

Phys 2120-4 8/31/12

Note Title


8/31/2012

Ch 20 Electric field.

$\vec{E}$  vector  $N/C$   $\vec{F} = q\vec{E}$

$\vec{E}$  has a value at each point.

$\vec{E}(\vec{r})$



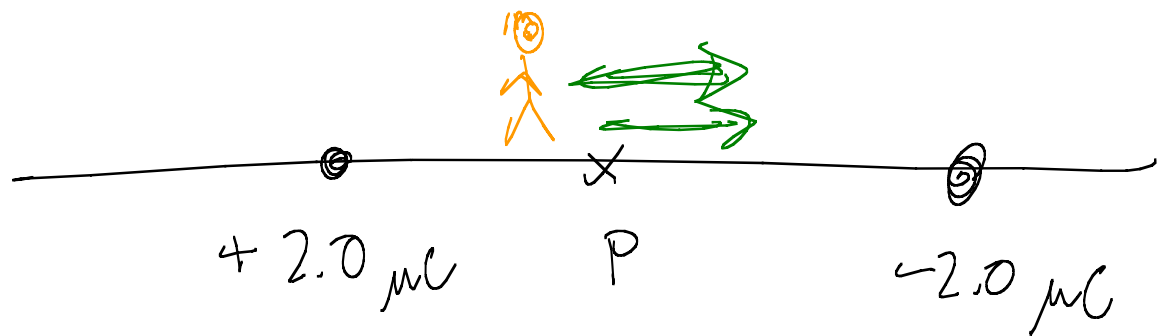
20.27

From pt charge

$$c) |\vec{E}| = k|q|/r^2$$

$$k = 9.0 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2}$$

$$|\vec{E}| = 2 (9.0 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2}) (2.0 \times 10^{-6} \text{C}) / (2.5 \times 10^{-2} \text{m})^2$$

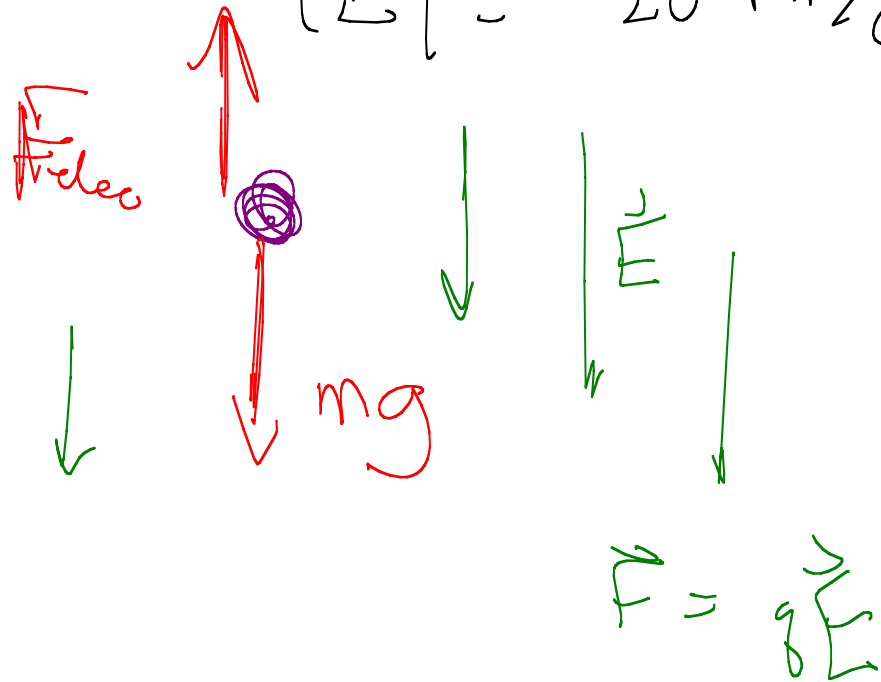


$$= 5.2 \times 10^6 \frac{\text{N}}{\text{C}} \hat{i}$$

5.0 cm

20.32 Oil drop, Millikan What mass of drops?

$$|\vec{E}| = 20 \text{ MN/C} = 20 \times 10^6 \frac{\text{N}}{\text{C}}$$



10 elementary charges

$$\begin{aligned} q &= 10 (-1.6 \times 10^{-19} \text{ C}) \\ &= -1.6 \times 10^{-18} \text{ C} \end{aligned}$$

$$mg = |q|E$$

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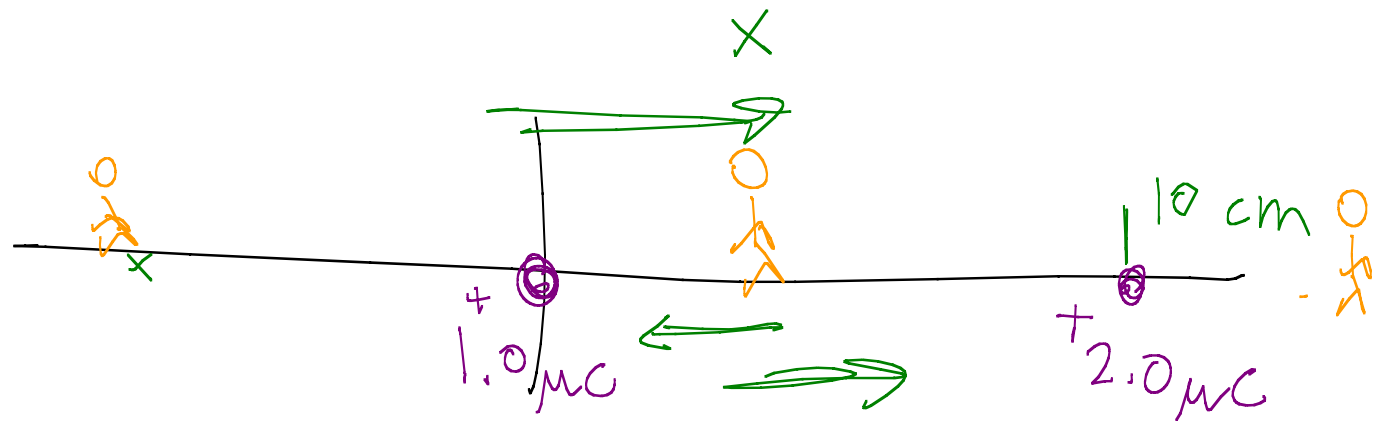
$$m = \frac{qE}{g} = \frac{(1.6 \times 10^{-18} \text{ C})(20 \times 10^6 \frac{\text{N}}{\text{C}})}{9.8 \frac{\text{m}}{\text{s}^2}}$$

$$= 3.26 \times 10^{-12} \text{ kg}$$

$$\Rightarrow R = 9.46 \mu\text{m}$$

$$\text{Assume } \rho = 0.9199 \frac{\text{g}}{\text{cm}^3}$$

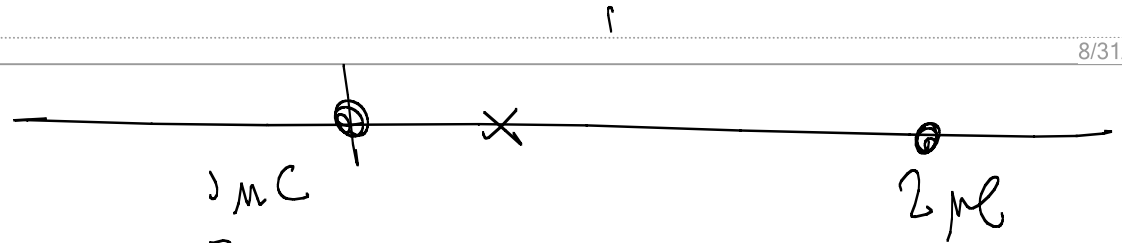
20.46 A  $1.0 \mu\text{C}$  charge and  $2.0 \mu\text{C}$  charge are  $10 \text{ cm}$  apart. Find a point where the field is zero



$$E_x = +k \frac{(1.0 \times 10^{-6} \text{ C})}{x^2} - k \frac{(2.0 \times 10^{-6} \text{ C})}{(10 \times 10^{-3} \text{ m} - x)^2} = 0$$

Do algebra  $k$ 's cancel,

$$(1.0 \mu\text{C}) (0.1$$



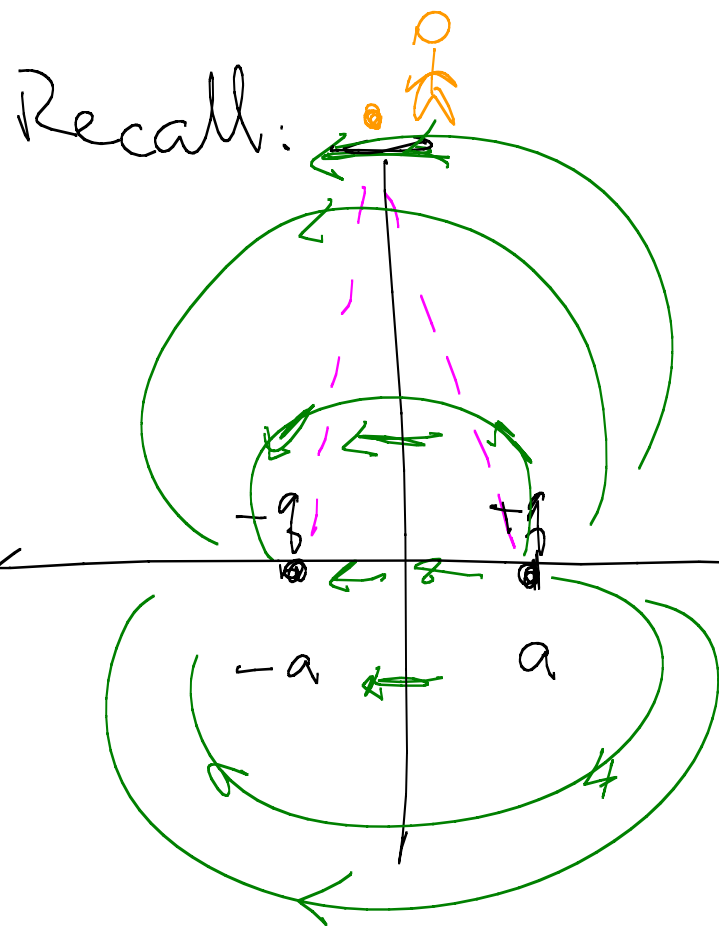
$$(1.0 \mu\text{C})(0.10\text{m} - x)^2 = (2.0 \mu\text{C})x^2$$

Take sqrt root

$$(0.10\text{m} - x) = \sqrt{2}x$$

$$x = 4.1\text{cm}$$

$$\Rightarrow 0.10\text{m} = (\sqrt{2} + 1)x$$



p. 340

Find field value

$$\vec{E} = \frac{-2kqa}{(a^2 + y^2)^{3/2}} \hat{i}$$

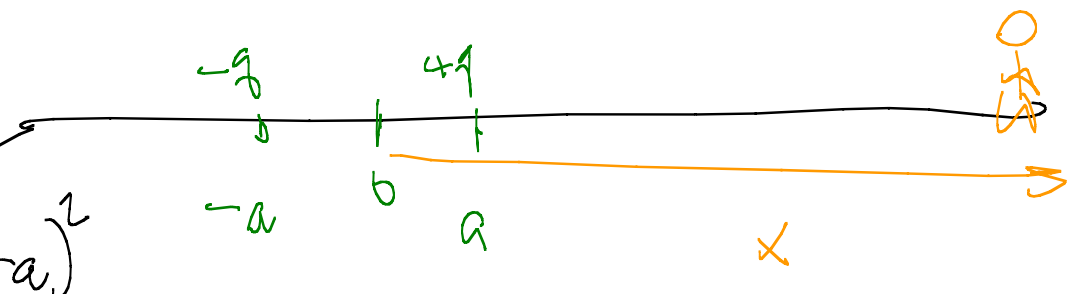
$x \gg a$

Spot  $y \gg a$

$$\vec{E} \approx \frac{-2kga}{y^3} \hat{i}$$



20.80 Find field when little man is on  $x$ -axis  
 $x \gg a$



The diagram shows a horizontal x-axis with an arrow pointing to the right. A stick figure is at the right end of the axis. Two points are marked on the axis: one at distance  $-a$  from the origin (labeled  $-q$ ) and one at distance  $a$  from the origin (labeled  $+q$ ). The origin is marked with a vertical tick and labeled  $0$ . The labels  $-a$  and  $a$  are in green, while  $-q$  and  $+q$  are in green. An orange arrow points from the origin towards the right, labeled  $x$ .

$$E_x = k \frac{q}{(x-a)^2} - k \frac{q}{(x+a)^2}$$

$$= \frac{kq}{x^2} \left[ \frac{1}{(1 - \frac{a}{x})^2} - \frac{1}{(1 + \frac{a}{x})^2} \right] = \frac{kq}{x^2} \left[ (1 + \frac{a}{x})^{-2} - (1 - \frac{a}{x})^{-2} \right]$$

$$\left(1 + \frac{a}{x}\right)^{-2} \quad \frac{a}{x} \text{ small}$$

$$\approx 1 - 2\frac{a}{x}$$

Use this

$$E_x = \frac{kq}{x^2} \left[ 1 + \frac{2a}{x} - \left( 1 - \frac{2a}{x} \right) \right]$$

$$= \frac{kq}{x^2} 4\frac{a}{x} = \frac{2k(2qa)}{x^3} = \frac{2kp}{x^3}$$

$$(1+x)^n$$

$$= 1 + nx + \dots$$

$$\approx 1 + nx$$

$x$  small

$x \ll 1$

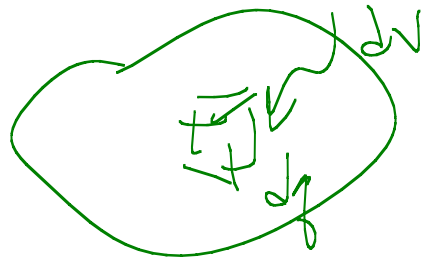
$$2qa = p$$

# Continuous Charge Distributions

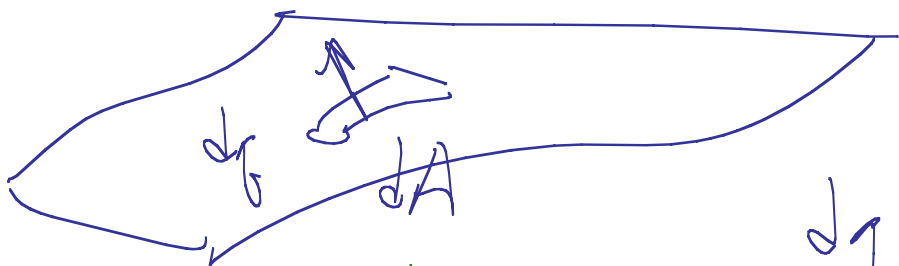


Charge density, charge per volume

$$\rho(\vec{r})$$



$$dq = \rho(\vec{r}) dV$$

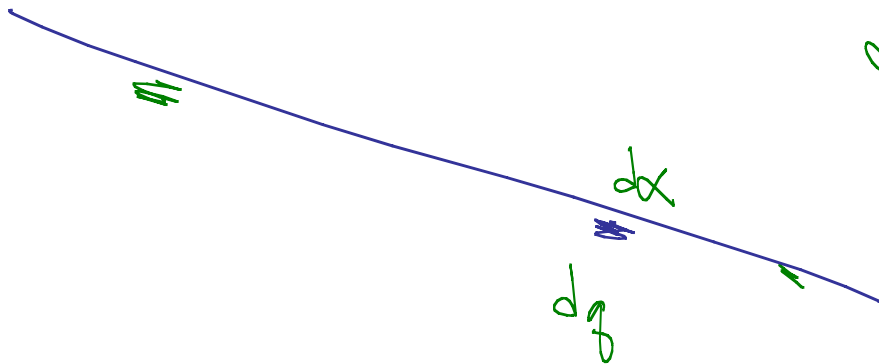


Sheet of charge

$$dq = \sigma(\vec{r}) dA$$



$$dq = \lambda dx$$

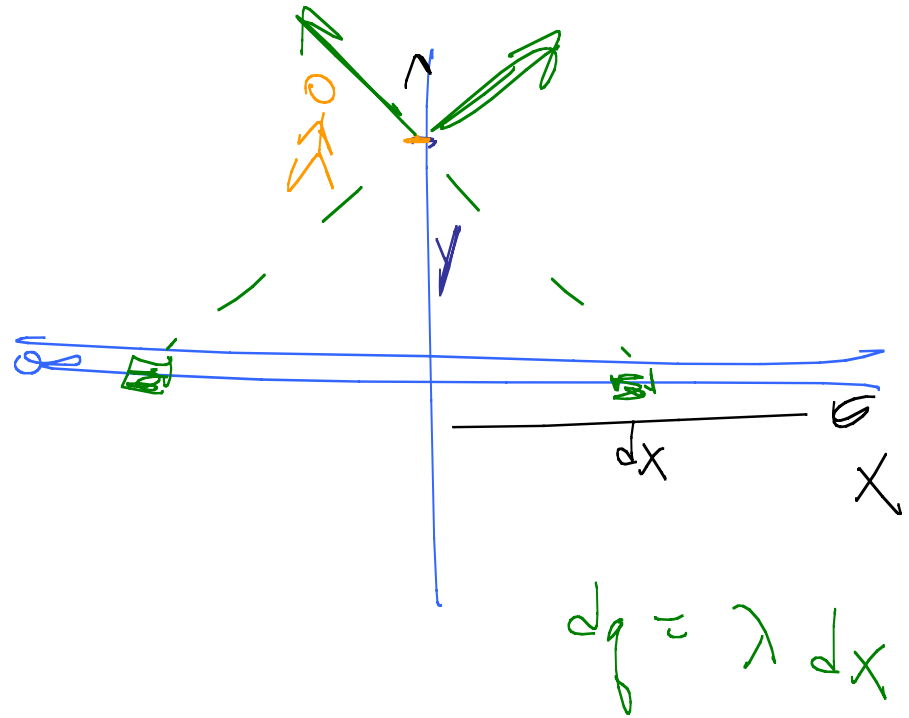


## Example 20.7

Long elec-  
power line

Uniform ch. density  
y-components

$$dE_y = \frac{k\lambda y}{(x^2 + y^2)^{3/2}} dx$$



$$dq = \lambda dx$$

$$\int_{-\infty}^{\infty}$$

Get  $E_y = \frac{2k\lambda}{y}$

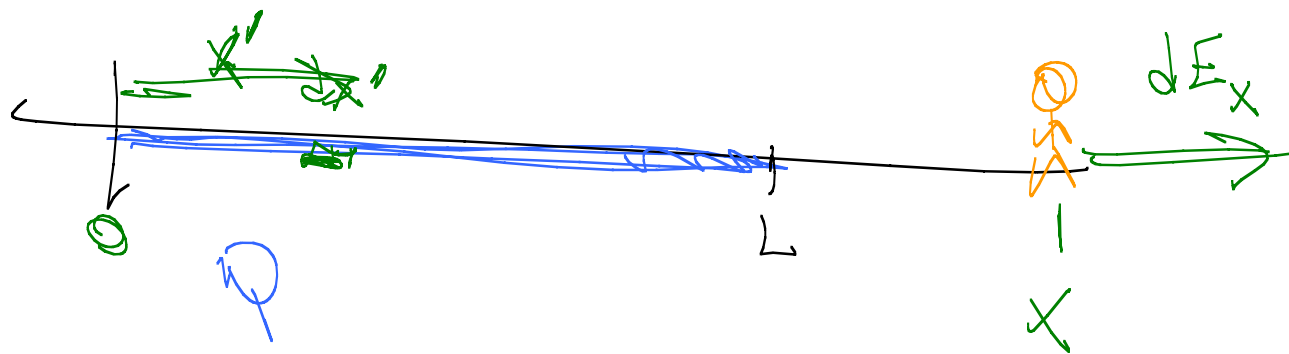


2.55 A thin rod lies on  
x-axis between  $x=0$



and  $x=L$  has total charge  $Q$

Show that for  $x > L$  is ...



Distance from man =  $x - x'$   
 of little piece

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

$$dE_x = k \frac{\lambda dx'}{(x - x')^2}$$

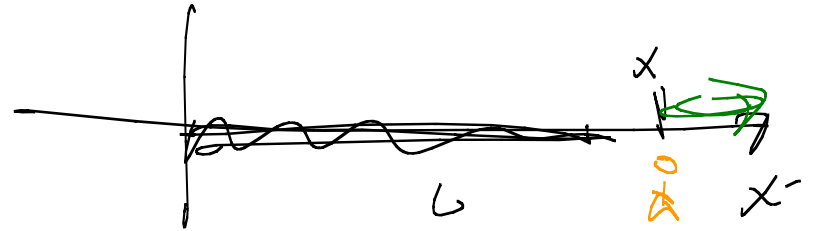
$$\lambda dx' = dq'$$

$$E_x = \int_0^L k \frac{\lambda dx'}{(x-x')^2}$$

$$= k\lambda \left( \frac{+1}{x-x'} \right) \Big|_0^L$$

$$= k\lambda \left( \frac{1}{x-L} - \frac{1}{x} \right)$$

etc.



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

$$\frac{kQ}{x(x-L)}$$



