Experimental Physics I
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Lecture – 01
Introduction

So today, I will start discussion on this course experimental physics 1. So, this is the lecture 1. So basically, I will give introduction about this course.

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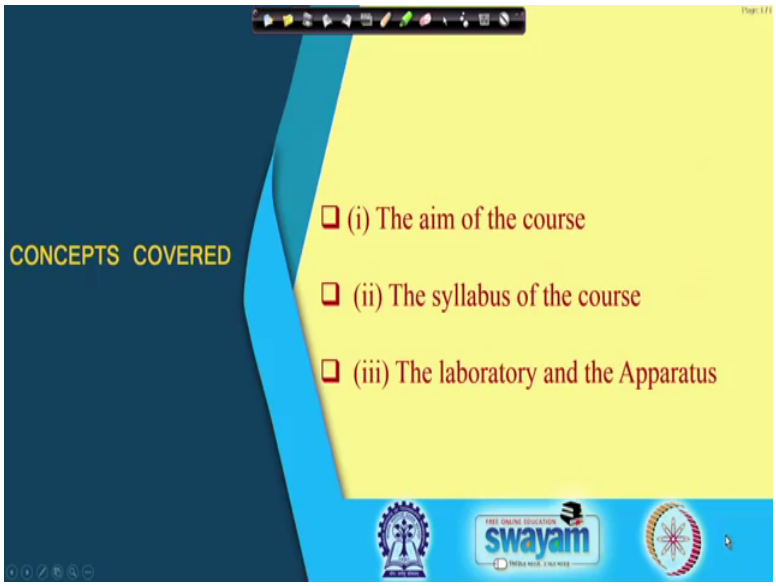

So, this concept we will cover in these lectures is basically, the aim of the course the syllabus of the course and the laboratory and the apparatus. So, about this we will discuss in this lecture.

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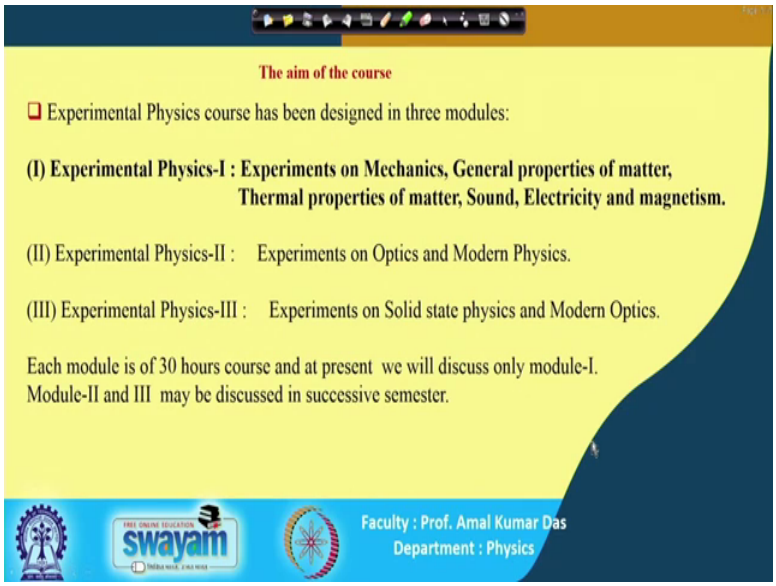

So, as you know the aim of this course basically, we want to learn about the experiment on physics. So, there are many topics on physics and we will discuss on selective experiments. So, we have designed the course in 3 modules. So, experimental physics 1, there we will discuss experiments on mechanics general properties of matter, thermal properties of matter, sound, electricity and magnetism.

Then experimental physics 2, there we will discuss experiments on optics and modern physics and experimental physics 3, in that module we will discuss experiments on solid state physics and modern optics. So, each module is of 30 hours course and at present we will discuss only model 1, model 2 and model 3, may be discussed in successive semester.

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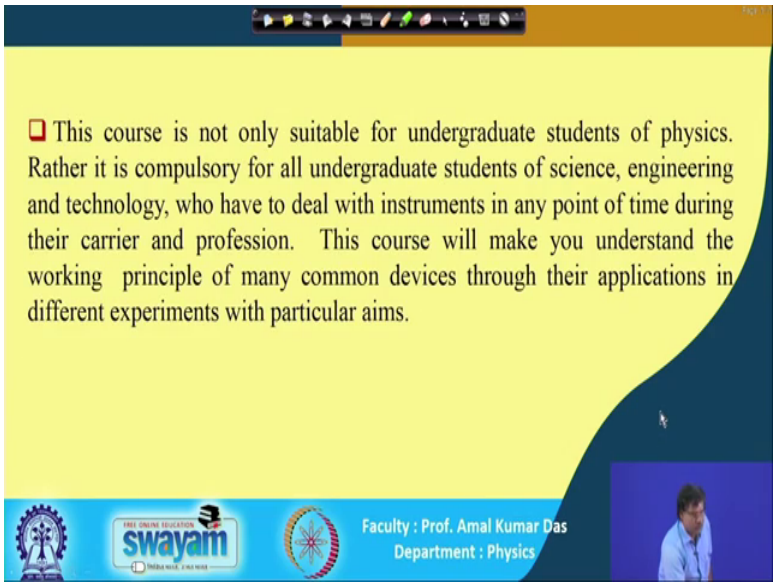

So, this course is not only for undergraduate students of physics rather, it is compulsory for all undergraduate students of science engineering and technology, who have to deal with instruments in any point of time during their carrier and profession. So, this course we will make you understand the working principle of common devices through their applications in different experiments with particular aims means in this course, we will discuss different experiments, their different tools, different parts of apparatus will be used and through application in those experiments, we will learn about the devices, which will be frequently used in your carrier and in your profession.

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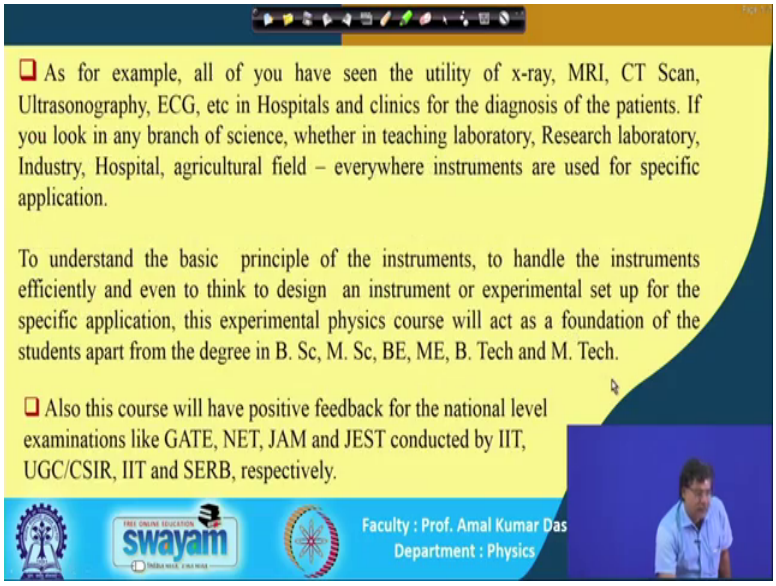

So, as for example, that all of you have seen the utility of the x-ray MRI, CT Scan, Ultrasonography, ECG etcetera in hospitals and clinics. Also if you look in any branch of science, whether in teaching laboratory, research laboratory, industry, hospital, agricultural field, everywhere instruments are used for specific application.

To understand the basic principle of the instruments to handle, the instruments efficiently and even to think to design an instrument or experimental setup for specific application, this experimental physics course will act as a foundation of the students apart from the degree in B.Sc, M.Sc, BE, ME, B.Tech and M.Tech. Also this course will have positive feedback for the national level examinations like GATE, NET, JAM and JEST conducted by IIT, UGC CSIR, IIT and SERB respectively.

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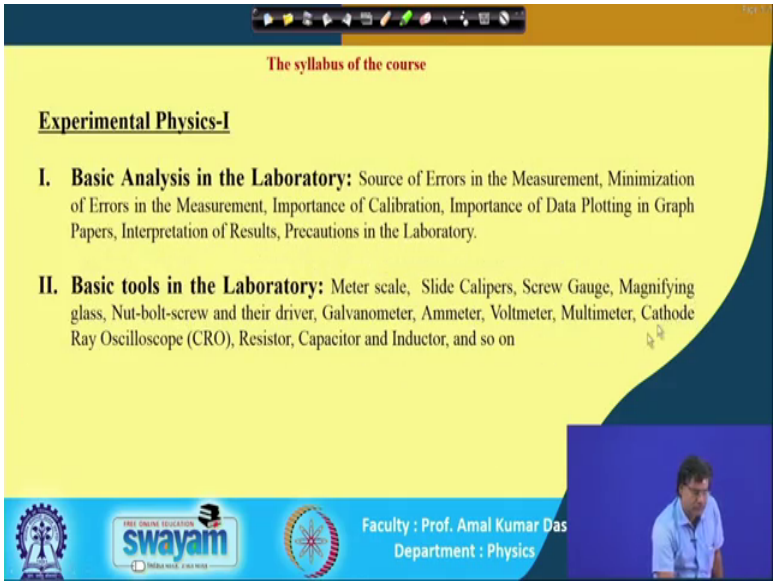

So, syllabus of this course means experimental physics 1. So, I will discuss about the basic analysis in the laboratory. So, when we will go to laboratory, you will perform experiment, specific experiment on different topics in physics. So, but there are common rules and regulations common there are some common things that everyone has to know. So, so that is basically how to take data, how to analyze their data, where is the what is the source of error in the measurement, how we can minimize the error in the measurement, how to calibrate the instrument, how to plot the data in graph ok.

And then after calculation you will get result, how to interpret that result and what are the precautions in the laboratory. So, this is a common phenomenon so, that I will

discuss and then we will discuss some basic tools in the laboratory. So, there is all the time you need it is most power most of the experiments, you need these common tools. So, those are this meter scale, slide calipers, screw gauge, magnifying glass, nut bolt screw and their driver, galvanometer, ammeter, voltmeter, multimeter, cathode, ray oscilloscope there is a CRO, resistor, capacitor, inductor and so on. So, these are the common tools, common components of any laboratory in science. So, I will discuss about those basic tools.

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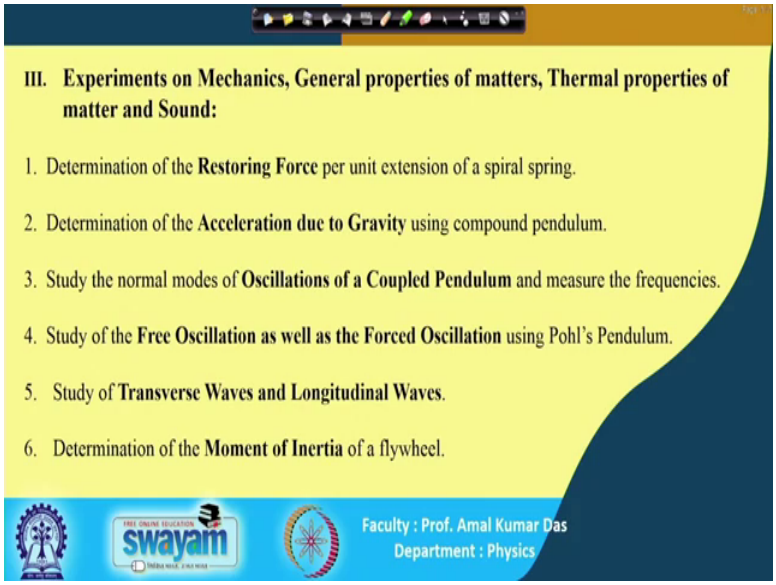

And then we will go the specific experiments. So, we have selected some experiments almost around 30 experiment, we have selected for this experimental physics 1. So, experiments on mechanics general properties of matter, thermal properties of matter and sound. So, those these are the experiments we have selected that will demonstrate in this course.

So, determination of the restoring force per unit, extension of a spiral spring. So, this is the one experiment on mechanics ok. So, you know the spring ok. So, spring has restoring force, if we extend it or compressed it ok. It want to go back it is original position equilibrium position ok.

So, how to measure the restoring force per unit extension ok? So, that experiment will perform, we will demonstrate then second experiment determination of the acceleration due to gravity using compound pendulum ok. So, g gravitational acceleration due to

gravity ok so, this is the universal constant. So, how to determine this universal constant using the compound pendulum? So that experiment will demonstrate.

Then third experiment study the normal modes of oscillations of a compound pendulum and major the frequencies ok. So, this oscillation of a compound pendulum ok. So, it has basically different modes. So, one mode is called normal modes ok. So, what is the frequency of this normal modes so, that experiment will perform and we will measure the frequency of the normal modes of the oscillation of the compound pendulum ok.

Then fourth experiment is study of the free oscillation as well as forced oscillation using Pohl pendulum. So, this is another type of pendulum. So, using that pendulum Pohl pendulum, we will measure the free oscillation and forced oscillation of the pendulum. So, it is basically in oscillation you know these there are natural frequency of oscillation then, if you apply force on this oscillation. So, externally. So, then it is a forced oscillation or another oscillation we tell damped oscillation means there are some resistance, when it is oscillating there are some resistance it is may be due to air, air resistance some may be some other resistance also this due to ad current etcetera. So, due to this is called damping ok. So, that is called damped oscillation ok.

So, here we will demonstrate this free oscillation and forced oscillation using the Pohl's pendulum then fifth experiment we will go for the study of transverse wave and longitudinal wave, you know the string, if we take a string and just you disturb it then it oscillates. So, that is the transverse oscillation. So that we will study this transverse oscillation and this longitudinal waves basically, this is the compressed of say when some waves are moving to the air. So, air this basically is particle air particles compressed and elongated ok.

So, it is basically displaced along the along the direction the waves are propagating so that is basically, longitudinal waves. So, we will demonstrate we will study the transverse waves as well as longitudinal waves.

So, the sixth experiment, we will demonstrate there is the determination of the moment of inertia of a flywheel. So, how to determine the moment of inertia of a body? So, here we will take this body as a flywheel and demonstrate, how to measure the moment of inertia.

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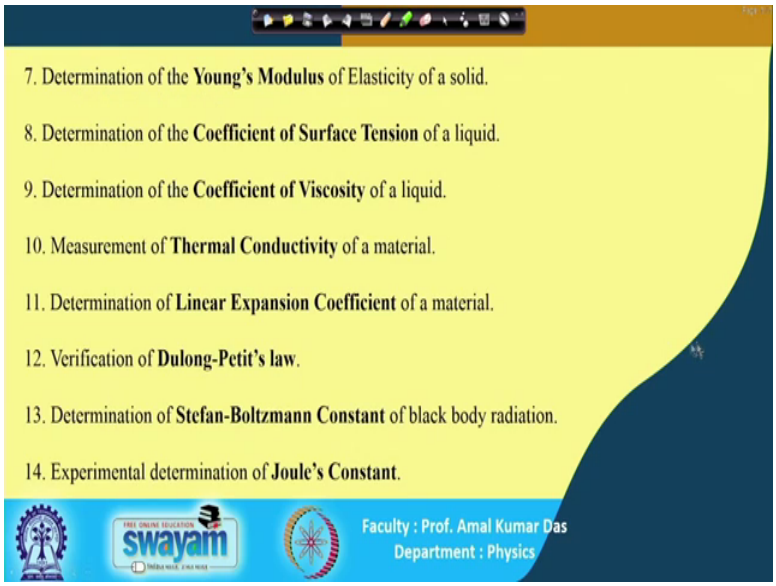

So, this way there are some other experiment seventh experiment, determination of Young modulus of elasticity of a solid. So, general properties of matter in this category. So, if we will how to measure the Young's modulus of elasticity of a solid, how to measure the surface tension of a liquid, how to measure the viscosity of a liquid, how to measure the thermal conductivity of a material ok. So, this is the thermal properties of the matter so, then linear expansion coefficient of a material. So, these experiments we will demonstrate the next wealth experiment, this verification of Dulong-Petits law ok. So, this specific heat related experiment. So, for this we will discuss and then determination of the Stefan-Boltzmann constant of blackbody radiation.

So, these are the basically, experiments on the heat. So, then next another experiment on heat this experimental determination of Joule's constant J so, that how to find out this Joule's constant that explained also we will perform and then some measurement on electricity.

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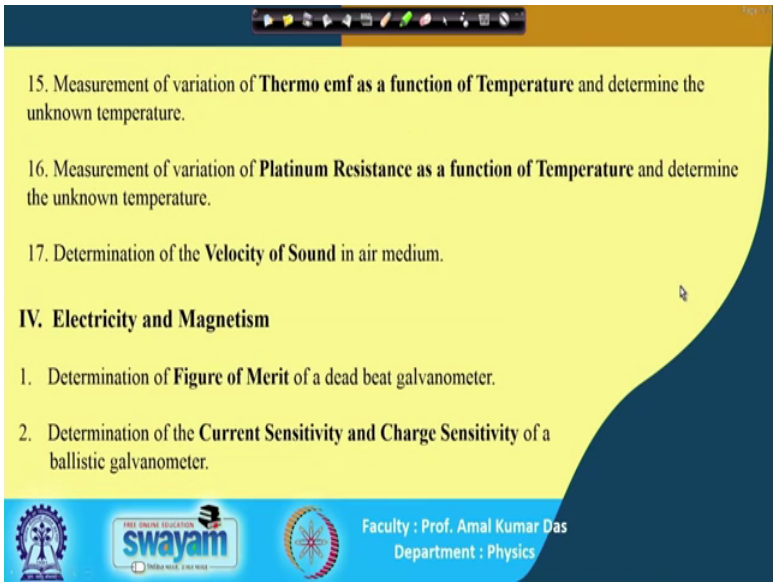

So, for this 15th experiment this variation of thermo EMF as a function of temperature and determine mine the unknown temperature.

So, these are basically it is a thermometer of this is a thermocouple using the thermocouple, how to measure the temperature ok. So, we will discuss physics behind this thermometer and then we will demonstrate, how to measure the temperature unknown temperature using this thermometer. So, first we have to calibrate this thermal this thermo thermocouple basically, due to the difference of the temperature it is generate EMF. So, that is the thermal EMF thermo EMF. So, temperature versus this thermo EMF that one has to calibrate.

So, after calibration then you can find out the any unknown temperature. So, that experiment we will discuss then another experiment of thermo as a thermometer this platinum resistance as a function of temperature determine, the unknown temperature. So, this is a another thermometer platinum resistance thermometer so, that also we will discuss then experimental sound, this how to determine the velocity of sound in a air medium. So, this you know this measuring the velocity of light, measuring the velocity of sound. So, these are the basic parameter. So, how to measure this basic parameter. So, in that group, one experiment we will discuss that is how to determine the velocity of sound in air medium.

So, then experiment on electricity and magnetism so, their this determination of figure of merit of a dead beat galvanometer. So, when you are going to experiment on this electricity. So, this galvanometer, voltmeter, ammeter right so, these are the basic tools ok. So, one should know about this basic tools basic apparatus ok.

So, this is one experiment ok. So, which will make you familiar with this with this galvanometer, voltmeter, ammeter, ok. So, what is figure of merit and what it what it tells about the galvanometer? So, we will discuss about the dead beat galvanometer and how to measure the merit figure of merit of this galvanometer that experiment will perform then this, what is the say current sensitivity and charge sensitivity of a ballistic galvanometer ok. So, different kinds of galvanometers are there ok. So, for dead beat and ballistic galvanometer very useful for the left. So, we will first we will do experiment to know about the dead beat galvanometer and ballistic galvanometer.

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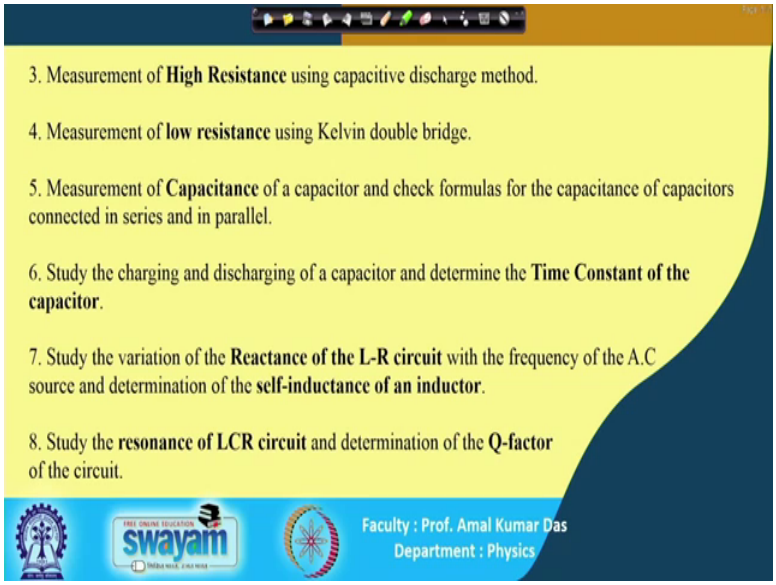

Then other experiment on electricity and magnetism are this measurement of high resistance using the capacitive discharge method how to measure the resistance ok, resistance having different range. So, in if it is in say kilo Ohm mega Ohm ok. So, then we tell it is a high resistance and then if it is milliohm micro Ohm. So, we tell it is very low resistance and then in between that is some other resistance.

So, here we will demonstrate, how to measure the high resistance, how to get the value of high resistance. So, there are different method, but here we will use the capacity of

discharge method and then another experiment next this low resistance. So, how to measure the low resistance? So, we will use again it has different method people use different method. So here, we will use the method that is called Kelvin double bridge method ok.

So, next experiment the how to measure the capacitance of a capacitor. So, you know this resistor capacitor inductor, these are the basic electric or electronic components right. So, we should know about this basic component. So, basically to know about these component. So, we will do some experiment so, that you can familiar with these basic components.

So, we will measure the capacitance of a capacitors and check the formulas for the capacitor capacitance of capacitors, when they are connected in series, when they are connected in parallels and then we will study the charging and discharging of a capacitor and determine the time constant of the capacitor. Next experiment, we will do this the variation of the reactance of the L-R circuit. So, reactance is the equivalent to resistance basically.

So, resistance of the L-R circuit LC circuit, it is a reactance, impedance, resistance. So, these are equivalent on only depending on the combination of the circuit whether, it is only R whether it is LR whether it is LCR ok. So, depending on that this different ten, impedance or reactance or resistance. So, we will study the variation of reactance of the LR circuit with the frequency of the AC source and determine the self inductance of an inductor ok.

So, the next experiment the, we will see this study the resonance of LCR circuit and determine the Q-factor of the circuits. So, you will say a circuit. So, quality of the circuits it determined measuring the Q-factor of the circuit. So, that experiment also we will do and then.

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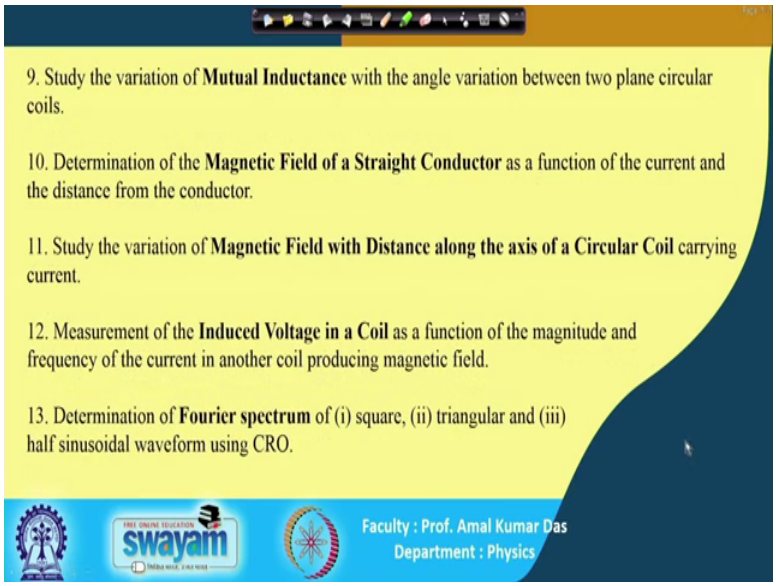

The next experiment this as I told is resistor capacitor inductor, these are the basic component. So, this next component is inductor. So, we will study the variation of mutual inductance with the angle variation between the 2 plane circular coils. So, coils basically is the inductor now, if you take 2 coils. So, interaction with this between these 2 coils. So, that is the called meter mutual inductance. So how mutually inductance varies when the angle between these 2 coils will vary so, that experiment we will perform. So basically, this will give you or teach you about the inductor.

And then you know this CPU current flows in a conductor. So, it generate magnetic field ok. So, that type of experiment we will perform. So, we will determine the magnetic field of a state conductor as a function of current and the distance from the conductor. So, how magnetic field depends on the magnitude of the current how magnetic field magnitude of the magnetic field depends on the on the distance of the point why do you want to measure the magnetic field. So, the distance of the point from the wire ok.

So, as a function of this current and distance we will measure the magnetic field when current flows in a state conductor. Then we will study the variation of a magnetic field with distance along the axis of a circular coil when current will pass through the circular coil. So, circular coil if you pass current through the circular coil. So, how magnetic field varies. So, we will measure the magnetic field along the axis of the coil as a function of

as a function of the distance of the coil as a distance of the point, where we want to measure the magnetic field from the center of the coil ok.

So, that experiment we will perform. So, this basically we will teach you how to generate magnetic field ok. So, in our laboratory for different experiment, you will see that we will use the magnetic field say, you want to measure the magnetic want to measure the variation of a of resistance of a material as a function of magnetic field, if we apply magnetic field whether resistance of the material changes if changes, how it changes ok. So, when you want to study this type of problem you want to demonstrate this type of experiment ok. So, you need magnetic field in the lab. So, how to get the magnetic field in the lab? So, this is the way then we use the electromagnet. In electromagnet is nothing, but the 2 heal mooch coil ok. We use to produce uniform field between the, these 2 coils ok. So, in that uniform field we place of our material and then we vary the magnetic field barring the current in the coil and then we measure the resistance of this material at different magnetic field ok.

So, here this is a basic experiment you know this it will. So, you will learn how to generate magnetic field in the laboratory. So basically, this is the purpose to choose this experiments and then next experiment is a measurement of the induced voltage in a coil as a function of magnitude and frequency of the current in another coil producing magnetic field ok.

So, you know this Lynch law this Faradays law; Faradays induction law right. So, basically if you have a coil ok. So, if you pass current through this coil so, it will generate magnetic field ok.

Now, if you take another coils ok. So now, if you take this coil without flowing current in this coil, if you take this coil close to this coil, which is producing magnetic field. So, this magnetic field is nothing, but the lines of force right magnetic lines of force. So, this lines of force will pass through, we will pass through this second coil and so, that we tell this flux this magnetic lines are passing through this and the second coil, we tell this flux passing through the second coil and magnetic field nothing, but the flux per unit area ok.

So, now this coil now this, the second coil is in flux is in magnetic field. Now if there is a variation of the magnetic field or variation the flux linked with the second coil, if it is it varies with time then there is a induced EMF produced generated in this second coil ok.

So, this induced EMF it is basically proportional to the change of the rate of the flux. So, if phi is the flux. So, d phi by dt that is the rate of change of the flux ok. So, this induced EMF is basically equal to minus d phi by dt. So, why minus? It is minus basically, it is this due to this EMF induced EMF there will be induced current in the coil second coil. So now, due in this induced current in the coil. So, when current in the coil. So, it produce magnetic field. So, that magnetic fields direction will be such that it will oppose this original magnetic field ok. So, that is why this minus sign is given. So, it is the it will oppose the magnetic field of the first coil ok.

So, in second coil this direction of the EMF should be such that; that means, direction of the current should be such that. So, the second coil will produce magnetic field induced magnetic field, that filed will be will opposed the original magnetic field ok. So, that is why it is the induced EMF is equal to minus d phi by dt. So, this is another very nice basic experiment that we will this we will discuss and then we will discuss the determination of the Fourier spectrum Fourier spectrum, you know Fourier analysis of signals ok.

So, any signal if it is a of one frequency that is fine, the most of the signals is not of one frequency is the superposition of the many frequencies ok. So, Fourier analysis use to separate those frequencies ok. So, there is the analysis of the spectrum ok. So, this is called. So, if we take any spectrum it has different components of the frequency, now this is the how to find out the different component of this of the frequency in that spectrum. So, there is basically there is a Fourier spectrum and that spectrum. So, we will determine that basically frequencies of the Fourier spectrum in form of square wave triangular wave or thus half sinusoidal waveform using the CRO.

So, again another basic instrument in the laboratory that is the there is the CRO cathode ray tube cathode oscilloscope ok. So, this is the basic instrument. So, using. So, this experiment will help us learn about the about the CRO ok. So, we will do experiment and for each experiment most of the experiment say, there are some common tools that will be used. So, there is the application of these common tools in different experiments. So, first I will discuss some basic tools and what are the basic tools that is what that is what I told it is a screw gauge and then slide caliper and then meter scale then volt meter then galvanometer then CRO cathode ray oscilloscope, these are the basic instrument.

So, in most of the experiments, experimental setup. So, these tools are used this apparatus are used. So, before I go to discuss this particular experiments, wherever I showed you. So, I will discuss about the basic a instruments ok.

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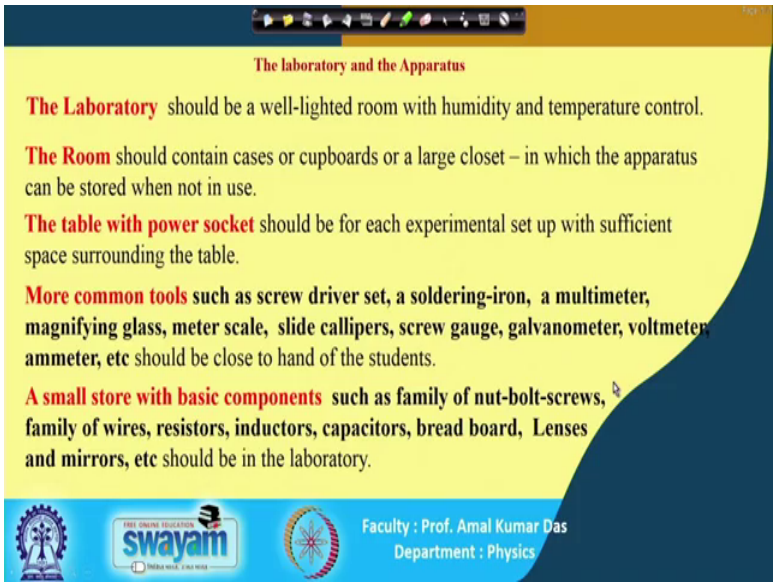

So, how should be so, these are the experiment we will discuss with time. So, so, then you have to go to laboratory, you need laboratory and then you need apparatus ok. So, how should be the laboratory? This is the I think you see these students when go to the laboratory. So, somebody has somebody maintained the laboratory ok. So, student do not bother about the laboratory. So, they get the readymade set up from the table and they you they are they perform the experiment ok.

So, this is I think we have to look in different way. So, you have to think if I want to develop a laboratory. So, how laboratory should be so, that if you think. So, then this. So, I believe that this laboratory should be well lighted room with humidity and temperature control. The room should contain cases or cupboards or a large closet in which, the apparatus can be stored when not in use because, you have to save your setup and when you are fabricating, generating, producing, something. So, you have to take care of a saving them also ok.

So, this there should be some arrangement for keeping the apparatus, when they are not in use, then there should be table with power circuit for each experimental setup with sufficient space surrounding the table and then there should be more common tools such

as screw driver set, a shouldering, iron, a multimeter,, a magnifying glass, meter scale slide, calipers, screw gauge, galvanometer, voltmeter, ammeter, etcetera these are very common tool and it should be always available to the students. So, it should be close to the hand of the students ok.

And then there should be a small store with basic components such as this family of nut, bolt, screws, family of wires, resisters, inductors, capacitors, bread, board lenses and mirrors etcetera, it should be always these are the basic components and various kind of these components should be in the laboratory because, these are small small components for. So, anytime you may need them and it should be available to you. So, there should not be wastage of time that it is not there so, because if we need one screw and if screw is not there you cannot do the experiment or what we want to do that you cannot do immediately. So, I think these are the basic components, which should be available in the laboratory ok.

So, I think these are the interaction about this course and then next we will discuss basic components and some common tools in next class so.

Thank you for your kind attention.