Research Methodology
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Lecture - 09
Logical Reasoning: Deductive Logic Part 02

In the logical structures that we have learnt in the last class, the conclusions were of 0-1 type, either it is true or false. All insects have 6 legs, so this insect has 6 legs. Yes or no? Yes or no type answer—that is where that kind of reasoning was applicable.

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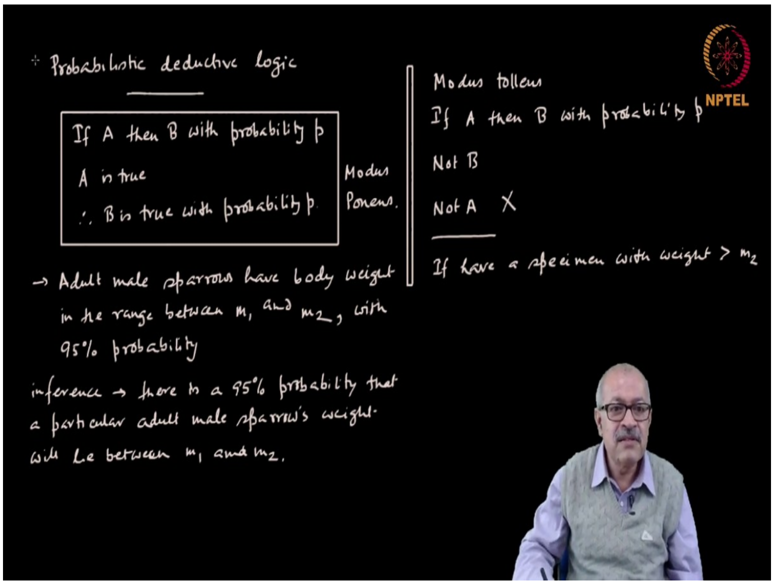

But in many cases, we have to make a probabilistic conclusion. Probabilistic conclusion of the type—this is called probabilistic deductive logic—of the kind that 99.99 percent of humans have heart on the left side of the chest. It is probabilistic. If that is the inductive inference available to us, that is the premise.

Then I have encountered a particular human. A doctor sitting in his chamber, a new patient has come, and without examining where the heart is, what will his conclusion be? Well, it will be that, I can say with 99.99 percent confidence, that the heart will be in the left-hand side, or the probability that the heart is in the left-hand side is 0.9999 or 99.99 percent.

In this case, what is the logical structure we are adopting? We are saying that the initial thing is given as ‘if A then B’, but then with a probability, not black and white, not always, but with probability *p*. Now, the second premise is that A is true. I have encountered a human. If A is a human, then B is ‘his or her heart will be on the left side of the chest with probability 99.99 percent’.

Now, A is true; that means, what I have encountered is a human. It is a human, A is true, therefore, we can infer that B is true with probability p. Same probability. So, that is the structure of argument then. This argument, this structure of argument, will be used again and again in science, whenever there is a probability involved in any decision-making process.

Suppose, a biologist is trying to find out the average weight of male sparrows. What will she do? She will go out in the field, catch a few male sparrows and weigh them and then using the methodology that we will be dealing with after a few classes—there are very definite methodologies for that—she will infer that something like this: Adult male sparrows have body weight in the range between, say, m_1 and m_2.

So, adult male sparrows have body weight in this range. Then, what can we infer on that basis? This is the inductive inference. The inductive inference has to be given in terms of some kind of a probabilistic statement and that is always given in terms of ‘with 95 percent probability’.

It is also stated often in terms of ‘adult male sparrows have body weight in the range between m_1 and m_2 and I can state that with 95 percent confidence’. So, the probability actually translates into the extent of confidence that I have in stating this fact. In any case, it is a probabilistic inductive inference.

And then a field biologist now has caught a new adult male sparrow and without weighing it, what will be her inference about that its body weight? It will obviously be, its body weight will lie between m_1 and m_2 and she will be 95 percent confident that the inference is correct.

So, the inference will be, there is a 95 percent probability that a particular adult male sparrow’s weight will lie between m_1 and m_2. So, you see this is a probabilistic inference, based on a probabilistic inference coming out of the inductive logic. I have now got a particular situation and my inference regarding the particular situation also has a probability assigned to it. This is the probabilistic modus ponens.

What about modus tollens? Let us draw a line here and then let us go to modus tollens. Let us see if it works in probabilistic sense. In the modus tollens, what do we say? If A then B with probability p; then not B, then we are trying to infer whether it is not A. Right? That was the situation in the modus tollens.

Let us look at this situation. We have A given as if it is a adult male sparrow. If A i.e., if it is adult male sparrow, then B is 'body weight lies in the range between m1 and m2'. So, A is adult male sparrow, and B is the body weight, a statement about the body weight. Not B means the weight is outside m1 and m2 range.

I have gone out in the field and I have caught something. 'Not B' means I have a specimen with body weight greater than m2. Greater than m2 means it is beyond this range. Given: 'not B' is true. Can we conclude that it is not an adult male sparrow? No, we cannot. Because there was a probability assigned to it, there is always a 5 percent probability that the body weight of an adult male sparrow will lie out of this range. And therefore, we cannot conclude this. Therefore, modus tollens does not work in the probabilistic sense.

So, this is an important conclusion that whenever we are applying the probabilistic deductive logic, we apply modus ponens. But modus tollens has difficulty, we cannot directly apply that in this kind of logical structure. We cannot apply that. But of course, you can have some doubt about whether the specimen that I have caught is an adult male sparrow or not. You can have some doubt.

And in case of that kind of a doubt, if you have got this result, in a particular case, then maybe you will like to redo the earlier part of the result where we calculated the average weight of the adult male sparrows and concluded that it lies between m1 and m2. That, we might have to redo, we may have some doubt about that. All that can happen.

But this statement that, because it is lying outside this range, therefore, it is not adult male sparrow, that argument would be wrong. Now, let me delete this and deal with something else.

In this case, we have dealt with a situation where the conclusions are black and white, 0 or 1 type. We have also dealt with cases where the conclusions are probabilistic type. There is another class, where there is a premise on the basis of which we have got an inference, but there is another premise which is true, and on that basis the inference is the opposite. Then what do we do?

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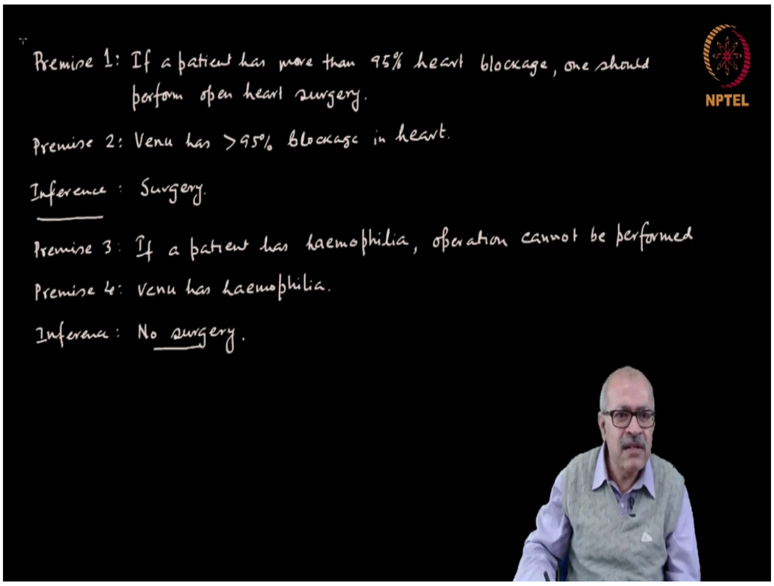

For example, a situation—doctors often face this kind of situation—a situation where you have a premise 1. Let me write it. Premise 1 is, ‘if a patient has, say, more than 95 percent heart blockage, then one should perform an operation’. I am not saying that this statement is true. Suppose such a statement is there: one should perform open heart surgery. And then premise 2 is that, say, a particular patient, Venu, has greater than 95 percent blockage in heart. Obviously, the inference is, surgery.

But then there can be another premise, premise 3: if a patient has, say, the disease haemophilia, then any cut actually it does not heal, the bleeding continues and the person may die. If a person, a patient, has haemophilia, an operation cannot be performed. Then premise 4 is Venu has haemophilia. Then what? Its inference would be no surgery.

See, in this case the premises 1 and 2, lead to a conclusion, and premises 3 and 4 lead to another conclusion. And these are contradictory to each other. In such cases, what we do is, we have to figure out which statement is stronger. Which conclusion is stronger and accordingly we have to make a decision.

In this case, even though the person has 95 percent heart blockage, and there is a probability of his dying of heart disease, the fact that he has haemophilia means that if he is operated upon, he is sure to die out of that. So, this is stronger. And therefore, the ‘no surgery’ conclusion stands. This was a simple line of argument, but this is actually what has to be applied in many practical situations. So, let us write down the structure of this line of logic, then it would be clearer.

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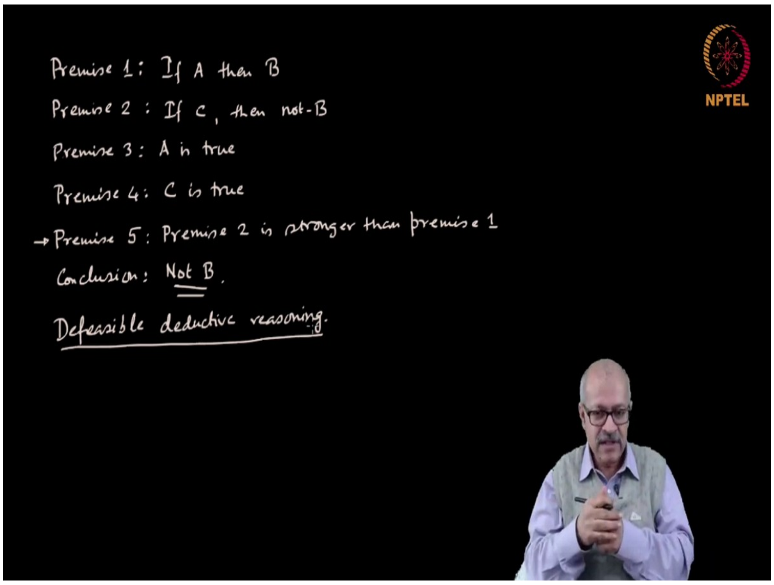

The structure is, premise 1 was if A then B. The premise 2 is if C then not B. And then we have a situation where premise 3 is that A is true. And premise 4 is C is also true. Then, you have to add another premise, premise 5, which is that premise 2 is stronger than premise 1.

And on that basis, we can conclude ‘not B’ because premise 2 is stronger than premise 1. So, here you are using an additional premise, which says which of the two premises defined earlier is stronger.

And this kind of situations are often encountered in sciences especially when we refer to the ethics of science. Because a scientist often faces the dilemma that logically his knowledge has to be used in order to further his professional career. And in order to further the professional career, there can be a situation where he has to perform something, do something, which is unethical. So, one logical structure asks him to do what is being asked, what the employer is asking. The other says, do not do that.

For example, the fact that we have food adulterants implies that some scientists, chemists, were involved in the act of inventing the food adulterants. The fact that we have biological weapons implies the some scientists were involved in the act of inventing biological weapons, with the full knowledge that is not for the welfare of humanity, that is, to the destruction of humanity. But still people are doing that.

Why? Because of their failure to apply this logic. The ethics of science demands that our knowledge, the knowledge that we have obtained by spending public money, using that knowledge we will do welfare for the society. Our knowledge will be used for the upliftment of humanity. While at the same time there is a premise that our knowledge will be used for our own career advancement.

Now, the career advancement, where I have got a job and the employer asks me to prepare or invent a food adulterant. Do I do it or do I not do it?

There the first premise that our knowledge is something that we have obtained almost as a free gift from society. The knowledge that has been obtained over millennia of human experience and research, I have obtained it over a very small span of time through the process of education and this education has to be given to me by society. And therefore, I have to use that knowledge for the welfare of the society. That is a overriding premise.

But there is also a premise that I have to use my knowledge to further my career. That should logically be a secondary premise that is of lesser importance, not stronger. Stronger should be that I cannot use my knowledge for any act that will cause harm to humanity.

But the fact that we do have biological weapons, we do have killing machines, we do have food adulterants—all that imply that many scientists fail to apply this kind of logic properly. This kind of logic is called defeasible deductive reasoning.

So, in applying deductive reasoning, we have come across a few types of deductive reasoning. We have learned about modus ponens, modus tollens, probabilistic modus ponens and the difficulty in applying the probabilistic modus tollens. We have also learnt about the defeasible deductive reasoning. Now, we come to a very important branch of deductive reasoning called syllogism. We are now coming to that.