

State Examination Commission – Physics Higher Level, 2007

Question 8

Define electric field strength and give its unit of measurement. (9)

Describe how an electric field pattern may be demonstrated in the laboratory. (12)

The dome of a Van de Graff generator is charged. The dome has a diameter of 30 cm and its charge is 4 C. A $5 \mu\text{C}$ point charge is placed 7 cm from the surface of the dome.

Calculate:

(i) the electric field strength at a point 7 cm from the dome

(ii) the electrostatic force exerted on the $5 \mu\text{C}$ point charge. (15)

All the charge resides on the surface of a Van de Graff generator's dome. Explain why.

Describe an experiment to demonstrate that total charge resides on the outside of a conductor.

Give an application of this effect. (20)

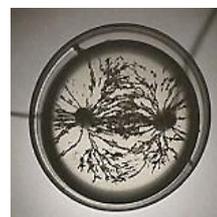
(permittivity of free space = $8.9 \times 10^{-12} \text{ F m}^{-1}$)

Define electric field strength and give its unit of measurement. (9)
basic definition

Describe how an electric field pattern may be demonstrated in the laboratory. (12)

Connect a high voltage source up to two electrodes and dip these electrodes into a shallow dish of olive oil into which some semolina has been sprinkled.

The semolina will be seen to align itself along electric field lines.



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Calculate:

(i) the electric field strength at a point 7 cm from the dome

$$\begin{aligned} E &= \frac{q}{4\pi\epsilon d^2} \\ &= \frac{4}{4\pi(8.9 \times 10^{-12})(0.22)^2} \\ &= 7.39 \times 10^{11} \text{ NC}^{-1} \end{aligned}$$

(ii) the electrostatic force exerted on the $5 \mu\text{C}$ point charge. (15)

$$\begin{aligned} F &= Eq \\ &= 7.39 \times 10^{11} \times 5 \times 10^{-6} = 3.69 \times 10^6 \text{ N} \end{aligned}$$

All the charge resides on the surface of a Van de Graff generator's dome. Explain why.

The charges repel each other until there is no motion of charge inside the conductor, hence the electric field inside the conductor is zero. The charges are then far from each other on the outer surface.

Describe an experiment to demonstrate that total charge resides on the outside of a conductor.

Give an application of this effect. (20)

The surface of a conducting can is connected with a wire to the Van de Graff generator. The Van de Graff generator is turned on and a lot of charge is deposited on the conducting can. A proof plane is used to sample the charge on the outside surface of the can and the charge sample is placed on the gold foil electroscope. The leaves of the electroscope deflect to show that there is a charge on the outside of the can.

Next, the charge on inside surface is sampled. The proof plane is carefully inserted through a hole in the top of the can where it touches the inside surface and is removed. The charge sample is deposited on the foil electroscope. The leaves do not deflect and shows that no charge is on the inside surface.

An application of this effect is in co-axial cable where an inner copper wire, carrying an electrical signal, is shielded from stray electric fields by another copper mesh cage surrounding it.