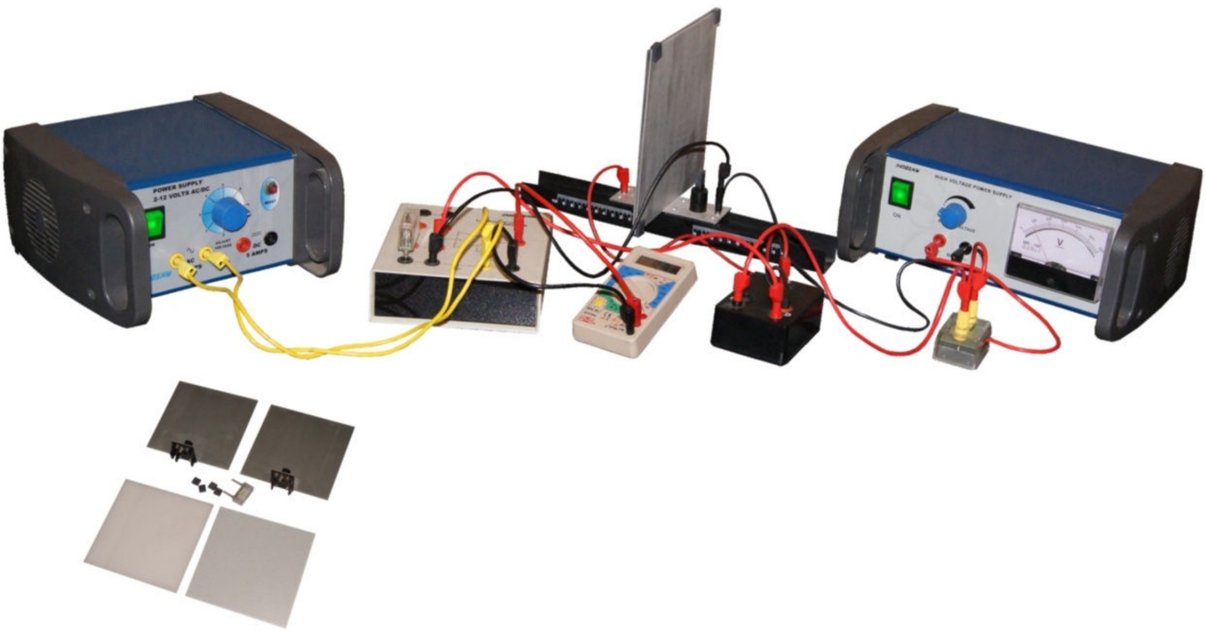
INDOSAW
COMMITTED TO EXCELLENCE

INSTRUCTION MANUAL

DIELECTRIC CONSTANT

(Cat No. SK042)



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OBJECTIVES:

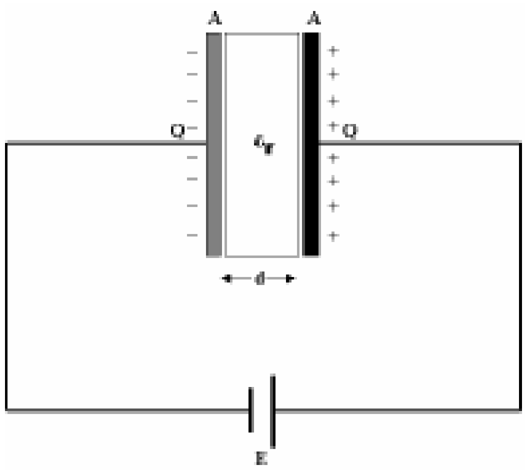
1. Measuring the charge Q on a plate capacitor as a function of the applied voltage E.
2. Determining the capacitance C as a function of areas A of plates.
3. Determining the capacitance C with different dielectrics between the plates.
4. Determining the capacitance C as a function of the distance d between the plates.

WORKING PRINCIPLE:

The relation between capacitance, charge and charging voltage is given as:

C= Q / E ……………………. (1)

Where Q is charge on the capacitor & E is charging voltage.
It is very clear from this expression that the capacitance of a plate capacitor depends on the area A of the plates, the distance d between the plates and the non-conductive material between the plates.
The capacitance of a parallel plate capacitor is given by the following formula:



$$C = \varepsilon_r \varepsilon_o \frac{A}{d} \quad ………………… \quad (2)$$

Where, e_o = 8.85 x 10^{-12} As/Vm; permittivity of free space,
This formula is valid as long as the distance between the plates is much smaller than the dimensions of the plates and the field E between the plates is homogeneous. The permittivity e_r describes the change of the capacitance relatively to the vacuum value caused by the introduction of the material. The relation (2) is studied in the experiment by means of a demountable capacitor with variable geometrical dimensions. Capacitor plates with areas A = 400 cm^2 and A = 800 cm^2 are available. The distance d between the plates can be increased with spacers in steps on 1 mm. First the charge Q on the capacitor is measured as a function of the voltage E. The capacitance C is then determined as the slope of the straight line. In order to confirm the proportionality

$$C \,\alpha\, A \quad ……………… \quad (3)$$

Which is derived from equation (2), the measurement is carried out at a fixed distance d with different areas A of the plates. In addition, the permittivities () of two different dielectrics (polystyrene and glass) are determined by placing the dielectrics between the capacitor plates. Variation of the distance d between the plates at a constant area A helps us confirm the proportionality

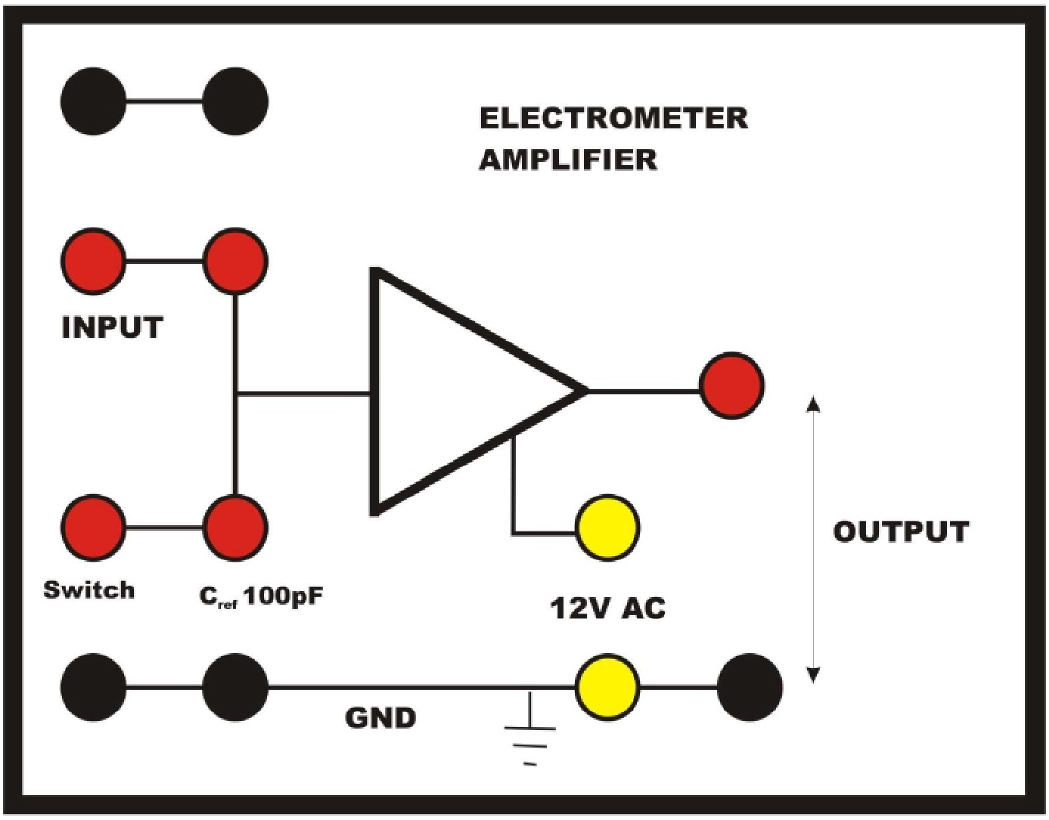
$$C \,\alpha\, d ………………… \quad (4)$$

The output charge is being measured by means of an electrometer amplifier, which is operated as a coulomb meter. Any voltmeter may be used to display the output voltage V0. From the reference capacitance Cref

$$Q = Vo.Cref \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

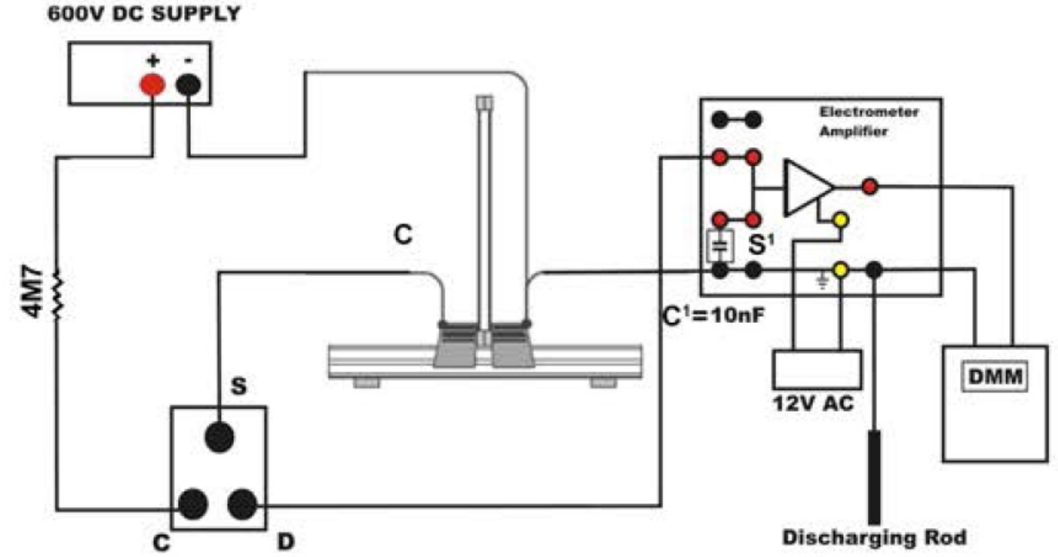
is obtained. For example, with Cref = 10nF and Vo = 1 volt we get the charge Q = 10nAs.
The unit nAs is same as nC(nano-coulomb).

ELECTRICAL CIRCUIT
The photoelectrons incident on the metal ring of the photocell charge a capacitor, generating the limit voltage U0 required for determining the kinetic energy. The electrometer amplifier is used to measure the voltage at the capacitor.
- Connect the 220 nF or 100 nF capacitor at Cref and the push switch at Switch.
- Connect photocell +ve & -ve terminal to input of electrometer amplifier ground.
- Connect the multimeter to the output of the electrometer amplifier.
- Connect the 0-12V AC power supply unit (12 V AC) to the electrometer amplifier via 100cm yellow leads.



Note: Never use the electrometer amplifier in DC output.
- Connect the optical bench (and possibly the rod of the basic device of the photocell) to the ground connection of the electrometer amplifier, and connect this terminal to the external ground of the mains unit.

Setup Procedure:
The experimental setup is illustrated in fig.



DIELECTRIC CONSTANT SETUPS

1. Mount the pair of small plates (A=400cm^2), and set the distance d between the plates to 4mm with the spacers.
2. Connect the earthing of mains inlet socket with the earth terminal of the electrometer amplifier.
3. Connect negative terminal of the dc power supply to the right plate and to the earth of the electrometer amplifier. Connect the connection rod.
4. Connect the positive side of the power supply to the socket C (means charging position) of the two-way switch.
5. Connect socket S of the two-way switch to the left plate and socket D (i.e discharging position) to the input of the electrometer amplifier.
6. Connect the reference capacitor cref = 220nF at the electrometer amplifier imput terminals, and connect the digital multimeter to its output, set 20V DC position.
7. Connect the digital multimeter to 0-600V DC power supply and set 600V DC position.
8. Connect 12V AC Power supply to electrometer amplifier.
9. Hold the discharging rod in your hand to get static charge, at each time when charging & discharging processes.

Important Instruction:
1. Before taking a freesh reading press s1 to short the capacitor.

2. Leave switch s1 and connect s to change the capacitor for 3 to 5 second.

3. Again press push switch s1 and connect s to discharge position. Note the DMM reading.

CARRYING OUT THE EXPERIMENT:

A. CHARGE MEASUREMENT FOR DIFFERENT AREAS OF PLATES:

1. Establish the connection set (S) to discharging (D) position with the two-way switch; discharge the plate capacitor with the discharging rod check the zero at output.
2. Hold the discharging rod in your hand (to store the charge), change to the connection set (S) to charging (C) position) with the two-way switch, and set the charging voltage E to 50 V.
3. Change back to the connection S to D, measure the charge Q with the electrometer amplifier, and note down the charge reading displayed in multimeter & repeat the procedure of discharging to discharge the plate charge.

Note: During discharging measurement the output voltage of electrometer amplifier will very, therefore wait for 30-60sec to read out stable reading. Each measurement should be taken for same time interval.

4. Repeat the measurement with other voltages (E).
5. Replace the pair of small plates with the pair of large plates (A = 800 cm2, d = 4 mm) & repeat the steps no. 1 to 3 to record readings.
6. Establish the connection S to D, and discharge the capacitor with the connection rod.
7. Hold the connection rod in your hand, repeat the procedure of charging & discharging and record the series of measurements with different applied voltages using large plates (A = 800 cm2).

OBSERVATION:

TABLE- 1 Cref= 220nf , d=4mm, Q = Vo.Cref

E (in volt)	**Q/nAs at A=400cm2**	**Q/nAs at A=800cm2**
50		

Plot a graph between the E Applied voltages vs Q charge store in plate, Slope of the straight line is the capacitance C.
Charge Q is recorded as a function of the applied voltage with different areas A of the plates. Slope of the straight line is the capacitance C.
Ratio of the capacitances in air is approximately same as the ratio of the areas.

$$C \alpha A$$

B. CHARGE MEASUREMENT FOR DIFFERENT DIELECTRICS:

1. Place the polystyrene sheet between the pair of small plates, and take care about the surfaces of plates are in complete touch with the sheet.
2. Establish the connection S to D in the two-way switch, and discharge the capacitor with the connection rod. Change back the connection to the S to C to charge to charge the plates & change back to the S to D for discharge.
3. Hold the connection rod in your hand, and measure the charge Q as a function of the voltage E.
4. Now, replace the polystyrene plate with the glass plate, establish the connection S & D, and discharge the capacitor with the connection rod.
5. Hold the connection rod in your hand, charge the plate by making connection to S to C & S to D back to get charge reading and record the series of measurements with glass sheet as dielectric.

OBSERVATION:

TABLE- 2 Cref= 220nf , Q = Vo.Cref

E (in volt)	Q/nAs at POLYSTYRENE	Q/nAs at GLASS
50		

MEASURING THE CHARGE AS A FUNCTION OF THE VOLTAGE FOR DIFFERENT DIELECTRICS

Record the charge as a function of applied voltage for different dielectrics (A=400cm2) is shown in the above graph. Make a difference that the change of material as a dielectric the change in the charge at the plates. In air dielectric the lowest the charge & at the glass as dielectric the charge is maximum, which directly affect the capacitance.

OBSERVATION:

TABLE- 3 Cref= 220nf , Q = Vo.Cref

DIELECTRIC	AREA A CM2	CAPICITANCE C IN PF
AIR	400	C1
AIR	800	C2
POLYSTYRENE	400	C3
GLASS	400	C4

Permittivity of the polystyrene & glass can be determined from the measuring values.
Polystyrene εr= C3/C2 Since value of C2 is at A=400cm2
Glass εr = C4/C2 Since value of C2 is at A=400cm2
For polystyrene εr = 1.6 for glass εr = 4.2

C. CAPACITANCE MEASUREMENT AS A FUNCTION OF THE DISTANCE BETWEEN THE PLATES:

1. In this case, we will be varying distance between plated and maintain the charging voltage at a constant value.
2. Set voltage E to 300 V.
3. Remove the glass plate and set the distance d between the plates to 1 mm with the spacers.
4. Establish the connection S to D in the two-way switch, and discharge the capacitor with the connection rod.
5. Hold the connection rod in your hand, change to the connection S to C to charge the capacitor, and then change back to the connection S to D for the charge measurement.
6. Read the charge Q and record it.
7. Keep increasing the distance between the plates subsequently to 2, 3, 4, and 6 mm, recharge the capacitor, and measure the charge output.

Table (4) determining the capacitance as a function of distance between the plates.
The charge Q (at E=300V) & the capacitance C as a function of the distance ‘d’ between the plates.

OBSERVATION:
TABLE- 4 Cref= 220nf , E=300Volt, Q = Vo.Cref

‘d’(in mm)	Q/nAs	C=Q/E IN PF
1		

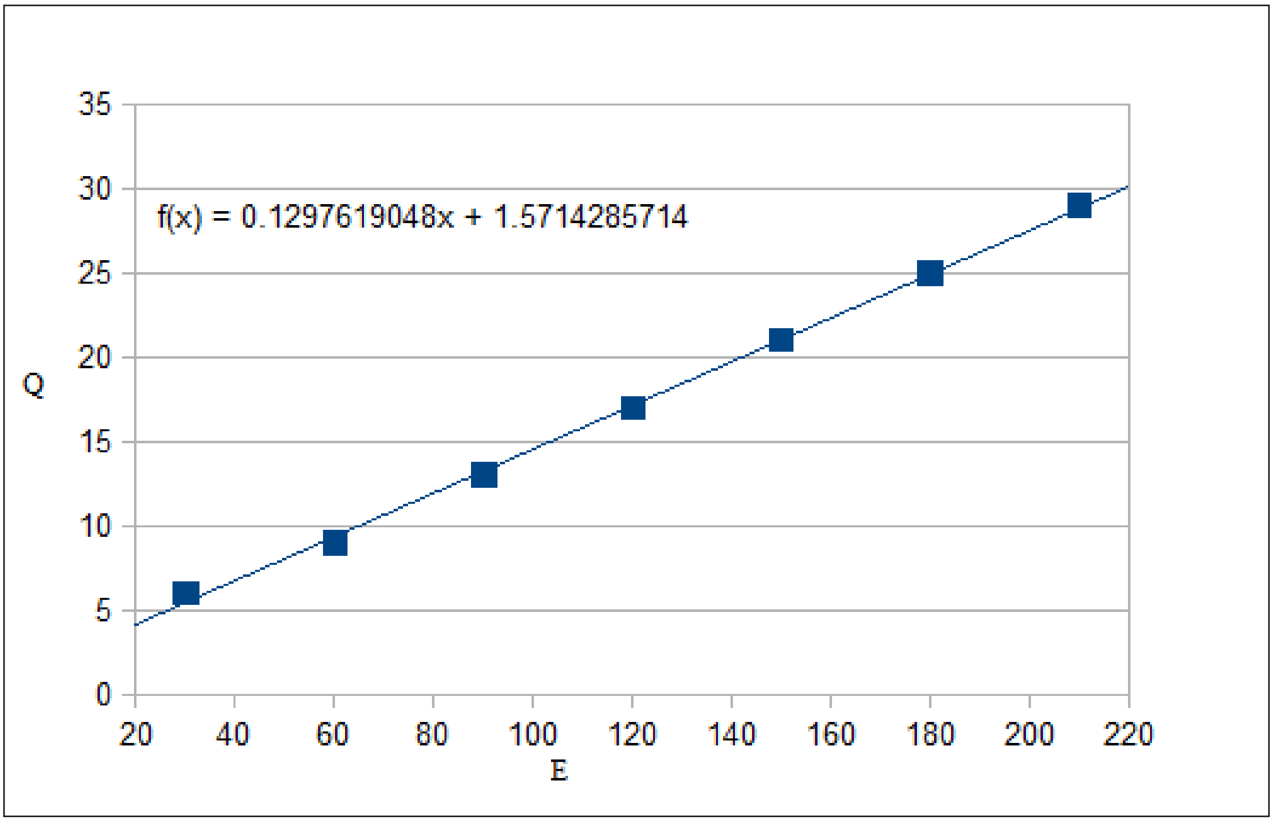
Table 4, determining the capacitance as a function of the distance between the plates.
The charge Q (at E=300V) & the capacitance C as a function of the distance ‘d’ between the plates.
The capacitance of the plate capacitors as a function of the distance between the plates is shown the curves below.

C α l/d

TEST RESULT OF DIELECTRIC CONSTANT

Table 1:- Creff = 100nF , D= 3mm Dielectric medium is **AIR.**

E(in volt)	Vo at A= 400 cm^2	Q in nC (nano Coulomb)
30	0.06	6
60	0.09	9
90	0.13	13
120	0.17	17
150	0.21	21
180	0.25	25
210	0.29	29



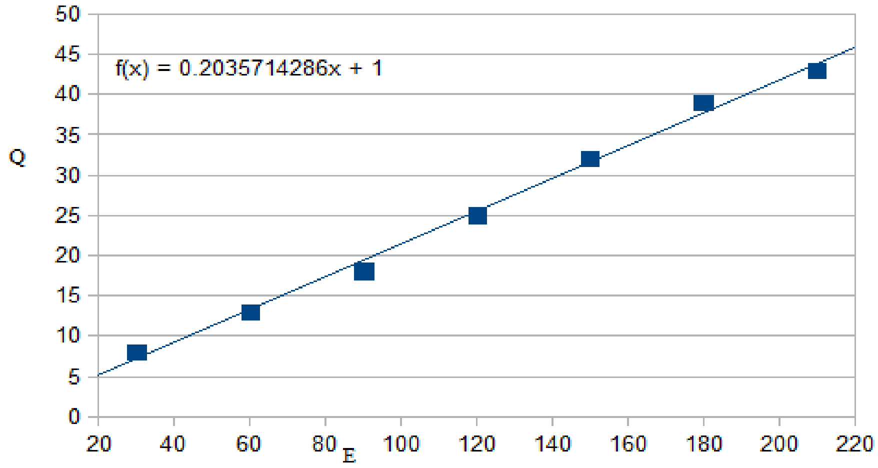
C= KeoA / D
putting the value of C= 129 pFe, o=8.85 X 10^{-12}, , A= 400 cm^2 and D= 3mm

K comes to be 1.09 which is very close to literature value.

Literature value of Dielectric constant of air is 1.

Table 2:- Creff = 100 nF , D = 4.2mm Dielectric medium is **POLYSTYRENE**

E(in volt)	Vo at A= 400 cm²	Q in nC (nano Coulomb)
30	0.08	8
60	0.13	13
90	0.18	18
120	0.25	25
150	0.32	32
180	0.39	39
210	0.43	43



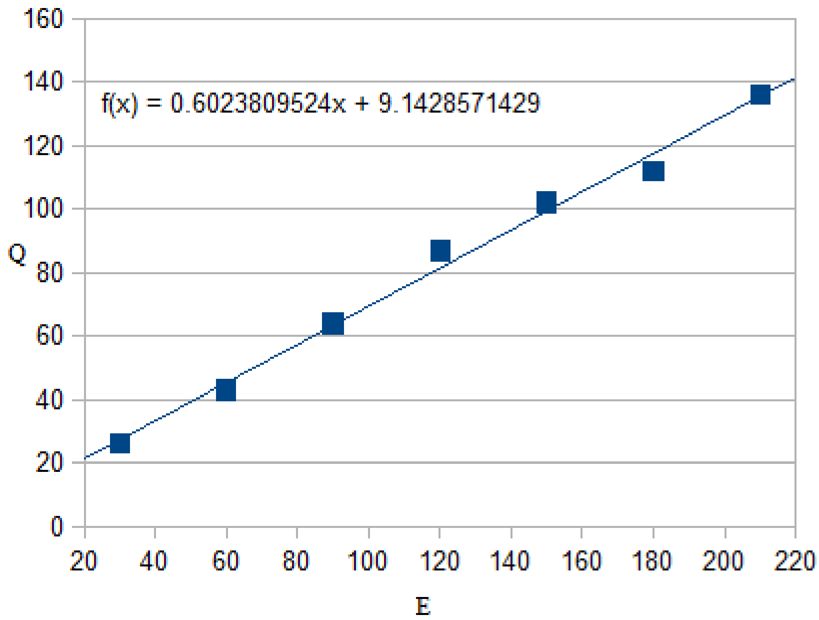
C= KεoA / D
putting the value of C= 203 pF , εo=8.85 X 10^{-12} , A= 400 cm^2 and D= 4.2mm

K comes to be 2.40 which is very close to literature value.

Literature value of Dielectric constant of polystyrene is 2.56.

Table 3:- Creff = 100 nF , D=4 mm Dielectric medium is **GLASS**

E(in volt)	Vo at A= 400 cm²	Q in nC (nano Coulomb)
30	0.26	26
60	0.43	43
90	0.64	64
120	0.87	87
150	1.02	102
180	1.12	112
210	1.36	136



C= KεoA / D
putting the value of C= 602 pF , εo=8.85 X 10^{-12} , A= 400 cm^2 and D= 4mm

K comes to be 6.80 which is very close to literature value.

Literature value of Dielectric constant of GLASS is 5-10.

Important instruction :-

1. The Earth terminal should be at zero potential. Check it before performing the experiment.

2. After making connections, touch the discharging rod, connected to earth terminal, with connecting wires, bodies of power supplies, table, bench of capacitor plate, electrometer amplifier, and your clothes to discharge all the stray charges to earth , in each trial .

3. During experiment keep the discharging rod in your hand.

4. After setting the two way switch at discharging position, take your hands away from the setup and wait till the reading is stable.

5. Any type of disturbance near the setup even the movoment of other persons near it must be avoided.

6. For quick stability of readings use capacitor of larger capacity.

7. Use plastic clips to grip the aluminium plates with polysterene plate in between , while finding the dielectric constant of polystyrene.

8. Use spacers when using 800 cm^2 plates as capacitors.