2nd cut

(0:00 - 12:39)

which are given by classical Newtonian mechanics and so we have the mass times the derivative of the speed, the velocity which is the acceleration and this has to be equal to a certain force that we are applying to our charge so so here we are embedding our charge in an electric field so our force is going to be simply given by the charge, point charge times the electric field that we are applying let me drop the arrays because just let's consider the whole dimension in the case of this so if this is a static field it means that it does not vary over time it means that at any moment this charge will feel an acceleration and so if we keep this static field the acceleration will lead us to an infinite velocity which of course is not what we observe in nature so in nature we have something which is slowing us down and the charge is not reaching infinite velocity actually we get some conditions in which we get a stationary case in which the velocity achieves a limit value which is the limit velocity in general this is given by considering the frictional force and I start to anticipate that because we will need that for the oscillating case and this frictional means that it has to be proportional to the velocity itself so the higher is the speed of the point charge the higher will be the force which is slowing the charge down so that we reach a balance between the electric field which is accelerating them and the friction due to the fact that this is not in turn free it is electron in the material and the material is slowing down the electron from accelerating further what I thought was elegant at this point is that actually we can conceive this frictional force by considering a different picture which is let's say t equals zero so the initial moment the electric field is off so before zero the electric field is off we start the electric field at t equals zero and we get an acceleration for a time comprised between zero and a certain value tau which is called the relaxation time we get that the charge is accelerated by the force the electrical force elementary charge times the electric field then at t equals tau we actually have to recall this is how we can model that that the electron is not free it is nearly free and if we are considering a metal or a semiconductor our electron will collide with the lattice so it will be nucleized which is relatively not probable other electrons which are bound to the lattice phonons, whatever, can result in an interaction with the lattice so after the collision we have a random direction for the electron exiting from the collision which means that on average the velocity we can say that it is equal to zero so this collision stops the electron it can bounce back, it can move forward it can stop exactly but on average the velocity that we achieved due to this acceleration is lost and we have basically reset our system to the case t equal to zero so after the collision we have an electron which is basically disoriented, confused which means that it immediately fills again the electric field and starts accelerating back until it gets another collision after a time tau of course tau is an average value which can be calculated on the average time needed occurring between two subsequent collisions of nearly three electrons in a lattice so in the end which is the velocity that we call it for our electron well, we are sensing an acceleration we know this expression here we can write that as one divided by m integral between zero and tau which is the time in which the charge experienced this electric force of the force and there should be a minus sign somewhere I guess, I'm not sure it was probably here it does not have a sign so in the end what we end up is of course this has to be integrated over time so in the end we have QEm everything is static, it does not depend over time here we have our tau which is this time interval during which the charge can accelerate and here this is multiplying and this is the mobility and this is where you start from when you are considering the microscopic slow because then you have to define the current density here which is defined as QB times the concentration how can I call it this is not current this is nearly free electron concentration ok and so the velocity will find to be equal to this mcj is going to be equal to q rho q tau divided by m and if you keep all of this together you will get that this is equal to the ohms law and the conductivity is given by q square tau rho divided by m ok so this is something that I guess you are already bored about because you have seen other times but I think it was useful in order to introduce what happens in an alternating field so in this case we are not considering anymore this because we have seen that an electromagnetic wave is given by this expression here now we can still make some simplification which is going to save our life which is the following q is a point and we assume that the fact that this is oscillating is going to displace our charge for a certain amount x0 above which it is oscillating ok so we are going to apply a field which is reaching in polarity every period and so when the polarity is in one direction this will pull the electron in the right hand then we switch the polarity and then the polarity is switched again and so we find basically an elongation for our oscillation in the electron now what we can assume is that this elongation here is much smaller than our wave which is 2pi divided by 2 so it means that the fact that this wave basically this light beam or the frequency or whatever we have started with ourselves does not change over space in the space that we are considering for the oscillation of our electron so as we said we can neglect this partial dependence this implies that this term here can be forgotten and we are just considering still it's a big deal we have to find out and I guess it's something we see on website