good morning to all of you today we will continue with our discussion on electrostatics let us recall that in the last lecture we had discussed about capacitance and capacitors

so let me recall a capacitance is a device which consists of two conductors which are separated by a dielectric or air and carrying equal and opposite charges

so if you shift some electrons from one conductor to another conductor then one of the conductors gets positively charged the other conductor gets negatively charged and they are separated by certain distance and this unit forms a capacitor and this capacitance as we will see stores energy electrostatic energy which can be used for various purposes and capacitors form a very very important component of all electronic circuits charging of a capacitor means you take a capacitor and connect a battery to it and in that process transfer electrons from one conductor to the other conductor and that leads to a charging and then if you disconnect your capaci battery then the capacitor remains charged we had calculated as an example we started looking at a parallel plate capacitor

so parallel plate capacitor consists of two plates of area a separated by distance d

so let me draw three dimensional figure here

so there are two plates here one plate here another plate and ah

so you may have positive charges on the upper plate the lower plate is negatively charged and in between these two plates there is an electric field pointing like this and

so area is of this plate is a and d is a separation

so in this example the upper plate is carrying positive charge the lower plate is getting carrying negative charge and we had calculated the capacitance of this device d is the separation between the plates is the area of the plates and epsilon zero is the permittivity of free space and unit of capacitance is fared and you can see that farad is a unit which is because c is q by v capacitance has coulomb per volt one farad is one coulomb per volt that thyroid comes from michael faraday's name and thats the unit of capacitance farad is a very large capacitance typically in circuits we use micro farads or pico farads of capacitance we are also look at an example and shown that a typical capacitance you can get about 10 farads now today what i want to do is to discuss some more examples of capacitance and as a next example we will take a cylindrical capacitor

so you can imagine a central conductor surrounded by another conductor in the form of a cylinder and if i draw the cross section i have the central conductor here and the outside conductor

so let me draw a thickness of the outer conductor here

so this is one conductor here this is another conductor and i want i let me call this ah radius this coaxial

so this is radius a and this radius is b the outer radius the radius of the inner conductor is a the radius of the inner surface of the outer conductor is b

so let me assume that the inner conductor is positively charged and there is an equal amount of negative charge on the outer conductor

so what i need to calculate to calculate capacitance is a relationship between the voltage between the two two conductors and the charge in the two conductors because that proportionality constant gives me the capacitance

so to calculate voltage i need to know the electric field we have already done this before

so for calculating electric field what i do is i take a gaussian surface of radius r and of length l

so if the cylinder is like this if the inner conductor is here and outer

conductor is like this i will take a gaussian surface of length l this length l and of radius r from the center

so and we have already discussed by symmetry arguments the electric field will be radial away from the center

so and

so there is no gaussian flux electric flux on the top and bottom surface of the cylinder of the gaussian surface there is only flux from the cylindrical surface

so whose area is two pi r into l into electric field is a flux must be equal to the charge contained

so if i assume that lambda is the charge per unit length

so the charge contained is lambda into l by epsilon zero lambda is the charge per unit length

so so much length of the conductor contains lambda l charge

so electric field becomes lambda by two pi epsilon zero r this we have already calculated before and because the electric field is in the radial direction from the ah axis outwards i can write the electric field as e is equal to this in r cap

so that is the electric field on of the of the coax this configuration of one conductor cylindrical conductor surrounded by another cylindrical conductor now i need to calculate the potential difference between the outer and inner conductors

so we know how to calculate potential differences

so let me calculate the potential difference v is equal to v of the inner conductor minus v of the outer conductor

so which is equal to minus integral b to a e dot d r which is equal to lambda by four pi two pi epsilon zero into a to b d r by r which is equal to lambda by two pi epsilon zero into log of v by a

so thats the potential difference between the inner and outer conductors

so the inner conductor is at a higher potential it is positively charged

so the inner conductor is a higher potential compared to the outer conductor now i want to write this in terms of the total charge

so if i take a length l the charge will be is equal to lambda into l

so i replace lambda by q by l in this equation and i get the following equation v is equal to q by two pi epsilon zero l into log b by a and

so because we know that v is equal to q by c we can define the capacitance of this configuration c is equal to two pi epsilon zero l by log v by a that is the capacitance of a length l of the ah of this cylindrical capacitor we can define a capacitance per unit length is equal to c by l which is equal to two pi epsilon zero by ln of v by a

so as you can see here the capacitance only depends on the geometric parameters for a parallel plate capacitor it was epsilon zero a by d here the capacitance per unit length please remember this is capacitance per unit length of the cylindrical conductor cylindrical capacitor and this the capacitance per unit length is given by two pipe sine zero by log b y now let me take some examples here let me take a inner radius of two millimeters an outer radius of four millimeters and

so the capacitance c is equal to two pi epsilon zero by l n b by a which is equal to two pi into eight point eight five into ten to the minus twelve by ln of four by two and you can estimate this to be approximately equal to eighty pico farad per meter which is actually eighty into ten raise power minus twelve farad conversion

so what it implies is if you take one meter length of this cable of this cylindrical capacitor it will have a capacitance of 80 picofarads you must have seen such cylindrical conductors cylindrical capacitors that are that are used

for connecting television and vcrs through cables and those cables are called coaxial cables have a typical capacitance of about say 70 picofarad per meter there are also insulators within the between the conductors there

so we have right now assuming that the two conductors are separated by free space

so that is an example of a cylindrical capacitor and this capacitance which we have written here is a capacitance per unit length of the cylindrical capacitor let me take another example a spherical capacitor spherical capacitor consists of one inner spherical conductor surrounded by an outer spherical conductor the inner sphere is charged positively assumed to be charged positively the outer sphere is assumed to be charged negatively and same charge is put on the inner and outer spherical conductor let me assume that the radius of inner sphere is equal to r a and radius of outer sphere is equal to rb

so as as you can see here there are electric field lines now going from positive to negative

so i need to again just like before calculate the potential difference between the in out outer and inner conductor and find out how that is related to the charge contained in the capacitors in the index conductors

so let me assume the charges are capital q and minus q here plus q and minus q which are put on the inner and outer conductors to calculate potential difference i must calculate the electric field which you have done before but let me recall i take a gaussian surface of a spherical gaussian surface of radius r centered at the center of the inner conductor sphere and ah

so by symmetry as we have seen before the electric field lines are all radial pointing away from the center

so the electric flux is equal to four pi r square into e is a radial electric field and

so it is four pipes r square into e and the charge contained is capital q

so by by gauss's law we have four pi r square e is equal to q by epsilon zero or electric field is equal to q by four pi epsilon zero r square and because the electric field is radial i will write this as r cap

so thats the electric field which you have already seen before the electric field of the spherical conductor here is exactly like that of a point charge at the center of the spherical conductor please note here that the outer conductor is also charged but the electric field of the outer conducting charge is zero inside the inside this volume the only electric field that exists here is because of the positive charge here the outer charges do not contribute electric field within but the electric field lines are starting from the inner conductor and ending on the outer conductor

so once having calculated the electric field i can now calculate the potential difference

so v is equal to minus integral r b to r a e dot d r which is equal to integral q by four pi epsilon zero r square d r r a to r b which is equal to q by four pi epsilon zero ah minus of one by r r a to r b which is equal to q by four pi epsilon zero one by r a minus one by r and i can write this as v is equal to q by four pi epsilon zero r b minus r a by r a r b

so that is the potential difference between the inner and outer conductors capital q is the charge carried by the conductors

so the capacitance of this device c is equal to q by v which is equal to four pi epsilon zero r a r b by r b minus r a

so thats the capacitance of this spherical capacitor

so the spherical capacitor has an inner sphere conductor spherical conductor of radius r a surrounded by an outer spherical conductor of radius r p both conductors carry the same amount of charge capital q and this particular device

forms a capacitor with a capacitance of this value and this gives me the capacitance of this configuration ah i can also look at the following situation where if i let the radius of the outer conductor go to infinity if i let the radius rb go to infinity that is radius of the outer conductor go to infinity i will get the capacitance of a single sphere of charge of radius r a

so ah limit r b tending to infinity capacitance becomes four pi epsilon zero into r a that is the capacitance of a single sphere conducting sphere of radius r a the other conductor which is supposed to be carrying negative charges as infinite size

so that is the capacitance of a of a sphere

so as an example lets take lets look at a sphere spherical capacitor with r a is equal to one millimeter and r b is equal to infinity

so c is equal to four pi epsilon zero r a which is equal to ten to the minus three by nine into ten point nine which is about ah point one one pico farad which is actually point one one into ten raise to minus 12

so that is a capacitance of a sphere of radius 1 millimeter

so if i put a charge of one pico coulomb then the voltage generated v is equal to q by c which is equal to ten to the minus twelve by point one one into ten to s minus twelve which is about nine volts

so if i put one pico coulomb of charge on this sphere of spherical conductor of radius one millimeter i will develop a voltage of nine volts and you can beyond this point you can calculate what is the electric field of ah this spherical capacitor etcetera etcetera i leave that problem to you and you can calculate this in fact i can also calculate the electric field the capacitance of a of a large object like the earth the capacitance of the earth

so to do this we assume the earth to be spherical the radius of the earth is six thousand three hundred and seventy one kilometers and

so the capacitance is equal to four pi epsilon zero into the radius which is equal to six point three seven one into ten power six by nine into ten point nine which is about seven point zero eight into ten to the minus four farad which is actually seven hundred and eight micro farad

so that's a capacity earth such a large object as the earth has a capacitance of about 700 micro farads

so you can imagine the farad is actually a very very large unit and typically we are dealing with pico farads and nano farads and all micro farads of capacitance

so as we have seen in the three examples the planar parallel plate capacitor the cylindrical capacitor and the spherical capacitor the capacitance of these devices is a purely geometric quantity determined by the size shape and separation between the pair of conductors which form the capacitance

so in principle you can calculate the capacitance of different kind of configurations but we will restrict these three configuration because you can actually numerically analytically evaluate these numbers otherwise if you have more complex geometries one would have to do a numerical simulation to calculate the capacitance now in many situations i would need ah capacitance of certain values in circuit design as you will see later on in some of your later studies but i may have capacitance of only certain known values

so how do i form capacitance of other other other numbers other values

so i can use capacitances in parallel or in series

so what i want to do is to study now capacitances or capacitors connected in series and in parallel

so i can actually connect many capacitors either in series or parallel

so for example series would imply that i have one capacitor here another capacitor another capacitor here this is the two point

so i can have capacitor c one capacitor c two capacitor c three
 so this is a series connection they are all in series one after the other i can have also a situation where i have a capacitor like this another capacitor like this a third capacitor like this
 so c one c two c three
 so these are the points which are connecting these are capacitors in parallel in fact i can mix these two configurations i can have some capacitance series some capacitors in parallel
 so the objective is now to find out what is this equivalent what kind of capacitance is equivalent to
 so i would like to replace all the three capacitors this this device consisting of three capacitors by a single equivalent capacitor
 so my objective now is to calculate what is the equivalent capacitor of a series of capacitors connected in series or a series of capacitors connected in parallel and we will look at an example which actually contains both such configurations
 so let me look at first capacitors connected in series capacitor is connected in series
 so let me redraw the figure again here
 so i have one capacitor another capacitor another capacitor and the way we charge the capacitor is to connect a battery
 so please remember the battery is drawn with two unequal lines and the capacitors are all drawn with two equal lines
 so let me call this capacitance c one this capacitance c two is capacitance c three let me denote by the voltage across the capacitance v one voltage is v two here and voltage v three and v is the voltage applied by the battery
 so the potential difference between these two points must be total v
 so what i get immediately is the potential difference b must be equal to b one plus v two plus v three v one is the potential difference between these two points b two is the potential difference between these two points we see the potential difference between these three points these two points
 so the potential difference between these two points which is essentially the potential difference between the two terminals of the battery is v one plus v two plus v three
 so if i add the potentials i will get the total potential difference between the two terminals of the battery which is what i have as v
 so we want to understand what happens when the battery is connected to the capacitors
 so we have a pos this is the positive side of the battery this is a negative side
 so the positive side is connected to the upper plate this capacitor c one which is then connected to c two which is connected to c three
 so let us see what happens when the battery is connected the positive charge of the battery pulls electrons from the upper plate of the capacitor c one and
 so the upper plate of the capacitor c one gets charged positively
 so this induced positive charge actually creates a negative charge on the lower plate of the capacitor c one now this negative charge on the lower plate of c one is actually created by pulling electrons from the upper plate of c two which then gets positively charged and this one then makes the lower plate of c2 to have negative charges and this negative charge now pulls the electrons from the upper plate of c3 and leaves it positively charged which then can makes the lower plate of c three to be negatively charged
 so let us see what happens
 so as soon as i connect the positive sign of of the battery to the capacitor c

one the positive side pulls electrons from the upper plate leaving net positive charge on the appropriate capacitor c one which then makes the lower plate of c one to have negative charges which are coming from the upper plate of c two which then leaves the upper plate of capacitor c two to be positively charged then that in makes the lower plate of c two to have negative charges which then makes the upper plate of c three positively charged and the lower plate of c three negatively charged

 so what is now happening is that let us now try to see what happens in this part of the circuit which i draw by a dash dot headline here now in this modern circuit look here that the lower plate of c one and the upper plate of c two are connected to each other through this conducting wire and they are not connected to any part of the circuit any other part of the circuit

 so the net charge within this must be equal to zero

 so whatever charge you have here must have the same but opposite charge on the lower plate and this charge is actually equal to the charge on the upper plate of the capacitor c one and

 so whatever charge has been supplied by the battery which is plus q here is also inducing a minus q on the lower plate

 so if this is plus q here this is minus q on the lower plate of the capacitor c one which then induces plus q on the upper plate of c two which then induces minus q on the lower plate of c two which then induces plus q on the upper plate of c three and finally minus q on the up lower plate of c three

 so what has actually happened is the battery has only supplied a charge q and that charge q is now the same in all the capacitors c one c two and c three

 so the net charge supplied by the capacitor is only q and this charge is the same in all the capacitors because they are connected in series

 so let us see what happens this battery when i connect the positive charge of the battery positive terminal to the capacitor then it induces positive charge here it pulls electrons from the upper plate it induces the gives a charge plus q on the upper plate which then induces the minus q on the lower plate which is which then has a plus q on the upper plate of c two which has a minus two on the lower plate of c two a plus two on the upper plate of c three and a minus q on the lower plate of c three

 so please note here that all the capacitors are carrying the same charge q which is the charge supplied by the battery

 so if each of the capacitors has a charge q then i can write the following equation for the voltages across each capacitor

 so i have called v one as the voltage across this capacitor v two is the potential difference across this capacitor v three the potential difference across this capacitor

 so this capacitor has a charge q a capacitor c one and a voltage v one

 so v one must be equal to q one by q by c one v two which is the potential difference across this plate of the capacitor v two must be equal to q by c two and similarly v three the potential difference across this capacitor must be v three is equal to q by c three

 so the total potential difference is v one plus v two plus v three each of the capacitance has a voltage v one which is q by c one v two which is q by c two and v three which is q by c three and where c one c two c three are the three capacitors and as i have used the fact that all the capacitors have the same charge q supplied to them and this is the d chart supplied by the battery

 so with these two equation this equation and this equation i can combine to form an equation which tells me the overall capacitance of the device v is equal to v one plus v two plus v three which is equal to q by c one plus q by c two plus q by c three

so i want to replace this by

so i what i am trying to do is to find out the equivalent capacitance

so i have these three capacitors here

so c one c two c three potential v

so i am trying to find out what is that capacitor which is equal to this if i call this capacitance c what is the value of c for which this this and this are exactly equivalent

so this is v and the charge is q

so this capacitance c must be equal to q by v and i can get from

so this i can use this equation to find out v by q is equal to one by c one plus one by c two plus one by c three and as you can see here c is q by v

so this is equal to one by c is equal to one by c one plus one by c two plus one by c three

so if you have three capacitors in parallel in series like this the total capacitance or the equivalent capacitance of this is actually one by c one plus one by c two plus one by c three and inverse of that

so one by c which is c the equivalent capacitance is one by c one plus one by c two plus one by c three

so for example if i had a a capacitance of ten micro farads and a capacitance of two micro farads connected like this the total capacitance will be such that i have one by c is equal to one by ten plus one by two which is equal to twelve by twenty

so c is equal to twenty by twelve

so this is all micro farads microfarads

so the capacitance is add in such a fashion this through this kind of equation

so given any sequence of capacitance which are connected in series i can calculate the equivalent capacitance

so i can actually write a generalized equation which is the following

so if i had n capacitors connected in series the equivalent capacitor is equal to sigma i is equal to one to n one by c i

so which is actually equal to one by c one plus one by c two plus one by c that is the total capacitance

so i can use this formula to calculate the capacitance of a series of capacitors which are connected in series now i want to discuss what happens to capacitances connected in parallel

so let me consider the following circuit here

so i have

so c one c two c three b is the potential applied across the three capacitors the three capacitors are connected in parallel you can see that the potential difference between these two points is v between these two points is v and these are connected by conductor

so this is also v this potential difference also v

so all capacitors have a potential difference of b now let me assume charge on c one is equal to q one charge on c two is equal to q two and charge on c three is equal to q three

so please remember in this case the potentials across all the capacitors are the same but this battery has to supply a charge q1 to this capacitor it charge q2 to this capacitor and a charge q3 to this capacitor

so the total charge supplied by the capacitor by the by the battery q is equal to q one plus q two plus q three and we know that because i have assumed that the potential the the the charge q c the charge q one is on capacitor c one q two is on c two q three is on c three i have the following three equations i have q one is equal to c one v q two is equal to c two v and q three is equal to c three v same potential different capacitors are different charges

so i get q is equal to c one plus c two plus c three into v

so now as before if i want to replace the three parallel capacitors by a single capacitor

so i have the three capacitors here

so i want to make it equivalent to a single capacitance c

so this is c one c two c three b is the potential difference q is the charge on the supplied by the battery

so c must be equal to q by v q by v sorry small q

so i can use these two equations to get the capacitance equivalent capacitance c as c one plus c two plus c three

so when i connect capacitances in parallel three capacitances in parallel the total capacitance is c one plus c two plus three if i connect the same capacitances in series the net capacitance is c which is one by c equal one by c one plus one by c two plus one by c three

so the the way the capacitors add to given equivalent capacitance depends on the way you connect them

so in general for n capacitors in parallel c is equal to sigma i is equal to one to n c i the total capacitance is simply the sum of the capacitance capacitor capacitance of each of the capacitor

so if in the earlier example i had taken two capacitance two capacitors of capacitances ten microfarads and two microfarads

so if i were to connect them now in parallel

so this is ten micro farad and this is two micro farad the total capacitance c is equal to ten plus two

so by this configurations you can actually achieve capacitances which you want in a circuit by putting capacitances which you have in parallel or in series and you can have multiple combinations to achieve capacitances that you desire

so to look at another example in which i can have i want to show you that it is possible that in a circuit there are capacitances both in series and parallel

so let me look at the following example

so i have the following circuit

so i have one capacitor here then i have two capacitors

so this is c one c two c three

so now its a more complicated circuit i have these two capacitors are in parallel and this combination is now in series with the other capacitor

so my problem is now to find out what is equivalent capacitance of this that means what is the capacitance between these two points

so what i will do is i can use the per the discussion that we have had first what i will do is i will use the parallel these two capacitors to be in parallel and and equate this to another circuit another circuit where i have c one and another capacitor here

so i will replace these two capacitors by an equivalent capacitor here

so i have c one and let me call it c two three

so first i look at the parallel combination and find the equivalent capacitor this equivalent capacitor is now in series with this capacitor

so this becomes equal to a capacity

so these two are in parallel to give me an equivalent capacitor c two three then c two three is in series with c one to get me the total capacitance c equivalent capacitance between these two terminals

so let me try to apply this this

so first let me calculate c two three

so to calculate c two three remember these c two and c three are in parallel

so c two three must be equal to c two plus c three remember parallel capacitors add up like this

so the equivalence equivalent capacitor c two three is c two plus c three
so what i get is this equivalent ah device now here
so this is
so this is c one and this is c two plus c three
so the equivalent capacitor now c is equal to is given by one by c is equal to one by c one plus one by c two plus c three
so i can solve this equation to get my equivalent capacitor
so let me take an ex the following example
so let me take c one is equal to twenty five micro farad c two is equal to five micro farad and c three is equal to twenty micro farad
so c two three is equal to c two plus c three which is twenty five micro farad
so this parallel combination of c two and c three gives me one equivalent capacitor which has a capacitance of twenty five micro farad
so now i have is a series combination of twenty five micro farad another twenty five micro farad and remember that for series i have one by c is equal to one by c one plus one by c two three which is equal to one by twenty five plus one by twenty five which is equal to two by twenty five
so c is equal to twenty five by two which is twelve point five micro farad
so this combination of circuits in which i had this was twenty five micro farad c two was five micro farad and c three was twenty micro farad the equivalent capacitance of this configuration is actually twelve point five micro microfarad
so this configuration will will behave as if there was a capacitance of 12.5 micro farad
so please note i have been able to generate a 12.5 microfarad capacitance by adding capacitances a 25 micro farad five micro farad and twenty micro farad in such a combination that i get twelve point five micro farad i will leave the problem to you you can actually exchange these capacitances in different comp combinations and find out what are the all possible capacitances that you can generate with these three capacitance for example you can have all three of them in series all three of them in parallel two of them in series and one in parallel and parallel to the other one etcetera etcetera
so i leave the problem to you you please try to find out all kinds of combinations of these three capacitance capacitors which can lead you to different different capacitance values and that will give you a an indication of how i am able to generate different different capacitances from these three capacitances now let me continue with the same problem and find out the following
so i have this ah capacitance here and i have these two capacitances
so this was c one c two c three now let me assume i apply potential difference of ten volts
so v is equal to 10 volts
so i want to calculate how many how much charge are the how much is the charge in each of these capacitors and what are the potential differences
so what is the charge supplied by the capacitor by the battery q is equal to the net capacitance time the voltage which is 12.5 micro farad to ten volts which is equal to one twenty five micro coulomb
so the battery has supplied one twenty five micro coulomb to charge these capacitors now this 125 micro coulomb will get distributed among the various capacitor charge capacitors
so i want to find out what are the various charges in the three capacitors and what are their potential difference
so what is the potential difference between these two points what is the potential difference between these two terminals of the of the capacitor and

so on

so first i see is let me calculate this potential difference

so 125 microfarad has been supplied to this char to this plate

so this plate also has 125 micro farad

so v one must be equal to q by c one c one is the capacitance of this capacitor

so i have the the charge supplied by the battery is one twenty five micro coulomb which is supplied to this these two plates and this 125 micro coulomb generates a potential difference of q by c one which is one twenty five ten to the minus six my capacitance was twenty five micro farad which is equal to five volts

so we have applied ten volts across these two terminals but out of this five volts gets dropped across this capacitance and then of course the remaining five volts must be across these two because this difference is ten volts

so these two capacitance have a potential difference of five volts across their terminals

so i can now calculate what is the charge on each of those

so q two q two is equal to c two into v

so c two was five micro farads into five volts which is twenty five micro coulomb and q three is equal to c three to b which is twenty into ten to the minus six into five volts which is hundred micro coulomb

so see what happens is now

so i have let me draw the the diagram here

so i have these two and i have these two here these two plates

so there is a

so if i connect

so i have 125 micro coulomb here there is

so this is c1 this was c2 and this is c3

so there is 25 micro coulomb here and there is 100 micro coulomb

so these two totally have 125 micro coulomb which is actually the same as the charge containing the upper capacitor

so the battery has actually supplied 125 micro coulomb and out of which there is a potential drop of 5 volts here and there is a potential drop of 5 volts between the 2 remaining capacitors

so you see that given a configuration of capacitors i can use the law for adding capacitors connected in series or in parallel and find the equivalent capacitor from there i can calculate the potential difference across each capacitor the charge contained in each capacitor and all that i need as far as ah the capacitance values are concerned

so this is a very nice way to solve this problems in ah containing capacitors

so you can actually try ah different kind of capacitances ah to ah and i will give you one problem here which you may like to analyze consider a parallel plate capacitor as shown

so you have two conducting plates separated by distance d

so this is my capacitor now what i do what i do is a solid metallic slab of thickness d by two is intro is inserted between the two plates without touching them

so it is like this

so i put a plate now this is conducting of width d by two the question is what is the capacitance before insertion and appearances the area of the plates is a the next topic which i would like to discuss is i will briefly introduce now and then we will continue the discussion in the next class is energy stored in a capacitor

so as i mentioned to you in the beginning capacitors are used as devices which store electrostatic energy

so when you charge a capacitor you do work to create an electric field within the place of the cap between the plates to the capacitor you move the charges around and charge the capacitor

so once you charge the capacitor and disconnect the battery you have stored some energy within the capacitor and that energy that you stored can be released at any time later on when you whenever you need

so this is what happens in various applications for example ah if you look at the flash that you use in a camera there is a capacitor which gets first charged by from your battery and that capacitor once it gets charged suddenly releases the charge through the bulb of the flashlight which then flashes and gives you an illumination for taking your photograph

so that is an example

so similarly you have a large number of examples where you need a certain release of electrostatic electrical current through a circuit and there you can use these capacitors first of all you charge them and discharge them whenever you need

so why what i would like to do is to calculate what is the energy stored in a capacitor

so the charging process develops a potential difference between two capacitors

so let me assume some general capacitor like this

so i have plus q here and minus q here and

so you can see here there are electric field lines will be generated between these two capacitor plates etcetera

so i want to calculate what is the energy stored in the capacitor

so what i will do with the next class is to start from this point calculate what is the work done in moving charges electrons from the positive to the negative terminal and calculate the energy that is required to charge the capacitor from having no charges in the two capacitors to having plus q and minus q and we will calculate that energy and i will show you that that energy is also related to the elect energy contained in the electric electrostatic field between the two conductors ok

so we will do this in the next class thank you very much you