Hello friends, my name is Doctor Manoj Kothawale, Assistant Professor Department of Physics. DM'S college and Research Center, Assagao Goa.Now I want to talk on module number 13 which is forming part of Unit 4 properties of electromagnetic radiation. Name of module is black body radiation, radiation law, Stefens law, Wiens law, Rayleigh–Jeans law and Planck's law. Outline of the module is study of spectrum of radiation intensity versus wavelength for black body . Radiation law, stefens. Law, Wiens law Rayleigh Jeans law and Planck's law, learning outcomes. Student will be able to describe Spectra of radiation intensity versus wavelength for black body using Wiens law. Stefens law, Jeans law and Planck's law. let us understand first what is black body a body which absorbs the entire radiant energy incident upon it is called a perfectly black body. However, in nature, no perfect black body exists. For practical purposes, lamp like that absorbs 90% of light incident upon it can be considered as perfectly black body, wherein the coefficient of absorption of perfectly black body is considered to be. Now artificially I can construct a black body. Let us say for example Ferry's black body. You can see here in the figure. What we need is double walled sphere. This is a double wall sphere with small interior allowing incident light to get into the cavity. There is conical projection made which will help to reflect light and the inner surface of this double walled sphere is coated with lampblack. So once this light entered it falls here on the conical projection and then it undergoes multiple reflections inside the cavity. So at every point of incidence on the cavity absorbs around 90%. So within fraction of second there undergoes multiple internal reflections and it absorbs within a fraction of second. Now with respect to amount of emission of light or absorption of light. We can describe it nicely using Kirchoffs, Law of radiation. It states the coefficient of admission is equal to coefficient of absorption for all the bodies at a given temperature. Now having this knowledge. We can move to black body radiation spectrum. What is black body radiation Spectra? It is nothing but graph of radiation intensity versus wavelength of a given body at various temperature, so it shows the power radiated per unit area of the black body per unit wavelength and this intensity of black body radiation depends on wavelength Lambda of the emitted radiation and temperature of the body. If you look at this graph, this energy radiated is spread over the. Wide range of wavelength Lambda starts with UV light visible and infrared. Let us look at this graph 1 by 1. Let us consider a body is at a temperature of 2000 Kelvin. So radiation intensity starts increasing for higher wavelengths, attains maximum and then for longer wavelength intensity again decreases. Now consider the case we will increase the temperature of body. Let us say 3000 Kelvin. What we notice? Again intensity starts increasing as wavelength increases. Attains maxima again. For longer wavelength it decreases. So you can take two more cases, 4000 Kelvin and 5000 Kelvin. So nature of the curve remains same, it increases, attains maxima and for longer wavelength it again decreases. So for all the temperature. The nature of the graph remains same, but what we notice are the two points number one. This red color marks that is corresponding to peak of the graph. You can see this peak of the graph is shifted towards the left side. It is the lower wavelength and #2 as I increase the temperature of the body, you notice that area under the curve also increases. I mean graph is getting shifted to the higher value or the upper side. So area covered under the graph is increases. Now with this experimental observation about radiation intensity versus wavelength or radiation spectrum, we can make 2. Conclusions. Or we can summarize this graph into two laws. First Weins displacement law. It is studied by connecting maxima of the intensity curve. In this curve we see that hotter the body shorter the wavelength corresponding to emission peak in the radiation come quantitatively. I can write Lambda Max into T constant. $\boldsymbol{\lambda_{max} T = constant}$ Well Lambda Max is the wavelength at which black body radiates most strongly for a given temperature. So we have noticed in the previous graph as you increase the temperature of the body. Here we increase from 2000 to 3000, then 4005 thousand Kelvin. This peak shift towards the shorter wavelength. And why is displacement law allows us to estimate temperature of distance star by measuring wavelength of radiation they emit? Similarly, another law we can explain. That is Stefens law. Now Stephens Law talks about total power of black body radiation emitted across the entire spectrum, wavelength at a given temperature. So what it says that heat energy related per unit time per unit area is directly proportional to 4th power of its absolute temperature in terms of equation, $\boldsymbol{P(T) = \sigma A T^4}$ where P is total power at temperature, T, A is the surface area of black body T's temperature in Kelvin Sigma is Stefens Boltzmann Constant. Now if you notice in the radiation intensity graph, this total power is represented by the area covered under the. Graph so we have noticed as you increase the temperature, total area covered under the graph also increases. So total power radiated is also increases with increase in temperature. Stefens law enables us to estimate how much energy a star is radiating by remotely measuring its temperature. Now, **Rayleigh–Jeans law**. tried to explain the experimental observation of a black body radiation graph. Now they have used a classical approach to black body radiation problem where radiation is treated as waves. And the modes of electromagnetic waves trapped in the cavity are in equilibrium and they continuously exchange their energies with the cavity walls. The result of this classical model for black body radiation curve is known as **Rayleigh–Jeans law**. In terms of equation, $\boldsymbol{B(\lambda, T) = \frac{2cK_BT}{\lambda^4}}$ Where, $B(\lambda, T)$ power emitted per area, per steradian, per unit wavelength and other symbols have usual meaning. Now, if you see these radiation intensity versus wavelength, red colored dots are the circles is nothing but the experimental data, whereas the results what we have obtained using **Rayleigh–Jeans law**.is shown by this solid blue color line. If you notice the **Rayleigh** results fits well with the experimental data only at the longer wavelength, however, does not match is at the shorter wavelength in ultraviolet region. So in the limit of short wavelength relations, law predicts infinite radiation intensity. Which is inconsistent with the experimental results. Where radiation intensity have a finite value in the UV region of the spectrum, so this divergences between the results of classical theory and the experiment is called ultraviolet catastrophe. So it shows that how classical physics fail to explain mechanism of black body radiation. So Planck's law came into picture where Plank introduced in his model with assumption that the cavity radiation originate from atomic oscillations inside the cavity walls, and these oscillations can have only discrete values of energy. Therefore, radiations trapped inside the cavity walls can exchange energy with the walls only. Discrete amounts, so energy of the oscillator can have only discrete or quantized value. This is put forward by Planck's law, so he writes $\boldsymbol{E_n = nhf}$ Where, n=1,2,3….., f is the frequency of Planck's oscillator and h is *Planck's constant*. So in terms of equation, Planck's law can be written as $\boldsymbol{B(\lambda, T) = \frac{2\pi hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}}$

Where, $B(\lambda, T)$ power emitted per area, per steradian, per unit wavelength and other symbols have usual meaning. Now let us look at the experimental data and Planks output, if you see this red color circles. Our experimental data and blue color line is a results obtained using Planck's law. Now, both or I can say Planck's law is perfectly overlapping with experimental data. So perfect match of observed data and Planck's law. So Planck's hypothesis agrees with the experimental black body radiation curve and Planck's law. Also explain wein’s and Stefens law. So this is we obtained through Planck's law. This is the reference for our model. I hope you like the video.