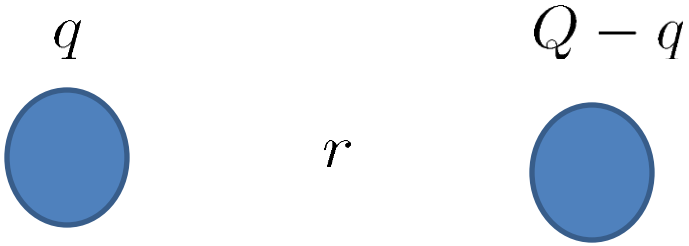
Copyright statement

- The images and the pictures in this lecture are provided by the CDs accompanied by the books

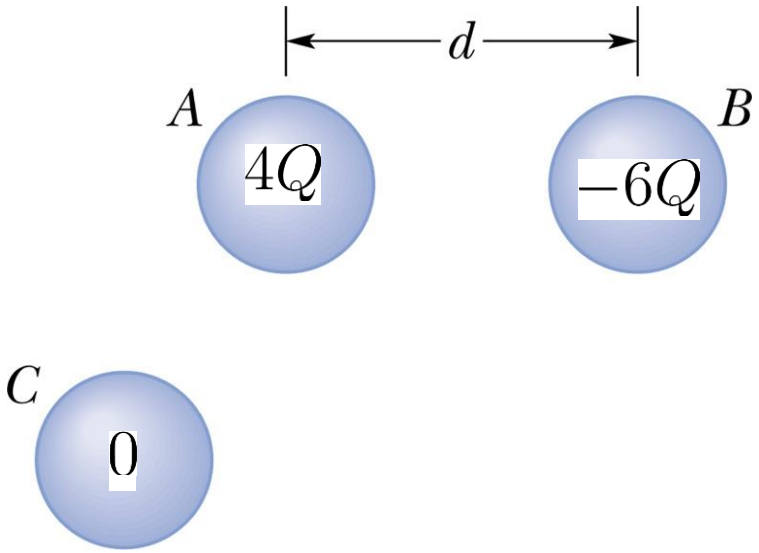
  1. University Physics, Bauer and Westfall, McGraw-Hill, 2011.
  2. Principles of Physics, Halliday, Resnick, and Walker, Wiley, 8th and 9th Ed.

- The rest is made by me.

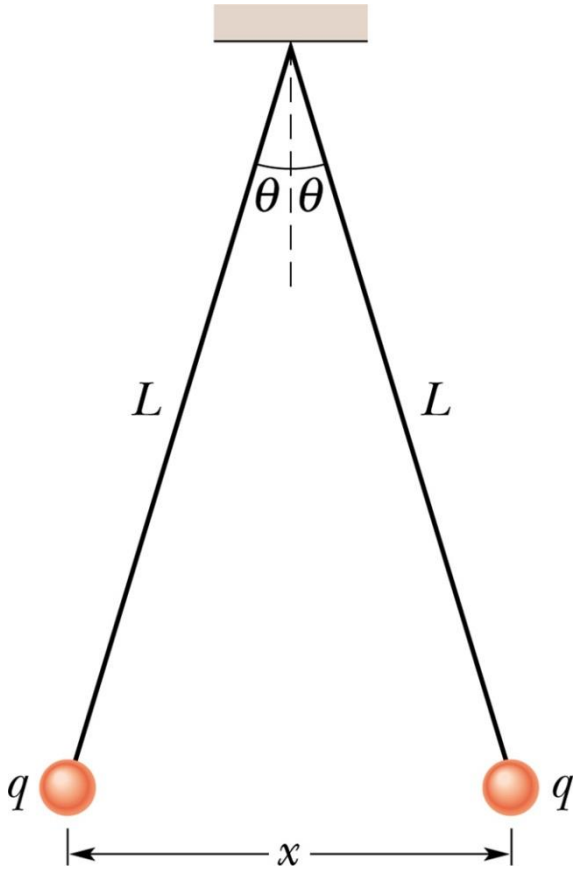
Problem 1



Problem 2

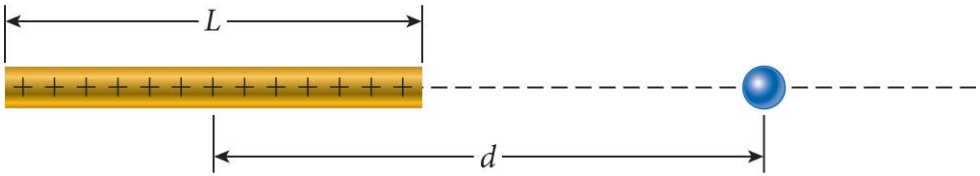


Problem 3

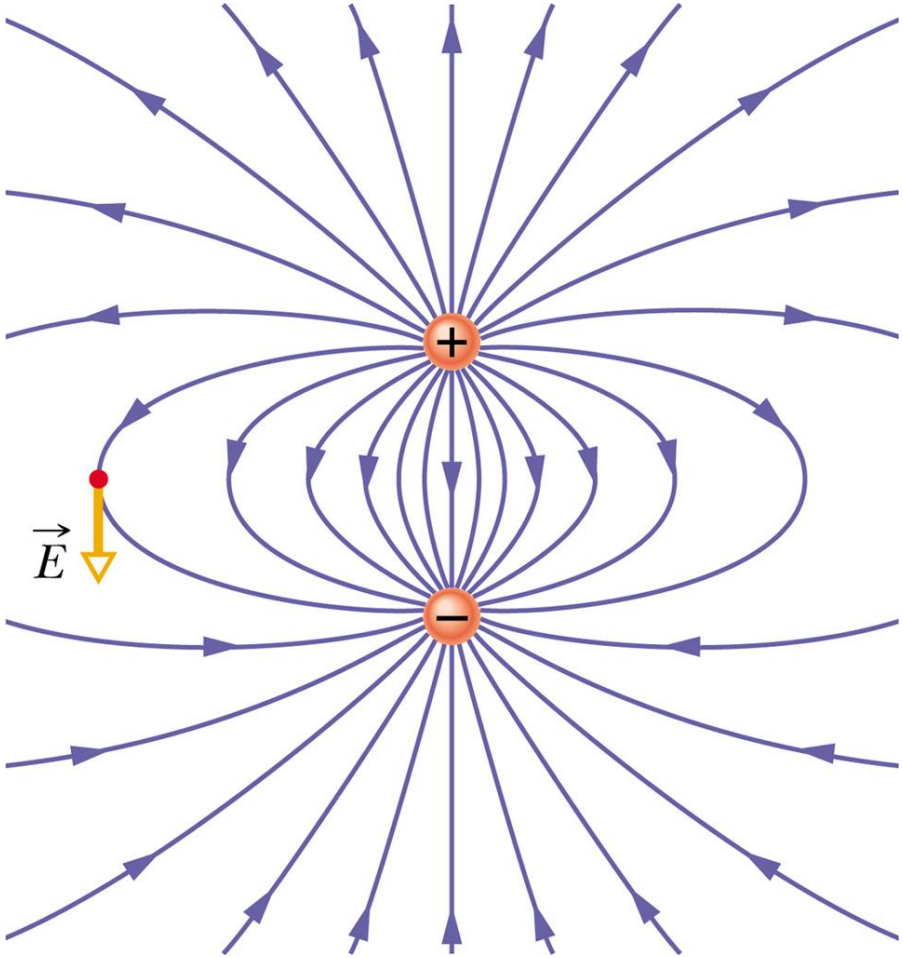


$$x = \left(\frac{q^2 L}{2\pi\epsilon_0 m g}\right)^{1/3}$$

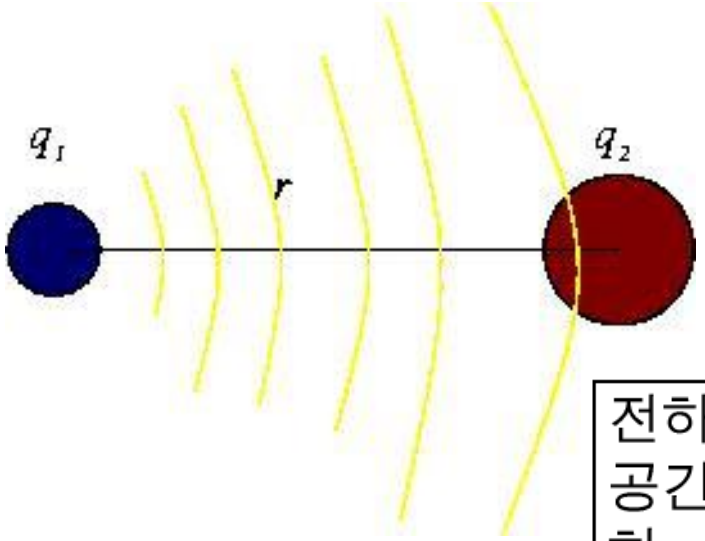
Problem 4 (21.52)



Chap. 22 Electric fields and Gauss' law



What is electric field?



$$\mathbf{F}_{21} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{\mathbf{r}}$$

How can separate charges exert force on the other?

전하 q_1은 전하 q_2가 있는 곳을 포함한 모든 공간에 전기장 $\mathbf{E}$를 만든다. 이 전기장이 전하 q_2에 힘을 준다.
→ *action at a distance*

(정보의 전달속도는 광속보다 빠를 수 없다.)

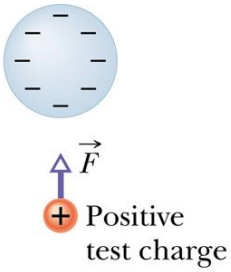
$$\mathbf{E} = \frac{\mathbf{F}}{q_0}, \quad q_0 : (\text{시험전하 (test charge)})$$

$\mathbf{E}$의 SI 단위: N/C

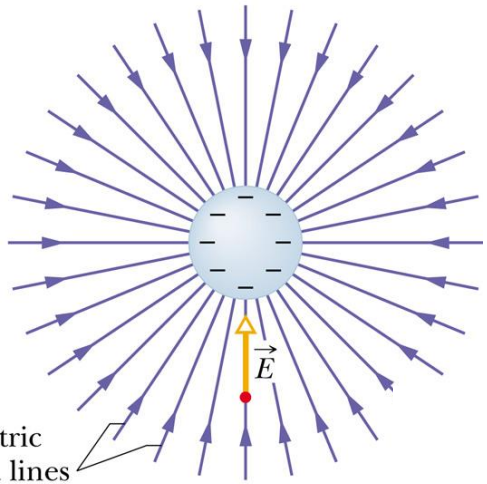
Electric field lines

1) Field line은 +전하에서 나오고 –전하로 들어간다.
2) Field line에 접선방향이 electric field 방향이다.
3) 서로 교차하지 않는다. (electric field는 한 점에서 한 값만을 갖는다.)
4) 힘의 크기는 field line의 밀도에 비례

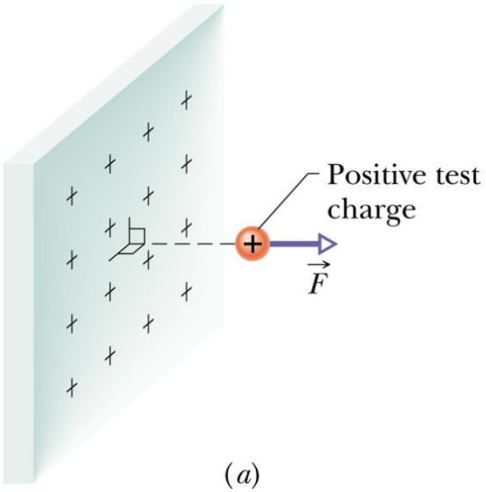
※ field line의 밀도: 단위면적을 뚫고 지나가는 field line의 수


$\vec{F}$
Positive
test charge

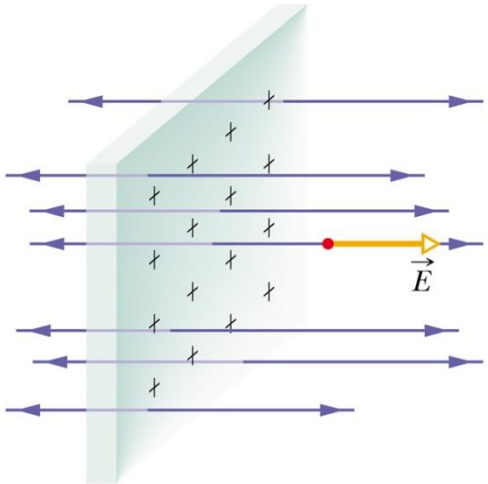
(*a*)


$\vec{E}$
Electric
field lines

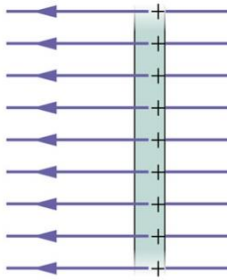
(*b*)


Positive test
charge
$\vec{F}$

(*a*)

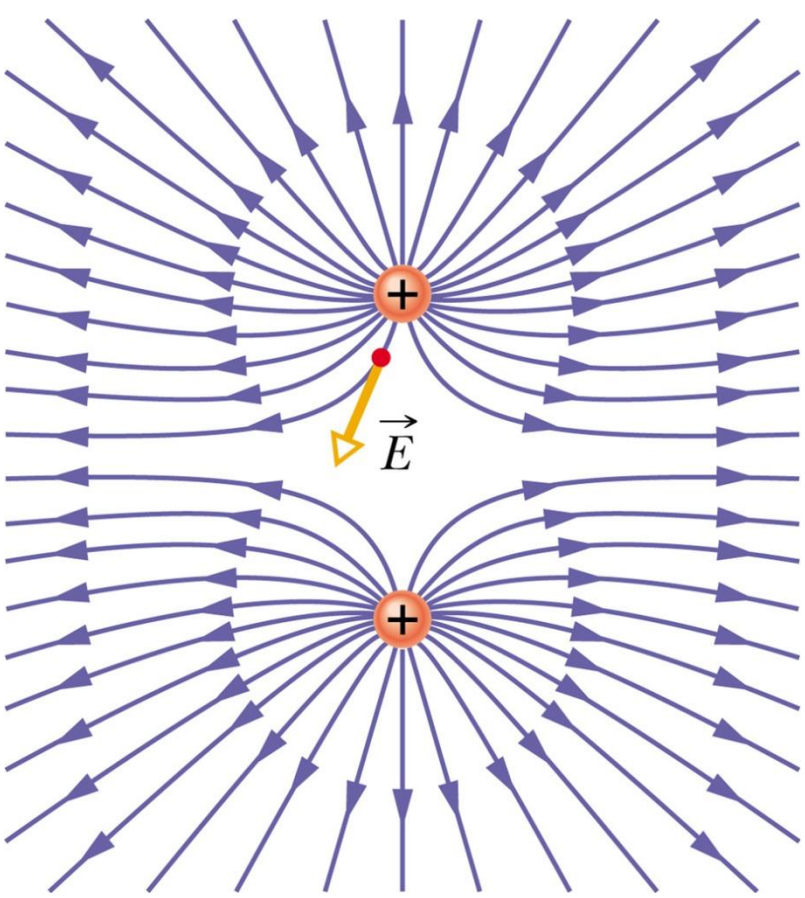

$\vec{E}$

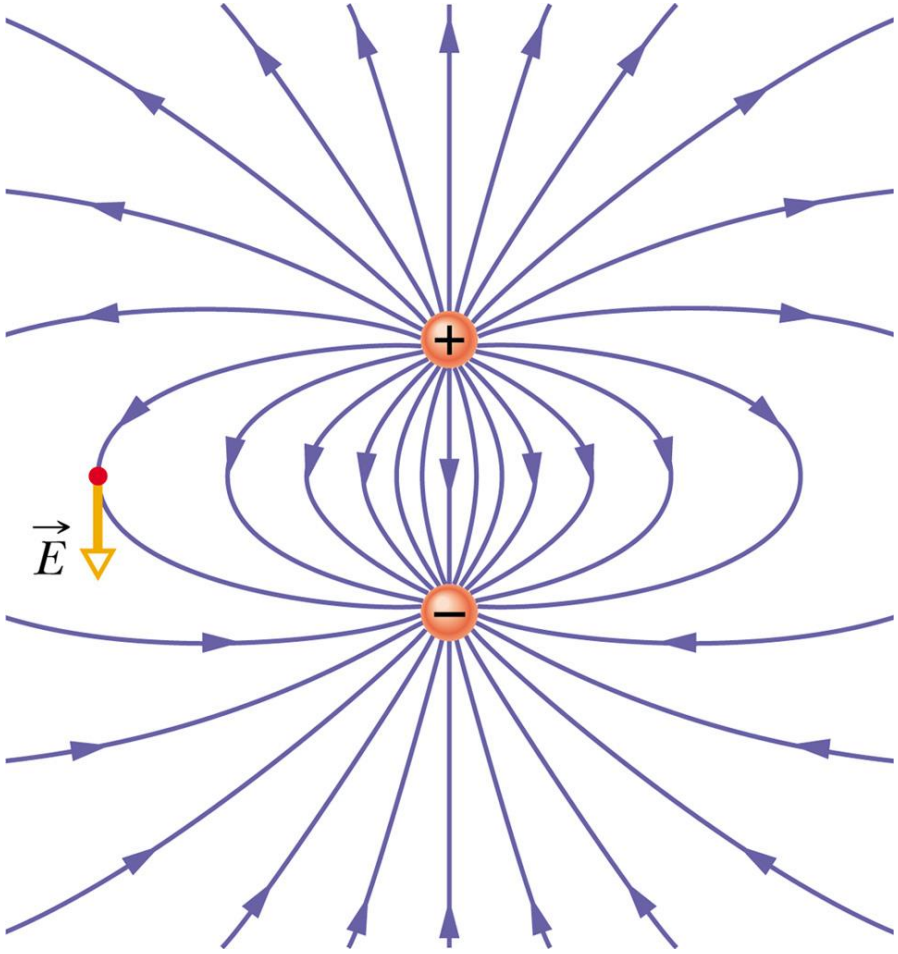
(*b*)



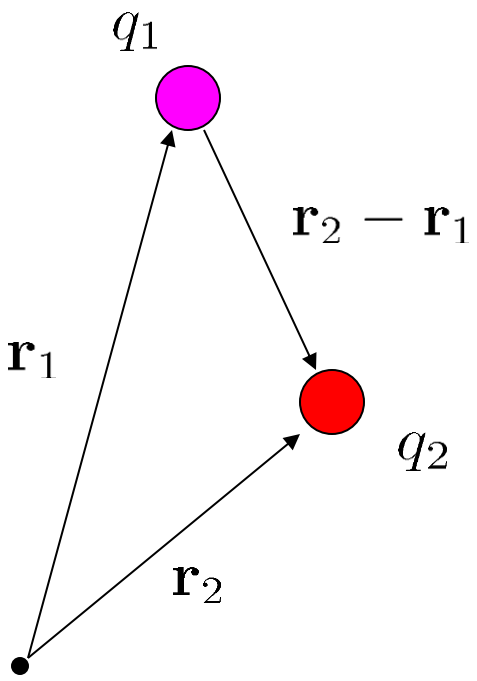
(*c*)

Electric dipole





q_1에 의한 $\mathbf{r}_2$에서의 electric field



$$\mathbf{E}(\mathbf{r}_2) = \frac{\mathbf{F}(2 \leftarrow 1)}{q_2} = \frac{1}{4\pi\epsilon_0} \frac{q_1(\mathbf{r}_2 - \mathbf{r}_1)}{|\mathbf{r}_2 - \mathbf{r}_1|^3}$$

Computation of the electric field E

1) Point charge q

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{|\mathbf{r}|^2}\hat{\mathbf{r}}$$

2) Many point charges

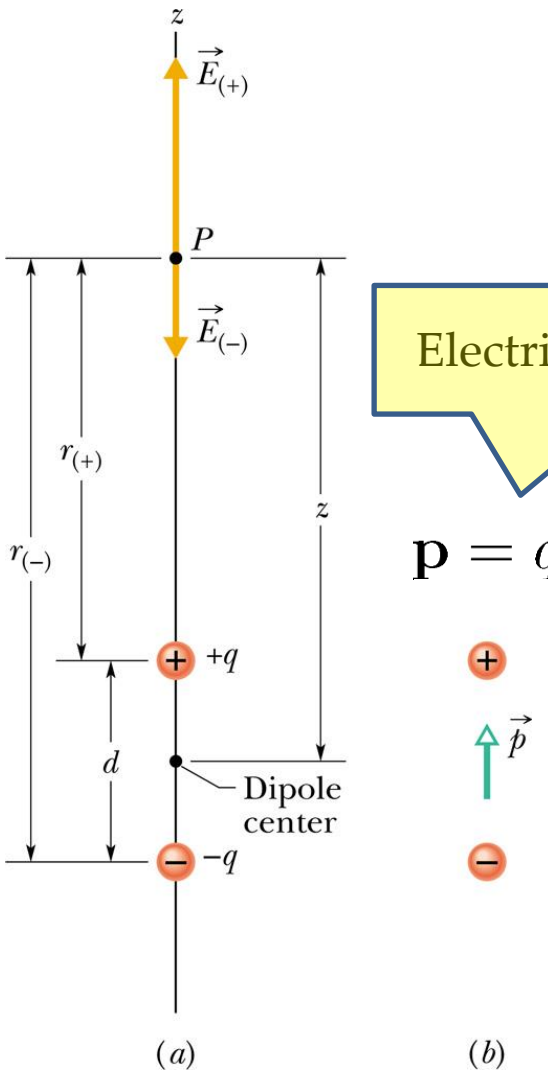
$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\sum_{\mathrm{i}}\frac{q_{\mathrm{i}}\,\hat{\mathbf{r}}_{\mathrm{i}}}{|\mathbf{r}_{\mathrm{i}}|^2}$$

3) Continuous charge

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\int\frac{dq\;\hat{\mathbf{r}}}{|\mathbf{r}|^2}$$

Principle of superposition

electric dipole

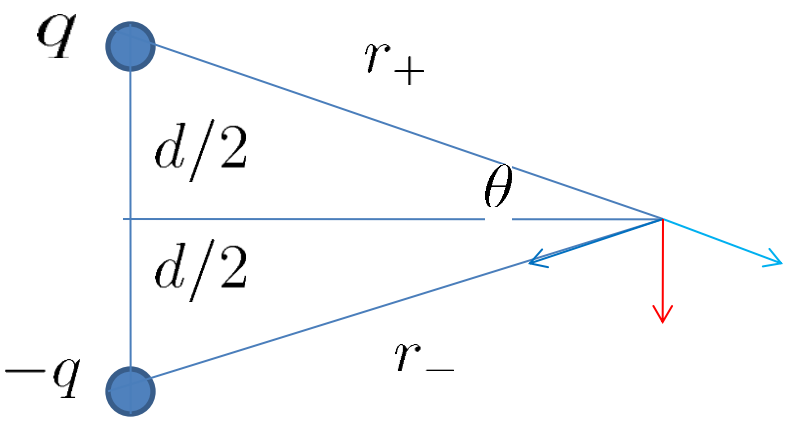


Electric dipole moment

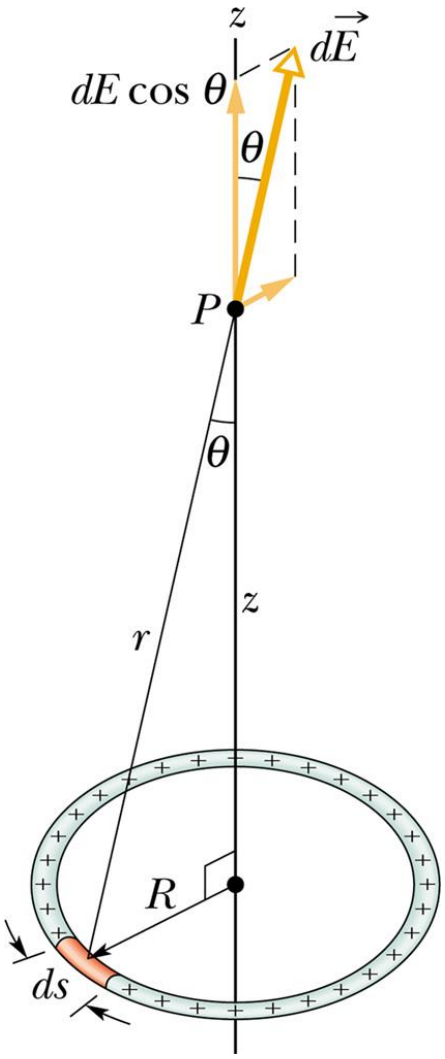
$$\mathbf{p} = q\mathbf{d}$$

$$E = E_{(+)} - E_{(-)} = \frac{q}{4\pi\epsilon_0 z^2}\frac{2d}{z} = \frac{1}{2\pi\epsilon_0}\frac{qd}{z^3}$$

Electric field normal to the electric dipole moment

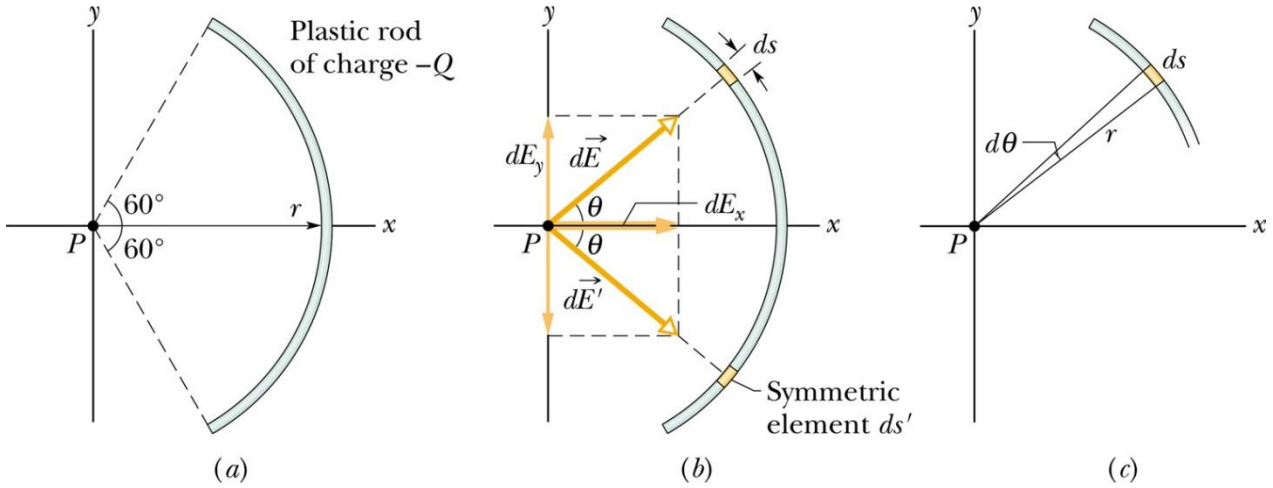


Charged ring



$$E = \frac{qz}{4\pi\epsilon_0(z^2 + R^2)^{3/2}}$$

Problem 1: charged arc



Electric field due to an infinite line of charge