4. All P are M. All S are M. So, all S are P.
5. No M are P. Some S are M. So, some S are not P.

6. No M are P. All M are S. So, some S are not P.
7. All P are M. Some S are not M. So, some S are not P.
8. Some M are P. All S are M. So, some S are not P.
9. All M are P. Some S are not M. So, some S are not P.
10. Some P are not M. Some S are not M. So, some S are not P.

3.3.3 Answers for 3.3.2

1. Some M are P. No S are M. So, some S are not P. Mood: IEO. First figure. The syllogism violates Rule 3: invalid.
2. All M are P. No S are M. So, some S are P. Mood: AEI. First figure. Violates Rule 4 and Rule 5: invalid. (Since it violates Rule 5, it is invalid on the modern view of existential import, but if that were the only rule it violated, it would be valid on the traditional Aristotelian view. However, it also violates Rule 4 [having an affirmative conclusion with a negative premise], and so is invalid on the traditional Aristotelian view.)
3. No P are M. Some S are M. So, some S are not P. Mood: EIO. Second figure. Satisfies all five rules: valid.
4. All P are M. No S are M. So, no S are P. Mood: AEE. Second figure. There is an equivocation on the word animals. In the second premise animals means nonhuman animals. In the first premise animals means (roughly) living organisms capable of moving about. The syllogism thus violates Rule 1: invalid.
5. All M are P. No S are M. So, no S are P. Mood: AEE. First figure. Violates Rule 3: invalid.
6. No P are M. Some M are S. So, some S are not P. Mood: EIO. Fourth figure. Satisfies all five rules: valid.
7. All M are P. All S are M. So, some S are P. Mood: AAI. First figure. Violates Rule 5: hence invalid on the modern view. But since it does not violate any other rules, it is valid on the traditional Aristotelian view.
8. All M are P. Some M are S. So, some S are P. Mood: AII (nominally). Third figure (nominally). If this were the correct form of the syllogism, it would be valid. But there is an equivocation on the term banks, which is used in the sense of the bank of a river in the first premise, and in the sense of a financial institution in the second premise, so that this argument does not have three and only three terms, but four terms, and thus it violates Rule 1. In effect, it is not really a syllogism. (Note that it is possible for an argument with four or more terms to be valid, though that isn't the case with this example.)
9. All P are M. All S are M. So, all S are P. Mood: AAA. Second figure. Violates Rule 2: invalid.
10. Some M are not P. All S are M. So, some S are not P. Mood: OAO. First figure. The syllogism violates Rule 2: invalid.

3.3.4 Valid or Invalid?

1. Some great scientists are famous. No TV stars are great scientists. So, some TV stars are not famous.
2. No deathly ill people are hypochondriacs. All hypochondriacs are dysfunctional people. Accordingly, some deathly ill people are dysfunctional people.
3. Some books written by Kant are not great books. For no great books are books that put their readers to sleep. But some books written by Kant are books that put their readers to sleep.
4. No humans are animals. All members of homosapiens are animals. Therefore, no humans are members of homosapiens.
5. All values that can be quantified are important values. No human emotions are values that can be quantified. Consequently, no human emotions are important values.
6. No great altruists are great thinkers. Some great thinkers are people who make life better for humanity in general. It follows that some people who make life better for humanity in general are not great altruists.
7. All cars are vehicles. All Ford automobiles are cars. Hence, some Ford automobiles are vehicles.
8. All banks are edges of rivers. Some banks are financial institutions. Thus, some financial institutions are edges of rivers.
9. All acts that promote the general welfare are commanded by God. For all acts commanded by God are obligatory acts. And all acts that promote the general welfare are obligatory acts.
10. All of the greatest human achievements are accomplishments that have come at a great price. Some accomplishments that have come at a great price are not brilliant discoveries. We may conclude that some of the greatest human achievements are not brilliant discoveries.

3.3.5 Answer: 3.3.4

1. Some M are P. No S are M. So, some S are not P. Mood: IEO. First figure. The syllogism violates Rule 3: invalid.
2. All M are P. No S are M. So, some S are P. Mood: AEI. First figure. Violates Rule 4 and Rule 5: invalid. (Since it violates Rule 5, it is invalid on the modern view of existential import, but if that were the only rule it violated, it would be valid on the traditional Aristotelian view. However, it also violates Rule 4 [having an affirmative conclusion with a negative premise], and so is invalid on the traditional Aristotelian view.)
3. . No P are M. Some S are M. So, some S are not P. Mood: EIO. Second figure. Satisfies all five rules: valid.
4. All P are M. No S are M. So, no S are P. Mood: AEE. Second figure. There is an equivocation on the word animals. In the second premise animals means nonhuman animals. In the first premise animals means (roughly) living organisms capable of moving about. The syllogism thus violates Rule 1: invalid.

5. All M are P. No S are M. So, no S are P. Mood: AEE. First figure. Violates Rule 3: invalid.
6. No P are M. Some M are S. So, some S are not P. Mood: EIO. Fourth figure. Satisfies all five rules: valid.
7. All M are P. All S are M. So, some S are P. Mood: AAI. First figure. Violates Rule 5: hence invalid on the modern view. But since it does not violate any other rules, it is valid on the traditional Aristotelian view.
8. All M are P. Some M are S. So, some S are P. Mood: AII (nominally). Third figure (nominally). If this were the correct form of the syllogism, it would be valid. But there is an equivocation on the term banks, which is used in the sense of the bank of a river in the first premise, and in the sense of a financial institution in the second premise, so that this argument does not have three and only three terms, but four terms, and thus it violates Rule 1. In effect, it is not really a syllogism. (Note that it is possible for an argument with four or more terms to be valid, though that isn't the case with this example.)
9. All P are M. All S are M. So, all S are P. Mood: AAA. Second figure. Violates Rule 2: invalid.
10. Some M are not P. All S are M. So, some S are not P. Mood: OAO: First figure. The syllogism violates Rule 2: invalid.

3.4 Lecture 14: Syllogistic Poem, Reduction of Syllogisms

3.4.1 Syllogistic Poem: Patrick Hurley 263

Barbara, Celarent, Darii, Ferioque prioris;
Cesare, Camestres, Festino, Baroco secundae;
Tertia, Darapti, Disamis, Datisi, Felapton,
Bocardo, Ferison habet: quarta insuper addit
Bramantip, Camenes, Dimaris, Fesapo, Fresison.

3.4.2 Analysis:

1. First Figure: BARBARA, CELARENT, DARI, FERIO M P/S M
 - 1) The minor premise must be affirmative.
 - 2) The major premise must be universal.
2. Second Figure: CESARE, CAMESTRES, FESTINO, BAROCO P M/S M
 - 1) One premise must be negative.
 - 2) The major premise must be universal.
3. Third Figure: DARAPTI, DISAMIS, DATISI, FELAPTON, BOCARDO, FERISON MP/MS
 - 1) The minor premise must be affirmative.
 - 2) The conclusion must be particular.
4. Fourth Figure: BRAMANTIP, CAMENES, DIMARIS, FESAPO, FRESISON
 - 1) If the major premise is affirmative, the minor premise must be universal.
 - 2) If the minor premise is affirmative, the conclusion must be particular.
 - 3) If either premise is negative, the major must be universal

3.4.3 Reduction

The names of the moods are in a code that tells how to convert the syllogism in question to a syllogism of the first figure, which was regarded as more perfect:

1. s: means that the subject and predicate of the preceding proposition should be exchanged, without changing the quantity.
2. p: means that the subject and predicate of the preceding proposition should be exchanged, while changing the quantity of the proposition.
3. m: exchange the major and minor premises.
4. c: an indirect reduction to BARBARA by contradicting the conclusion, using it as a premise and deriving the contradiction of the premise followed by "c", which becomes a reductio ad absurdum of the denial of the mood, e.g. BOCARDO, extended to the derivation of the conclusion from the original premises:

3.4.4 Reduce each of the second and third figure syllogisms to some first figure syllogism

3.4.5 Some Important References;

1. Raymond McCall, Basic Logic, Barnes & Noble, 1967.
2. symbolic apparatus from Elementary Logic, by Benson Mates (Oxford, 1972)

Part III

Classical Logic: First Order Logic

Chapter 4

Propositional Logic

4.1 Lecture 15: Nature and Scope of Propositional Logic

4.1.1 Symbolize the following, which require frequent use of the \rightarrow .

1. John will make supper only if Mary is working late.
2. Mary will make supper if John is working late.
3. John will not make supper unless he is very hungry.
4. John works late if and only if Mary does not.
5. Not both John and Mary will make supper.
6. If I keep my gas guzzler I contribute to global warming, but if I buy a new car I consume a lot of natural resources.
7. I'll get a bicycle if and only if the city builds a bike path and I don't buy either a new or a used car..
8. I won't buy both a bicycle and a used car unless I either get a raise or inherit a lot of money.

4.1.2 Answers

1. $J \rightarrow M$.
2. $J \rightarrow M$.
3. $\neg H \rightarrow \neg J$.
4. $L \leftrightarrow \neg W$.
5. $\neg(J \wedge M)$.
6. $(K \rightarrow W) \wedge (N \rightarrow C)$
7. $B \leftrightarrow (P \wedge \neg(N \vee U))$.
8. $\neg(R \vee I) \rightarrow \neg(B \wedge U)$.

4.1.3 Which of the following sentences are declarative?

1. The sum of the numbers 3 and 5 equals 8.
2. Jane reacted violently to Jack's accusations.
3. Every even natural number 2 is the sum of two prime numbers.
4. Could you please pass me the salt?
5. Ready, steady, go.
6. May fortune come your way.

4.1.4 Answers for 4.1.3

1. 1-3 are declarative
2. 3-6 are not declarative, as they cannot be clearly spoken to be true or false.

4.2 Lecture 16: Syntax of Propositional Logic

4.2.1 For each of the following compound propositions, construct the parse tree. What is the main connective in each case?

1. $(\neg p) \wedge q$
2. $\neg(p \wedge q)$
3. $(q_1 \wedge q_2) \wedge q_3$
4. $q_1 \wedge (q_2 \wedge q_3)$
5. $\neg((p \vee q) \wedge r)$
6. $((\neg p) \wedge (\neg q)) \vee (\neg r)$

4.2.2 Parse each of the following compound propositions. Represent the answer by introducing appropriate parentheses

1. $p \wedge q \wedge \neg r$.
2. $p \vee q \vee \neg r$
3. $q \wedge \neg p \vee q$
4. $p \wedge q \vee \neg r \wedge p$.

4.2.3 Answers for 4.2.2

1. $(p \wedge q) \wedge \neg r$.
2. $(p \vee q) \vee \neg r$
3. $(q \wedge \neg p) \vee q$
4. $[(p \wedge q) \vee (\neg r \wedge p)]$.

4.2.4 Which of the following words are well formed?

1. $(P \wedge Q) \vee R$
2. $\vee(\wedge PQ)R$
3. $(P \wedge Q)$
4. $P \& Q$
5. $((\neg P)) \vee Q$
6. $((((P \wedge Q) \vee R))$

4.2.5 Answers 4.2.4

1. $(P \wedge Q) \vee R$: Not strictly a wff, as parenthesis is missing, but in practice, it can be avoided.
2. $\vee(\wedge PQ)R$: Clearly not a WFF.
3. $(P \wedge Q)$: WFF
4. $P \& Q$: Not a wff, because of $\&$
5. $((\neg P)) \vee Q$: Not strictly a wff, we may skip brackets and simply write it as $\neg p \vee q$.
6. $((((P \wedge Q) \vee R))$; Excessive brackets when removed, becomes $(p \wedge q) \vee r$

4.3 Lecture 17: Logical Connectives: Truth Tables

4.3.1 Descriptive Questions

1. Why is an argument form with inconsistent premises valid rather than invalid?
2. What is the relationship between validity and logical implication?
3. Why do all three definitions of logical equivalence amount to the same thing?
4. Can one say that a statement form is valid? Why or why not?

4.3.2 Compute the complete truth table of the formula and show whether it is a tautology, contingent or contradiction.

1. $((p \rightarrow q) \rightarrow p) \rightarrow p$
2. $p \vee (\neg(q \wedge (r \rightarrow q)))$
3. $(p \wedge q) \rightarrow (p \vee q)$
4. $((p \rightarrow \neg q) \rightarrow \neg p) \rightarrow q$
5. $((p \rightarrow q) \vee (p \rightarrow \neg q))$
6. $((p \vee q) \rightarrow r) \rightarrow ((p \rightarrow r) \vee (q \rightarrow r))$

4.3.3 Use the truth table method to decide whether the following pairs of statement forms are logically equivalent

1. $\neg(p \wedge q)$ and $(\neg p \vee \neg q)$.
2. $p \leftrightarrow \neg q$ and $(p \rightarrow q) \wedge (p \rightarrow \neg q)$
3. $\neg p \leftrightarrow q$ and $\neg(p \leftrightarrow q)$
4. $(p \wedge q) \rightarrow q$ and $p \rightarrow (p \wedge q)$
5. $(p \vee q) \rightarrow p$ and $\neg q \rightarrow \neg(p \wedge q)$

4.4 Lecture 18: Truth Table Method: Validity, Consistency, Logical Equivalence

4.4.1 Use the truth table method to decide whether the following sets of statement forms are consistent.

1. $(p \rightarrow q), (\neg p \vee \neg q), \neg(q \rightarrow p)$
2. $(p \leftrightarrow \neg q), \neg(p \leftrightarrow \neg q), (p \rightarrow (p \vee q))$.
3. $(p \vee q) \rightarrow p, (\neg(p \vee q) \rightarrow \neg p), p \leftrightarrow \neg q$

4.5 Lecture 19: Semantic Tableaux Method for Propositional Logic

4.5.1 Check Consistency of the group of statements

1. If the human population continues to explode, then the planet will become polluted and most animal species will become extinct.
If the planet is polluted, then the human population will not continue to explode.
If the human population does not continue to explode, then it is not true that most animal species will become extinct
2. $(p \rightarrow q), (\neg p \vee \neg q), \neg(q \rightarrow p)$
3. $(p \leftrightarrow \neg q), \neg(p \leftrightarrow \neg q), (p \rightarrow (p \vee q))$.
4. $(p \vee q) \rightarrow p, (\neg(p \vee q) \rightarrow \neg p), p \leftrightarrow \neg q$
5. There will be war only if arms production continues.
There will be war only if arms production does not continue.
Arms production will continue.
There will be no war.
6. If John was elected, then education was supported but taxes were not raised.
John was elected if and only if Mary was not elected.
If Mary was elected, then taxes were not raised but education was supported.

4.5.2 Symbolize and construct proofs for the following valid arguments using Semantic Tableaux Method

Source: Understanding Symbolic Logic,

1. Either Plato or Democritus believed in the theory of forms. Plato believed in the theory of forms only if he was not an atomist, and Democritus was an atomist only if he did not believe in the theory of forms. Democritus was an atomist. Therefore, Plato was not an atomist.
2. If I smoke or drink too much, then I don't sleep well, and if I don't sleep well or don't eat well, then I feel rotten. If I feel rotten, I don't exercise and don't study enough. I do smoke too much. Therefore, I don't study enough.
3. If the Bible is literally true, then Earth was created in six days. If Earth was created in six days, then carbon dating techniques are useless and scientists are frauds. Scientists are not frauds. The Bible is literally true. Therefore, God does not exist.
4. If nuclear power becomes our chief source of energy, then either there will be a terrible accident or severe waste disposal problems. If there are severe waste disposal problems and an increase in uranium costs, then Americans will cut their energy consumption. There will be a terrible accident only if safeguards are inadequate. Nuclear power will become our chief source of power, and uranium costs will increase, but safeguards are not inadequate. Therefore, Americans will cut their energy consumption.
5. Either scientists don't know what they are talking about, or the sun will eventually burn out and Earth will become dark and cold. If scientists don't know what they are talking about, then Mars is teeming with life. If Earth becomes dark and cold, then either the human race will migrate to other planets or will die out. Mars is not teeming with life, but the human race will not die out. Therefore, the human race will migrate to other planets.

4.5.3 Construct proofs for the following more challenging problems, justifying each step that is not a premise, using Semantic Tableaux Method:

1. $(F \vee G) \vee H, (F \rightarrow H) \wedge (H \rightarrow T), \neg T \vee W, \neg W \wedge S \vdash G \wedge S$
2. $D \rightarrow (A \vee C), D \wedge \neg A \vdash C$
3. $F \rightarrow (G \wedge \neg H), (Z \rightarrow H), F \vdash \neg Z$
4. $(B \vee C) \rightarrow A, A \rightarrow (S \vee T), B \wedge \neg S, (T \wedge A) \rightarrow (W \rightarrow S) \vdash \neg W$

4.6 Lecture 20: Knights and Knaves Puzzles

4.6.1 Knights and Knaves Puzzles

There is an island far off in the Pacific, called the island of Knights and Knaves. On this island, there are people called knights (who always tell the truth) and knaves (who always lie). They may be either male or female.

1. We have three people A, B, and C on the Island of Knights and Knaves. Suppose A and B say the following: A: All of us are knaves.
B: Exactly one of us is a knave.
Can it be determined what B is? Can it be determined what C is?
2. Suppose A says, "I am a knave but B isn't." What are A and B?
3. We again have three inhabitants, A, B and C, each of whom is a knight or a knave. Two people are said to be of the same type if they are both knights or both knaves. A and B make the following statements: A: B is a knave.
B: A and C are of the same type.
What is C?
4. Again three people A, B and C. A says "B and C are of the same type." Someone then asks C, "A and B of the same type?" What does C answer?
5. We have two people A, B, each of whom is either a knight or a knave. Suppose A makes the following statement: "If I am a knight, then so is B." Can it be determined what A and B are?
6. Someone asks A, "Are you a knight?" He replies, "If I'm a knight, then I'll eat my hat!" Prove that A has to eat his hat.
7. Given two people, A, B, both of whom are knights or knaves. A says, "If B is a knight then I am a knave." What are A and B?
8. Two individuals, X and Y, were being tried for participation in a robbery. A and B were court witnesses, and each of A, B is either a knight or a knave. The witnesses make the following statement:
A: If X is guilty, so is Y.
B: Either X is innocent or Y is guilty. Are A and B necessarily of the same type? (i.e. either both knights or both knaves.)
9. On the island of knights and knaves, three inhabitants A, B, C are being interviewed. A and B make the following statements:
A: B is a knight.
B: If A is a knight so is C.
Can it be determined what any of A, B, C are?
10. Suppose the following two statements are true: (1) I love Betty or I love Jane. (2) If I love Betty then I love Jane. Does it necessarily follow that I love Betty? Does it necessarily follow that I love Jane?
11. Suppose someone asks me, "Is it really true that if you love Betty then you also love Jane?" I reply, "It is true, then I love Betty." Does it follow that I love Betty? Does it follow that I love Jane?
12. This problem, though simple, is a bit surprising. Suppose it is given that I am either a knight or a knave. I make the following two statements:
(a) I love Linda.
(b) If I love Linda then I love Kathy.
Am I a knight or a knave?

13. Is There Gold on This Island? On a certain island of knights and knaves, it is rumored that there is gold buried on the island. You arrive on the island and ask one of the natives, A, whether there is gold on this island. He makes the following response: There is gold on this island if and only if I am a knight." Our problem has two parts:
 - (a) Can it be determined whether A is a knight or a knave?
 - (b) Can it be determined whether there is gold on the island?
14. Suppose, instead of A having volunteered this information, you had asked A, Is the statement that you are a knight equivalent to the statement that there is gold on this island?" Had he answered Yes," the problem would have reduced to the preceding one. Suppose he had answered No." Could you then tell whether or not there is gold on the island?
15. One inhabitant approaches you and says: I spoke this exact same sentence yesterday." Can you determine whether he is a knight or a knave?
16. Here is a bit of an off-beat question. One day, on the island of Knights and Knaves, you see an inhabitant. You go up to her and ask: Are you a knight or are you a knave?" She says: I won't tell you" and walks away. Is it possible to decide if she is a knight or a knave?

Source: Raymond Smullyan, *What is the name of the book*

4.7 Lecture 21: Semantic Tableaux Method: Further Examples

4.7.1 See Scanned copy for Lady or Tiger Puzzles

4.8 Lecture 22 Natural Deduction Method

4.9 Lecture 23: Natural Deduction: Examples

4.9.1 Using Natural Deduction method, show that the following logical consequence in the following arguments

1. Either Plato or Democritus believed in the theory of forms. Plato believed in the theory of forms only if he was not an atomist, and Democritus was an atomist only if he did not believe in the theory of forms. Democritus was an atomist. Therefore, Plato was not an atomist.
2. If I smoke or drink too much, then I don't sleep well, and if I don't sleep well or don't eat well, then I feel rotten. If I feel rotten, I don't exercise and don't study enough. I do smoke too much. Therefore, I don't study enough.
3. If the Bible is literally true, then Earth was created in six days. If Earth was created in six days, then carbon dating techniques are useless and scientists are frauds. Scientists are not frauds. The Bible is literally true. Therefore, God does not exist.

4.10 Lecture 24: Conjunctive and Disjunctive Normal Forms

4.10.1 Find a disjunctive normal form for each of the following propositional terms:

1. $p \rightarrow (p \rightarrow q)$
2. $(\neg p \vee r) \wedge \neg(q \rightarrow s)$;
3. $(p \rightarrow q) \wedge (q \rightarrow p)$;
4. $(p \rightarrow (\neg p \vee q)) \wedge \neg(p \rightarrow q)$;
5. $(p \rightarrow q) \wedge \neg(p \vee (\neg q \wedge r))$.

4.11 Lecture 25 CNF, DNF and satisfiability and Validity:

4.12 Lecture 26 Resolution and refutation method

4.12.1 Using resolution refutation method, show whether the following arguments are valid or invalid

1. $A \vee B \vee C, A \vee B \vee C \vee D, \neg B \vee C, \neg A \vdash_{RR} C$.
2. $A \rightarrow B, B \rightarrow C, C \rightarrow D, D \rightarrow (E \vee F), \vdash A \rightarrow F$
3. Either scientists don't know what they are talking about, or the sun will eventually burn out and Earth will become dark and cold. If scientists don't know what they are talking about, then Mars is teeming with life. If Earth becomes dark and cold, then either the human race will migrate to other planets or will die out. Mars is not teeming with life, but the human race will not die out. Therefore, the human race will migrate to other planets.

4.13 Lecture 27 Resolution and refutation method: Examples

4.14 Lecture 28: Axiomatic Propositional Logic

4.15 Lecture 29: Hilbert Ackermann Axiomatic system

4.15.1 Prove the following theorems using Russell-Whitehead Axiomatic System

1. $\vdash p \rightarrow p$
2. $\vdash \neg p \rightarrow p$
3. $\vdash p \rightarrow \neg\neg p$.
4. $\vdash \neg\neg p \rightarrow p$

5. $\vdash (p) \rightarrow p$

6. $\vdash q \rightarrow (p \rightarrow q)$

7. $\vdash (p \rightarrow \neg q) \rightarrow (q \rightarrow \neg p)$

8. $\vdash (p \rightarrow (q \rightarrow r)) \rightarrow q \rightarrow (p \rightarrow r)$.

4.16 Lecture 30: Proofs in the PM system

4.16.1 See Scanned copy for problems and solutions

4.17 Lecture 31: Hilbert and Ackermann System

4.18 Lecture 32: Characteristics of formal system PM

Chapter 5

Predicate Logic

5.1 Lecture 33: Outlines of Predicate Logic

5.1.1 Symbolize the following in Predicate Logic

1. Some people who ate chicken got sick. (Px, Cx)
2. Everyone who got sick ate either chicken or ham salad.
3. Not everyone who ate chicken and ham salad ate both potatoes and bean salad.
4. No beautiful people who are not good will get to heaven.
5. Some good people are appreciated even though they are not either rich or famous.
6. Not only the rich or famous will get to heaven.

5.2 Lecture 34: Building blocks of Predicate Logic

5.2.1 Which of the following are sentences in Predicate Logic

Definition 1 *A sentence is a formula with no free variables*

1. $\text{bought}(\text{Ravi}, \text{Book})$
2. $\text{bought}(\text{Savita}, \text{Car})$
3. $x = x$
4. $\forall x (\exists y ((y = x) \rightarrow x = y))$
5. $\forall x \forall y (x = y \rightarrow \forall z (R(x, z) \rightarrow R(y, z)))$

5.2.2 Answers

1. Not a sentence. It has free variables.
2. Not a sentence.
3. Not a sentence in PL
4. Sentence, it has no variables.
5. Sentence.

5.3 Lecture 35: Quantifiers, freedom, bondage

5.3.1 Determine free and bound variables of next formulas

1. $\forall x (\forall y P(x, y, z) \rightarrow Q(x, y))$.
2. $\forall y \exists z (P(x, y, z) \rightarrow \exists z Q(z, x))$
3. $\exists x \forall y (P(x) \vee Q(x, y)) \rightarrow \forall y Q(x, y)$.
4. $\forall x (R(x, y) \wedge R(y, z) \rightarrow \exists z (S(x, z) \wedge R(z, y)))$

Answers

1. Variable z is free and the second occurrence of y is free; whereas x is bound, in both the occurrences.
2. x is free on both occurrences, other variables are bound.
3. Second occurrence of x is free, where as the variable "y" is bound on both occurrences.

5.4 Lecture 36: Translation in to predicate Logic

5.4.1 Translating simple syllogistic sentences

1. All A are B
2. No A are B
3. Some A are B
4. Not all A are B
5. Some A are not B

Answers

1. $\forall x (A_x \rightarrow B_x)$
2. $\neg \exists x (A_x \rightarrow B_x)$.; It is same as $\forall x (A_x \rightarrow \neg B_x)$.
3. $\exists x (A_x \wedge B_x)$
4. $\neg \forall x (A_x \rightarrow B_x)$.
5. $\exists x (A_x \wedge \neg B_x)$.

5.5 Lecture 37: Semantics of Predicate Logic

5.6 Lecture 38: Truth, satisfiability, validity in Predicate Logic

5.7 Lecture 39: Formation Trees for wff's in predicate Logic

5.8 Lecture 40: Semantic Tableaux Method for Predicate Logic

5.8.1 Using Semantic Tableaux method show whether the following arguments are valid or invalid?

5.9 Lecture 41: Semantic Tableaux method: Satisfiability, Validity

5.9.1 Which of the following wff in PL are valid?

1. $\forall_x(P(x) \rightarrow \exists_x P(x))$.
2. $\forall_x P(x) \rightarrow P(a)$.
3. $\forall_x[(P(x) \wedge Q(x)) \rightarrow \forall_x P(x) \wedge \forall_x Q(x)]$
4. $\exists_x P(x) \rightarrow \forall_x P(x)$

5.9.2 Answers for 5.9.1

1. 1-3 are valid.
2. 4 is invalid.

5.9.3 Use semantic tableaux to prove the following claims

1. Everyone who loves themselves, loves some one.
2. $\forall_x(Px \leftrightarrow Qx) \vdash \forall_x((Px \wedge Qx) \vee (\neg Px \wedge \neg Qx))$
3. There is an abstract object which is loved by every mathematician. **Therefore**, every mathematician loves atleast one abstract object.
4. Some Scientists are bureaucrats. Some bureaucrats are immoral. **Therefore**, some Scientists are immoral.
5. No one loves all and only those people who do not love themselves.

5.9.4 See answers in the scanned copy

5.9.3

5.10 Lecture 42: Natural Deduction in Predicate Logic

5.10.1 See section Scanned copy for questions and Answers

5.11 Lecture 43: Important theorems in First order Logic

5.12 Lecture 44: Limitations of first order logic and Introduction to the course

5.12.1 Some Questions

1. What are the limitations of First order Logic?
2. What are the differences between predicate logics and propositional logics?
3. Analyze the following sentence using Predicate Logic. *The present king of India is bald.*

5.12.2 Answers

1. It fails to explain "vague" predicates, sentences like "this sentence is false", future contingent sentences (like there will be a sea battle tomorrow), etc.
2. Fundamental difference is that predicate logic makes use of quantifiers whereas propositional logic does not.
3. Non-denoting Definite descriptions: In 1905, Bertrand Russell raised the question of the truth-value of sentences containing non-denoting definite descriptions (On Denoting).
 - (a) The present king of France is bald.
 - (b) There is no present king of France, so the definite description does not denote.
 - (c) Russell decided to treat any such sentence as false, on the grounds that the use of the definite description indicates the existence of what it ostensibly denotes.
 - (d) Thus, the sentence The present king of France is bald is false.
 - (e) An alternative approach is to declare that the sentence has no truth-value when a definite description it contains fails to denote
 - (f) Russell Symbolized it as: $\exists y((Fx \wedge \forall y(Fy \rightarrow (x = y)) \wedge B_x)$
4. What is the Syntactical Proof of Implication of Russells Transcription($\exists x)(Fx \wedge (\forall y)(Fy \rightarrow x = y)) \wedge (\forall x)(Fx \rightarrow B_x)$. by Tellers

5.13 References

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4. Graham Priest, A very short introduction to logic, Oxford University Press, 2001

5. Martin Gardner, *aha! Insight aha! Gotcha*, AMS series, 2002
6. Raymond Smullyan, *What is the name of this book? The riddle of Dracula and other interesting puzzles*, Dover publications, 1978
7. Cederblom, Jerry, Paulsen, David, *Critical Reasoning: Understanding and criticizing Arguments and theories*, paperback, 2005

Part IV
Description and Syllabus

Chapter 6

About the Course

6.1 Description of Course:

Logic is one of the oldest intellectual disciplines in the human history. It has been studied as a sub-discipline of philosophy for over 2400 years, its most recent rigorous formulation in the early 20th century made it an integral part of the foundations of mathematics, and led to the creation of computer science. The subject matter of logic is primarily concerned with a systematic study of evaluating arguments, and the basic principles of valid reasoning. Reasoning is involved in most of the intellectual activities, logic serve as a justificatory tool in the domains of knowledge such as mathematics, natural science and computer science. The objective of the course is to enhance your skills in reasoning logically and analyzing various kinds of arguments you will come across elsewhere in your studies and in the course of your lives. This course familiarize you with certain formal methods for representing and evaluating arguments and inferences. The uniqueness of this course is the introduction of basic concepts of logic through some logical puzzles, taken from the books of Raymond Smullyan and Martin Gardner.

6.2 Syllabus

Basic concepts, Inductive and Deductive Arguments, Formal and Informal Fallacies, Syllogistic logic and its limitations, Origin of modern logic, Basic principles of first order logic(propositional and predicate logic), Decision procedures (truth table, natural deduction, semantic tableaux method), limitations of first order logic, Godel's incompleteness theorem.