3055 BA SANGAM COLLEGE

PH: 6674003/9264117 E-mail: basangam@connect.com.fj

WORKSHEET 10

SCHOOL: BA SANGAM COLLEGE YEAR: 13

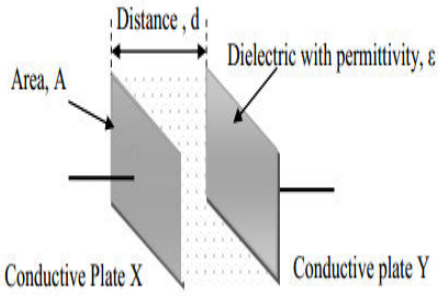
SUBJECT: PHYSICS NAMEOF STUDENT: _____

STRAND	4- ELECTROSTATIC
SUB-STRAND	CAOACITORS AND CAPACITANCE
LEARNING OUTCOME	• To understand about capacitors and capacitance

Capacitors and Capacitance

- Capacitor consists of two conductors separated by an insulator used to store electrical energy temporarily in an electric field
- Capacitors are commonly used in a variety of electric circuits eg used to tune the frequency of radio receivers, as filters in power supply, electronic flash units such as cameras.

Symbol



- The capacitance of the capacitor is ratio of the magnitude of the charge to the magnitude of the potential difference between the conductors.

$$C = \frac{Q}{\Delta V}$$

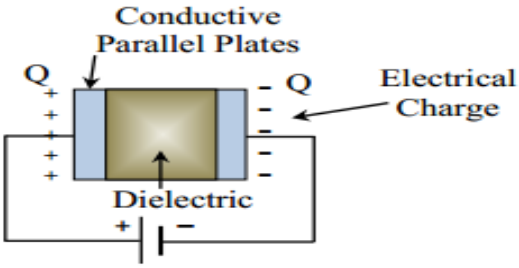
Capacitance Units: Farads (F)

Where: Q = charge on each plate,(C)

C = capacitance,(F)

ΔV = potential difference across the plates (V)

- The capacitance of parallel-plate capacitor is proportional to the area of its plate and inversely proportional to the plate separation.



is found by:

$$C = \varepsilon_o \frac{A}{d}$$

Where, ε_o = permittivity of free space 8.85×10^{-12} $C^2N^{-1}m^{-2}$ (or Fm^{-1})

A = is the area of plate (m^2)

d = plate separation (m)

EXAMPLE

A parallel plate capacitor of plate area 0.04 m^2 and plate separation of 0.25 mm is charged to 24 V. Determine the charge on the plate and the electric field between the plates.

Parallel Plate Capacitor

$$C=\varepsilon_0\frac{A}{d}=\left(8.85\times10^{-12}\right)\left(\frac{0.04}{0.25\times10^{-3}}\right)=1.42\times10^{-9}\,F$$

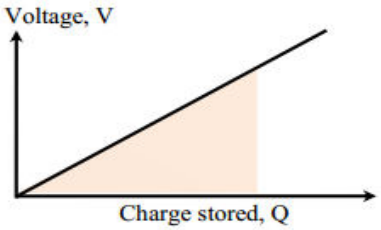
$$Q=C\Delta V=\left(1.42\times10^{-9}\right)(24)=3.4\times10^{-8}\,C$$

$$E=\frac{q}{A\varepsilon_0}=\left(\frac{1.42\times10^{-9}}{(0.04)\left(8.85\times10^{-12}\right)}\right)=9.6\times10^{4}\,Vm^{-1}\ \text{OR}\ E=\frac{\Delta V}{d}=\frac{24}{0.25\times10^{-3}}=9.6\times10^{4}\,Vm^{-1}$$

Energy Stored in a Charged Capacitor

-The most important applicationsof capacitors depend on their ability to store energy.

-A plot of voltage versus charge for a capacitor is a straight line with slope 1/C is the total work required to move a charge



We can express the potential energy stored in a charged capacitor in the following terms.

$$U=\frac{1}{2}QV=\frac{1}{2}CV^2=\frac{Q^2}{2C}$$

NOTE : Because the volume occupied by the electric field is Ad, the energy per unit volume known as the energy density.

$$U_E=\frac{U}{Ad},$$

$$U_E=\frac{1}{2}\varepsilon_0E^2$$

Units: Jm^{-3}

EXAMPLE

An airfilled capacitor consists of two parallel plates, each with an area of 7.60 cm^2 and separated by a distance of 1.80 mm. If a 20.0 V potential difference is applied to these plates, calculate the:

a) electric field between the plates.

$$E=\frac{\Delta V}{d}$$

$$E=\frac{20.0\ V}{1.8\times10^{-3}\ m}=11.11\,kV.m^{-1}$$

b) capacitance.

$$C=\left(\varepsilon_0\frac{A}{d}\right)=8.85\times10^{-12}\left(\frac{7.6\times10^{-4}}{1.8\times10^{-3}}\right)$$

$$=3.74\,pF$$

c) energy density.

$$U_E=\frac{1}{2}\varepsilon_0E^2$$

$$U_E=\frac{1}{2}\left(8.85\times10^{-12}\right)\left(11.11\times10^{3}\right)^2$$

$$U_E=5.46\times10^{-4}\ Jm^{-3}$$

d) charge on each plate.

$$Q=C\times\Delta V=\left(3.74\times10^{-12}\right)(20.0)$$

$$=74.8\,pC$$

EXERCISE

A parallel plate capacitor is 100cm by 50cm and the plates are separated by 10cm. They are connected to a 12V battery. Calculate

a) the capacitance of the capacitor (2marks)

b) the electric field strength (1mark)

c) the energy stored in the capacitor (1mark)

d) the charge stored on the capacitor (1mark)

2. The plates of a parallel plate capacitor are separated by a distance of 5.0 mm and the area of each plate is 2 cm x 10 cm. If the plates are in a vacuum and the potential difference between the plates is 2000V,

Determine:

i) the capacitance (2marks)

ii) the charge on each plate (1mark)

iii) the electric field intensity between the plates and the energy stored in the capacitor (2marks)