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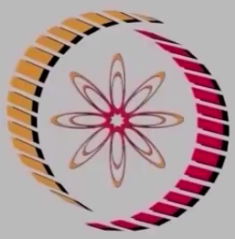

National Programme on Technology Enhanced Learning (NPTEL)

Course Title

Electromagnetic Wavesin Guided and Wireless

Lecture-41

Summary

by

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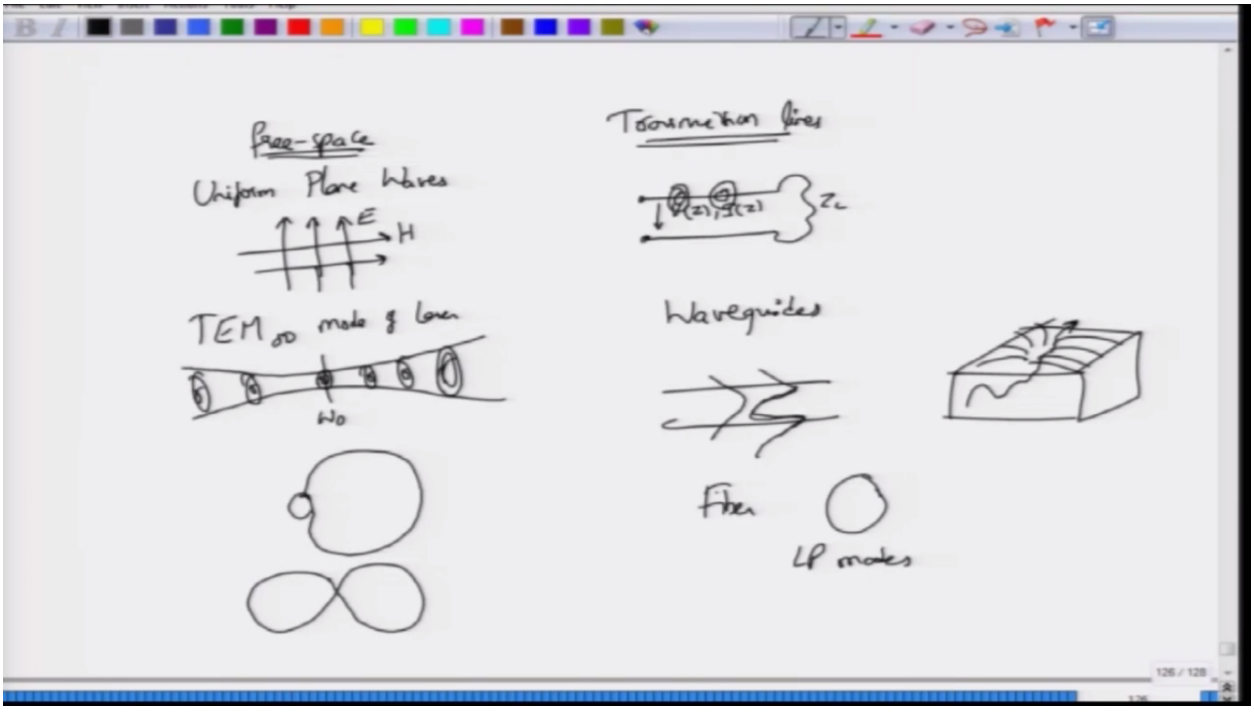

Before we conclude I just like to point out the different ways in which we have considered electromagnetic waves and the corresponding guided structure is first we considered

electromagnetic waves in free space medium. Here we saw that you have uniform plane waves. Uniform plane waves are the simplest solution of Maxwell's equations. There are no boundaries involved and the nature of these plane waves was that the electric and magnetic field lines were crossed with respect to each other and the wave front was plane and it was wavefront propagating along a particular distance.

We also saw in the same free space case propagation of a TEM00 mod of a laser and what we saw was that in free space as you move with a distance you will essentially reach a point where the beam waist would be minimum and then because of diffraction the beam waist actually increases on both sides. So these are the modes in the free space. Of course I did not write down the electric fields here but you can show that the electric fields actually will be and the magnetic fields will be curling around and forming lines in this manner. So you can verify this one later on. So this was the TEM00 mode of a laser.

When it came to and of course we had antennas so we looked at antenna pattern. So this was one of the antenna pattern that we saw. This was another antenna pattern that we saw. The doughnut pattern. And this was another antenna pattern. So all these different shapes of radiation fields are how the free space is responding to the source that you have. So uniform plane waves are kind of point sources far away from the plane that you are considering. TEM is a laser beam located with a very small aperture. The radiation of by an antennae is how you actually shape the electric and magnetic fields such that they become the guided modes. So our kind of interfacing the structure with the free space in order to obtain the different types of modes. Then we actually talked about transmission lines which kind of fell between the extreme frequencies of of one side where you can neglect I mean extreme side in one side where you can neglect the wave nature and where you can replace everything by a ray approach that is what I'm trying to get to is between the circuit regime and the geometric optics which I mean the geometric optics regime the sizes of the obstacles or mirrors or components was too high or too large compared to the wavelength so that wavelength could be considered approximately going to zero and on the circuit side you had this wavelength being so large that the circuit elements would start to look like points. So in between this is what we have transmission lines, wave guides, and other this thing. So in the transmission line what we saw was that you had these waves essentially in the form of the voltages and that currents and these voltages and the currents were guided and depending on what the load that you had kept they could be reflected, they could be changed and overall properties could be altered and we saw some problems with transmission lines in the sense that they would lead to lot of signal integrity problems but the essential fact is that they also constitute electromagnetic waves being guided along the structure. So the voltage would be between these planes and the current would be a surrounding – the magnetic field would be surrounding the conductor's and the specific way in which this would be present for a coaxial cable, for a micro strip and so on would also be the modes that are guided. So by mode don't think of modes only in the file you know wave guide modes. Everything is a mode in the sense that everything will satisfy, that satisfies Maxwell's equations plus any boundary conditions you can call them as modes.

Then we also saw wave guides. We saw two types of wave guides one is a dielectric slab wave guide in which the modes was present and some portion of the light was leaking out. So this was one mode and then this was another mode and so on, sorry this should have been more symmetric, but these are other again these are modes. In this case there are modes which are being guided in the core of the wave guide and outside they are not being guided, they are being radiated away. We also saw metallic wave guides in which for example we saw this three

dimensional metallic wave guide in which the modes are guided here. They will form a complicated electric field pattern. Unfortunately I did not talk about that but you can look up any textbook and again here the modes are propagating along the Z direction and then they will have a certain distribution in the electric and magnetic fields.

So this was the wave guides thing that we talked about. We talked about diffraction. We talked about interference in context of wave guide we also talked about fiber wave guides where we saw that the modes are given by the NP modes and so on. So these are all different modes. These are all different electromagnetic waves and in today's communication side we also of course looked at how these electromagnetic waves understanding of these could lead us to understand the basic channel properties that are widely used in today's wireless communication.

So what my suggestion is that whatever we have learned is just a starting point in this course but the basic theme that has been there is that everything can be understood in terms of electromagnetic waves and the corresponding Maxwell's equations with appropriate boundary conditions. So if you master these things that I have taught you then you can pretty much talk to different people you can talk to antenna people, you can talk to signal integrity people, you can talk to wave guide microwave people, you can talk to optics people and then finally you can talk to wireless channel or wireless people as well people who work with wireless channel models. So you get a basic tool in terms of Maxwell's equations and the corresponding boundary conditions and you can apply this to many different areas in today's engineering.

Thank you very much.