Research Methodology
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Lecture - 16
Historical Perspective: Renaissance to the Development of Mechanical Materialism
Part 02

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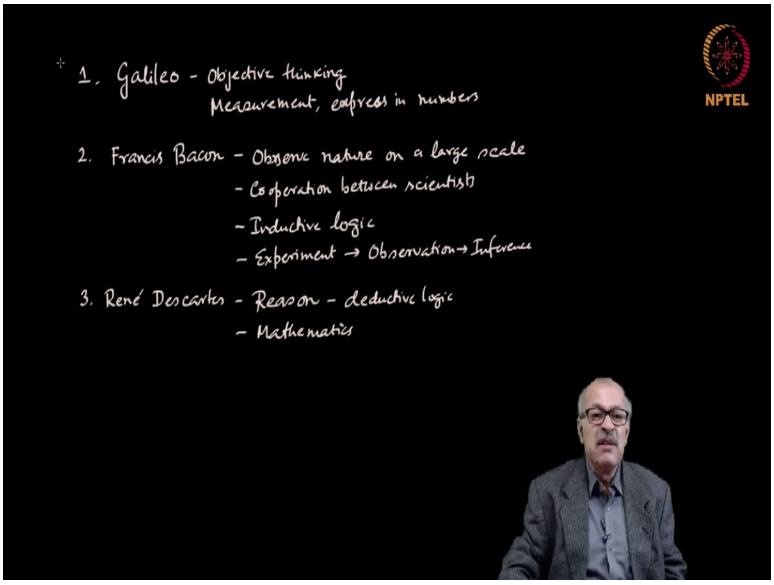

Isaac Newton was born in the year that Galileo died, 1642. I will not discuss his life sketch. What is interesting is that during his student years, there was a plague in England; due to which his university closed down for a couple of years and he went home.

Since he was a son of a peasant family, so he had to tend his firm, look after sheep during this time, and he proved to be useless as far as tending sheep is concerned. But in these two years of rustic solitude, he concentrated on a few problems.

And in these two years, he solved many of the problems that bugged people at that time. He, for example, invented differential and integral calculus. He solved the problem of gravity. He arrived at a law of gravity. He also arrived at the laws of motion and derived the trajectories of the planets starting from those premises—the postulates that he had made. And all that was done, when he was just a young man having to return home for a couple of years.

When the plague subsided, he went back to his university. Somehow, even though his academic results were undistinguished, his professor understood the worth of this man and recommended him to be given a professorship: the Lucasian professorship of the University of Cambridge. Then he became the Lucasian professor.

Notice the time. It is important to understand the time. That was the time when slowly industries were being built. The feudal system was being replaced by the capitalist system. Industries were being built and industries were producing goods that had to be transported.

In order to produce goods, you would need to needed a lot of fuel; you would need a lot of iron and therefore, mining had to be done. Importance of mining increased. In those times, mines were rather primitive. One major problem faced in the mines was to pump out water and to ventillate the mines. So, you needed better pumps for that purpose.

Then from the iron ore, iron had to be extracted. That requires some idea of metallurgy: How to make good iron and stronger iron.

Industrial requirement was that, whatever was the produce of the industry, had to be sold and therefore, that had to be carried over long distances. Now, the way to carry things over long distances is not over land, because on carts how much can you carry? People realised that much more can be carried in waterborne transport.

So, around that time, canals were dug for inland transport and for sea transport, bigger and better ships had to be built. That posed a few scientific problems before the scientific community. What should be the cross section of the canals, so that water can flow effortlessly? Will it be like this? Will it be like that? Will be like that? So, various possibilities are there. And when you have some kind of sluice gate, what should be the shape of the sluice gate so that water can go through when it is opened?

Regarding the seaborne transport, you had to make better ships. Ships in those times were made of wood and later they started being made of iron. But when they were made of iron, they might sink unless made properly. Now, when a ship is buffeted by waves, that rocks. Right? So, one has to figure out the laws governing the rocking of a floating body. That concerned a problem of mechanics. The earlier problem of water flowing through various channels was a problem of hydrodynamics.

In case of the sea fearing, one major problem was, how to figure out where you are in the middle of the sea? What is coordinate? How to figure that out? So long people did not know that, the ships had to go with the shore-line in view. So, they had to go very close to the shore line. Naturally they had to traverse longer distances.

And around the 16th century, people started going into the sea leaving the shore line, and then the problem was: how can you find the latitude and the longitude? Now, finding the latitude is relatively easier, because that depends on the season and the inclination of the sun. But finding the longitude is a more difficult problem and for that, one had to depend on your idea of the stars and the planets.

Figuring out the longitude in the daytime can, in some ways, be done by looking at the sun. But at night, you have to look at the stars and the planets. So, people started looking at the stars and the planets and trying to find out the longitude from that.

So, for the first time, people started looking at that with practical interest. And if, when you started from a port, the Mars was at a certain point when you were right in the middle of the sea three months later, then Mars would be at a different point. Then unless you know where it is in the sky, where it can be predicted to be in the sky, it is difficult to find your position using the position of Mars.

So, predicting the positions of the planets became a practical necessity. You would notice that I am talking about certain necessities, certain demands, coming from the society, because of the societal changes that were happening. The problems that Newton addressed were effectively these problems.

The problems essentially concerned mechanics. Newton solved these problems, even though he did not directly talk about the practical problems. He abstracted the problems, theoretically solved those problems, which would have a immense impact on practical activities. But his discoveries had more impact than just that.

Notice that, in the first volume of his Principia Mathematica and the second volume, he was basically talking about the hydrodynamic problem of flow of water, problem of rocking ship and things like that, but in the last volume, he took up the problem which is presently known as the laws of mechanics and the law of gravity. Law of gravity: any two bodies attract each other with a force equal to $G\, m_1\, m_2 / r^2$.

So, G times mass of the first body times mass of the second body divided by the distance between the two bodies squared. That was the law of gravity.

The laws of mechanics: the three laws you know. Most important of these was the second law: force is equal to mass into acceleration, and acceleration is a double derivative of position. Therefore, that gives a differential equation and if you solve the differential equation—you can write the differential equation for any body—you can solve the differential equations and the solution will give you the ability to predict its position at a later time.

And if you apply that technique to the heavenly bodies, like the planets, you can predict the position of the these bodies at a later point of time and you can wait and see whether it really goes there or not. People found that it really goes there, which means, for the first time, we acquired the ability of predicting heavily bodies' motion.

So far, people were only guessing and all sorts of wild guesses were there regarding their position, their motion. But now, we could predict motion. We learnt that their motions are not just arbitrary motions dictated by somebody, these are law governed and we can know the laws; we can predict their positions.

This had enormous impact on human psychology. Even his friend Edmond Halley, during his lifetime he saw a comet, applied Newton's technique, Newton's method, and predicted that it will come back 74 years later. He died, but it came back 74 years later. So, that gives people a lot of confidence in science.

For the first time, people had a confidence in science, that science is true. It allows you to reach truth. It can predict behaviour of bodies that are so far, we were thinking that these are 'heavenly bodies', under the control of some supernatural force. So far, the idea was that everything that happens, happens because of what I mentioned as the 'final cause'. Somebody makes that happen.

For the first time, that idea was challenged. You have seen that Aristotle's idea was that force produces motion. So, during the medieval period whenever there was a motion, people looked at who is applying the force, and all the time they came to an imaginary conclusion that some supernatural entity is applying the force to make any motion happen.

So, behind any motion, they saw a supernatural hand. But following Galileo, when Newton exactly formulated his first law: any body goes in a uniform rectilinear motion unless applied on by a force. From that, people understood that force is not necessary for every motion. If you do not apply force, things will go in a uniform rectilinear motion. So, force or an agent applying the force is not necessary for explaining every motion.

But then, we do see change in motion. The motion of Mars around the sun is changed in motion at every point of time, because it is not going in a uniform rectilinear motion. Then, also Newton showed that the agent applying the force is also a natural law; it is the law of gravitation. It is a uniform law that applies to everything without exception. And so, that also was no longer shrouded in mystery. What applies the force—that was also known.

And so, after Newtonian mechanics came, slowly the earlier ideas of a divine hand in everything that happens—that receded, and because of that, again materialism came to the forefront. Even though Newton himself may or may not have been a materialist, but what happened was, his mechanics again brought in materialism to the forefront, because no longer people saw a divine hand in everything that happens.

But the materialism that was born through Newtonian theory—I mean, it was born actually after Newton, using Newtonian principles—that materialism was born with a defect. The defect was that the Newtonian picture gave people an impression of the universe where everything is law-governed.

Everything moves, all the planets are moving in their own orbits, whatever you do: you throw a cannon ball that also falls at a particular place—everything happens following immutable laws. As if the whole thing is like a gigantic machine. The universe, to the post-Newtonian scholars, looked like a gigantic machine.

As any machine, like a wrist-watch, is composed of smaller components, each put together makes the whole wrist-watch. In the same way, whatever people looked at, they saw that as a component of a machine. And due to that reason, this kind of materialism, the materialism that was born following the advent of Newtonian mechanics, is called ‘mechanical materialism’.

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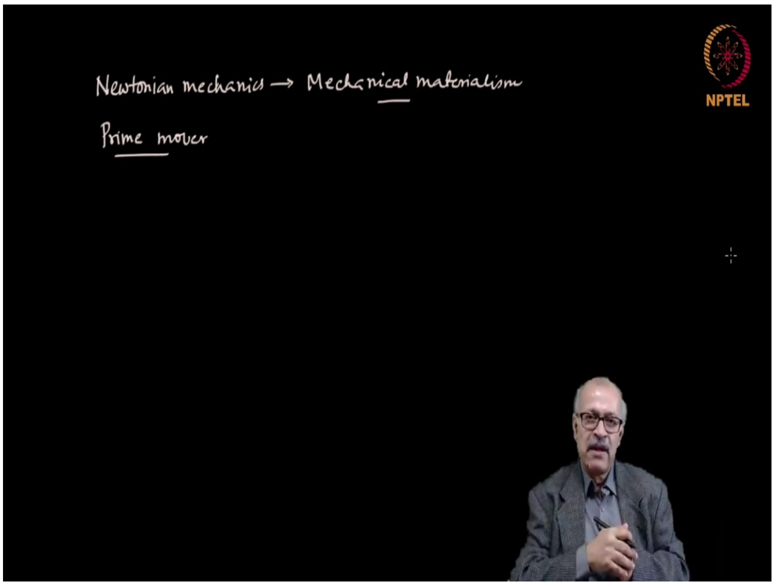

What was born new from Newtonian mechanics was mechanical materialism, and people thought that they can predict everything. In fact, one post-Newtonian scholar Laplace, whose Laplace transform you may have heard of, Laplacian operator you have learnt of; so, that Laplace. He was basically a master (Refer Time: 16:51) of celestial mechanics. He wrote a book on celestial mechanics and in that book, he claimed that he can predict the motion of every particle, if he is given the initial condition of every particle in the universe and a computing machine of enough capacity, then he will be able to predict the motion of every particle in future.

And since we are all made of particles, he effectively said that the future of everything can be predicted using Newtonian laws, provided you are given enough computing power. Why cannot we do that? We simply do not have that computing power, but in principle that can be computed. That was the point he was making. So, why is it computable? Because the whole thing is like a machine. So, this machine-like picture is a characteristic of mechanical materialism.

There was another issue that was raised by people almost contemporary to Newton. It was that, I understand that once something has motion, it will continue to have motion. But then, who imparted motion first? Who give the first push? Who gave the first kick? That was a question that was raised.

Facing that question, Newtonian scholars fell back to idealism in some way, because they introduced the idea of there being some kind of a ‘prime mover’. A prime mover—the idea was essentially an agent that gave the universe first push to start its motion. And after that you do not need his intervention, because everything would move according to the Newtonian laws. That was the idea.

So, in this period we see the advent of Newtonian mechanics and the advent of mechanical materialism. And in the post Newtonian period, there were great developments in science, because materialism had come to the forefront. So, people were trying to formulate the understanding of everything in terms of material processes and phenomena. That enabled people to get rid of some of the unfounded ideas that were born in the earlier period.

For example, people believed in spirits in many things, mysterious spirits. For example, there was believed to be some spirit of magnetism. There was a theory called phlogiston theory; the spirit of burning. People believed that the burnable substances contained a substance called ‘phlogiston’ and when a piece of wood, for example, burns, phlogiston comes out and forms a flame. That was the idea.

When there is heat transfer from a hot body to a cold body, people believed that the hot body contains a substance called ‘caloric’, from which the word calorie came. The caloric is a substance that flows from the hot body to the cold body.

In biological things, in living matter, people believed that there is some kind of a spirit of biological matter called ‘vital force’. If the vital force is there, then living beings will be there. Inanimate objects do not have the vital force.

So, there was this kind of subjective ideas prevailing in the scientific community and in the period post Newton, people examined these.

For example, Benjamin Thompson, who was later called Lord Ramford. examined whether the caloric was really there. When heat flows from a hot body to a cold body, then it was believed that the substance called caloric goes from the hot body to the cold body. So, he took some amount of ice and allowed it to melt, which means that it has absorbed caloric, and then, he weighed the ice, as well as the resulting water. He found that the weights are the same, masses are the same. So, even though it was melted, it has got more heat, but its weight has not changed. So, there is no physical material exchanged.

Similarly, he did that for other things. He noticed that whenever a canon is bored, that means, the cylinder of the canon was bored, a lot of heat was produced. He then tried to find out where is the heat coming from and he measured the amount of heat by immersing the cannon in water and saw how much the temperature of water increases and he found out how much mechanical energy was spent in the act of boring and he found that these are equal.

Through these, he essentially established that the caloric was not a substance. It was basically a form of energy that was transferred. And you can convert mechanical energy into heat energy.

It was earlier believed that lightning was the wrath of god. Benjamin Franklin showed that it is nothing but flowing electricity. Earlier people knew about static electricity obtained by rubbing things, but now, they realised that this is only static electricity; nothing mysterious about it.

Alessandro Volta invented ways of producing flowing electricity in batteries. Scheele, Priestley, and Lavoisier: they almost at the same time produced oxygen, isolated oxygen. But, because of their belief in the phlogiston theory, Scheele and Priestley could not identify that as a new element which Lavoisier did. Lavoisier could figure out that this was a new element, which is actually aiding burning and aiding breathing. He named it oxygen and he introduced the method of writing the chemical symbols like, CO_2, the way we write. He introduced that way of writing chemical symbols. Thus, chemistry was born. It was no longer the earlier phase of alchemy.

So, all these developments were happening in the time following the prescriptions of mechanical materialism. And then, in England, the demand for increasing production resulted in people moving from wood as a source of heat to coal as a source of heat. Finally, people analysed the various ways of producing mechanical energy out of heat and Newcomen, a person called Newcomen, first invented a device to convert heat into the rotational motion of a shaft. It was slow. It was wasteful. But still, it did its purpose and started being used in, for example, mines for ventilation purpose. But soon, James Watt invented his steam engine, which revolutionised industry.

Following that, most of the industries started using the motive power obtained from coal as the motive power for running industries and the industrial revolution started.

With this I will close the class today. And the result of the Industrial Revolution we will take up in the next class: what was the philosophical impact of this.