DEGREE IN COMPUTER ENGINEERING

PHYSICS **EXERCISES CH 5**

Electric potential.

1. Three point charges q_1 = 24 nC, q_2 = –30 nC and q_3 = 50 nC are located respectively at (5,3,-3) m, (2,3,3) m and (-2,1,5) m.

a) Find the electric potential at (1,1,1) m.
b) Find the work done by the electrostatic force to move a point charge of –10 nC from (1,1,1) to the origin. Will the charge move spontaneously towards the origin?

2. The electrostatic potential energy of a system of point charges is the work done by an external agent to bring that system of charges from an infinite separation to their final positions, in which the charges have stored a potential energy. It is obtained by calculating the potential energy for every pair of charges and adding the terms. What would be the electrostatic potential energy of the system of point charges described in the previous exercise?

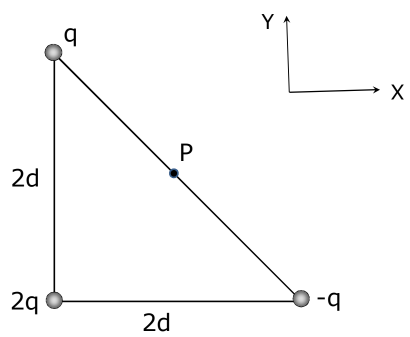
3. Two point charges q_1= 40×10^{-9} C and q_2= -30×10^{-9} C, are separated 10 cm from each other.

a) Find the electric potential at the midpoint of the line between the two charges (point A) and at 8 cm from q_1 and 6 cm from q_2 (point B).
b) Find the magnitude of the electric field in both points.
c) What would be the work done by an external agent (against the electrostatic force) to move a charge q=+25×10^{-9} C from B to A? Would the charge move spontaneously from B to A?

4. The electric potential and the magnitude of the electric field at some distance *d* from a point charge *q* are 600 V and 200 N/C. Find *d* and *q*.

5. Three point charges *q*, *2q* and *–q* are located at the corners of an isosceles right triangle of equal sides *2d*, as shown in the attached figure.

a) Find the electric field at the midpoint between *q* and *-q* (point P).
b) Find the electric potential at P.
c) Find the work to bring a charge -5Q from the infinite to P.



6. A proton starting from rest is accelerated by a uniform electric field of magnitude 640 N/C. After some time, the speed of the proton is 1.2 × 10^6 m/s.

a) How long does it take for the proton to reach that speed?
b) Find the distance travelled by the proton until it reaches that speed.
c) Find the kinetic energy of the proton when it reaches that speed in J and eV.

DATA: m_p=1.67x10^{-27} kg

Electric potential.

7. An electron beam in a cathode ray tube (traditional TV) is accelerated towards the TV screen. The electrons start from rest and accelerate through a potential difference of 30kV. Find:

a) The mechanical energy of the electrons expressed in J and eV. *Take the origin of potential at the screen.*
b) The speed of the electrons when they reach the TV screen.

DATA: $m_e = 9.11 \times 10^{-31}$ *kg*

8. An infinite charged plane has a charge density $\sigma = 8.8 \times 10^{-7}$ C/m^2. The electric potential is chosen to be zero at a distance *d* from the plane, so at any point of the plane the potential has a value of 2×10^3 V.

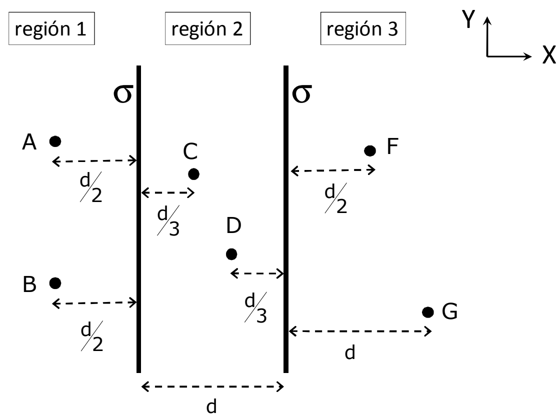
a) Find the magnitude of the electric field 10 cm and 30 cm away from the plane.
b) Find the distance *d* from the plane at which the potential is zero.
c) Find the electric potential 10 cm and 30 cm away from the plane.

9. Find the electric field for the electric potential function given by $V(x,y) = 3x^2 - 2y$.

10. Two infinite parallel planes uniformly charged with a positive surface charge density σ are separated a distance d.

a) Find the magnitude and direction of the electric field on each of the three regions indicated in the figure.
b) Calculate the following differences of electric potential:

b1) $V_A - V_B$
b2) $V_C - V_D$
b3) $V_F - V_G$



11. A spherical shell of radius R=5 cm surface charge density σ =100 nC/m^2 is centred at the origin of a Cartesian reference frame. A point charge of -5 nC is positioned along the X axis at x=10 cm. Find the electric potential at:

(a) (4, 0) cm
(b) (10, 5) cm

12. Find the electric potential for r>R due to the following spherical charge distribution of radius R:

$\rho(r)=0 \quad 0<r<R/2$
$\rho(r)=\rho_o \quad R/2<r<R \qquad (\rho_o$ constant)

TIP: Use the electric field obtained in Chapter 4, exercise 6.

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Electric potential.
ANSWERS

1. a) V(1,1,1) = 36 V

b) $W_{él} = 2.13 \times 10^{-7}$ J >0 → spontaneous process

2. $U_e = -2.72 \times 10^{-6}$ J

3. a) $V_A = 1.8 \times 10^3$ V $V_B = 0$

b) $E_A = 2.5 \times 10^5$ N/C $E_B = 9.37 \times 10^4$ N/C

c) $W^{ext}_{B \to A} = 4.5 \times 10^{-5}\,\mathrm{J} > 0 \to W_{él} < 0 \to$ non − spontaneous process

4. d = 3 m q = 0.2 μC

5. $\vec{E}(P) = \dfrac{\sqrt{2}\,q}{4\,\pi\,\varepsilon_0\,d^2}\,\vec{\imath}$ $V(P) = \dfrac{\sqrt{2}\,q}{4\,\pi\,\varepsilon_0\,d}$ $W_{él} = \dfrac{5\sqrt{2}\,q\,Q}{4\,\pi\,\varepsilon_0\,d}$

6.
a) $t = 1.96 \times 10^{-5}$ s
b) x = 11.75 m
c) $E_c = 1.2 \times 10^{-15}$ J = 7.52 keV

7.
(a) $4.8 \times 10^{-15}\,J = 3 \times 10^4\,eV$ when the origin of potential is taken at the screen.
(b) $v = 10^8\ ms^{-1}$

8.
a) E (10 cm) = E (30 cm) = 4.97×10^4 N/C
b) d = 4.02 cm
c) V (10 cm) = -2972 V V (30 cm) = - 12915 V

9. $\vec{E} = -6x\vec{i} + 2\vec{j}$

10. a) $R1:\ \vec{E} = -\dfrac{\sigma}{\varepsilon_0}\,\vec{\imath}$ $R2:\ \vec{E} = 0$ $R3:\ \vec{E} = \dfrac{\sigma}{\varepsilon_0}\,\vec{\imath}$

b1) $V_A - V_B = 0$ b2) $V_C - V_D = 0$

b3) $V_F - V_G = \dfrac{\sigma\,d}{2\,\varepsilon_0}$

11. V (4, 0) = - 185 V V (10, 5) = - 647.8 V

12. $V(r > R) = \dfrac{7\rho_0 R^3}{24\varepsilon_0 r}$