**DEGREE IN COMPUTER ENGINEERING**

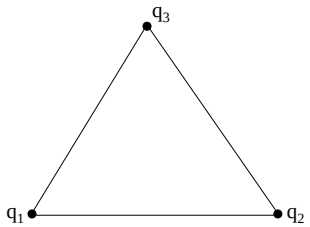
**PHYSICS** **EXERCISES CH 3**

*Coulomb's Law. Electric Field.*

**1.** A point charge of $q_1$=1C is positioned at (-1,1,3) m.
(a) What force will it exert on a second charge of $q_2$=-2C located at (2,-1,0) m?
(b) Find the magnitude of this force.

**2.** Three point charges of $q_1$ = Q, $q_2$ = -2Q and $q_3$ = 3Q are respectively positioned at (2,-3,1), (-2,0,3) and (2,2,-1) (all coordinates expressed in m). What is the net force exerted on $q_1$?

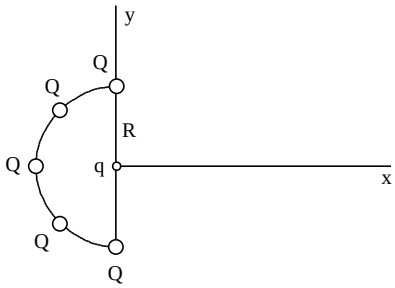
**3.** Three charges are placed at the corners of an equilateral triangle of side *l*, as shown in the figure (*l* = 1 m, $q_1$=$q_2$=5 nC, $q_3$= -5 nC). The left corner is taken as the origin of the reference frame. (a) Calculate the forces exerted by $q_1$ and $q_2$ on $q_3$ and draw the force diagram. (b) Find the net force acting on $q_3$.



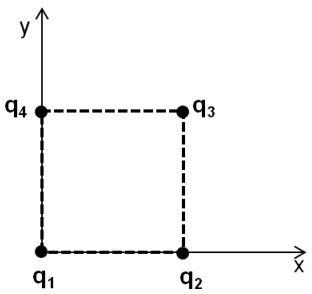

**4.** Two small spheres (R~0) of mass 1 g located near the Earth surface are suspended from a common point by strings of length 20 cm. Each sphere carries a charge Q. The spheres are in equilibrium when the separation between them is 5 cm. Find Q.

**5.** Five equal charges are equally spaced on a semicircle of radius R as shown in the figure. Find the electric force on a charge q located at the centre of the semicircle.

*Suppose all charges positive.*




**6.** Four charges of 1nC each are located at the corners of a square (see figure). The length of the sides is 2m, and one corner is taken as the origin of the reference frame. (a) Find the electric field due to $q_1$ at the centre of the square. (b) What would be the net force exerted on a -1nC charge located at the centre? (c) Calculate the net electric field acting at (0, 2) m.




**7.** Two charges of equal magnitude and opposite sign Q and – Q are located at x = a/2 and x= –a/2 along the X axis. Find the magnitude and direction of the electric field $\vec{E}$ at any point of the positive Y axis.

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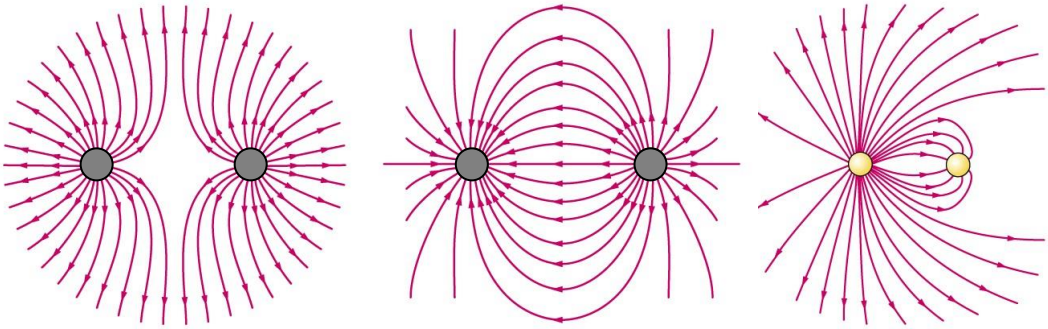
**8.** A point charge $q_1$= +6 nC is at the origin of the reference frame and a second point charge $q_2$=+10 nC is located at (6,0) m.

a) Find the electric field at (0,8) m.

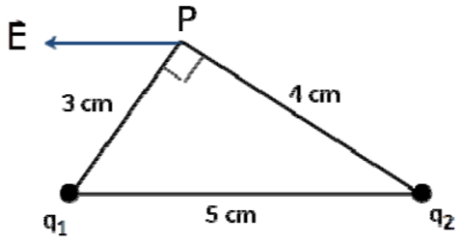
b) Where would we have to put a charge $q_3$ =+1 nC so that the net electric field at (0,8) m is zero?

**9.** The electric field lines for different systems formed by two point charges are shown in the figures below. What is the sign of the charges on each system, and what are the relative magnitudes of the charges?

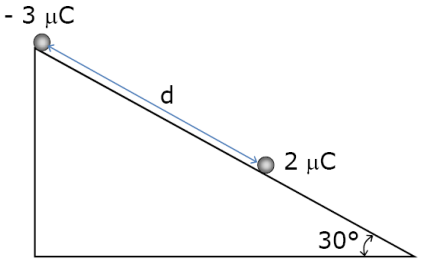
1 2 3



**10.** Two charges $q_1$ and $q_2$ are located as shown in the attached figure. It is known that $|q_1| = 2\mu C$, and that $\vec{E}$ is the total electric field at point P. Find $q_2$ and $\vec{E}$.




**11.** A fixed -3 μC charge is located at the top of a plane inclined 30º with respect to the horizontal. A point mass M of charge 2 μC is at equilibrium on the plane when the distance between the two charges is d=0.74 m. Find M.



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**12.** A charge of Q = 5 μC is uniformly distributed throughout the volume of a sphere of radius R= 20 cm.

a) Find the charge density.
b) Find the charge density if the charge is uniformly distributed on the surface of the sphere.
c) Find the charge density if the charge is uniformly distributed along a line coinciding with the equator of the sphere.

**13.** An electron travelling with a constant initial velocity $\vec{v}_0 = 2\times10^6\vec{i}$ m/s enters a region with a uniform and constant electric field $\vec{E} = 400\vec{j}$ N/C.

a) Draw the forces acting on the electron.
b) Calculate the acceleration of the electron after entering the field.
c) Find the trajectory described by the electron.
d) Find the position of the electron after 10 ns and its deflection with respect to $\vec{v}_0$.

DATA: mass of the electron m= $9.11 \times 10^{-31}$ kg
charge of the electron $q_e$ = $-1.6 \times 10^{-19}$ C

*Neglect any effect due to gravity*

**14.** A positively charged particle of mass 1 g falls from rest in free space from a height of 5 m, in a region where there is a uniform electric field of magnitude $10^4$ N/C. The particle reaches the floor with a speed of 21 m/s.

a) Discuss the direction of the electric field.
b) Find the charge of the particle.

**ANSWERS**

**1.** (a) $\vec{F}_{1,2} = (-5.2, 3.5, 5.2)\times10^8\, N$ (b) F = 8.2 x $10^8$ N

**2.** $\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{29^{3/2}}\left(-8\vec{i} - 9\vec{j} + 10\vec{k}\right)$

**3.** (a) $\vec{F}_{1,3} = (-112.5\vec{i} - 194.85\vec{j})nN$ $\vec{F}_{2,3} = (112.5\vec{i} - 194.85\vec{j})nN$ (b) **F** =- 3.9 $\times10^{-7}$ N $\vec{j}$

**4.** Q = 1.85 $\times10^{-8}$ C

**5.** $\vec{F} = \frac{qQ}{4\pi\varepsilon_0 R^2}\left(1+\sqrt{2}\right)\vec{i}$

**6.** (a) $\vec{E}_{1,C} = (3.18, 3.18)\, N/C$ (b) F=0 (c) $\vec{E}_{net,4} = (-3.04, 3.04)\, N/C$

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**7.** $\vec{E}(y) = -k\dfrac{Q\ a}{\left(\dfrac{a^2}{4}+y^2\right)^{3/2}}\vec{i}$

**8.** a) $\vec{E} = -0.54\,\vec{i} + 1.56\,\vec{j}$ $[N/C]$

b) $(x,y) = (-0.76, 10.2)$ $[m]$

**9.** 1. $q_{left}$ = +Q, $q_{right}$ = +Q

2. $q_{left}$ = −Q, $q_{right}$ = +Q electric dipole

3. $q_{left}$ = +4Q, $q_{right}$ = −Q

**10.** $q_2 = 4.7x10^{-6}$ C $\vec{E} = -3.3x10^{7}\,\vec{i}$ $[N/C]$

**11.** M = 20 g

**12.** a) $\rho = 1.5\times10^{-4}$ C/m$^3$

b) $\sigma = 1\times10^{-5}$ C/m$^2$

c) $\lambda = 4\times10^{-6}$ C/m

**13.** b) $a = 7\times10^{13}$ m/s$^2$

c) $y = 8.8\,x^2$ it follows a parabolic trajectory.

d) $\vec{r}(t = 10ns) = (0.02, -3.5\times10^{-3})m$

$\alpha$ = 19.4º angle between $\vec{v}$ and $\vec{v}_0$

**14.** a) $\vec{E} = -E\vec{j}$

b) q = 3.4 $\mu$C