Research Methodology
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Lecture - 15
Historical Perspective: Renaissance to the Development of Mechanical Materialism
Part 01

Before we go forward, let me clarify one common misconception. Science and all these developments in philosophical currents did not only happen in Europe, in India also similar developments happened. We know that in the Indian subcontinent there was a Indus Valley Civilization which occurred approximately from 3500 to around 1700 BC and then the Vedic age from about 1500 BC to around say 600 BC.

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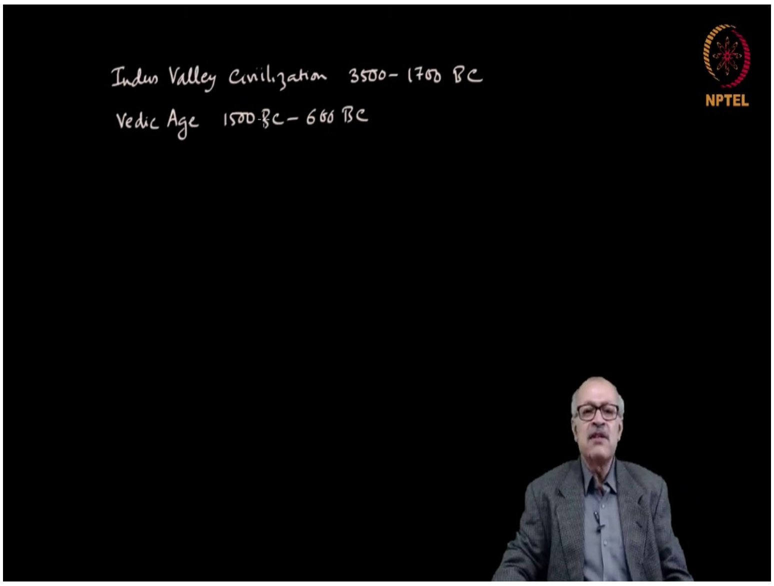

We do not have much of archaeological evidence from the Vedic Age, but we do have a lot of documentary evidence – because we have the Vedas, Vedanga, Vedanta, Upanishads, Puranas and a lot of Vedic literature. From that we can piece together that, in those times also, there was reasonably good development of philosophical currents.

Let us very briefly analyze that. If you look at the Vedic gods and goddesses, you will find that they are embodiments of some natural forces. Varuna: the wind, Agni: the fire, Surya: the sun, or some warrior like Indra: things that are material, things that are not abstract and ideal, material things. They wanted to please these and they wanted to get something in return. So, all the hymns will be asking for food, rice, they will be asking for cows for example, or win in wars or something like that.

So, they were trying to please the things that are also natural forces and what they are asking in return these are also natural things, and in that sense, anthropologists term this phase of human society also as materialistic, because the basis of the thought was the material things around them.

The Vedic age ended around 600 BC with the advent of Jainism and Buddhism. But towards the end of the Vedic Age, when Upanishads were written, at that time we see the onset of idealism: idea is prior. There was the question of something that is creator of everything, the Brahman, and all those concepts came.

So, we see the onset of idealism, but at the same time there was also materialistic currents in philosophy. For example, there was the Lokayata school of philosophy. There was the Sankya school of philosophy. There was Nyaya and Vaishishika schools of philosophy and these were, in the main, materialists schools of philosophy.

So, the materialist schools and the ideal schools ran side by side. They were also fighting in the Indian subcontinent for intellectual space. For example, the Lokayata philosophy believed that everything is made of Chaturbuta. What are these Chaturbuta? Air, water, soil and fire.

So, it is, you can see, similar to what the Greeks thought. In Greece, Aristotle added a fifth element, the element of the sky. He called it Ether: an idea that continued for a long time. In India also with this four, later was added vyom, the element of the sky. So, things were more or less similar, you can see. For example, the Lokayata school demanded evidence for any belief and they did not believe in, say, soul for example, anything that is super or outside the human body.

The Sankya school, for example, stressed on the idea of causality. Things have a cause. The Vaishayika school was founded by Kanada. He believed that everything is made of minute particles, atoms. So, the ideas that we have seen being born in Greece, is not that they were only born in Greece. They were independently born in the Indian subcontinent also.

And, out of these two schools of philosophy, materialism and idealism, later in Indian subcontinent also, idealism became the dominant philosophy after especially Shankara, who propagated the idea that the material world is illusion, Maya. His kind of Vedantic philosophy. After him, from the 8th-9th century, the idealist school become dominant in the Indian subcontinent, what happened in Europe during the middle ages.

So, with that, let us go back to Europe because we have now come to the 16th-17th century and in that period the Renaissance was happening. During the Renaissance period, the main focus changed. So far it was: ‘believe, don’t question’. But now the attitude changed to ‘question, don’t believe’, and if you do not believe in the established existing beliefs, when you have to find things anew.

You have to learn about nature anew. How to do that? When humanity faced that question, three people came forward to lay down the path. One was Galileo. There are three people. I will come to their points.

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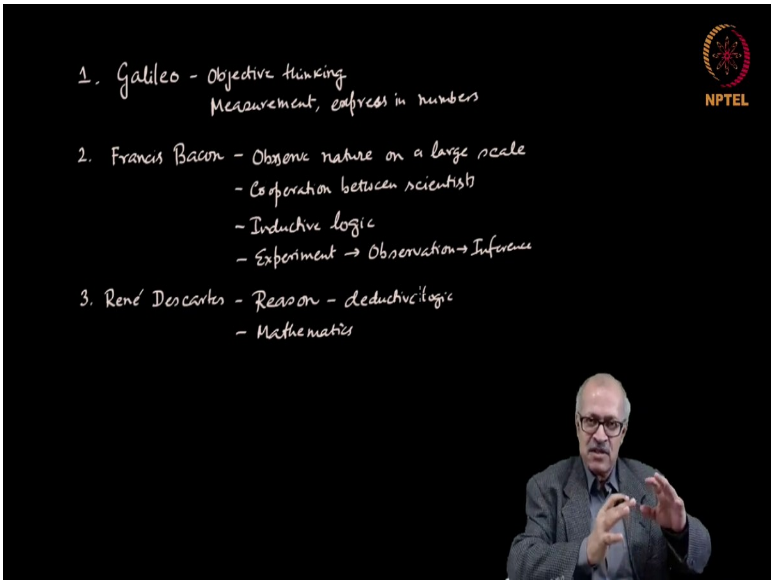

The first was, as we have seen, Galileo. Galileo’s main contribution was to introduce objective thinking. When one analyses the way he himself did his work, people realized another point he was making. So far you have been talking about things in a nebulous way. Something being fast, something being slow, something being heavy, something being lighter. Galileo made the point that, measure them and express these quantities as numbers. If you can do that, it will be possible to relate these quantities by some kind of a relationship. So, measurement and expressing in numbers: very important because much of later development of science happened following his prescription.

The second person I will be talking about is Francis Bacon, in England. They were basically contemporaries. Francis Bacon made the point that so far we have believed things without any evidence. We have just believed so far, which cannot be supported any further. So, we have to gain knowledge afresh. How to do that?

He said that the only dependable way to do that is by large-scale observation. So, observe on a large scale. Observe nature, all natural processes, on a large scale. 'Natural processes' means somebody would observe plants, somebody would observe animals, somebody would observe the earthly processes, the physical, chemical, the heavenly bodies. So, observe nature on a large scale.

And he said that, that cannot be done by individual scientists working alone. You need a cooperation of scientists. Many scientists should work together to make the observations. Otherwise individuals observing something in isolation will not make sense, because all those observations have to be put together.

So, cooperation between scientists. He said that the way to gain knowledge about nature, to find out the laws of nature, would be to put all those observations together and then extract the generalities by using inductive logic. So, inductive logic. His method was by inductive logic.

So, he recommended people to do experimentation on a large scale or observation on the things that cannot be experimented with, and then experiments would lead to observations and from the observations you have to make your inference regarding the laws of nature.

So, his prescription was: experiment → observation → inference, and the way to do that was induction, inductive logic. Inductive logic: we have already done that, so you understand what inductive logic means. His prescription was to build an edifice of science by large scale observation.

His point was that, if you do observation on a large scale, the weight of facts will lead you to truth. The way to reach truth was by logical reasoning and the logical structure would be induction. That was his point.

The third person I will talk about is Rene Descartes. Rene Descartes was in Holland, though he spent some of his time in France. I will not talk about their life sketches. I will basically talk about the philosophical points they were making.

Rene Descartes made the point that the way to build science, the way to reach truth, was reasoning. He underscored the importance of reasoning. Reason. And he said that reasoning must have a logical structure and that logical structure, he stressed, must be deduction.

So, deductive reasoning. He said that if one is engaged in reasoning, then an individual scientist can also work alone. Francis Bacon was saying that individual scientist working alone will not be very fruitful. It will require cooperation of many scientists because you will be observing nature on a large scale. While Descartes was making the point that base yourself on reason, and a single scientist working alone can also do reasoning.

So, what he was suggesting was complementary to what Bacon was suggesting. He stressed the importance of deductive logic. How would you apply deductive logic? He said that, always start from something that you are confirmed that it is true. Do not start from a shaky basis. Start from something that you know for sure to be true and then use deductive logic to arrive at conclusions that will be different from where you started.

And then we said that a good way of applying deductive logic this way is to take recourse to mathematics. If you take recourse to mathematics—mathematical reasoning is basically deductive reasoning—and therefore, mathematical deductive reasoning will take you on the right path. So, he underscored the importance of mathematics.

So far mathematics was sort of a pursuit of mathematicians, but now Descartes underscored its importance in building physical understanding about the working of nature. So, mathematics became mainstream in physics. Descartes himself was a mathematician, a good mathematician, accomplished mathematician and he developed what is known as the Cartesian coordinates, Cartesian geometry. That geometry goes after his name: ‘Cartesian’ means by Descartes.

The Cartesian coordinate system unified two different branches of science: geometry and algebra. An algebraic equation now became a geometrical curve. So, he unified two different branches and made it amenable to representation of physical reality.

So, his point then was to use reason, use deductive logic, use mathematics and start always from something that you know for sure to be true, obtained from experiment or whatever, which is confirmed to be true.

In mathematics, what is assumed to be true are the axioms. But Descartes said that in physical reality also, you can find things that are known to be true. And then from there, you deduce. He said that, when you consider some phenomenon, then you must not leave anything that might be of importance to the phenomenon that you are investigating.

So, you start from something that you already know and you are investigating a particular phenomenon, then make sure that you do not leave out of your purview something that might be of importance.

Then he said that, do not ask grand questions. Ask questions that are tractable. If you have a bigger question, then break it up into smaller parts and take each question at a time. Each question should be small and tractable: tractable using the method that he outlined, so that ultimately at the end of the day, you find success in unraveling some aspect of nature.

So, these three people actually laid down the path of doing science. The scientific method was effectively laid down by this three people and, as you can see, later developments of science followed the path shown by them.

The most important thing that happened following their time was the founding of the Royal Societies, because of Bacon’s prescription that scientists should make observations on a large scale and they should discuss, they should put their findings together to extract some laws of nature. That required discussions among scientists and for that, scientists started meeting periodically, and through that, the scientific societies, mainly the Royal Societies took shape. Most of these took shape in the 1650’s and 1660’s.

Great developments were happening following their prescription. For example, Robert Boyle, who for some time was the President of the Royal Society, he discovered what is known as the Boyle’s Law. His assistant Robert Hooke discovered what is known as the Hooke’s Law of springs. Von Guericke in Germany, he invented a way of creating vacuum and showed the power of the vacuum or the pressure of the air by the two-hemisphere experiment. Two hemispheres evacuated of air and a bunch of horses could not separate them.

Those demonstrations were dramatic and that caught the imagination of people. Boyle came to know about Von Guericke’s experiment. He and Hooke then made another machine to create vacuum and they investigated the character of vacuum. For example, they asked: ‘does sound travel through vacuum?’, ‘does magnetism travel through vacuum?’ and things like that, and investigated those.

Torricelli demonstrated vacuum, the Torricellian vacuum as it is known. Then in Holland Leeuwenhoek, invented a microscope and for the first time he observed micro-organisms. He sent a letter to the Royal Society of England, and reading that letter the Royal Society sent a delegation to Holland to look at his microscope.

The delegation was led by Robert Hooke. Leeuwenhoek showed them the results, but he did not tell them how the microscope was made. But Hooke was himself a scientist, he could figure out how it was made. He came back. He built a microscope of his own, observed microscopic structures and wrote a book called ‘Micrographia’.

So, that was a time when many things were happening in every front, many discoveries were happening. All that was crowned by the great contribution of Isaac Newton.