Engineering Mechanics
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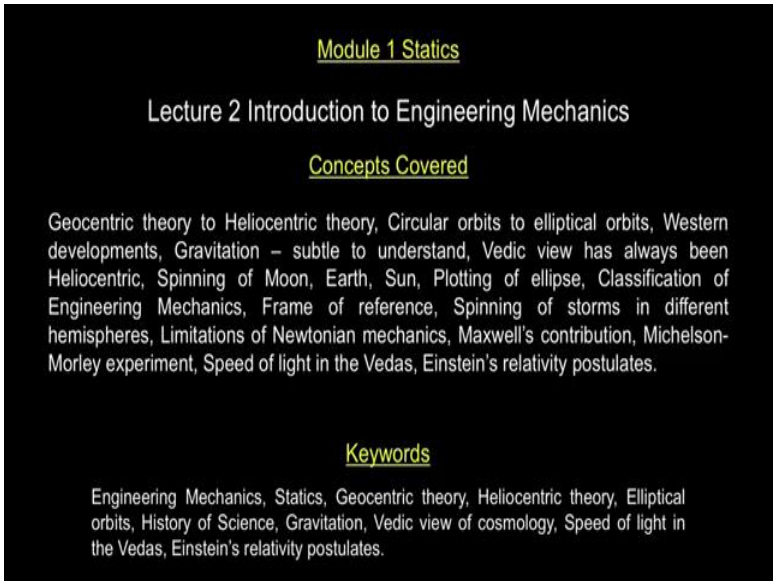
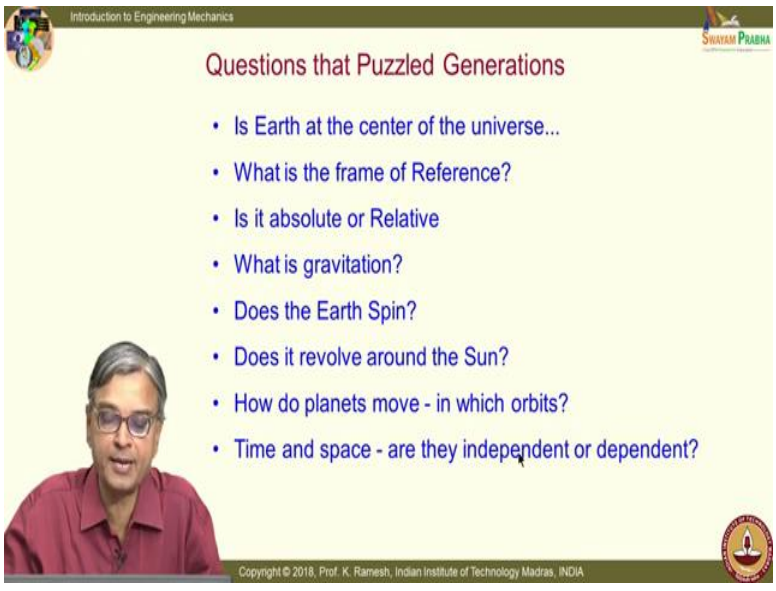
Module - 01
Statics
Lecture - 02
Introduction to Engineering Mechanics





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Let us continue our discussion on Introduction to Engineering Mechanics.

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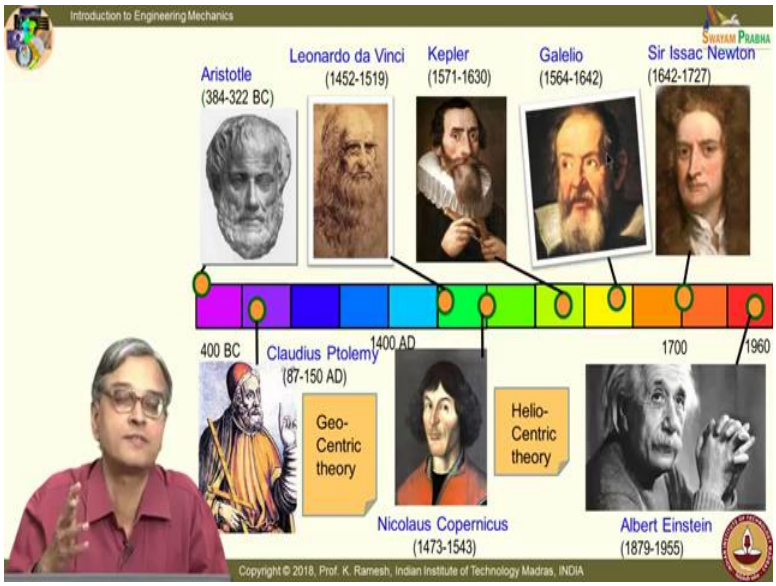
In the last class we had looked at questions that puzzled generations is earth at the center of the universe. What is the frame of reference? Is it absolute or relative? What is gravitation? Does the earth spin? Does it revolve around the sun? How do planets move in which orbits? Time and space, are they independent or dependent?

You know you might think that these questions look very trivial, because in your high school physics you are taught

the modern view of what is our understanding on solar system and so on and so forth. Only when you start thinking on your own and try to figure out what is around you get stumbled on these questions. They are not trivial they appear to be trivial.



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And if you look at Aristotle, he was the first person to start a scientific thinking and then they all believed that earth is at the center of the universe. They were very convenient to think, we are also so important. So, we can do anything with any other species on the world and people also thought that all other planets revolved around earth in circular orbits; there was no idea of elliptical orbits. And as I told you earlier this scale is not linear, I have shown from 400 BC to 1960 and bulk of the scientific development happened at the period 1400 to 1700. Until then people were thinking that earth is at the center of the universe.

And people were finding it very difficult to communicate that sun is the center of whatever that we have talk about and all other planets revolve around the sun you call that as a heliocentric theory. Even though they determined that heliocentric theory is possibility even Galileo could not say it openly fine. So, it was very difficult the social climate was totally different in those times. So, people were thinking generations of generation that the earth is at the center of the universe and you know we also get enamoured, if somebody gives a very complex explanation of facts, then you think it is correct.

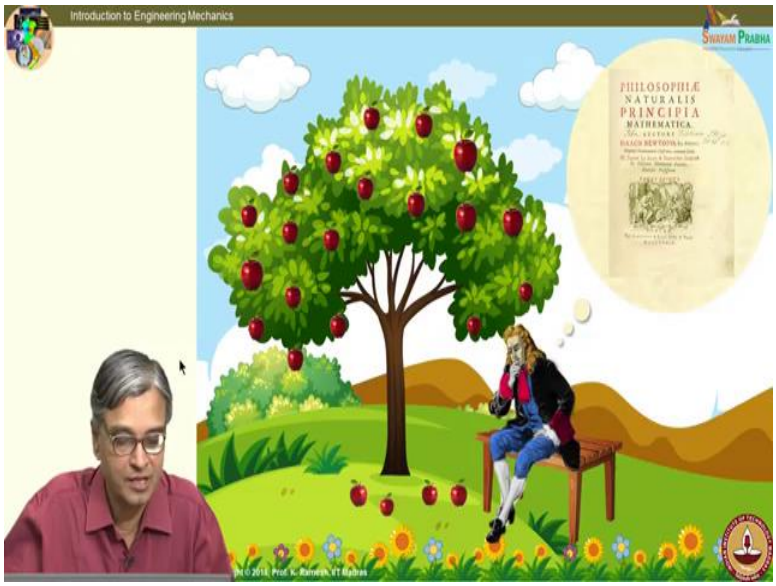
If something says very simple terms you think what is great about it. And you know whatever the theories that they proposed they looked at the stars and then verified whether their observations tally with whatever the predictions. And one of the common observations people made in those days was when you see a planet at some point in time it will appear

from earth that it is going in the opposite direction that is called retrograde motion. It was very difficult to explain using circular orbits.

And Ptolemy he said the epicyclic type of motion and he provide an explanation it was very complicated, but people were happy that what you observed; he had given an explanation. So, geocentric theory is valid. And if you look at elliptical orbits and heliocentric theory approach, it is very easy to explain why you see a retrograde motion of the planets. So, going from geocentric to heliocentric was not simple and also if you look at there are also scientific historians who argue about when there is a concept who has propounded it is first. We all know elliptical orbits is credited to Kepler, but if you look at the history, they would name another scientist called Tycho Brahe.

He had made lot of observations and in fact whatever the laws which Kepler has got based on his observations. So, some credit should also be given to Tycho Brahe, but we will not get into those historical disputes my idea is to get into what is our mechanics and you find until 1700 when Isaac Newton proposed his Newton's laws people were not convinced about heliocentric theory.

Then only people got convinced and I also said it took 2000 years to understand what we commonly perceive as solar system and then Einstein came in the picture you have a whole lot of special theory of relativity, even few days back people verified some of his predictions. So, that is what happens the predictions come much earlier experimental verification takes several years and sophistication in verifying those concepts ok.



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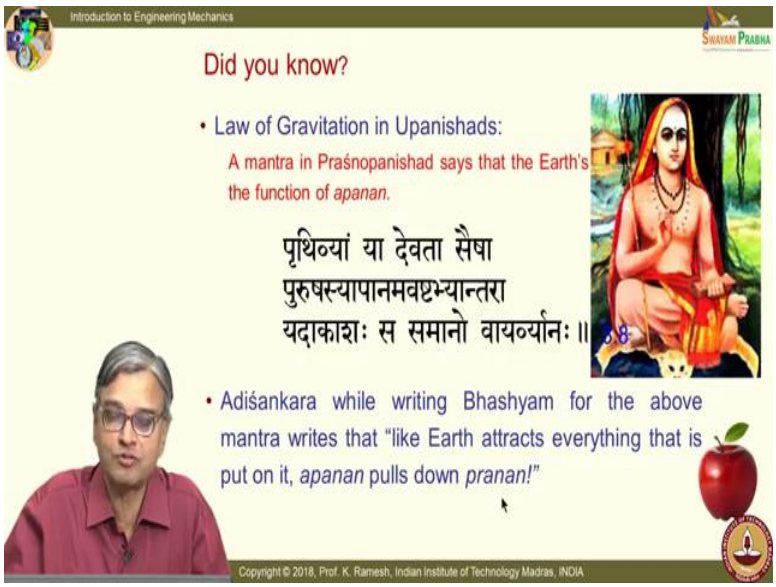
And as I said that gravitation was very difficult to comprehend because this is action at a distance it is not a physical interaction. So, in a lighter vein you find that, when I have Principia of Mathematica written it dislodged the views of Aristotle.



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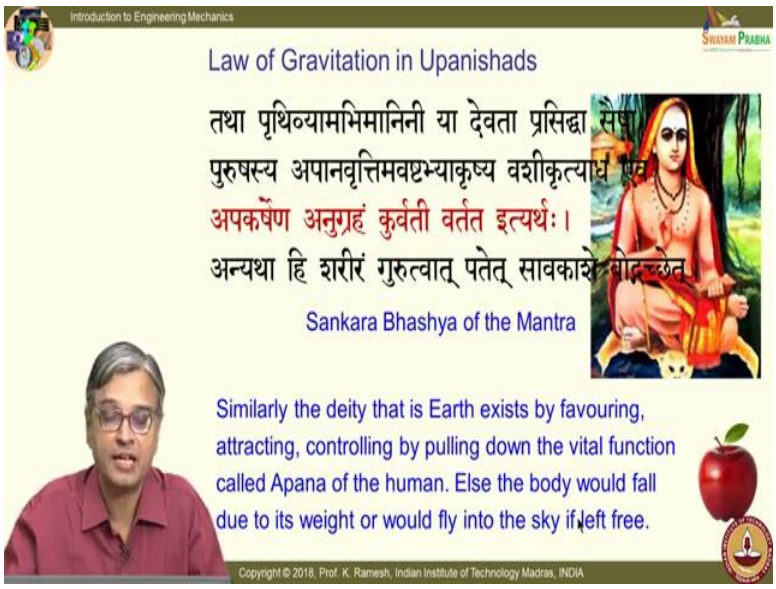
And I also mention that in Sanskrit literature it is packed with lot of information unless you have a good interpreter you will not be able to totally understand what that Sanskrit words means. And in this case, we had Adisankara who had written a Bhashya which says "like Earth attracts everything that is put on it, apanan pulls down pranan!" and I could also get the actual Bhashya this is the mantra.



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I could also get actual Bhashya "Apakarshena anugraham kurvathi varthatha ithyarthaha…" that is what he says. And in addition, he has also said that if you do not have gravitation the body would fly into the sky if left free. So, it is not a casual reference he knows what he is talking about ok.

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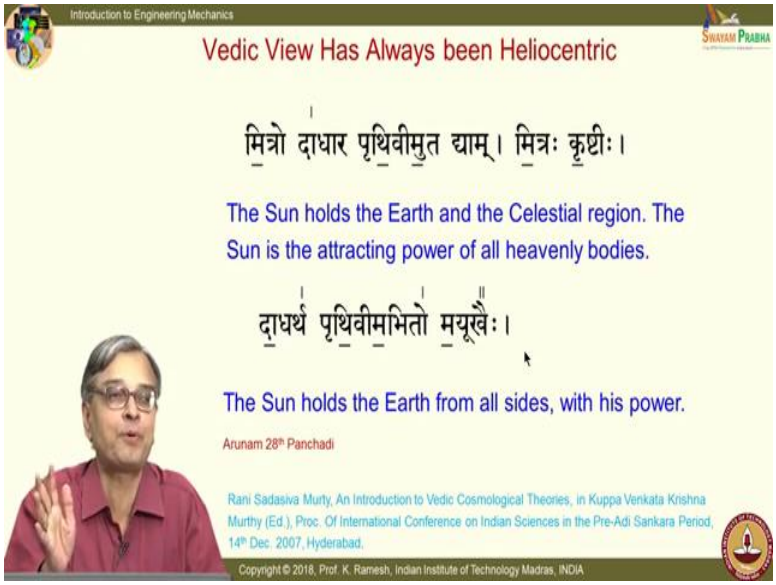
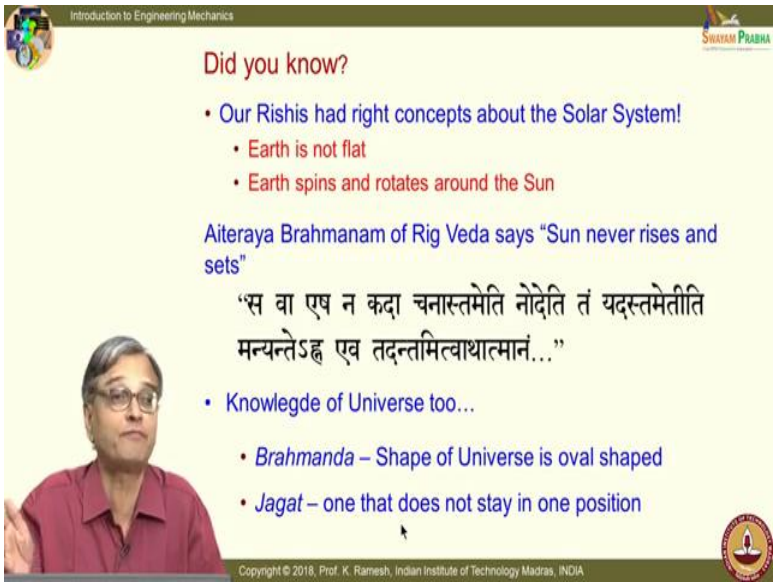
And that credit you will have to give to our ancient Rishis also and if you look at Vedic view it has always been heliocentric. It has never been geocentric see the struggle whether it is geocentric or heliocentric was there in the west haunting them for generations and if you look at " Mithro dadhara prithivi mutha dyam. Mithrah krishtihi…" and the sun holds the earth and the celestial region, the sun is the attracting power of all heavenly bodies. And you also have a reference in which part of the Krishna Yajurveda it is there. Not just one reference you also have other references. See you can also say you pick out one reference, which is convenient to you and then say everything is contained in the Vedas.



It is not an argument like that, one has to look at it with the dispassionate approach let us look at what is there and how we can understand it? And if you look at like that you also have another reference "Dadhartha prithivi mabito maukayihi…" the sun holds the earth from all sides with his power this is from different portion of Veda.



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And you also have very surprising approach that they had complete understanding of solar system. Earth is not flat, earth spins and rotates around the sun. For a very long-time people were not able to understand that earth can be a spherical ball and it has to spin and if you look at Aiteraya Brahmanam which says "Sa va yesha na kadachana asthamethi na udethi". Very clearly says

there is nothing like sunrises and sets, it is a perception because earth is revolving around itself. And they also had a clear knowledge of what the universe is; it is Brahmanda shape of universe is oval. Jagat one that does not stay in one position. Modern cosmology says that we are our entire supernova is traveling at a terrific speed not in one place ok.

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Let me ask this question does the moon spin? Somebody says yes, I am happy to hear that how do you say that the moon spins? What is your data to say that moon spins actually?

Student: (Refer Time: 10:01).

I have 3 animations here; I have animation number 1, here I have the moon is static. So, moon is not spinning around itself and it is moving around and you know these diagrams are not to scale just illustrations. So, if the moon does not spin how will you perceive when you are observing the moon from earth, you watch the animation you would be able to see all sides of the moon at different points from earth.

Suppose the moon spins then also you will see all sides of the moon. Does the moon spin like this? You have to know the fact because your generation is so glued to smart phones, you always look down you never look up. You have to see the

sky in all the earlier generations people looked at cosmology and that is where they had all the inspirations. You have to know a very important fact sitting on earth we always see only one side of the moon we never see the other side of the moon.

Can this happen moon spins at the same time you see only one side of the moon the answer is yes. It is possible that is what you see in the last animation what I have is the moon is spinning, but spinning at a appropriate speed, it is called synchronized motion. And you find whenever you see from the earth you see only one side of the moon. So, the idea here is whether the moon spins or not is not that very clear, it is a subtle point. If some generation some civilization says that moon spins you have to give credit to their intelligence.

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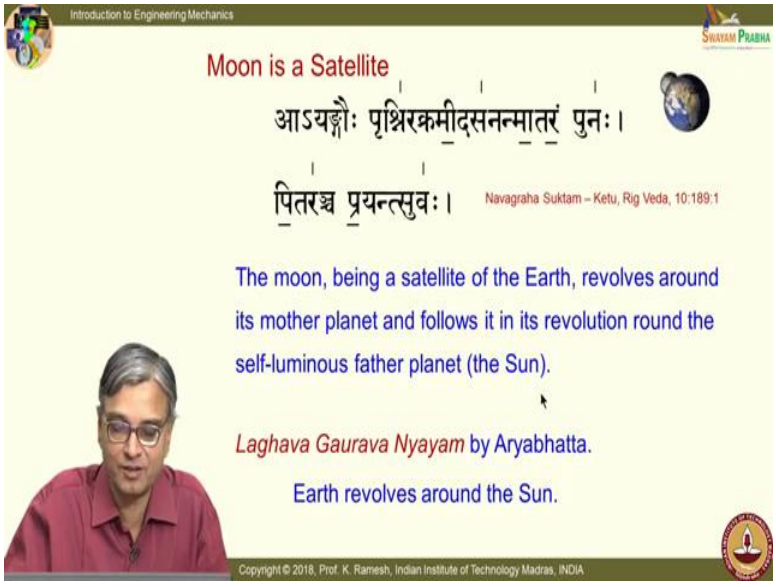
Let us see what our ancient wisdom is our scholars know that earth, moon spins around their axis. And you have a nice shloka "Bhumir bramyathi buddha yeva marutaha…" means earth spins it is a shloka of Sivotkarsha Manjari of Neelakanta Dikshita and he says the Brahmanam which is spinning is not only for the Yajamanan, but also for water, air, Agni, Akasam, sun, moon and earth very clear and when was this couplet written.



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In the period 1520 to 92 he is Appayya Dikshita and he is his grandson Neelakanta Dikshita.

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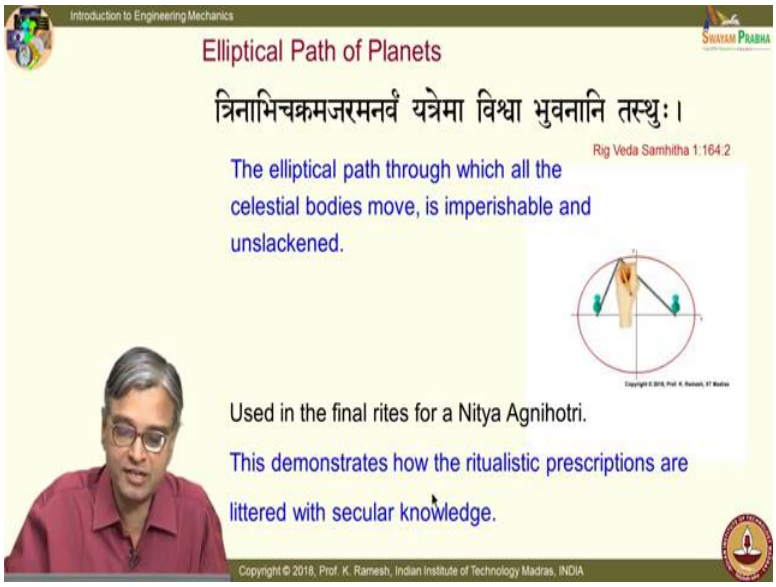
And you may say that you are taking out a shloka and then saying what is said in the Veda. It is very very penetrating and interesting "Aayangav prishnirakrami dasanan mataram punaha. Pitarancha prayanthsuvaha" which says very clearly the moon being a satellite of the earth revolves around its mother planet and follows it in its revolution around the self-luminous father planet. Can there be better explanation than the solar system? Unfortunately, in Indian education we have never attempted to bring in positivity of what is our tradition. It is so difficult to understand because we have lost our capability to understand Sanskrit. But it is embedded with wisdom and this is also used by Aryabhatta as Laghava Gaurava Nyayam; Laghava means light and Gaurava means heavy. So, earth revolves around the sun.



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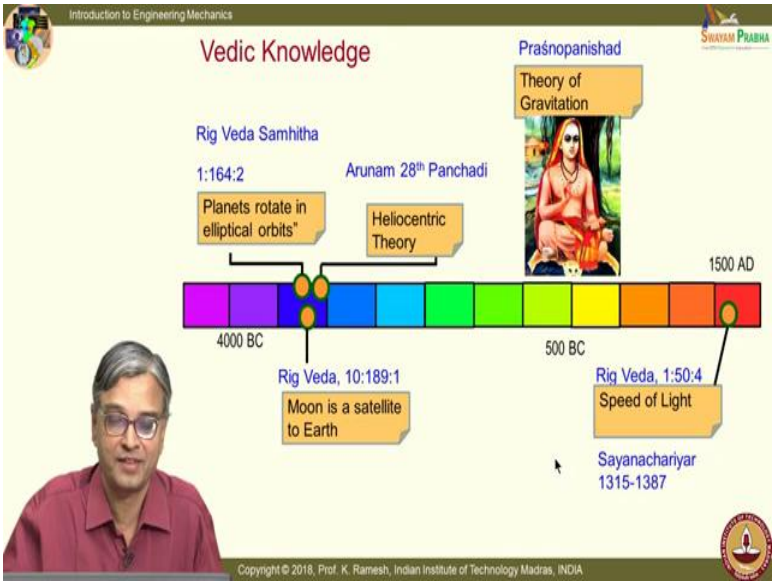
And there is another message in the Veda which starts like "Trinabhichakra majara manarvam yathrema vishva bhuvanani tasthuhu…". Suppose I give a piece of rope to you I ask you to draw a circle everyone in the class can do it. It is a very simple play you just tie one end of the rope put a pen or something like on the other end and then put it and you will get a circle.

Now, I ask you to draw an ellipse. How many of you can do that? I am happy. Because you have taught property of the ellipse and then you know how to do it with a piece of rope fine and do not you think you will be genuinely surprised if plotting of an ellipse is mentioned in the Vedas it is called "Trinabichakram". So, I have one focus, another focus, another focus and then I can beautifully plot an elliptical orbit and what does it say it says the elliptical path through which all the celestial bodies move is imperishable and unslackened. Imagine earth comes and says I am tired of revolving in the sun in 365 days. I am tired; I am now from now onwards I am going to travel it in 700 days.

What chaos will happen to the world; it does not happen know. It goes without any disturbance. And we have given credit to Kepler and there is a tie between Tycho Brahe or Kepler who has determined elliptical planets, elliptical orbits. And you find elliptical orbit is mentioned from it is fundamental aspect of its construction amazing.

I was very surprised when I came to know of this and I thought it is essential that I should bring this to your attention and you will be surprised this is used in the final rites of a Nitya Agnihotri. This demonstrates how the ritualistic prescriptions are littered with secular knowledge. It is all like germs you have to retrieve it from our tradition.



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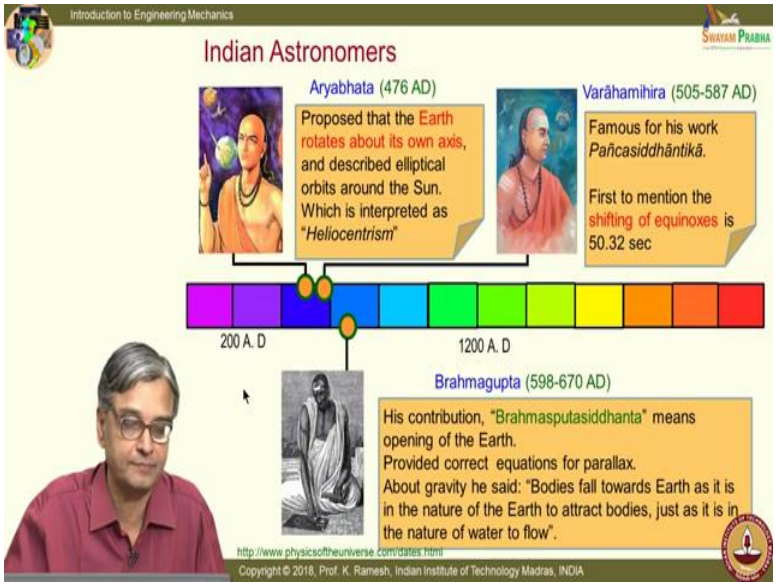
And here again I plot a time scale which is again non-linear and you know I am very conservative in the sense. From our perception, Vedas are we do not know when the origin is that is our tradition. As the earth is, I mean as the cosmos came into existence from that time onwards, we say. But you have Max Muller and other people western people who have given some kind of an arbitrary date.



Even if you take that date whatever the ideas that you find in the modern science it is dating back to Before Christ. We had the idea planets rotate in elliptical orbits we had the idea of heliocentric theory; we had the idea moon is a satellite to earth. Only when Adisankara interpreted we understood

theory of gravitation is also given in the Upanishads and later we will also see speed of light amazing it is also mentioned in the Vedas that was brought into focus by Sayanachariyar between 1315 and 1387.

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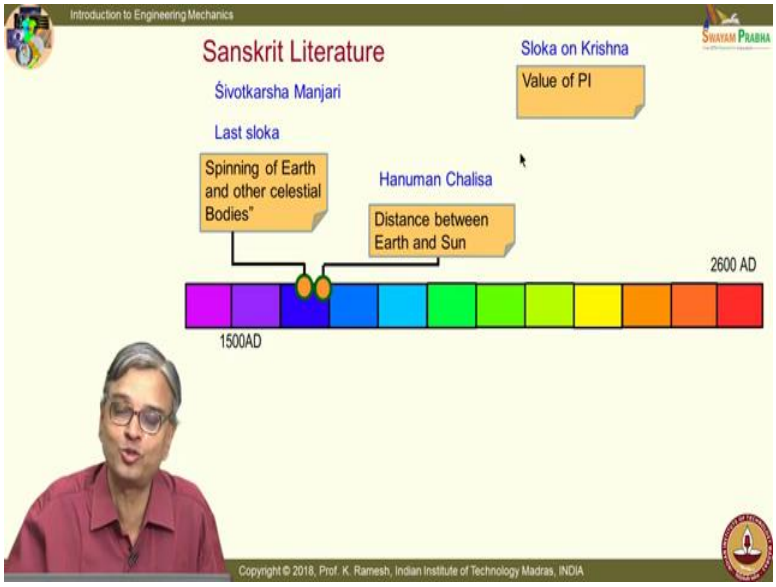
And we also had great astronomers our first satellite was Aryabhata named after him. He proposed that the earth rotates about it is own axis and described elliptical orbits around the sun which is interpreted as heliocentrism. Look at it was somewhere around 300 AD from a 4 76 500 AD or so ok. And you had Varahamihira this is another very difficult concept to understand.

See as we are going to look at gyroscopic motion you are going to look at what is known as precision; precision of earth ok. And that causes shifting of equinoxes and he has been able to give that number and imagine this precision one cycle takes something like 26000 years or so. It is not a phenomenon that one can find out in one's life. Several generations should have been looking at the sky and then finding out how to explain the data. Then finally, somebody understand that it is precession.



And we had that somewhere around 500 AD that is at least 1000 years before the western science talked about these concepts. And we also had Brahmagupta he talked about gravitation. Bodies fall towards earth as it is in the nature of the earth to attract bodies just as it is in the nature of water to flow.

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And we also have in Sanskrit literature spinning of earth which I have shown from Sivotkarsha Manjari. Because if you look at when something percolates down to poets it is a common knowledge, it is not confined to scientist. That is the way you have to look at it. And you have Hanuman Chalisa which Tulasidasa has composed it gives precise distance between earth and the sun and I had already shown you a shloka which showed the value of pi ok.

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Now, let us get back to our engineering mechanics. So, when I say engineering mechanics you know we want to make our lives simple. We start with a very simplified assumption mechanics of rigid bodies. What do you mean by a rigid body?

Student: (Refer Time: 20:09).

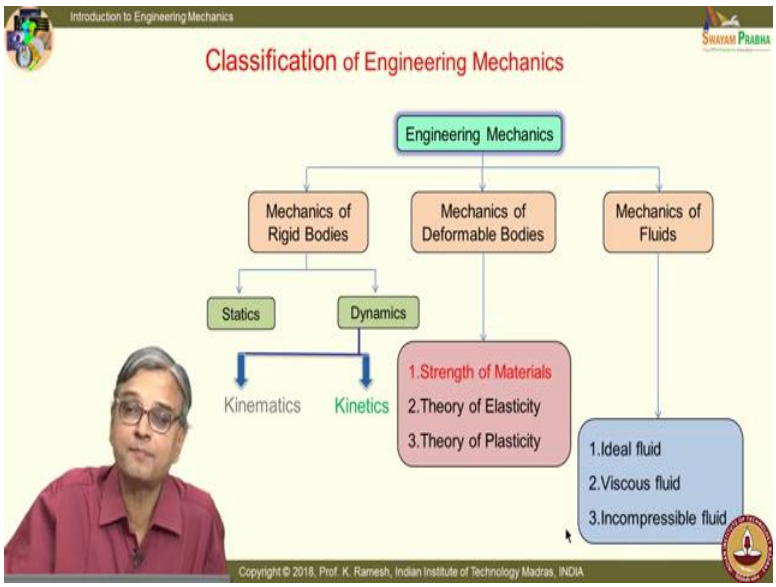
Not definite shape. There is a very simple and nice definition for rigid body please tell that.

Student: The distance between any two points in the body remains unaltered.

Very good very good that is the definition of rigid body. Is anything is rigid? When you say that I see a big granite stone I find that it is very rigid compared to I have a plastic board. Relatively a plastic board will not be able to with stand that high granite is going to have with stand a very high value of weight. But at a microscopic scale if an elephant stands on the granite it will also have deformations to make our lives simple, we idealize fortunately in this complete course all bodies as rigid ok.

And for aeronautics, mechanical and civil engineers they will also study mechanics of deformable bodies. Even when you go and look at the deformation, we would like to idealize a deformation and proceed with it and we will give a very important assumption. Let us consider first problems which have small deformations; we will not go near a problem which has large deformation, it is still in the purview of research only researchers will do large deformation and he will get a PhD thesis and get out of it.

Then you also have mechanics of fluids and if you get into mechanics of rigid bodies it can be classified into statics and dynamics and dynamics can be further classified into kinematics as well as kinetics. So, kinematics talks about the motions and kinetic talks about the forces that contribute to this. And if I go to mechanics of deformable bodies, I have strength of materials theory of elasticity and theory of plasticity. If you look at, we will have very simplifying assumptions. So, that you get an idea of what is it all about.



So, in initial stages of your learning you solve problems that are solvable you do not answer questions whatever you see around. Even simple questions are very difficult to answer you know about 20, 30 years back when person was arrested in the country all Vighnesha started drinking milk. And all physicists in the country they were trying to rationalize it was shown in the TV that is a TV era you take a spoon of milk take it to the deity it will vanish. And finally, they figured out that is because of surface tension.

So, what you will have to look at is seemingly what happens around you are not that simple to explain. We make a mathematical model make our lives simple and solve problems that are solvable in your initial set of courses from that you graduate and simplify a practical situation to a situation where you can analyze. And once you can do the mechanics of fluids, we start with an ideal fluid whereas all fluids have viscosity then you talk about viscous fluid. And you also give another assumption incompressible fluid that is how you develop the subjects ok. Have you been able to write this? Ok.

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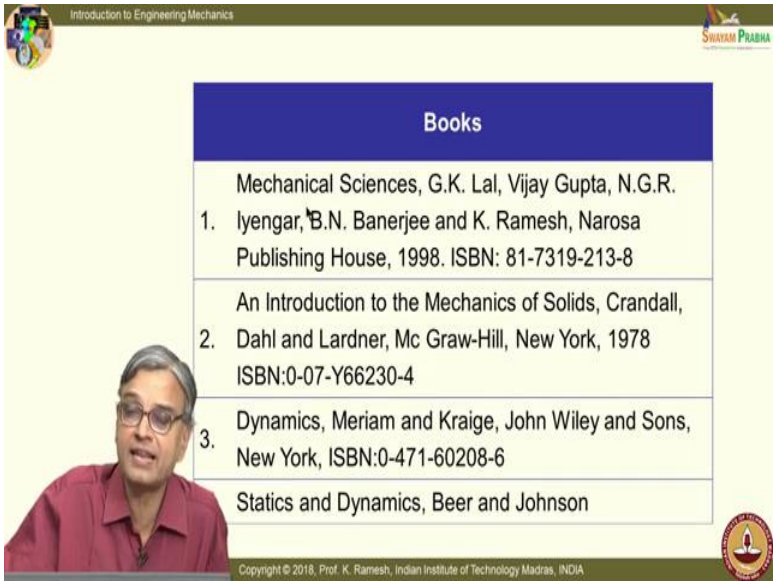
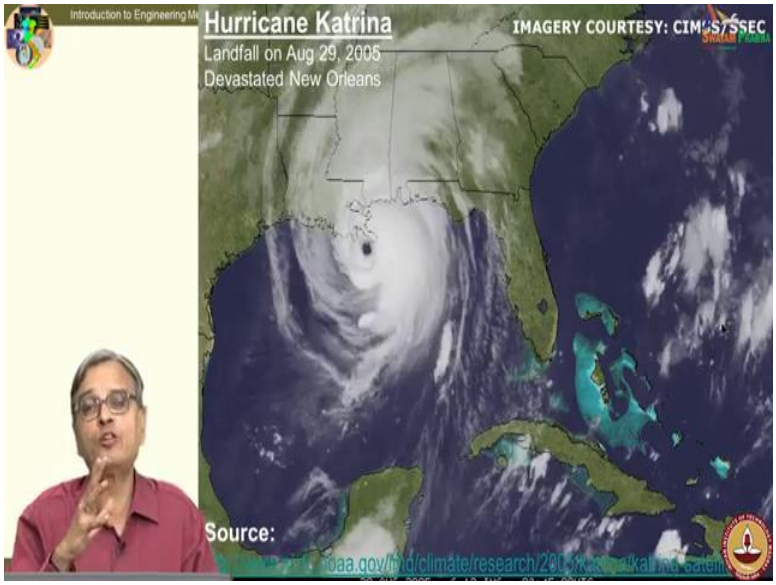
And the books that I would recommend are these a book by five of us. G. K. Lal and others from IIT Kanpur book on mechanical sciences. The first four chapters deal with statics that is what I had contributed to that that is very simple and clear. Then you also have a very nice book I would recommend all mechanical, aerospace and civil engineering students to buy this book an Introduction to the Mechanics of Solids, Crandall, Dahl and Lardner.



Then for the dynamics portion I would be following Meriam and Kraige. And there are also many other books you have a book by Statics and Dynamics by Beer and Johnson, Hibbeler there are quite a lot of books, but mostly the notes that you take in my class would be reasonably sufficient for you to follow the course. So, take your time to note down at least the title of the book rest of it you can find out by Googling, it is not that difficult for you to do. Can I go to the next slide?



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Say you do not learn enjoying only from books. You have to have very good sense of observing things ok. What do you see in this screen now you see a hurricane Katrina which devastated New Orleans. Can you guess what is it is relevance to this course? At

least I can say in the shloka Sivotkarsha Manjari it says air can spin around itself you see it is spinning around itself.

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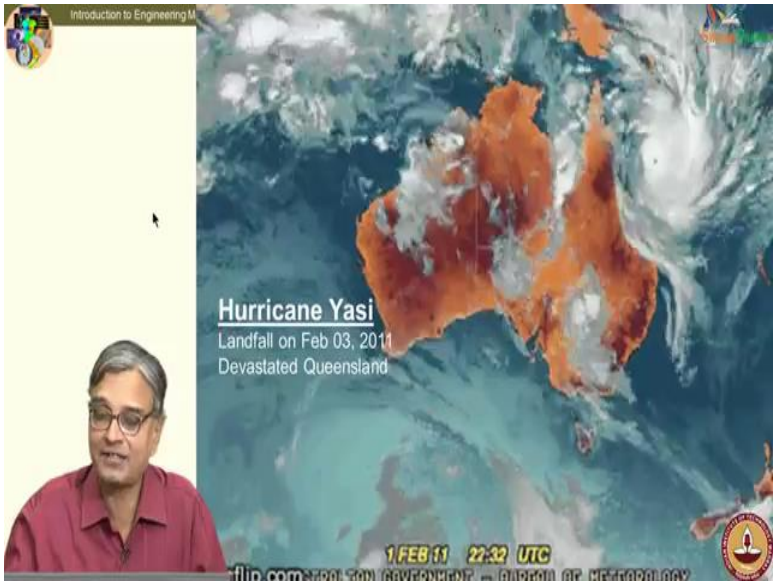
And let me see another slide is another hurricane Yasi which is hitting Australia it devastated Queensland, it happened in 2011 a very nice animations put in order by my students. I said that you have to observe these two carefully; how many of you have observed this have looked at a fact which I would like you to see in these two pictures? Do you get an idea? Yeah.

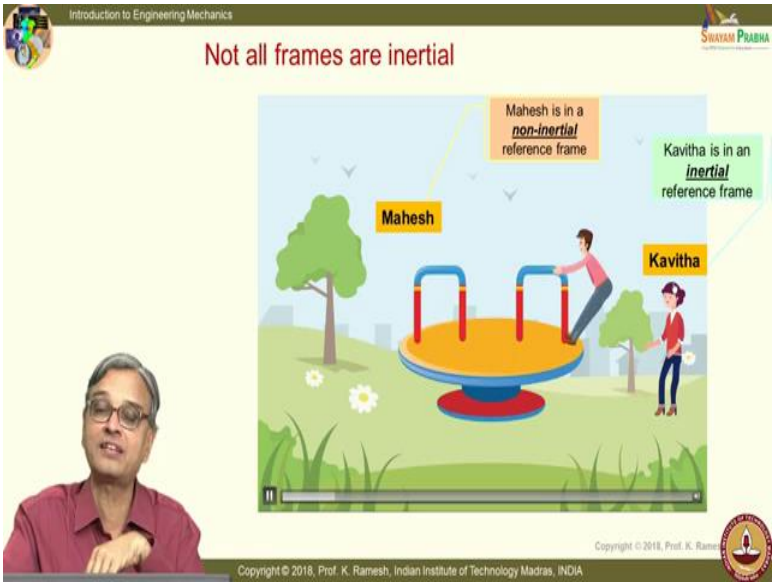


Student: (Refer Time: 26:50).

Let me go back and show let me show the first one you only see the cyclone that is moving. Please notice what is the way the cyclone is revolving? It is anticlockwise fine also associate this anticlockwise to the place. What is the place that it shows at the background? America's ok. So, it is in the which part of the earth; it is in the northern hemisphere. Now I come to the southern hemisphere I find a cyclone hitting the Australia all cyclones give us problems; no power, lot of rain, and you have to wait for candles and other things so on.

Unless you are really interested in nature and you observe you find there is a difference. Who is making it to revolve like this? And you will find all hurricanes in the northern hemisphere and southern hemisphere will be different, they will be rotating in a particular way. Here you find it is very clearly revolving as clockwise rotation and you would see when we take up dynamics. We would have effect called Coriolis Effect which would explain why it behaves like this.

So, as engineers I would like you to look at structures and ask questions how this is made why it is so? So, these two questions are very important. You do not learn engineering by reading your mathematical equations from the books, you have to look at physical structures, and also natural elements around you. You have to have the capacity to develop keen observation ok.



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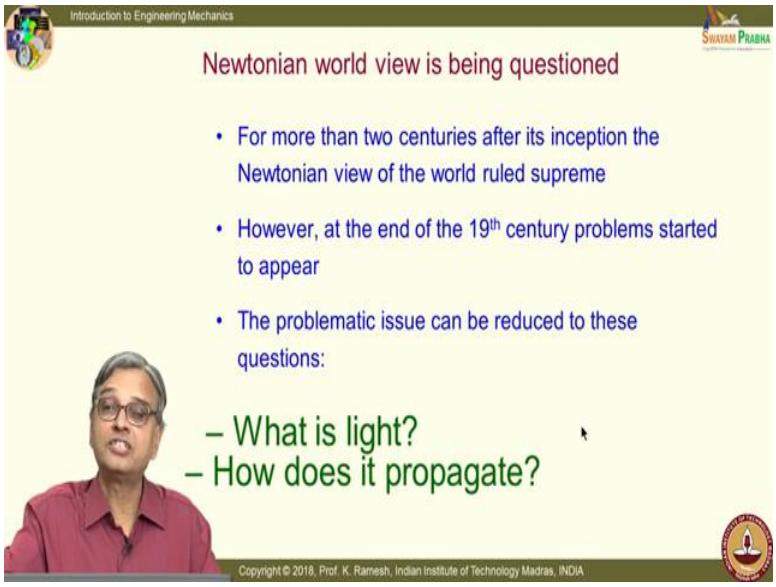
Now, this is another interesting illustration which shows because once you get into Newton's law of motion, we all talk about inertial frame of reference and I have two examples. Kavitha is standing in the garden and watching what Mahesh is doing; who is in the frame of inertial reference? I thought that this question everybody will answer. I have my own surprises see what the Newton's law says, I cannot have anything accelerating. When we looked at Galileo's relativity, I made a very important point both travelling in a straight line I said straight line is very important, it is a constant speed.



The same if I have a rotating platform rotating at a constant speed is it same as both travelling in a straight line with constant speed. These two are totally different that is why Newton said you need a force to change velocity and how do you perceive velocity, velocity is a vector; it has a direction and magnitude. So, in the case of a circular motion the direction keeps changing ok.

So, inertial frame of reference is what Kavitha is standing and Mahesh is in a non-inertial frame of reference. So, only if you refer physical laws from inertial frame of reference, they are valid. So, you have to apply Newton's law very very carefully, you cannot apply it the way you want it. So, you have to have a clear distinction between what is an inertial frame of reference and what is a non-inertial frame of reference ok.

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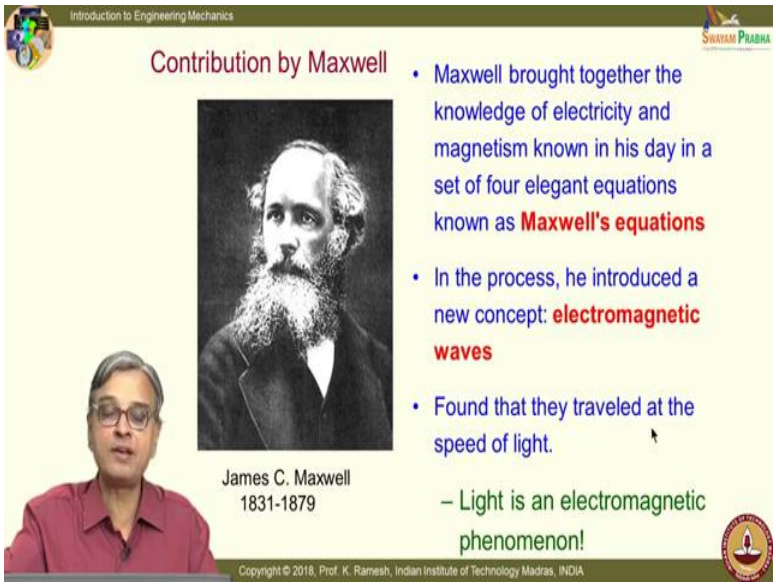
So, I said that Newton dethroned Aristotle's views after 2,000 years and it is unfortunate in science new scientist come, add more knowledge give trouble to us to study more at the same time they will dislodge earlier facts. So, the Newtonian world view is being questioned. For more than two centuries after its inception the Newtonian view of the world ruled supreme; nobody questioned it and people are happy.

Because Niels Bohr when they determined the atom, he convened the physicists and said we have determined the fundamental block of nature that is in the beginning of 19 century nothing more needs to be found out ok. So, that is how see civilization when they determine something, they are so enthusiastic about it. And it is very difficult when nobody else has found out a verification you pop your head and then say this is what it is, it is very difficult to make such statements ok. Though it may appear folly determination of atom is a very great scientific breakthrough ok.



So, at the end of 19th century problem started to appear. The problematic issue can be reduced to these questions. What is light? How does it propagate? These two are very important questions. How did the generations answer these questions?

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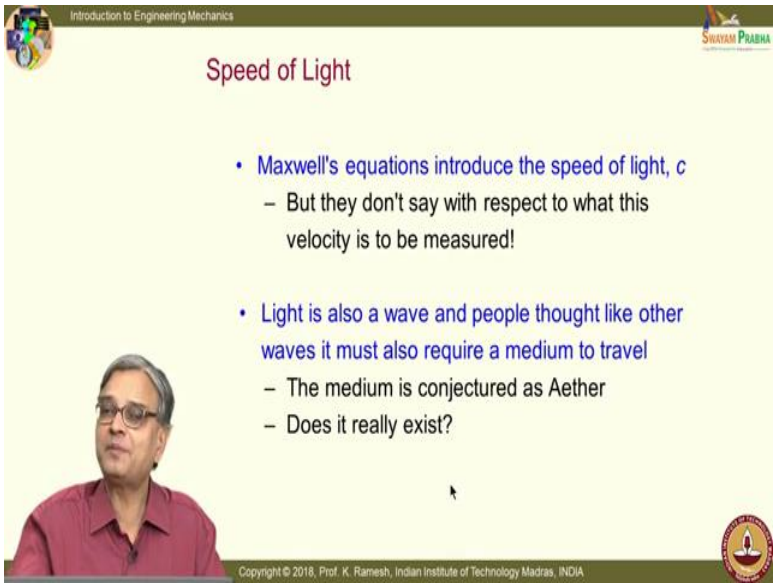
So, you had contribution by Maxwell; Maxwell brought together the knowledge of electricity and magnetism known in his day in a set of four elegant equations known as Maxwell's equations. What do these equations say? These equations say light is an electromagnetic wave. He introduced the concept of electromagnetic waves and he also found that they travel at the speed of light his statements are silent just the speed of light. With respect to what you had to measure that word is silent; people did not know they are clueless.



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And you all know see suppose you have a vacuum suppose somebody goes and speaks in vacuum can somebody hear you cannot hear. Sound is a wave it definitely requires a medium for it to travel light is also a wave ok. So, the generation when they have not understood what is light, they had lot of confusions, they had to conjecture different theories. So, the contribution of Maxwell was his equations introduced the speed of light c, but they do not say with respect to what this velocity is to be measured. And I have already said the light is also a wave and people thought like other waves it must also require a medium to travel. The medium is conjectured as Aether.

If you were in that generation you would have also thought being bright does not mean that you would have thought differently. Now you are taught in the schools there is no Aether you take it for granted as a fact and walk and do your daily routines you do not even have time to think about it ok. If you ask these fundamental questions, we will all stumble upon these questions and we will be looking for answers. Next the question is if I conjecture Aether does it really exist; you can verify it only by an experiment.

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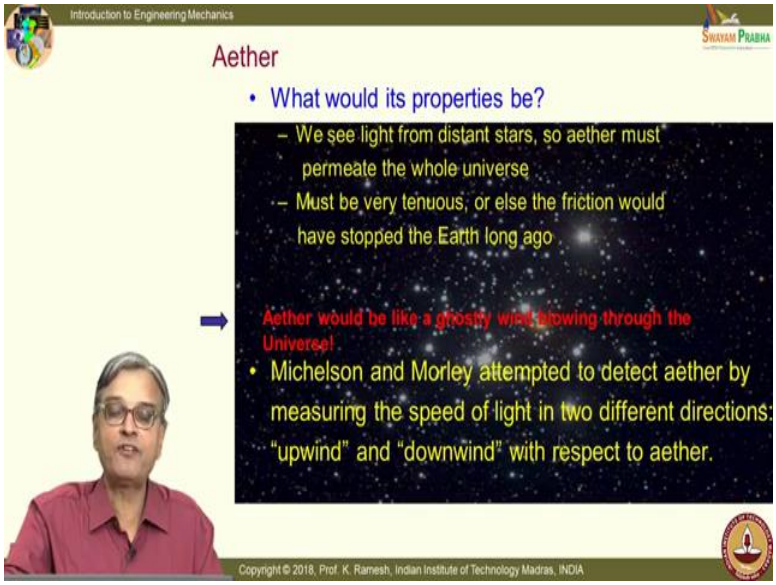
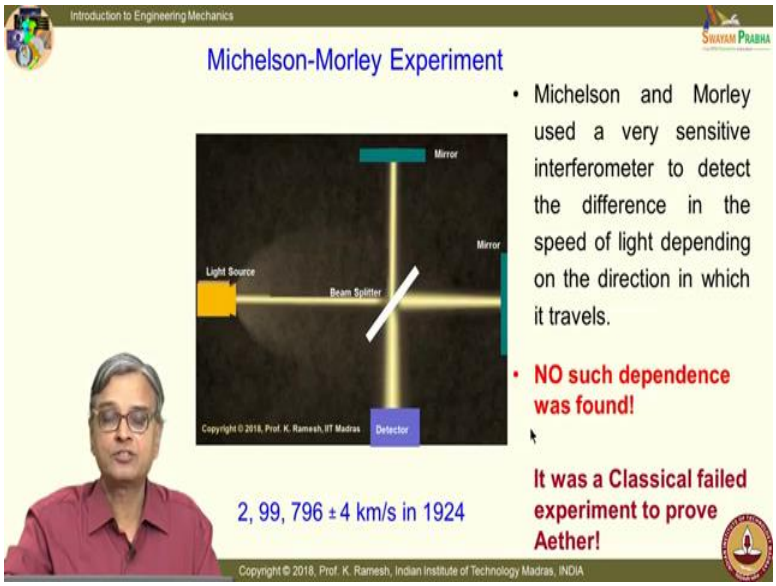
Suppose Aether exists what would be its properties? Because we see distant stars; they are several light years away. So, if it is so then Aether must be a very tenuous or else the friction would have stopped the earth long ago. Like I am said I am tired of going around the sun in 365 days I will take more time to do it Aether has not started doing it ok.



So, Aether would be like a ghostly wind blowing through the universe. So, these were the conjectures and it was for Michelson Morley who attempted to detect Aether by measuring the speed of light in two different directions; upwind and downwind with respect to Aether. The idea was from Newton's laws you will add and subtract and the velocity should change that is the idea behind it.



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And they had constructed a very sophisticated interferometer you had a light source which goes through a beam splitter goes through a mirror. So, these are two difference directions, and I have detector which detects this. And you know normally you think when I perform an experiment, I should get the result I want that is not the way experiments are performed people do it very carefully and it is the most celebrated failed experiments in physics.

What was the original idea behind the experiment? The experiment was to establish the existence of Aether. They rotated this interferometer at different directions then perform the experiment. He could not find in the detector any change because of directional dependence. It was a classical failed experiment to prove the presence of Aether. The message you get from that is there is no Aether and he also determined the speed of light it is 2,99,796 kilometers in 1924. It is a very sophisticated experiments at that point in time, they did not have a laser at that point ok. So, he had constructed a very sophisticated interferometer and did it.

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Now, let us go back I said speed of light is mentioned in the Vedas "Taranir vishwadarshatho jyothish kridasi soorya. Vishwa maabhasi rochanam…". This is the mantra and I said you need somebody to interpret this mantra. Otherwise it is not possible for us to understand what it is. Oh, sun you overwhelm all in speed visible to all source of light. You shine pervading the universe and we had the Sayanachariyar who has interpreted this "Tatha cha smaryata yojananam sahasram dhve dhve shate dhve cha yojane…".

This refers to it traverses 2,202 yojanas. "Ye kena nimishardhena kramamana namostu the…". So, nimisha is the time; it is remembered here that sun traverses 2,202 yojanas in half a nimisha that is what the reference to this mantra when Sayanchariyar who is a great scholar, and minister in the court of King Bukka of Vijayanagar Empire he had given this commentary.

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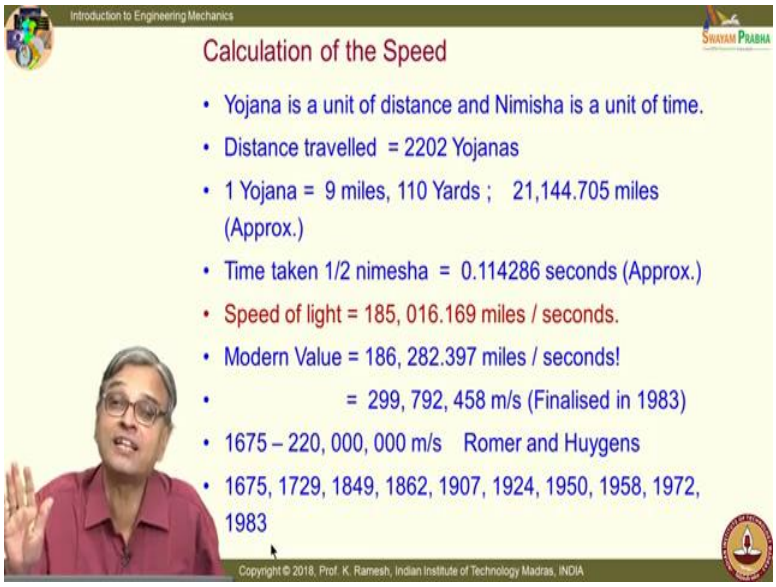
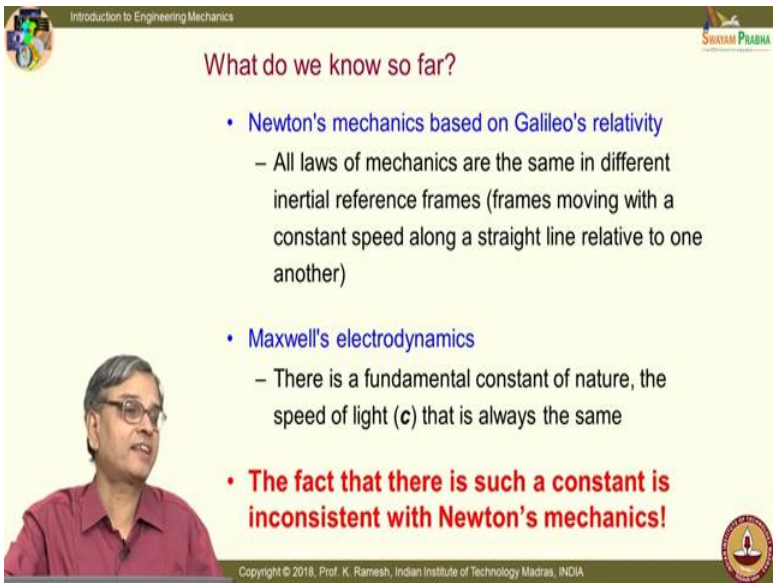
And now let us go and calculate the value for our own interest ok. What does it reveal? Yojana is a unit of distance and nimisha is a unit of time. Distance travelled is 2202 yojanas and 1 yojana is 9 miles and 110 yards. So, which goes to 21,444.705 miles and time taken is half a nimisha which is 0.114286 seconds, this works out to speed of light as 185,016.169 miles per seconds.



And the modern value is 186, 282.397 miles. So, it is quite close and in meters per second it is given in this form. And you should know that this was finalized in 1983, with several sophisticated instrumentation fine. And let us go back to scientific history and find out what was the value of speed of light with modern science knew at different points in time.

Romer and Huygens measured it in 1675 as 220, 000, 000 meters per second or 220, 000 kilometers per second far away from this. If you had compared the Vedic reference to speed of light you would say it is nowhere near the modern science. And the science says people measured the speed of light in 1675, 1729, 1849, 1862, 1907, 1924, 1950, 1958, 1972 and 1983.



Speed of light is frozen for modernity only in 1983. Even if you compare the speed of light measured by Michelson-Morley it does not compare with the Vedic value, but 1983 value compares with the Vedic

value. So, the choice is yours what credit that you should have given to our traditional wisdom which is buried which we were unaware of all these years.

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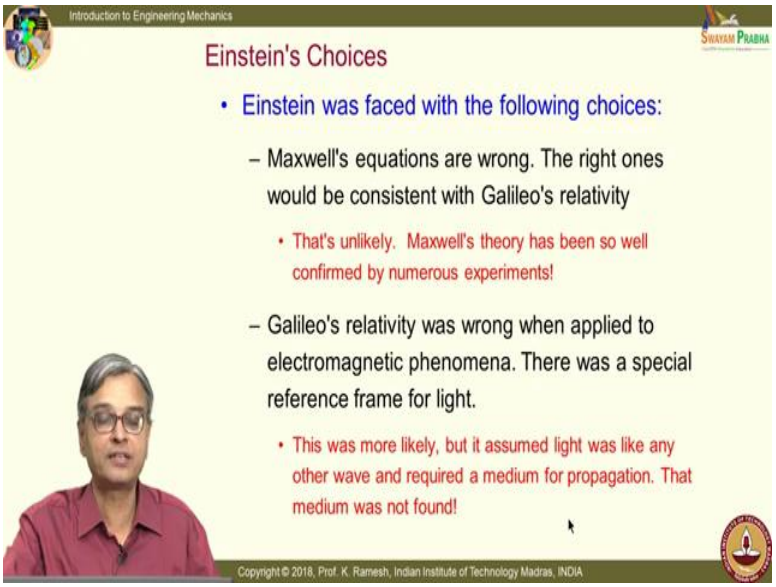
Now, let us get back to mechanics what do we know so far? Newton's mechanics based on Galileo's relativity all laws of mechanics are the same in different inertial frame reference frames; frames moving with a constant speed along a straight line relative to one another. Then we had Maxwell's electrodynamics, there is a fundamental constant of nature the speed of light that is always the same, but this is inconsistent with Newton's mechanics.



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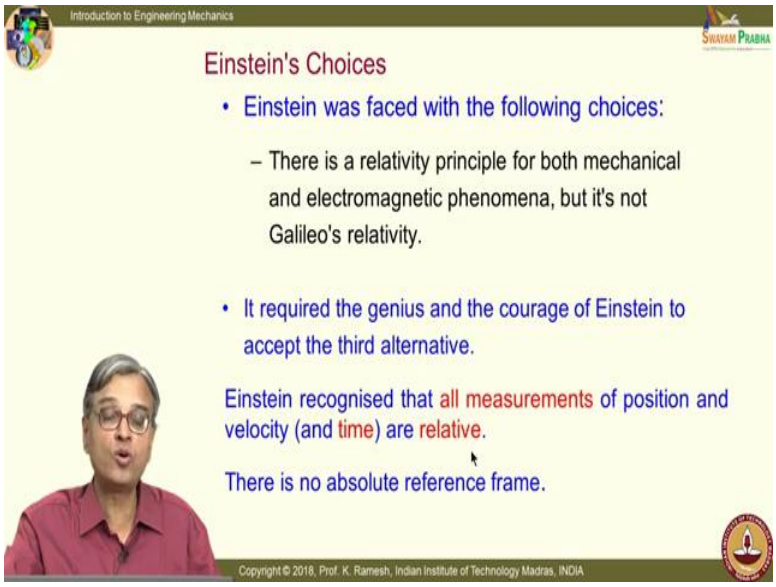
So, what do we do now? So, Einstein was faced with the following choices. Maxwell's equations are wrong the right ones would be consistent with Galileo's relativity which is not a right choice. Because Maxwell's theory has been so well confirmed by numerous experiments, Galileo's relativity was wrong when applied to electromagnetic phenomena; there was a special reference frame for light that



could be another possibility. If you look at this was more likely, but it assumed light was like any other wave and required a medium for propagation; that medium was not found from Michelson and Morley experiment there was no medium found.

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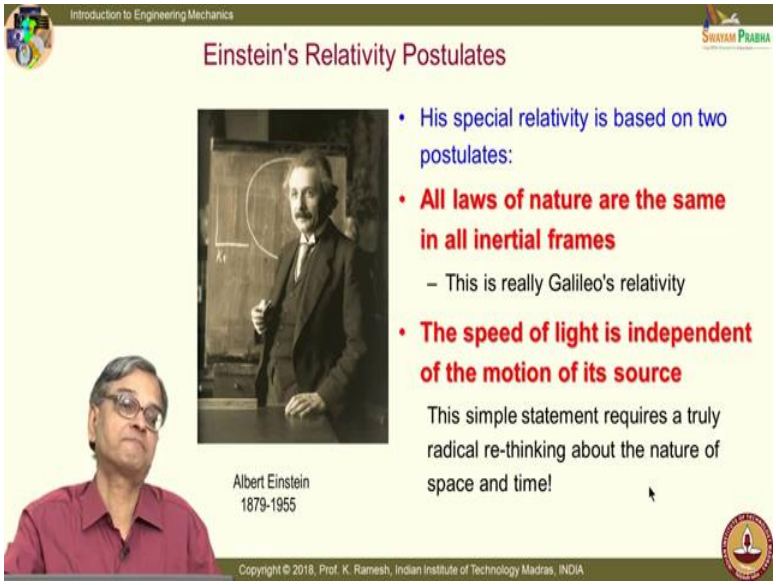
So, what is the third alternative? Einstein was faced with the following choices and the third alternative was there is a relativity principle for both mechanical and electromagnetic phenomena, but it is not Galileo's relativity. So, it required the genius and the courage of Einstein to accept the third alternative. He recognized that all measurements of position and velocity are relative. There is no absolute reference frame.



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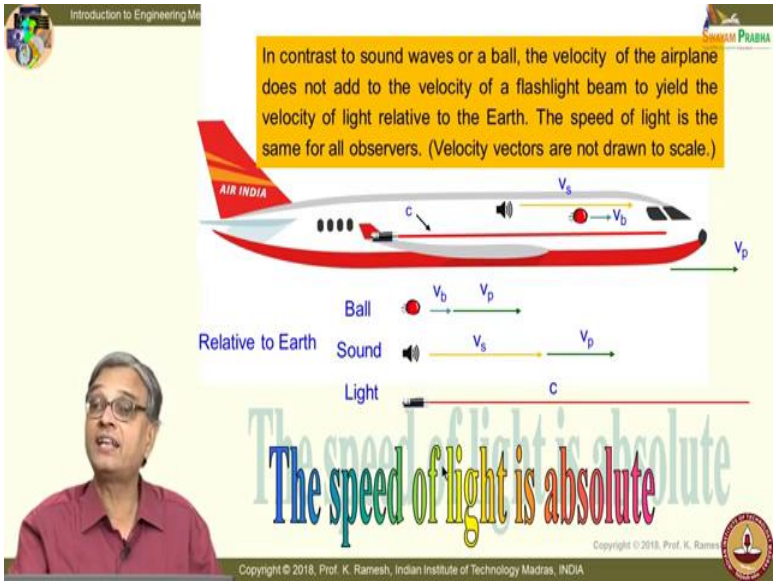

His special theory of relativity based on two postulates all laws of nature are the same in all inertial frames there is no change, this is really Galileo's relativity. The speed of light is independent of the motion of its source; the statement is very simple. This simple statement requires a truly radical re-thinking about the nature of space and time.

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And let us ponder about this; it is a very comical illustration you have a child travelling in the airplane, train to put the ball out. And somebody is listening to a cell phone music and somebody is taking a laser and then putting the light out ok. If the plane is travelling at a constant speed of *V*p as far as the observer on earth he would perceive the velocity of ball as velocity of ball plus velocity of plane. Same is true for sound; velocity of sound plus velocity of plane as the net velocity. The moment you come to light there is no change in the velocity; the speed of light is absolute that is what Einstein's special theory of relativity says ok. Let us try to understand it from a different perspective.

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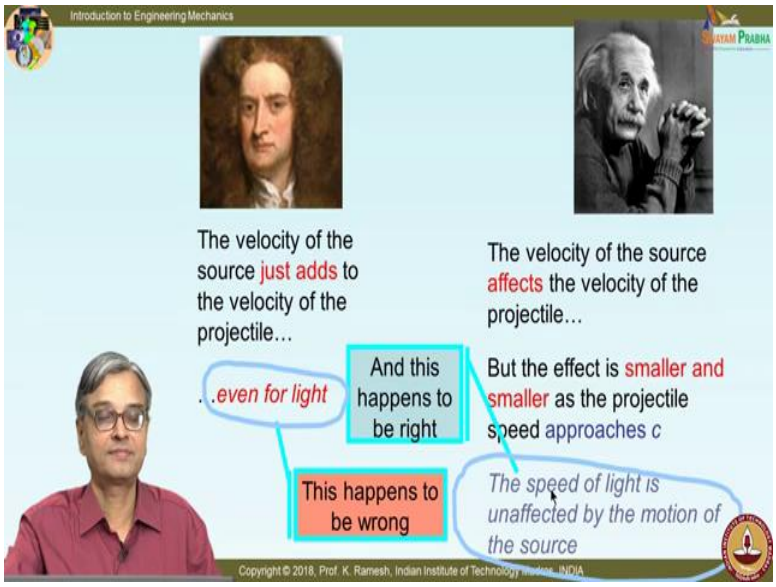
So, as per Newton's laws the velocity of the source just adds to the velocity of the projectile even for light that is what you can extrapolate from what Newton's laws can be looked at in this context. But for Einstein the velocity of the source affects the velocity of the projectile, but the effect is smaller and smaller as the projectile speed approaches the velocity of light.

Same statement but doctored in a different perspective and this is possible by another concept call time dilation, I am not going to get into this ok. So, people have accepted special theory of relativity, the speed of light is unaffected by the motion of the source what Newton's laws velocity just adds even for light happens to be wrong and this happens to be right.



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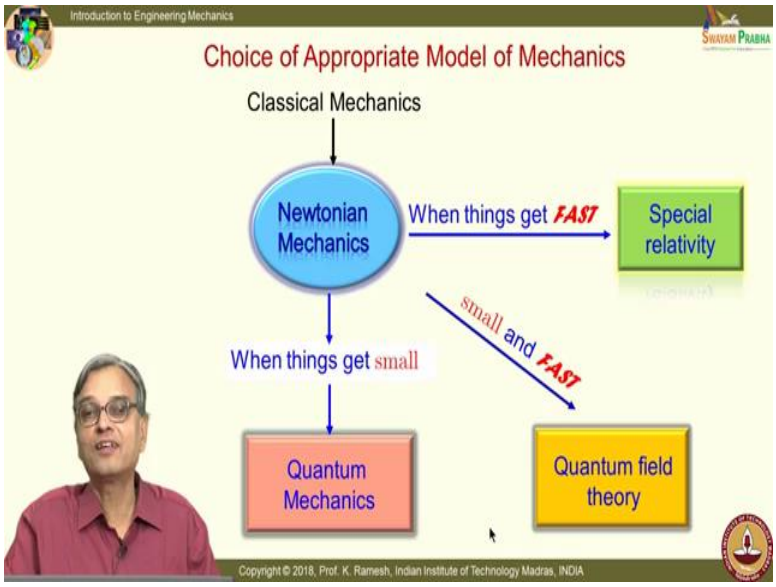
And in summary you know what we are going to look is classical mechanics is Newtonian mechanics. When things get fast apply special theory of relativity, when things get small



apply quantum mechanics, when things get small and fast apply quantum field theory. Fortunately, in this course we will confine our attention to Newtonian mechanics and which can explain many of our day-to-day activities.

But even for your GPS, unless you bring in relativity; those GPS satellites cannot transmit signal properly. And I said in any scientific development it is only destructing others has got funding. So, if you look at intercontinental missiles you cannot work with Newton's mechanics; you have to bring in special theory of relativity and then calculate its trajectory and then predict its target.

Thank you.