Lecture 5

Tues: Discussion / quiz

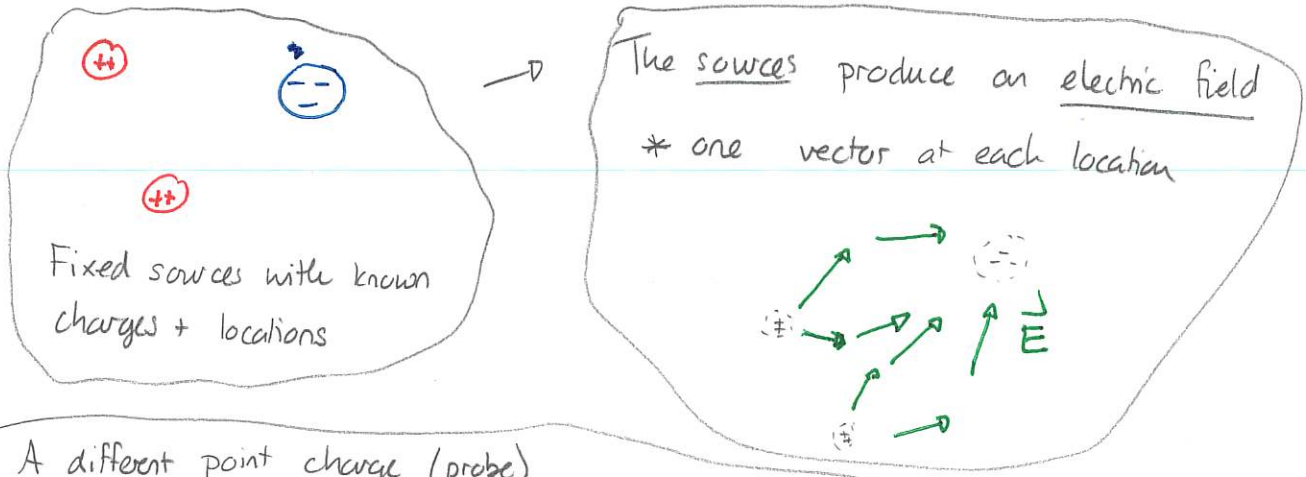
Ex 13, 18, 20, 22, 23, 24, 26

Weds: Normal Class

NOTE: Slightly different grading scale from prev years.

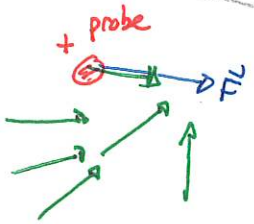
Electric fields

The conceptual scheme for electric fields is:



A different point charge (probe) is placed in the field. The net electric force exerted on the probe is

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



where q_{probe} = probe charge

$\vec{E}$ = electric field vector at probe location

Quiz!

The electric field produced by any charge distribution can be determined from the field produced by a point charge. The key rule is:

> The electric field produced by a point charge with charge q has
>
> 1) magnitude
>
> $$E = \frac{1}{4\pi\epsilon_0}\frac{|q|}{r^2}$$
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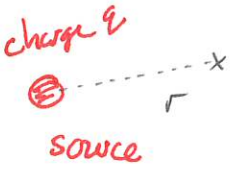
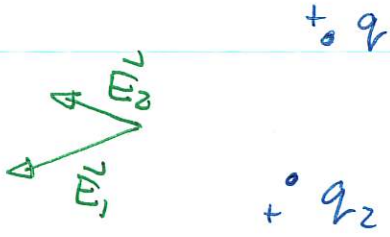
> 
>
>
> where r is the distance from the charge to the location where the field is computed.
>
> 2) direction $= \begin{cases} \text{radially outward for positive source} \\ \text{radially inward " negative source} \end{cases}$

For multiple sources the net field is the vector sum of the individual fields

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

where $\vec{E}_j$ is the field produced by source j.



Warm Up!

Quizz 80% - 95%

Electromagnetism and Optics: Group Exercise 1

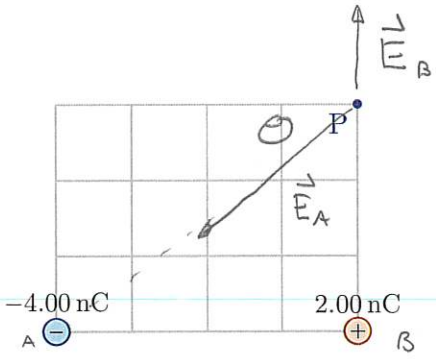
25 August 2026

Names: _____ _____ _____

_____ _____ _____

1 Electric field produced by two point charges, 1

Two charged particles are held fixed as illustrated; the grid units are each 0.0100 m. The aim of this exercise will be to determine the field at point P.



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.

Answer: a) Diagram shows.

For $\vec{E}_A$ $\quad r_A = \sqrt{(0.0300\text{m})^2 + (0.0400\text{m})^2} = 0.0500\text{m}$

$\tan\theta = \frac{3}{4} \Rightarrow \theta = \arctan\left(\frac{3}{4}\right) = 36.9^\circ$

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

$= \frac{1}{4\pi \times 8.85\times10^{-12}\,C^2/Nm^2}\frac{|-4.00\times10^{-9}\,C|}{(0.0500\text{m})^2} \Rightarrow E_A = 1.44\times10^4\,N/C$

$$E_B = \frac{1}{4\pi\varepsilon_0}\frac{|q_B|}{r_B^2}$$

$$= \frac{1}{4\pi \times 8.85\times10^{-12}\,C^2/Nm^2}\frac{2.00\times10^{-9}C}{(0.0300m)^2} = 2.00\times10^4\,N/C$$

c) $\vec{E}_B$ only has a vertical component.

	x	y
$\vec{E}_A$	-1.15×10^4 N/C	-0.86×10^4 N/C
$\vec{E}_B$	0	2.00×10^4 N/C

The components of $\vec{E}_A$ are.

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

$$= -1.44\times10^4\,N/C\ \cos 36.9^\circ$$

$$E_{Ay} = -E_A\sin 36.9^\circ$$

$$= -1.44\times10^4\,N/C\ \sin 36.9^\circ$$

So $\vec{E} = \vec{E}_A + \vec{E}_B$

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

$$E_y = E_{Ax} + E_{By} = -0.86\times10^4\,N/C + 2.00\times10^4\,N/C = 1.14\times10^4\,N/C$$

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

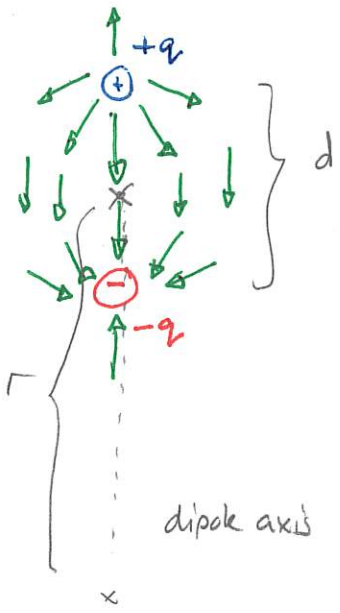
Warm Up2

END

Electric dipole

A (point) electric dipole is two particles with exactly opposite charges that are separated.

DEMO: Falstad EM fields



It is possible to obtain an exact expression for the field at any location. However it is useful to approximate the field for locations very distant compared to the separation between the charges. The result is

The electric field magnitude at any along the dipole axis is approximately

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

where * r is the distance from the dipole center

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

Electric dipoles can be a useful approximation for the electrostatic properties of materials. Examples:

1) Carbon monoxide molecule has a charge separation

$C=O \rightarrow$ (− +)

has an electric dipole moment $p = 4.06\times10^{-21}$ Cm

2) certain materials consist of dipoles