Phys 132 Sp 2026

Lecture 5

Thurs: Seminar Wubben 160

Fri: HW by 5pm

Ex 18, 19, 23, 24, 26, 27, 32, 34

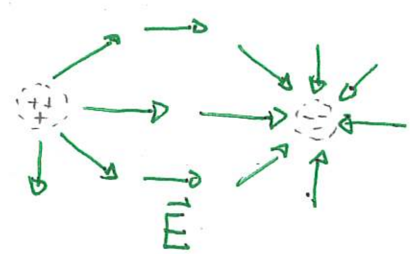
Electric fields

Electric fields offer a method to determine the forces exerted by source charges on one probe charge. The scheme is

Consider fixed sources with known charges and locations

Sources produce and electric field

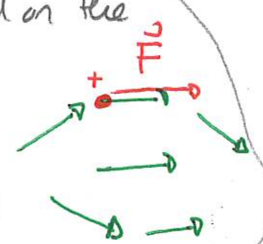
- collection of vectors, one at each location



Place a different point charge (probe) in the field. The force exerted on the probe is

$$\vec{F} = q_{probe}\,\vec{E}$$

where $\vec{E}$ is the electric field vector at the probe's location



Note that, for this to work, the units of electric field are N/C

Quiz 1 90% –

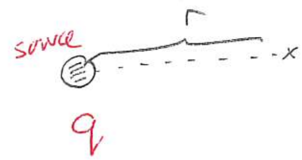
Quiz 2 40% – 80%

In order to determine the electric field produced by any charge distribution we need the electric field produced by a point source charge:

The electric field produced by a point source with charge q has

1) magnitude

$$E = \frac{1}{4\pi\epsilon_0} \frac{|q|}{r^2}$$



where r is the distance to the location where we want to compute the field

2) direction $= \begin{cases} \text{radially away} & \text{for positive source} \\ \text{radially toward} & \text{for negative source} \end{cases}$

Then for multiple sources we compute the fields due to individual sources and then add the vectors:

$$\vec{E} = \sum \vec{E}_i$$

where

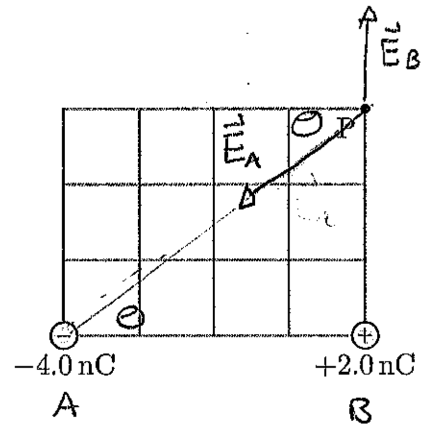
$$E_i = \frac{1}{4\pi\epsilon_0} \frac{|q_i|}{r_i^2}$$

Quiz3 60% – 80%

Quiz4

1 Electric field produced by two point charges, 1

Two charged particles are held fixed as illustrated; the grid units are each 0.010 m. The aim of this exercise will be to determine the field at point P. *(132S22)*



a) Indicate the directions of the electric fields produced by each source charge at point P.

b) Determine the magnitude of the electric field produced by each source charge at point P.

c) Using vector components add the two electric fields. Express the total electric field in terms of standard unit vectors.

$\tan\theta = 3/4 \Rightarrow \theta = 36.9^\circ$

Answer: a) see diagram

b) $E_A = \dfrac{1}{4\pi\epsilon_0}\dfrac{|q_A|}{r_A^2}$

$r_A^2 = \sqrt{(0.04\text{m})^2 + (0.03\text{m})^2}$

$r_A = 0.05\text{m}$

$E_A = \dfrac{1}{4\pi\, 8.85\times10^{-12}\,C^2/Nm^2}\dfrac{4.0\times10^{-9}C}{(0.05\text{ m})^2}$

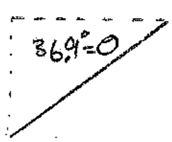
$E_A = 1.44\times10^4 N/C$

$E_B = \dfrac{1}{4\pi\times8.85\times10^{-12}C^2/Nm^2}\dfrac{2.0\times10^{-9}C}{(0.03\text{m})^2} \Rightarrow E_B = 2.00\times10^4 N/C$

c) $\vec{E}_B$ only has a y-component

$E_{By} = 2.00\times10^4 N/C$

$\vec{E}_A$ has both



	x	y
$\vec{E}_A$	$-1.15\times10^4 N/C$	$-0.86\times10^4 N/C$
$\vec{E}_B$	0	$2.00\times10^4 N/C$

$E_{Ax} = -E_A\cos 36.9^\circ$

$= -1.15\times10^4 N/C$

$E_{Ay} = -E_A\sin 36.9^\circ = -0.86\times10^4 N/C$

so $E_x = E_{Ax} + E_{Bx} = -1.15\times10^4 N/C$

$E_y = E_{Ay} + E_{By} = -0.86\times10^4 N/C + 2.00\times10^4 N/C$

$= 1.14\times10^4 N/C$

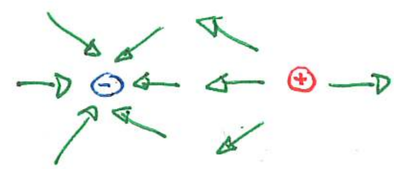
$\Rightarrow \vec{E} = -1.15\times10^4 N/C\ \hat{i} + 1.14\times10^4 N/C\ \hat{j}$

Electric dipole

An important arrangement of charges is an electric dipole. The simplest version consists of two point particles with exactly opposite charges.

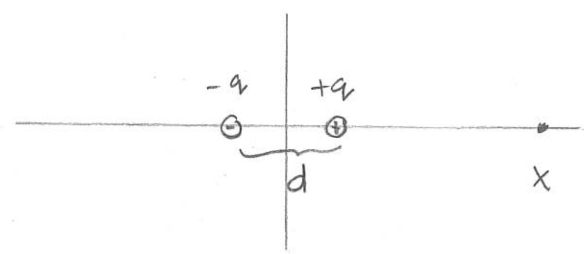
DEMO: PhET Charges + Fields

DEMO: Falstad Electric fields



One can determine an exact expression for the electric field. However a useful approximation is:

* consider a dipole arranged along the x-axis with the origin midway between the charges

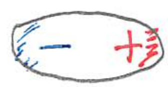


* then the field at point x is

$$E \approx \frac{1}{4\pi\epsilon_0} \frac{2p}{x^3}$$

where $p = qd$ is the electric dipole moment (units Cm)

In general any charge imbalance can form an electric dipole. This often occurs in molecules. For example carbon monoxide CO has structure

$C=O$ ⇝ 

and this has an electric dipole moment that is non-zero,

$p = 4.06 \times 10^{-31}$ Cm