Experimental Physics - II
Prof. Amal Kumar Das
Department of Physics
Indian Institute of Technology, Kharagpur

Lecture – 01
Introduction

You are welcome to the course: Experimental Physics II, I am Amal Kumar Das from Department of Physics, IIT Kharagpur. In this lecture, I will give introduction about this course.

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So, what is the aim and what are the concepts will be covered in this lecture? I will discuss about the aim of this course; syllabus of the course as well as about the laboratory and the apparatus.

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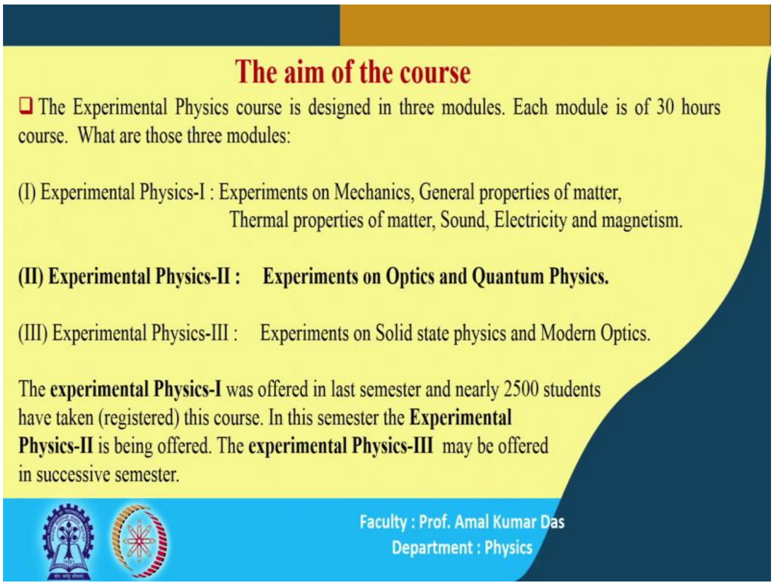

Let us first discuss about the aim of this course. The experimental physics course is designed in 3 modules; each module is of 30 hours. So, what are those 3 modules: the experimental physics-I, where experiments on mechanics, general properties of matter, thermal properties of matter, sound electricity and magnetism are discussed. In module 2, the experimental physics-II, we will discuss about the experiments on optics and quantum physics and in 3rd module, the experimental physics-III, we will discuss experiments on solid state physics and modern optics.

The experimental physics-I was offered in last semester and nearly 2500 students have taken this course. In this semester the experimental physics-II will be offered, and the experimental physics-III may be offered in successive semester.

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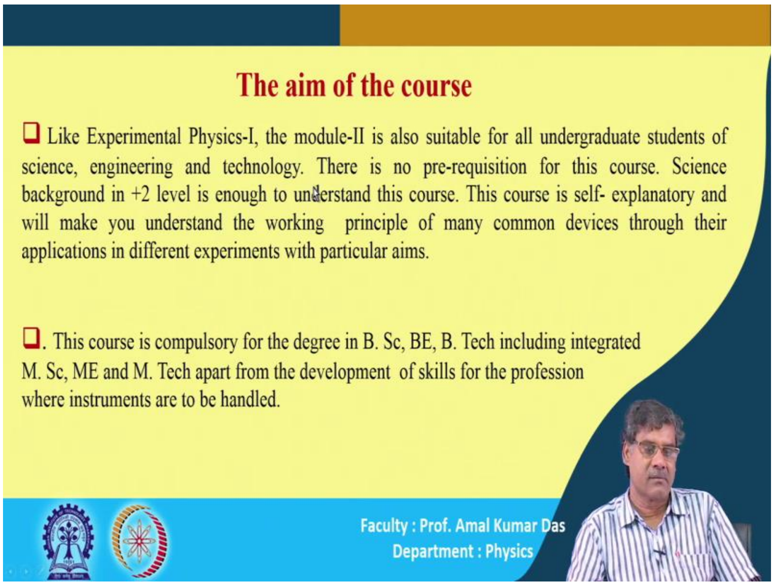

So, like experimental physics-I, who has taken this course you know that we have mainly discussed the experiments in very simple way and this course was suitable for science students, engineering as well as technology students.

Like the experimental physics-I, this module-II is also suitable for all undergraduate students of science, engineering and technology. There is no pre-requisition for this course; science background in plus 2 level is enough to understand this course. This course is self-explanatory and will make you understand the working principles of many common devices through their applications in different experiments with particular aims.

This course is basically compulsory for all students who are pursuing for their degree in B.Sc, B.E, B.Tech including the integrated M.Sc, M.E, M.Tech apart from the development of skills for the profession where instruments are to be handled.

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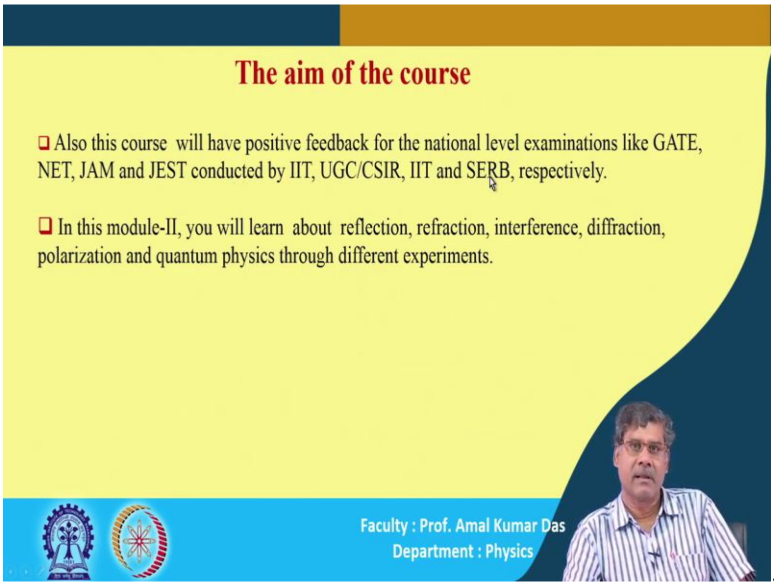

Also this course will have positive feedback for national level examinations like GATE, NET, JAM and JEST conducted by IIT, UGC & CSIR, IIT and SERB, respectively. In this module-II, you will learn about the reflection, refraction, interference, diffraction, polarization and quantum physics through different experiments.

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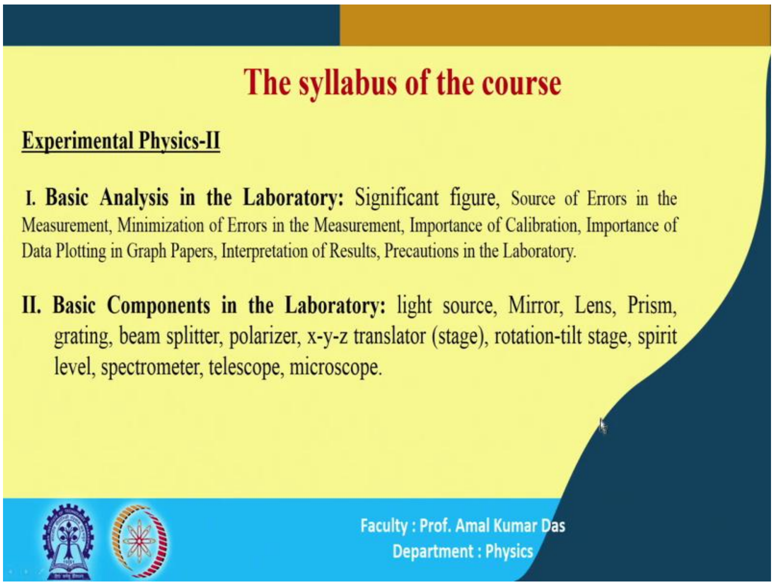

Now syllabus of this course are the following: I will discuss about the basic analysis in the laboratory, basically I will discuss significant figure, source of error in the measurement, minimization of errors in the measurement, importance of calibration, importance of data plotting in graph papers, interpretation of results, as well as precautions in the laboratory.

Also I will discuss about the basic components in the laboratory, which are required for this course. Mainly I will discuss about the light source, which is compulsory for the optics experiments and then I will discuss about the mirror, lens, prism, grating, beam splitter, polarizer, x-y-z translator, rotation or tilt stage, spirit level, spectrometer, telescope, and microscope. So, these are the basic instruments, tools in the optics lab. As I told that the light source is compulsory for optics experiments as well as you will see mirror, different kind of mirrors; one is plain mirror; mainly it is used for changing the direction of the light.

And there are other mirrors: convex mirror, concave mirror. Also there is lens; it is of two types: the convex lens, and the concave lens; again plano-concave, plano-convex etcetera. So, I will discuss about them and their principles, their properties and where we will use them, which I will discuss and then another important component is prism.

Using this prism, you can do experiment: how to measure the angle of the prism and this prism is used for dispersion of light; so, it has dispersive power and also prism is used to aligning the spectrometer, means to make ready the spectrometer for parallel rays; how to use this prism for getting parallel rays for the experiment that we will discuss.

And you know that grating is very important tools, very important components to use for the dispersion of light, means to separate the wave length of the light. So, this grating is used to measure the wave length of the unknown light, that will be discussed.

Then beam splitter: from same source of light, say, one ray will come and this ray we can split into two or more using the beam splitter. And polarizer is another tool, which is used to polarize the light. And to analyze the polarization of the light we use also this; that is called analyzer; that is nothing, but the same tool which can be used as a polarizer and also it can be used as an analyzer. So, depending on the use of, we call this same tool as a polarizer and an analyzer.

Also in optics experiment, you need to align the light; align the path of the light and for that you may need to translate the components: mirror or lens or whatever. Also we use different kind of stages with option that you can move your component along the x direction, along the y direction, along the z direction; such type of stage is frequently used in optics experiment.

Also you need stage for rotation of the components as well as tilting of the components. That type of stage is also very essential and very frequently used in optics experiment. And spirit level, it is used to do leveling the spectrometer and spectrometer itself is very important for this optics experiment. We will discuss about the spectrometer: what is the construction of this spectrometer, what are the components in the spectrometer and what are the purpose of different components in the spectrometer.

Also the telescope and microscope are very important components for optics experiment and we will discuss about the telescope as well as microscope.

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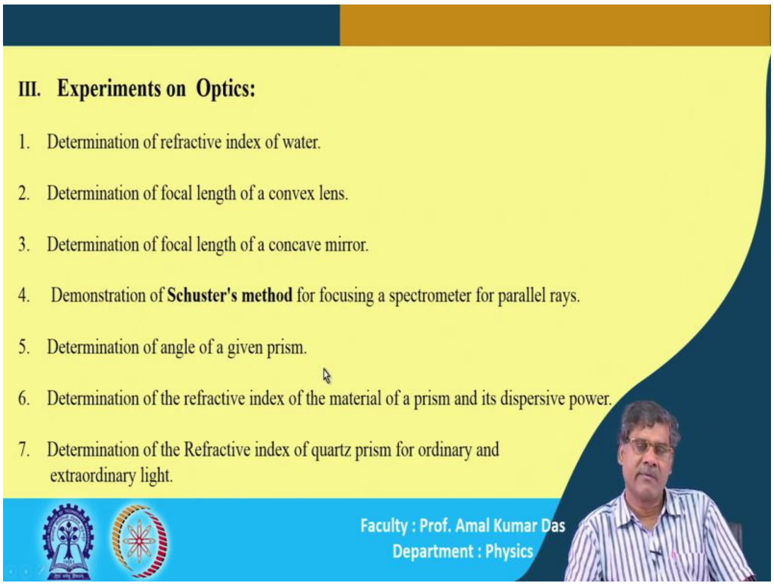

Then we will perform, will demonstrate different experiments on optics. One experiment is the determination of refractive index of water.

How to determine the refracting index of water that we will demonstrate in our laboratory. First I will discuss about the principle of this experiment and then I will show the experimental set up for this experiment and then how to perform the experiment, how to analyze data and how to get the result. In this case result is the refractive index of water, Then we will discuss about the determination of focal length of a convex lens, focal length of a concave lens and then we will discuss, will demonstrate about the Schuster's method. This is very important method in optics laboratory; this method is very important and what is the importance of this method that I will discuss. I will demonstrate the Schuster's method for focusing a spectrometer for parallel rays.

In many experiments you need parallel rays. From source the rays are coming which are not parallel; but for experiment I need parallel rays. So, how to get parallel rays: that basically one can get using this Schuster's method; that method I will demonstrate. Then we will demonstrate how to determine the angle of a given prism; if one prism is given to you, how to find out the angle of this prism; then we will discuss how to find out the refractive index of the material of the prism and its dispersive power; then will demonstrate how to determine the refractive index of quartz prism for ordinary and extraordinary rays.

So, what is ordinary, what is extraordinary rays, how it is formed and for ordinary and extraordinary light this same prism, but refractive index will be different for these two type of rays. So, that will be demonstrated, how to determine the refractive index for o-ray and o-ray means ordinary ray and e-ray means extra ordinary ray.

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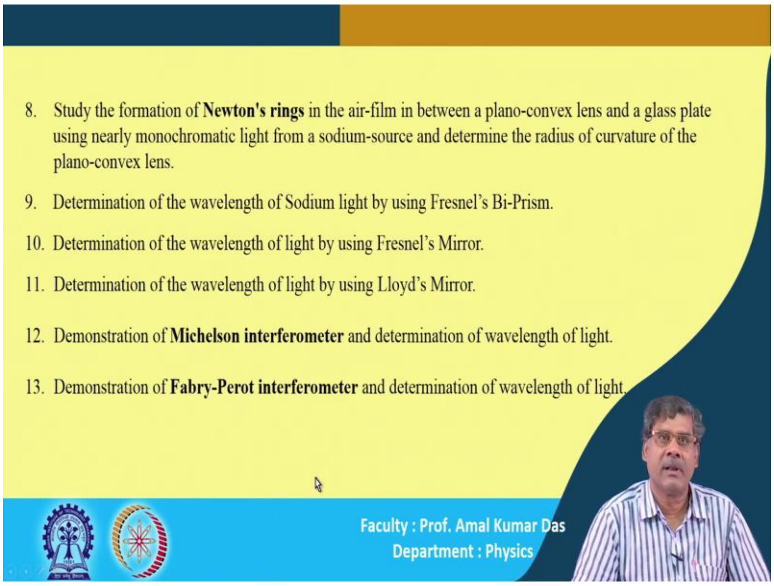

Then we will study the formation of Newton's rings in the air film in between a plano - convex lens and a glass plate using nearly monochromatic light from a sodium source and determine the radius of curvature of the plano-convex lens.

Here 7 to 13, the experiments here I am showing, so those experiments are basically the experiments of interference. Here basically you will learn about the interference and using the interference, how we can determine the wavelength of, say sodium light, using the Fresnel's prism or Bi-Prism or using the Fresnel's mirror or using the Lloyd's mirror. So, all these experiments are based on the interference of light.

Then these two interferometers are very important; the Michelson interferometer and the Fabry-Perot interferometer; we will demonstrate, will discuss about these two interferometers and how these interferometers are used for the determination of wavelength of light. So, that will be demonstrated in our laboratory.

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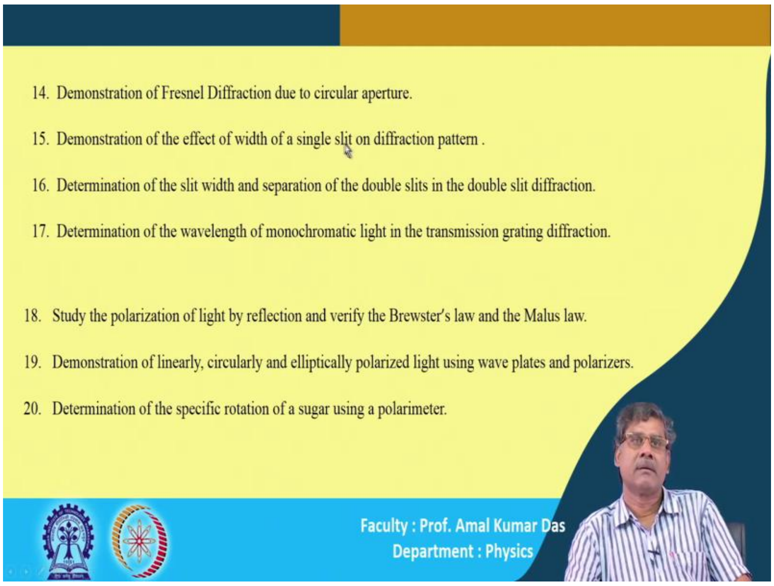

So, then here I think this 14 to 17, these four experiments are based on diffraction of light; we will demonstrate these experiments. The 14th experiment here is basically demonstration of Fresnel diffraction due to circular aperture. So, two types of diffractions are there: one is Fresnel diffraction and another is Fraunhofer diffraction.

I will discuss about Fresnel and Fraunhofer diffraction before doing experiment. So, this will demonstrate the Fresnel diffraction due to circular aperture. Fresnel diffraction can be seen for other type of sources: it may be sharp straight edge, it may be circular aperture etcetera. Next we will demonstrate the effect of width of a single slit that is a diffraction experiment for single slit; then for double slit; for multi-slits, n number of slits that is basically grating.

So, we will demonstrate all these three experiments based on the different types of slits and we will discuss how to determine the wavelength from these experiments or how to determine the grating element or spacing of the slit and width of the slit, or the effect of the width of the slit all these things will be discussed in these three experiments.

Then the last three experiments in optics are basically on polarization of light. So, we will study the polarization of the light by reflection and will verify the Brewster's law and Malus law. So, what is Brewster's law, what is Malus law, that we will discuss and we will verify these laws; that will be verified by the polarization of light by reflection and then next experiment we will demonstrate the linearly, circularly and elliptically polarized light using the wave plates and polarizers.

There are different kind of wave plates: the quarter wave plate, the half wave plate, and the full wave plate. So, that we will discuss during the experiment and then last experiment we will, we will discuss, we will demonstrate how to determine the specific rotation of a substance; in our case we will take sugar and we can find out, we can determine the specific rotation of sugar using an instrument that is called polarimeter.

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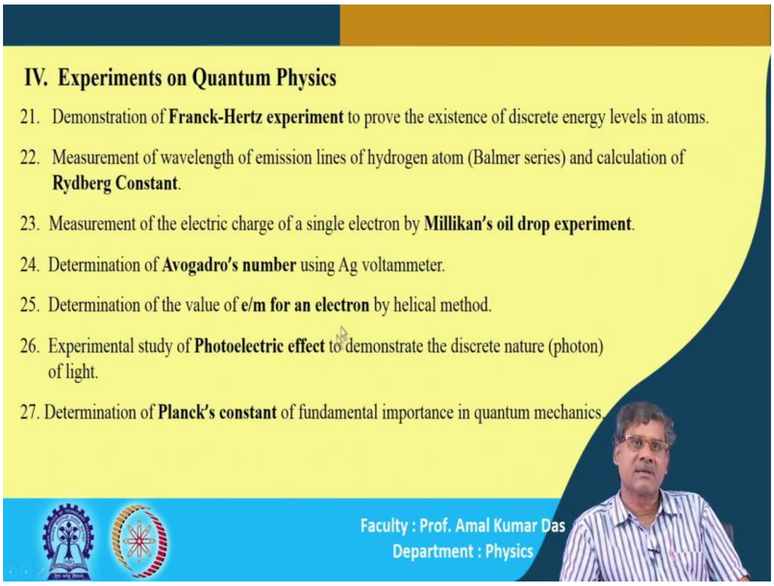

Next we will discuss, we will demonstrate few experiments on quantum physics. Before starting the rigorous quantum mechanics; some preliminary modern physics started to come, that basically will deal the quantum physics, right. So, basically quantization, quantum, quanta that concept when started to nucleate; that started basically after discovery of the Planck's constant and then photoelectric effect, then the Bohr theory of atom. So, in atom how the electrons are arranged, that was the preliminary stage of quantum mechanics. So, that time there was assumption in science, that you have to prove, all the model, all the speculation.

There are very important experiments, that time were used to verify the models, to verify the speculation; we will discuss some of them. So, this will discuss about the demonstration of Franck-Hertz experiment to prove the existence of discrete energy levels in atoms; this is very nice experiment; that will be discussed, will be demonstrated in our laboratory.

Then we will show how to measure the wavelength of emission lines of hydrogen atoms; basically Balmer series and how to, how to calculate the Rydberg Constant. As you know, this Rydberg constant in case of an explanation, in case of an explanation of the atomic spectrum, basically it was started from Balmer series. We will demonstrate in laboratory how to measure the wavelength of hydrogen atom.

Next we will demonstrate how to, how to measure the electric charge of a single electron by that experiment, famous experiment that is called basically Millikan's oil drop experiment; we will demonstrate this experiment in laboratory. Then we will discuss another experiment how to find out the Avogadro number; this is again another important fundamental constant, Avogadro number using voltameter, silver voltameter. Then we will discuss how to measure, how to find out the e by m; e by m of an electron, ok.

Electron charge and electron mass, ratio of electron charge and mass; how to find out this ratio using a method that is called helical method. Then we will study the photoelectric effect to demonstrate the discrete nature of light; that is the effect which was discussed, which was explained only considering the discreteness of the light and that is called basically photons; so actually the light have wave property as well as particle property; particle nature. So, this particle nature that will tell, that is the photons; so, that we will demonstrate in laboratory.

Then we will determine the Plancks constant which is a very fundamental constant, universal constant and that was basically, it has importance in quantum mechanics. So, how to find out the Plancks constant that also we will demonstrate in our laboratory. So, here I thought of demonstrating almost 27 experiment; but I will see if time permits I will discuss all experiments; the demonstration may not be in sequence, but I will try to discuss all of them. I will stop here; thank you for your kind attention.