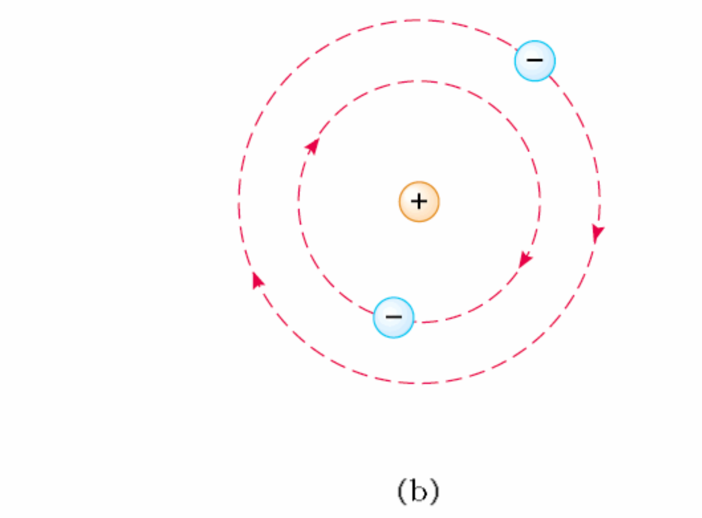
- **Two kinds of charges:**
  - **unlike charges attract**
  - **like charges repel**
- **Charge is conserved**
- **Charge is quantized**

Figure 42.2b

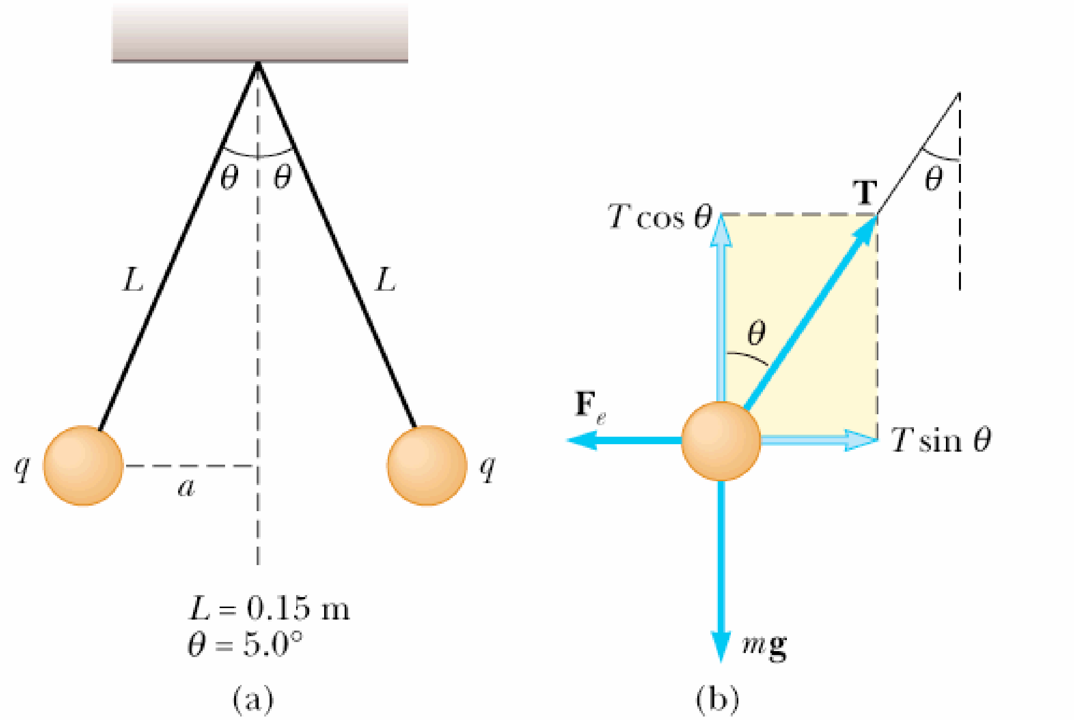


(b)

Fundamental amount of charge: Charge of a single electron: *e*

Coulomb's Law

$$F = k_e \frac{q_1 q_2}{r^2}$$



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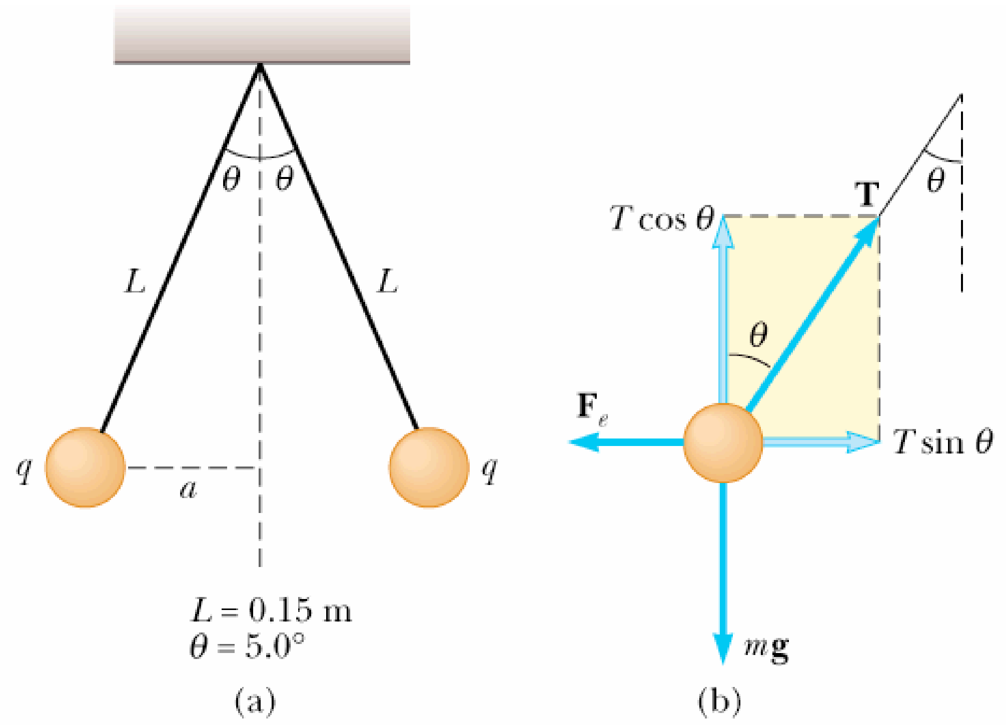
Two identical small charged spheres, each having a mass of 3.0×10^{-2} kg, hang in equilibrium, The length of each string is 0.15 m, and the angle is 5.0^o. Find the magnitude of the charge on each sphere.



(a) (b)

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$$\sin\theta = \frac{a}{L}$$

$$a = L\sin\theta = 0.013\ \text{m}$$

$$\sum F_x = T\sin\theta - F_e = 0$$

$$\sum F_y = T\cos\theta - mg = 0$$

$$\Rightarrow \quad T = mg/\cos\theta$$

$$F_e = T\sin\theta = mg\sin\theta/\cos\theta$$

$$F_e = mg\tan\theta$$

$$F_e = k_e\frac{q^2}{r^2}$$

$$\Rightarrow \quad |q| = \sqrt{\frac{F_e r^2}{k_e}}$$

Electric Field

A Field:

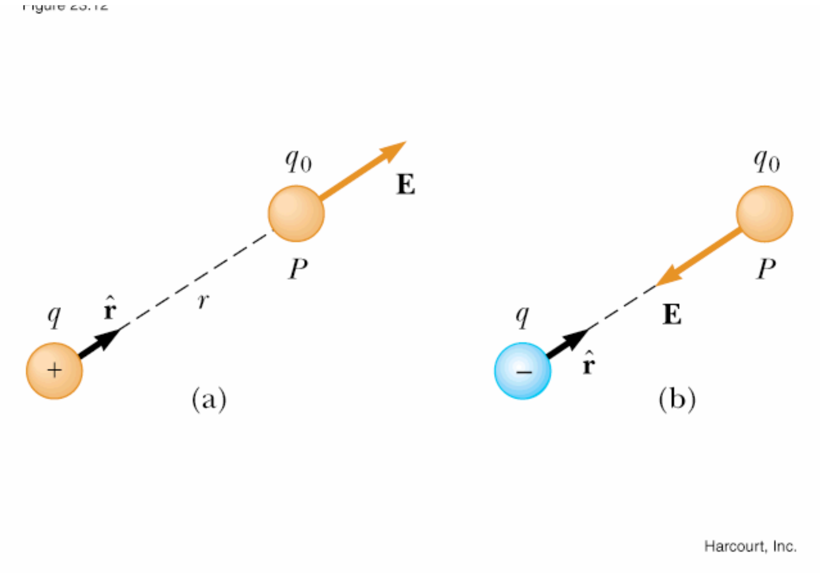
- **Has a well defined value at every point of space**

Examples:

- Elevation: H(x,y)
- Temperature T(x,y,z) Scaler field
- Wind Speed **W**(x,y,z) Vector field

A Field:

- **Has a well defined value at every point of space**
- **Field does not depend on how we measure it: ie: our measurement does not change the field**
- **The field is "out there" whether we measure it or not**



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Electric Field due to a charge q

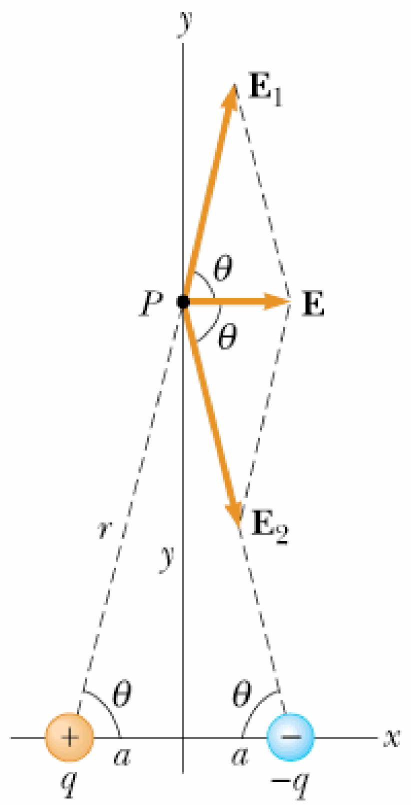
$$\mathbf{F}_e = k_e \frac{q q_o}{r^2}\,\hat{\mathbf{r}}$$

Electric field is the electric force acting on a unit positive charge

$$\mathbf{E} = k_e \frac{q}{r^2}\,\hat{\mathbf{r}}$$

$$\mathbf{E} = \frac{\mathbf{F}_e}{q_o} \longrightarrow \mathbf{F}_e = \mathbf{E}\, q_o$$

$$\mathbf{E} = k_e \sum_i \frac{q_i}{r_i^2}\,\hat{\mathbf{r}}_\mathbf{i}$$



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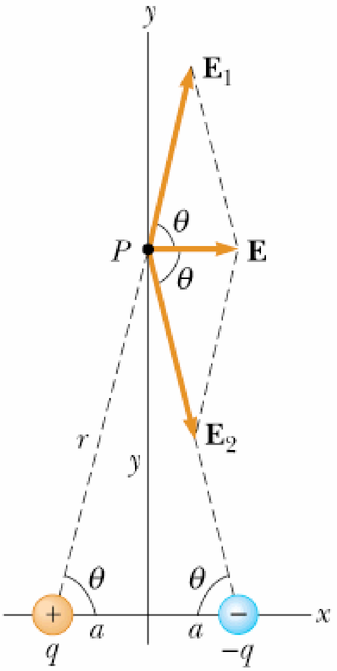
For the dipole shown, find the electric field $\mathbf{E}$ at a point P due to the charges, where P is a distance $y >> a$ from the origin.

The total filed is $\mathbf{E} = \mathbf{E1} + \mathbf{E2}$ where

cs for Scientists and Engineers, 5/e



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$$E_1 = E_2 = k_e \frac{q}{r^2} = k_e \frac{q}{y^2 + a^2}$$

$$E = 2 \cdot E_1 \cos\theta$$

$$\cos\theta = a/r = a/(y^2 + a^2)^{1/2}$$

$$\begin{aligned} E = 2 \cdot E_1 \cos\theta &= k_e \frac{q}{y^2 + a^2} \cdot \frac{a}{(y^2 + a^2)^{1/2}} \\ &= k_e \frac{2qa}{(y^2 + a^2)^{3/2}} \\ &\approx k_e \frac{2qa}{y^3} \end{aligned}$$

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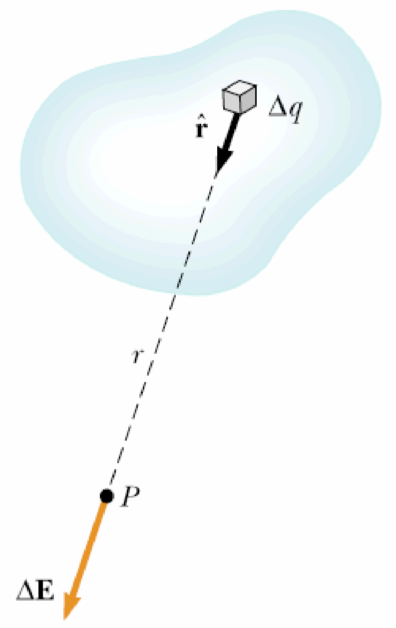
Figure 23.15



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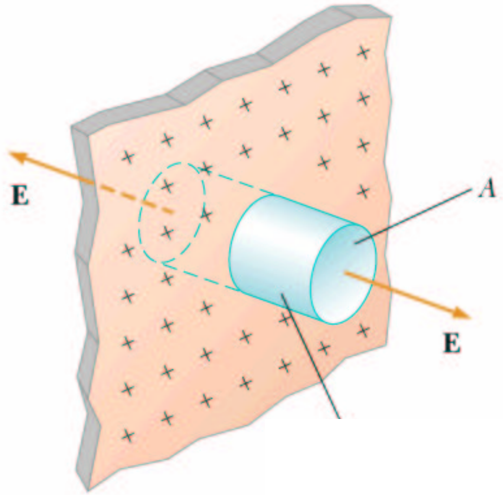
The elctric field at P due to one element carrying charge Δq is:

$$\mathbf{E} = k_e \frac{\Delta q}{r^2}\,\hat{\mathbf{r}}$$

$$\mathbf{E} = k_e \sum_i \frac{\Delta q_i}{r_i^2}\,\hat{\mathbf{r}}_\mathbf{i}$$

$$\mathbf{E} = k_e \lim_{\Delta q \to 0} \sum_i \frac{\Delta q_i}{r_i^2}\,\hat{\mathbf{r}}_\mathbf{i} = k_e \int \frac{dq}{r^2}\,\hat{\mathbf{r}}$$



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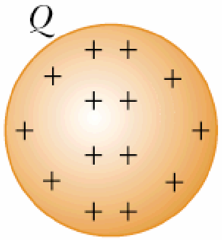


Harcourt, In

- **Volume charge density** ρ:

$$\rho = \frac{Q}{V}$$

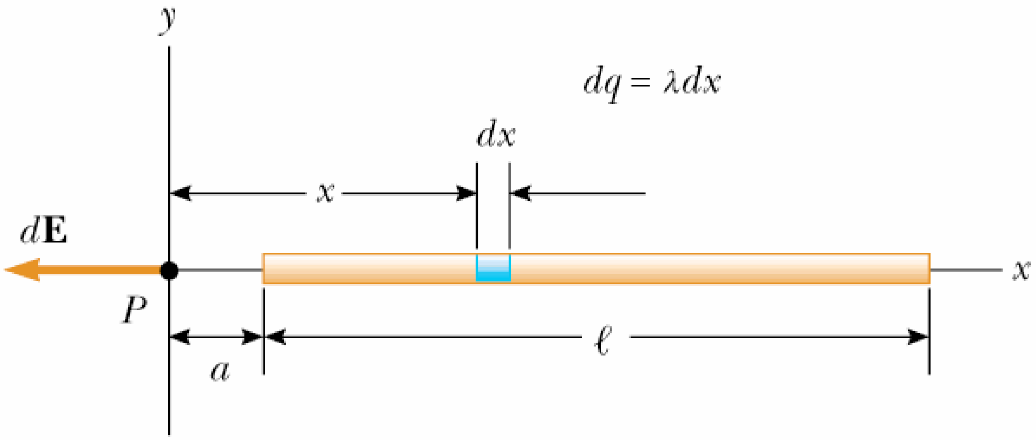
- **Area charge density** σ:

$$\sigma = \frac{Q}{A}$$

- **Linear charge density** λ:

$$\lambda = \frac{Q}{l}$$

Example 23.7 from the text book: Electric field due to a charged Rod



The example worked out in detail in the text book is similar to the one We did in class (the location of the rod is different).