Universitat d'Alacant
Universidad de Alicante

Degree in Sound and Image Engineering
Polytechnic University College
Department of Physics, Systems Engineering and Signal Theory

Fundamentals of Physics in Engineering I

Unit 6.- ELECTRIC FIELD

1.- Two equal positive point charges $q_1 = 2 \times 10^{-6}$ C are placed at two adjacent corners of a square with a side length $a = 1$ m, while two other equal positive charges $q_2 = 5 \times 10^{-6}$ C are placed in the other corners. Calculate the electric field and the electric potential at the centre of the square.

2.- Point charges $q_1 = -10^{-8}$ C and $q_2 = 10^{-8}$ C are separated by 10 cm in air, forming an electric dipole. Find the electric field produced by the dipole at the following positions: (a) At a distance of 5 cm from the positive charge along the direction of the line joining the charges. (b) At a point in that line at a distance of 4 cm of positive charge. (c) At a point equidistant 10 cm from both charges.

3.- There is a uniform electric field between two very large parallel plates with equal but opposite charges. An electron is released at rest on the surface of the negative plate and then, after $t = 15$ ns, it reaches the surface of the other plate, placed at a distance $d = 2.0 \times 10^{-2}$ m. (a) Calculate the intensity of the electric field (b) and the velocity of the electron when it reaches the second plate. (c) Which is the potential difference between the plates?

4.- An electron is projected within a uniform electric field $E = 2000$ N/C with an initial velocity $v_0 = 10^6$ m/s perpendicular to the field. (a) Find the motion equations of the electron. (b) How much will the electron deflect if it has travelled 1 cm on the x-axis, assuming that this axis determines the input direction of the electron? $m = 9.1 \times 10^{-31}$ kg, $q = -1.6 \times 10^{-19}$ C

5.- A charge q is uniformly distributed along a conducting ring of radius a. Find the electric field and the electric potential at an arbitrary point on the axis perpendicular to the ring plane and passing through the centre of the ring, as a function of the distance from this centre.

6.- Calculate the electric field and the electric potential produced by: (a) a segment of length L uniformly charged with linear charge density λ (**E** and V evaluated in points of the segment bisector); (b) an infinite line uniformly charged with linear charge density λ.

7.- A positive electric charge is distributed uniformly throughout the volume of an insulating sphere with radius R, being ρ the volume charge density. Find the magnitude of the electric field in points inside and outside the sphere as a function of the distance r from the its centre.

9.- An insulating sphere with radius R has a volume density charge proportional to the distance r from its centre $\rho = Ar$ for $r \leq R$, and $\rho = 0$ for points $r > R$, where A is a constant. Calculate: (a) The value of the constant A if the total charge of the sphere is Q. (b) The magnitude of the electric field in points inside and outside the sphere as a function of the distance r from its centre.

10.- The surface charge densities of three parallel infinite plane sheets placed at $x = -2$, $x = 0$ and $x = 2$ m, are $\sigma_1 = 2$ C/m^2, $\sigma_2 = 4$ C/m^2 and $\sigma_3 = -3$ C/m^2, respectively. Calculate the electric field and the potential produced by the three charged sheets in the different regions of the space determined by them, considering the potential is null at $x = 0$ m.

11.- Two concentric conducting spherical shells with radius a and b ($a < b$) have electric potentials V_1 and V_2, respectively. Calculate the electric charge on each of the shells.

12.- Let us consider two concentric isolated conducting spherical shells with radius a and b ($a < b$). The spherical shell of radius a is discharged and the spherical shell of radius b has a total charge Q on its surface. The inner spherical shell is connected to ground without touching the outer spherical shell. What is the charge induced in the spherical shell of radius a? What is the potential in the points between the two spherical shells?

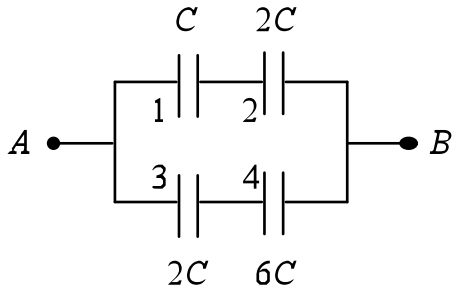
13.- Two concentric isolated conducting spherical shells with radius $R_1 = 5$ cm and $R_2 = 10$ cm, have electric potentials $V_1 = 30000$ V and $V_2 = 18000$ V, respectively. The inner spherical shell is connected to ground without touching the outer spherical shell, which will be the potential of the outer spherical shell?

14.- A conducting sphere with radius R_1 and charge Q is connected, using a conducting wire, whose capacitance is negligible, to another sphere of radius R_2 ($R_2 < R_1$), initially discharged. Assuming that the spheres are sufficiently far apart in order influence phenomena between them to be negligible, calculate: (a) The charges of each one of the spheres. (b) The potential. (c) The charge surface density of each sphere. (d) Repeat the exercise assuming that the distance between the centres of the two spheres is d.

15.- A copper slab with a thickness b, is inserted between the two flat plate of a parallel-plate capacitor. The copper slab is located exactly half the distance d (d> 0) between the plates. What is the capacitance before and after inserting the copper slab?

16.- The plates of a parallel-plate capacitor are separated $d = 5$ mm and have a surface $S = 2$ m^2. We introduce two dielectrics between them, one with a thickness of 2 mm and with a relative permittivity of 5, and another one with a thickness of 3 mm and a relative permittivity of 2. The capacitor is charged up to 3.54 $x10^{-5}$ C. Calculate: (a) The electric field in each dielectric. (b) The electric potential difference between the plates of the capacitor. (c) The capacitance of the capacitor.

17.- Given the system of the figure, calculate the energy stored by each capacitor if the potential difference between points A and B is V = 20 V, being $C = 4$ μF.



18.- Two capacitors connected in parallel accumulate an energy of 9 J x 10^{-4} when there is a potential difference of 5000 V between plates. When these capacitors are connected in series and we establish the same potential difference between the extreme plates, energy is 2 x 10^{-4} J. Find the capacitances of both capacitors.

19.- In a parallel plate capacitor with plate area S and a separation d between plates, a battery charges the plates with a potential difference V_0, then it is disconnected and we insert a dielectric with a thickness d. Calculate the energy before and after inserting the dielectric.

20.- (a) Calculate the energy stored in a conducting sphere of radius R and total charge Q. (b) What would the stored energy be in the case of a non-conducting sphere of radius R and charge Q uniformly distributed throughout its volume?

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