PHY F214 PHYSICS LAB-4 REPORT SEM-1 2017-2018

EXP No. =6 EXP NAME=DIELECTRIC CONSTANT

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DATE OF PERFORMING -31.08.2017

DATE OF SUBMISSION-6.09.2017

AIM:

1. **To find the relationship between the charge Q and voltage U across a plate capacitor for air and with the help of the slope find out the ε_0.**
2. **To measure the relationship between the charge on the capacitor and the inverse of the distance between the plates keeping the voltage as constant.**
3. **To find the dielectric constants ε_r for plastic and glass medium by eplacing them between the plate capacitor and then finding out the relationship between the U (voltage applied) and Q (charged stored on the capacitor) by measuring the slope of the Q vs U graph and comparing it with the slope of the graph when air was the medium between the plates.**

APPARATUS USED:

Plate capacitor,plastic plate,multimeter,glass plate,high value resistor (10M ohm) ,connecting cords,high voltage supply unit,universal measuring amplifier,known capacitor (220 nF).

PRINCIPLE USED:

For a parallel plate capacitor Q=CV where Q is the charge on the capacitor and V is the voltage across the capacitor while C is it's capacitance. For the parallel plate capacitor $C=\varepsilon_0\varepsilon_r A/d$ where A is the area of the plate and ε_r is the dielectric constant of the medium in between and d is the distance between the plates . We basically plot the Q vs V graph and then calculate the dielectric constant from the slope .

PROCEDURE:

First of all we connect the voltage source with the capacitor in series and let the capacitor charge fully keeping the distance between plates as constant then we remove the voltage source and connect the capacitor in parallel to another known capacitance capacitor and parallel to these two is the multimeter which measures the final common voltage of the capacitors for which we take the initial reading of the multimeter ,this gives us the charge on the unknown capacitor and let's us draw the graph of Q vs V . from this graph's slope we calculate the ε_0 as air is in between then we repeat the same thing by keeping glass plate and plastic plate and divide the slope of these with the slope of the air filled capacitor slope to get the value of the dielectric constants of glass and plastic .Lastly keeping air in between plates we change the distance between plates , keeping the voltage as constant and draw the0 graph of Q vs 1/d which comes a straight line.

OBSERVATION:

To measure the charge on the unknown capacitor we are connecting it inparallel to another known capacitor with capacitance say c1 and then charge distribution takes place between both the capacitors as soon as they are connected .The known capacitor get's almost the whole charge that was on the unknown capacitor and we measure the voltage across the known capacitor to calculate the charge on it by Q=c1V .Voltage taken should be the initial one as due to resistance the voltage on the known capacitor keeps on decreasing and then it will not give correct reading of the charge on the unknown capacitor.

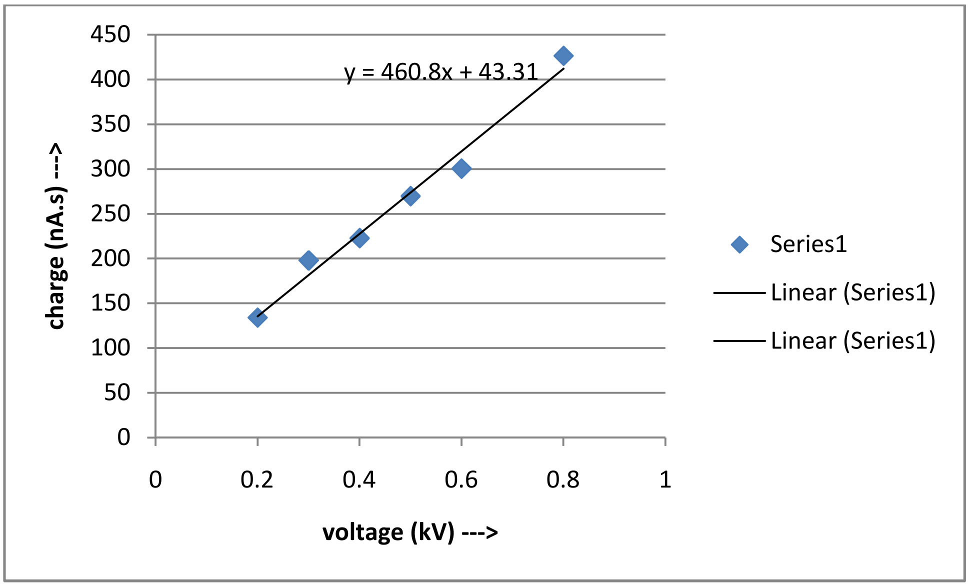
Task 1:determination of the ε_0 with air in between capacitor plates and using the slope of Q vs V graph

Firstly we make the distance between plates as constant d=2.5 mm with air in between plates and then measure the input voltage and thee output voltage

Capacitance of known capacitor=220nF

Input Voltage (kV)	Output Voltage (V)	Charge (nA.s)

0.2	**0.609**	**133.98**
0.3	**0.899**	**197.78**
0.4	**1.012**	**222.64**
0.5	**1.225**	**269.50**
0.6	**1.365**	**300.30**
0.8	**1.937**	**426.14**



Graph of Q vs V

This graph is when air is in between we can see that the charge increases linearly with voltage across it Q=CV , C here is 460.8 nA.s/kV so $460.8*10^{-12}$ F or $C=\varepsilon_0 A/d$, $A=5.309*10^{-2}\ m^2$,$d_{air}=$ 1.4mm ,$\varepsilon_0= 1.2151*10^{-11}$ F/m

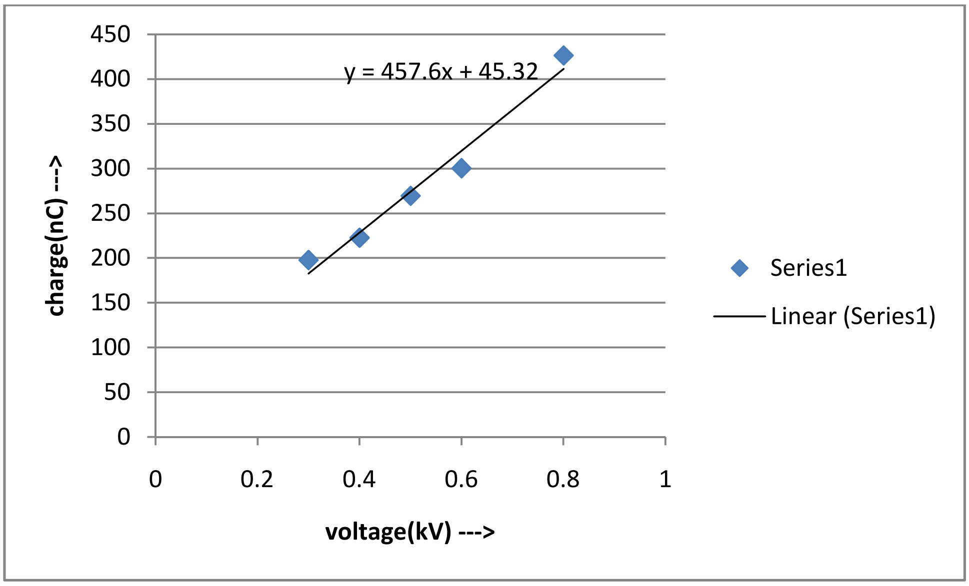
There is an error here at v=0 c=43.31 nC while it should be 0 C this is a really small charge and is within the range of experimental error.it could be due to the residual charges on the plate or due to deviation in the observed values due to environmental effects.

Task 2: determination of the dielectric constants of the plastic using it's Q vs C graph

We put the plastic plate inside the capacitor which results in a change in the capacitance and there is a change in the abilty of the capacitor to store charge . it changes by a factor of the ε_r new capacitance is $C=\varepsilon_0\varepsilon_r A/d$ if dielectric constant is >1 and distance between the plates is same as in air then the ability of the plate to store the charge increases as the electric field

inside the capacitor also changes by a factor of dielectric constant thus the total energy stored inside the capacitor changes as compared to when air was in between the plates.

Input Voltage(kV)	Output Voltage(V)	Charge(nC)
0.3	0.899	197.78
0.4	1.012	222.64
0.5	1.225	269.50
0.6	1.365	300.3



Graph of Q vs V

Here also we can see the linear relationship between the charge stored in the capacitor and the voltage applied across it.

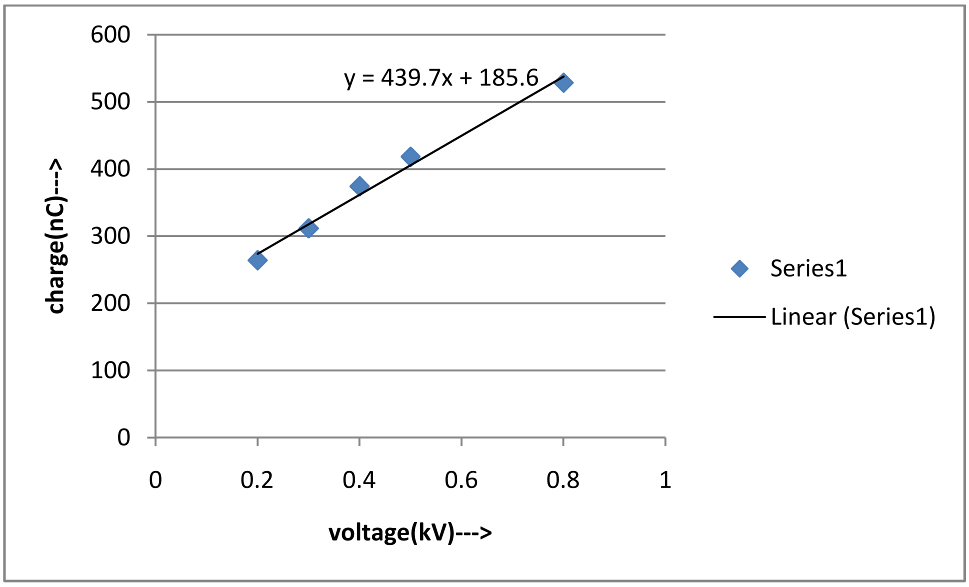
Q=CV , C= $457.6*10^{-12}$ F , $d_{plastic}$= 9.4mm , let it's dielectric const be $E_{plastic}$ so

$D_{plastic}/d_{air}E_{plastic}=C_{air}/C_{plastic}$, $E_{plastic}$=6.6677

There is an error here at v=0 c=45.32 nC while it should be 0 C this is a really small charge and is within the range of experimental error.it could be due to the residual charges on the plate or due to deviation in the observed values or due to the resistance of the wires.

Task 3: to calculate the dielectric constant of the glass and draw it's Q vs V graph

Input voltage(kV)	Output Voltage(V)	Charge(nC)
0.2	1.2	264
0.3	1.416	311.52
0.4	1.7	374
0.5	1.9	418
0.8	2.4	528



Graph of Q vs V

Here also the same as previous graphs we can see how the charge varies linearly with voltage applied Q=CV and for this case d=

From the graph $C=439.7*10^{-12}$ F , d_{glass}= 3.3mm ,

Let dielectric constant of glass be E_{glass}

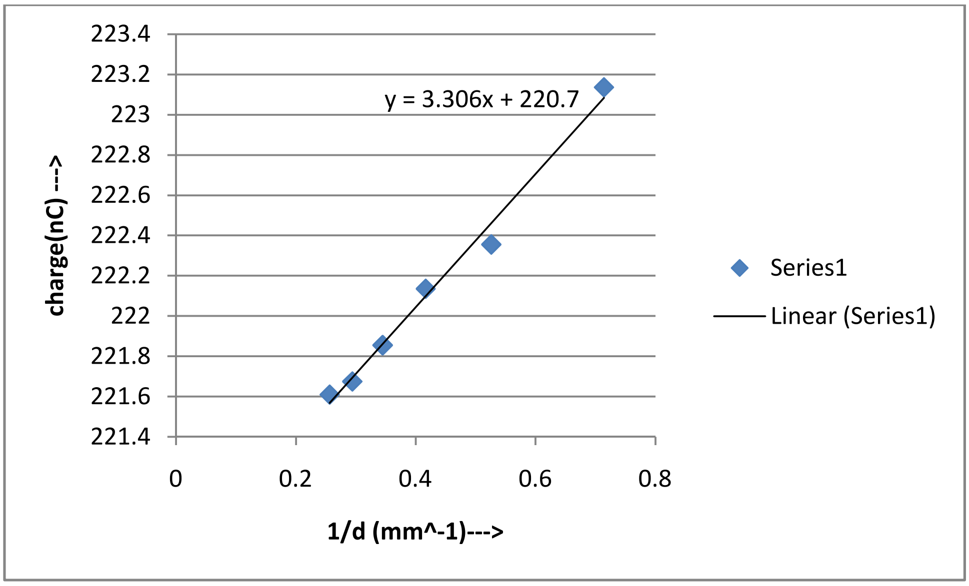
Then $d_{glass}/(d_{air}*E_{glass})=C_{air}/C_{glass}$, $E_{glass}=2.249$

There is an error here at v=0 c=43.31 nC while it should be 0 C this is a really small charge and is within the range of experimental error.it could be due to

the residual charges on the plate or due to deviation in the observed values due to environmental effects.

Task 4:to measure the variation of charge on the capacitor keeping the voltage constant and changing the distance

1/d (mm^{-1})	Output voltage(V)	Charge (nC)
0.714	3.135	223.135
0.526	2.355	222.355
0.417	2.135	222.135
0.345	1.855	221.855
0.294	1.675	221.675
0.256	1.61	221.61



Graph of Q vs 1/d

Here we know that Q=(εA/d)*V now if we keep the voltage across the capacitor as constant then the charge stored on the capacitor increases linearly with the increase in 1/d that is as distance increases the charge stored decreases .

We have some deviations of points because as we increase the distance between the two plates the electric fields no longer remain uniform inside

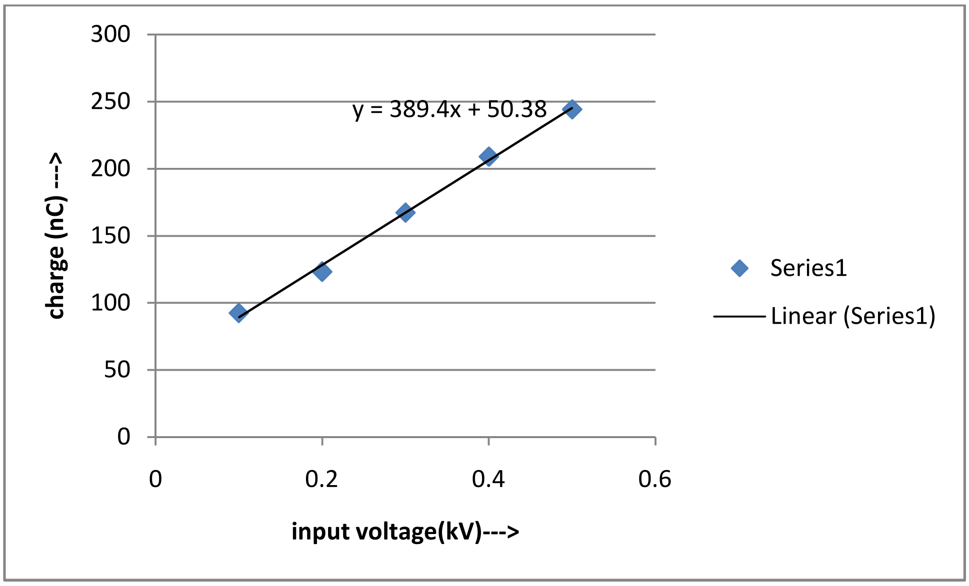
and hence there is a limit till which we can increase this distance after which the results won't be according to the laws.

Task 5 : the innovation part

We wanted to see what would be the effect of putting the two dielectrics inside it together and we thought it to behave like two capacitors of capacitance of glass and plastic one in series and theoretically thought that thee total capacitance keeping the two inside should come

$C_{equivalent}=C_{plastic}C_{glass}/(C_{glass} + C_{plastic}) = 314.22 * 10^{-12}$ F

Input voltage(kV)	Output voltage(V)	Charge(nC)
0.1	0.42	92.4
0.2	0.56	123.2
0.3	0.76	167.2
0.4	0.95	209
0.5	1.11	244.2



Graph of charge vs voltage

Here d=13.3mm and C = $389.4 * 10^{-12}$ F , the capacitance that should have come out theoretically should have been $314.22 * 10^{-12}$ F so it comes approximately same as theoretical and we can see that the two dielectrics

inside basically behave as if two capacitors with the same dielectrics have been put in series .

There is error in the capacitance value as compared to theoretical may be due to charge leakage or residual charges or other human errors like noting the voltmeter reading improperly etc.

INFERENCE:

1. **When the voltage was increased keeping the distance as constant the charge stored on the capacitor increased linearly this implies Q is proportional to V and the constant of proportionality is C called capacitance which depends only on the material medium kept in between the plates.**
2. **The epsilon not was calculated from the slope in case of air as a medium and it's value is 1.2151 * 10^{-11} F/m .**
3. **Next as we put in different material mediums the Q and V were still directly proportional but the constant of proportionality changed by a factor called the dielectric constant of that medium this is the property which defines the medium and it causes a change in the electric field inside it.**
4. **Next we saw how by increasing the distance between the plates the capability of storing charge that is capacitance decreases keeping the voltage constant and so the graph of Q vs 1/d was linear and increasing.**

POSSIBLE CAUSES OF ERROR :

1. **Residual charge: While measuring the charge on the capacitor we use another known capacitor and assume that after connecting both in parallel almost all the charge of the unknown capacitor comes to known capacitor while actually charges are distributed and the charge measured is actually lesser than the actual charge**
2. **Systematic error : In the power source ,multimeter,positive zero error in d of +0.6 mm.**
3. **Error in measurement: The first reading observed on a voltmeter is to be measured ,after which it suddenly changes.**

4. Charge dissipation : the charge could leak out of the capacitor as there is always a time gap in between removing the voltage source and attaching the known capacitor to the unknown capacitor.