LECTURE 1

- COURSE DETAILS

TEXT BOOK : UNIVERSITY PHYSICS 12th EDITION

- USEFUL RESOURCE

WALTER LEWIN'S LECTURES : MIT OPEN COURSE WARE

GRADE BREAKDOWN

PROBLEM SET : 15%
(HOMEWORK)

QUIZ : 9%

MIDTERM (3) : 45%

FINAL : 31% 5/3 (MON) 1:00 - 3:50pm

TAKE HOME : OPEN RESOURCE

2 QUIZ 6 PROBLEMS 9% OF GRADE

WEB ASSIGN : LOG IN : PLEASE TRY BY WEDNESDAY

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1. - DO PROBLEMS AT THE END OF CHAPTER
2. - READ TEXT BOOKS : PAY ATTENTION TO EXAMPLES
3. - ASK QUESTIONS AT THE LECTURE + STOP LECTURE
4. - COME TO OFFICE HOURS

MATERIALS COVERED

ELECTRICITY
- ELECTRIC FIELDS
- GAUSS'S LAW
- ELECTRIC POTENTIAL
- CAPACITANCE / DIELECTRICS
- CURRENT + RESISTANCE

MAGNETISM — CH 27- ~~29~~ 30

AC CURRENT CH ~~33~~ 31

[EM WAVES CH ~~34~~ 32]

DIFFICULTY

CH 21, 22, 23, 24 VERY DIFFICULT, HARD TO UNDERSTAND

25 EASY] CIRCUITS
26 EASY]

27, 28, 29, 30, ~~NOT~~ DIFFICULT

31 EASY CIRCUITS

WHY AND HOW IS IT DIFFERENT FROM 2048 ?

DEMO EM 324, 318 TWO KINDS OF CHARGES (→ SOMETHINGS UP)

CAN NOT "SEE" FORCES ∴ HARDER TO INTUIT AND GUESS ANSWERS

GREEKS RUBBED AMBER WITH WOOL ⇒ AMBER ATTRACTED THINGS

600 B.C.

BEN FRANKLIN 1706 – 1790 CHARGES NEGATIVE AND POSITIVE

CHARGES

ELECTRICAL CHARGE

ATOMS MAKE UP THE WORLD

↓

ELECTRONS $m_e = 9.109 \times 10^{-31}$ kg

PROTONS $m_p = 1.673 \times 10^{-27}$ kg

NEUTRONS $m_n = 1.675 \times 10^{-27}$ kg

(PROTONS, NEUTRONS) → QUARKS $\pm \frac{1}{3}$, $\pm \frac{2}{3}$ CHARGE

CONDUCTORS AND INSULATORS

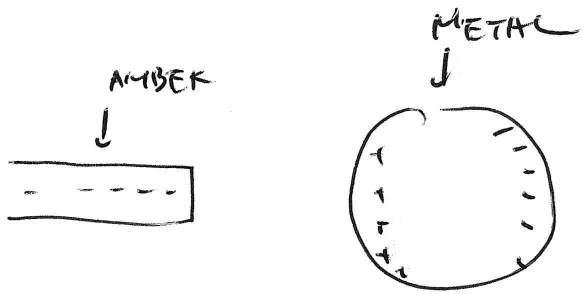
DEFINITION

CHARGES CAN MOVE FREELY ON CONDUCTORS

CONDUCTORS: COPPER

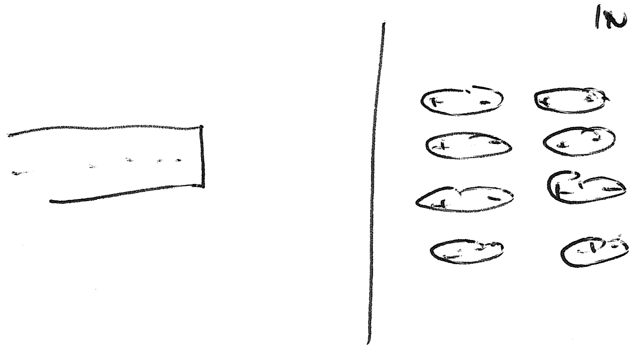
INSULATORS: DIAMONDS.. ETC.

CHARGING BY INDUCTION: METAL ROD

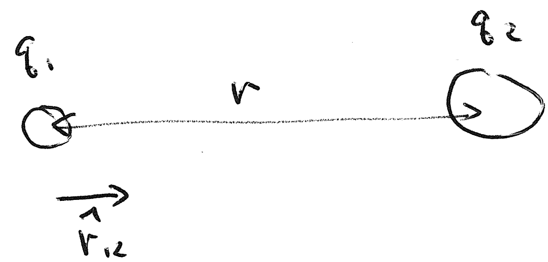


UNCHARGED OBJECTS: BALLOON EXAMPLE

INSULATING OBJECTS CAN BE "POLARIZED"



COULOMB'S LAW



$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r}_{12}$$

FORCE ON 2 BY 1

IF q_1, q_2 HAVE THE SAME SIGN REPELS

$\epsilon_0 = 8.854 \times 10^{-12}\ C^2/N \cdot m$

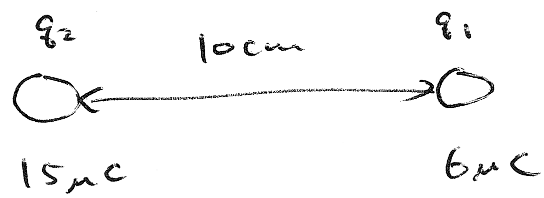
C: COULOMB UNIT FOR CHARGE

ELECTRON

e : -1.6×10^{-19} C

p : 1.6×10^{-19} C

EXAMPLE



$r = 0.1\ m$

$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$

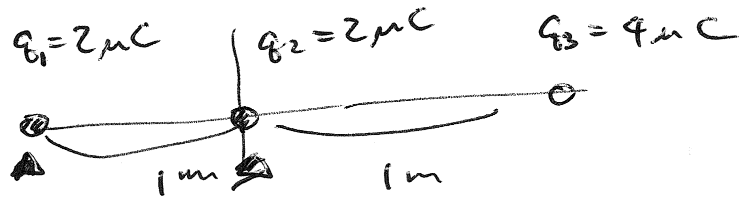
$|\vec{F}| =$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$$

$$= \frac{1}{4 \cdot 3.14 \times 8.85 \times 10^{-12}\ C^2/N\cdot m^2} \cdot \frac{(15 \times 10^{-6}\ C)(6 \times 10^{-6}\ C)}{(0.1\ m)^2}$$

$$\simeq \frac{1}{12 \times \frac{1}{8} \times 10^{-12}\ C^2/N\cdot m^2} \frac{90 \times 10^{-12}\ C^2}{0.01\ m^2} \sim \underline{100\ N}$$

LAW OF SUPER POSITION #1



FORCE ON q_3?

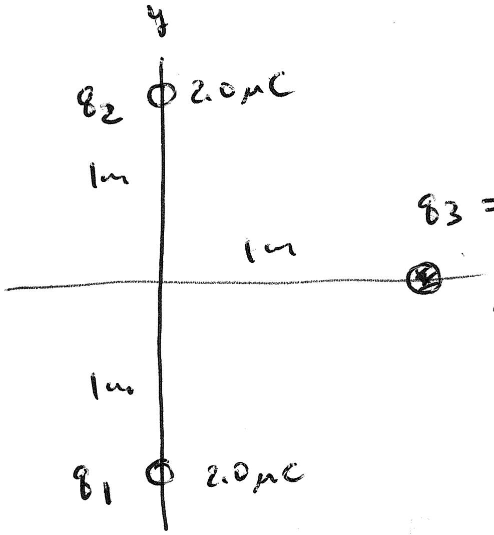
$$F_3 = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_3}{(2m)^2} + \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_3}{(1m)^2}$$

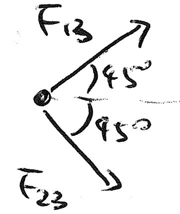
$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{(2\times10^{-6})(4\times10^{-6})}{4} + \frac{(2.0\times10^{-6})(4.0\times10^{-6})}{1}\right]$$

↓

= CALCULATE!

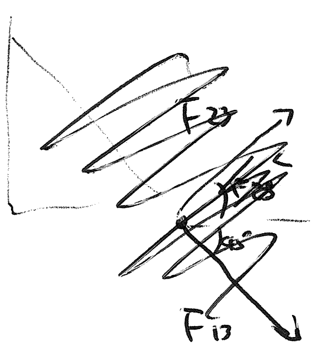
LAW OF SUPER POSITION # 2





FORCE ON 3 ?

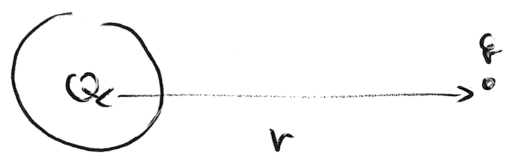
1. RESULTANT FORCE



$|F_{13}| \cos 45^\circ + |F_{23}| \cos 45^\circ$

ELECTRIC FIELD

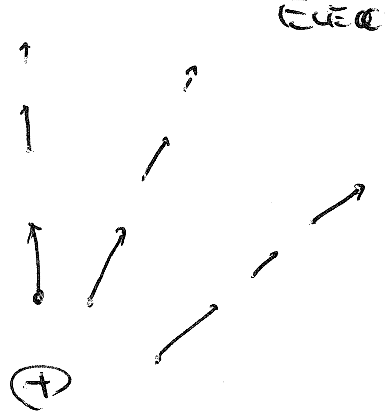
DEFINITION



$$F_q = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$$

$$F_q = \vec{E}\,q \Rightarrow \vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

ELECTRIC FIELD

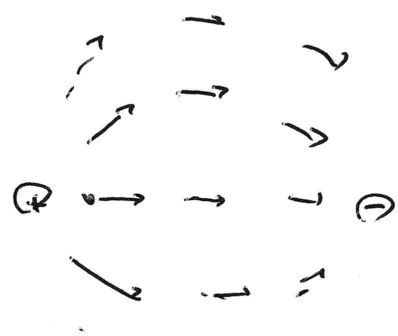


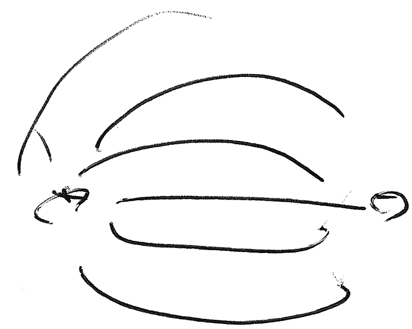
N/C

AND SO ON

ELECTRON IN A UNIFORM FIELD

"FIELD LINES"

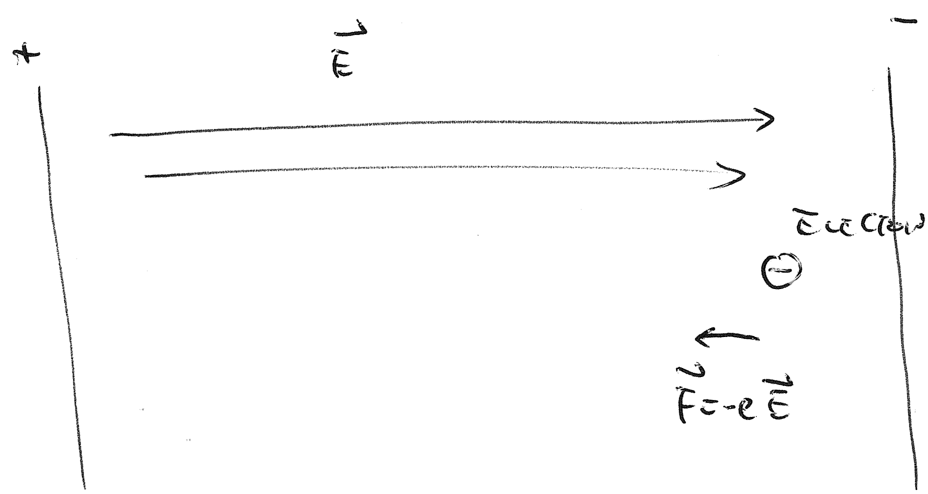


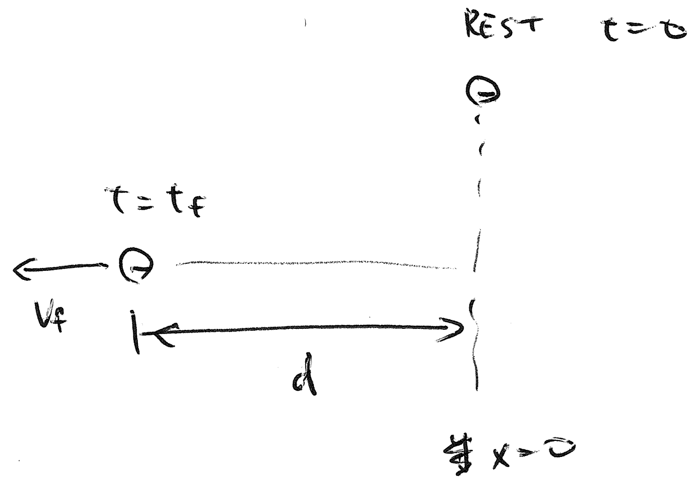


DEMO

...

ELECTRON IN A UNIFORM FIELD





V_f ?

$$\vec{F} = -e\vec{E}$$

$$\vec{F} = m\vec{a} = -e\vec{E}$$

$$a = -\frac{eE}{m}$$

$$v = -\frac{qE}{m}t$$

$$x = -\frac{qE}{2m}t^2$$

$$d = \frac{qE}{2m}t_f^2 \qquad t_f = \sqrt{\frac{2md}{qE}}$$

$$V_f = -\frac{qE}{m}\sqrt{\frac{2md}{qE}} = -\sqrt{\frac{qE}{m}}\sqrt{2d}$$

KINETIC ENERGY AT OF ELECTRON AT t_f ?

$$K.E. = \frac{1}{2} m v_f^2 = \frac{1}{2} \cancel{m} \frac{qE}{\cancel{m}} \cancel{2} d$$

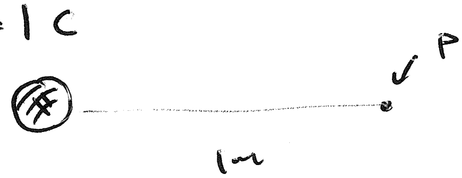
$$(K.E._f) = qEd$$

SIMILAR TO

mgd

CALCULATING $\vec{E}$

$Q = 1\,C$



$\vec{E}_p$?

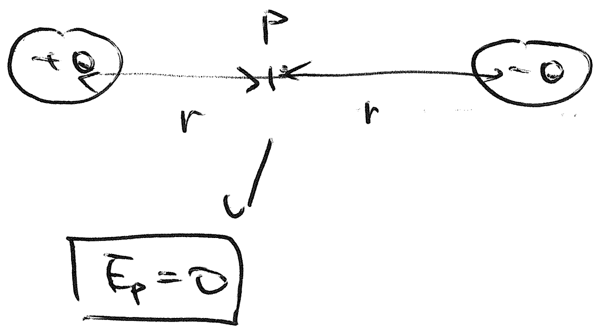
$$\vec{E}_p = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{1\,C}{(1\,m)^2}$$

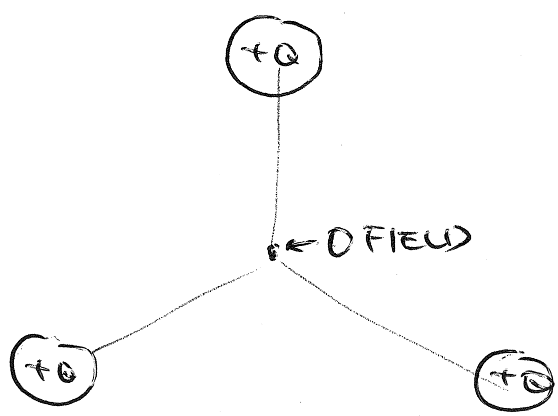
$$= \frac{1\,C}{4\pi\, 8.85\times10^{-12}\ C^2/\cancel{N m^2}\cdot m^2}$$

$$= 0.00899 \times 10^{12}$$

$$\simeq 9\times10^{9}\ N/C$$

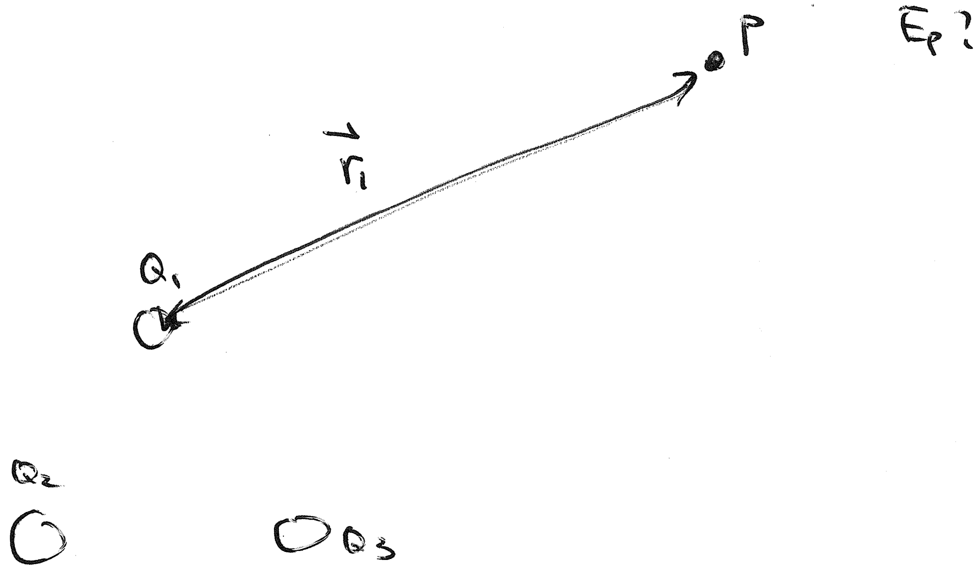
LIKE FORCES : LAW OF SUPER POSITION EXISTS





... AND SO ON

BUT WHAT ABOUT



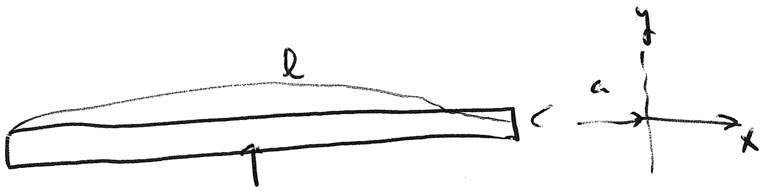
EASY TO WRITE DOWN

$$\vec{E}_p = \sum \frac{1}{4\pi\varepsilon_0} \frac{Q_i}{|\vec{r}_i|^2} \hat{r}_i$$

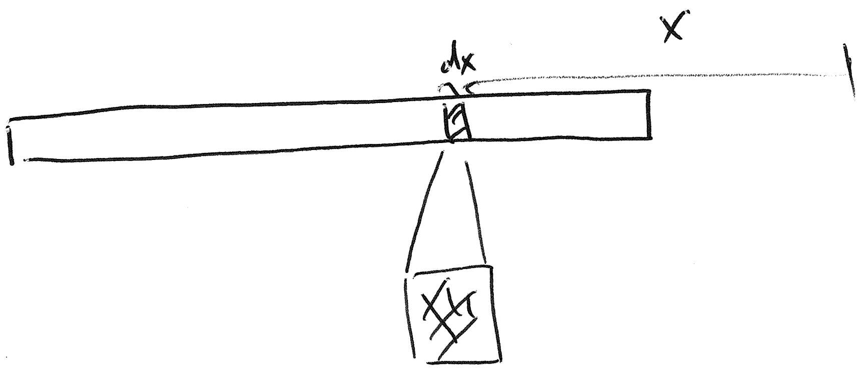
↓

COULD BE CONVERTED TO INTEGRAL

MORE COMPLEX EXAMPLE



Q UNIFORM CHARGE



CHARGE ON SEGMENT $= \frac{dx}{l} Q$

$$dE = \frac{1}{4\pi\varepsilon_0} \frac{\frac{dx}{l} Q}{x^2}$$

$$dE = \frac{1}{4\pi\varepsilon_0} \frac{Q}{l} \frac{dx}{x^2}$$

$$E = \int_{-(l+a)}^{-a} \frac{1}{4\pi\varepsilon_0} \frac{Q}{l} \frac{dx}{x^2}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{Q}{l} \cdot \left(-\frac{1}{x}\right) \Big]_{l+a}^{-a}$$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{l}\left(\frac{1}{a} - \frac{1}{l+a}\right)$$

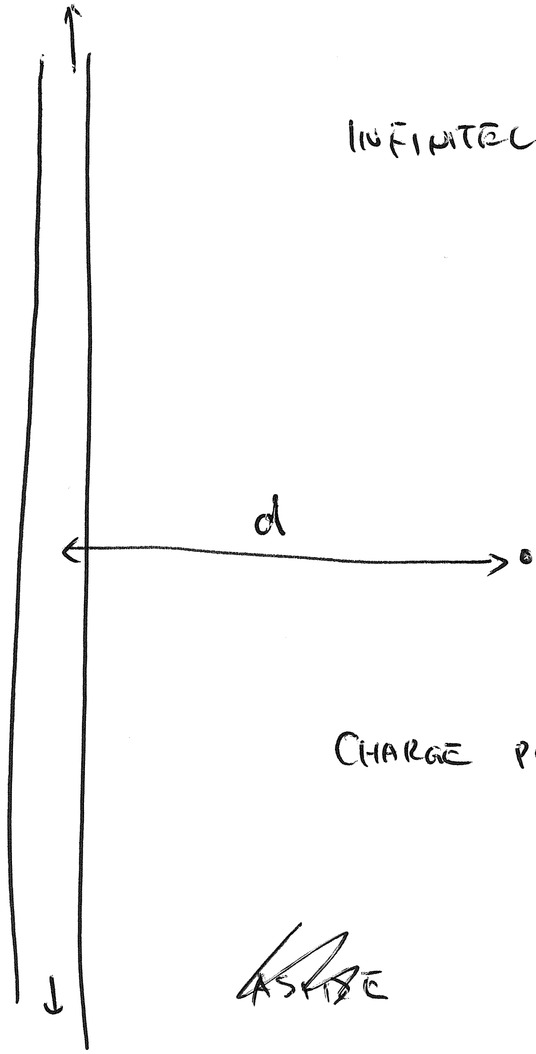
$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{l}\left(\frac{l}{a(l+a)}\right)\hat{x}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{a(l+a)}\hat{x}$$

$a \to \infty$

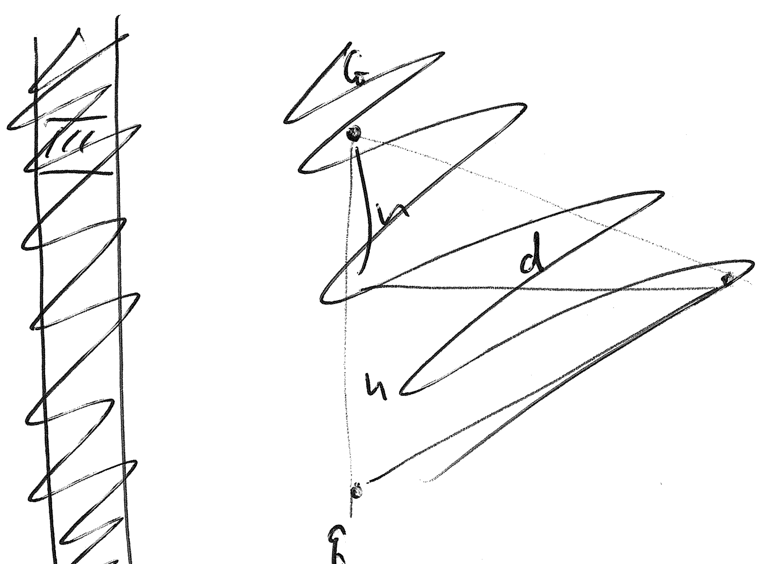
$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{a^2} \checkmark$$

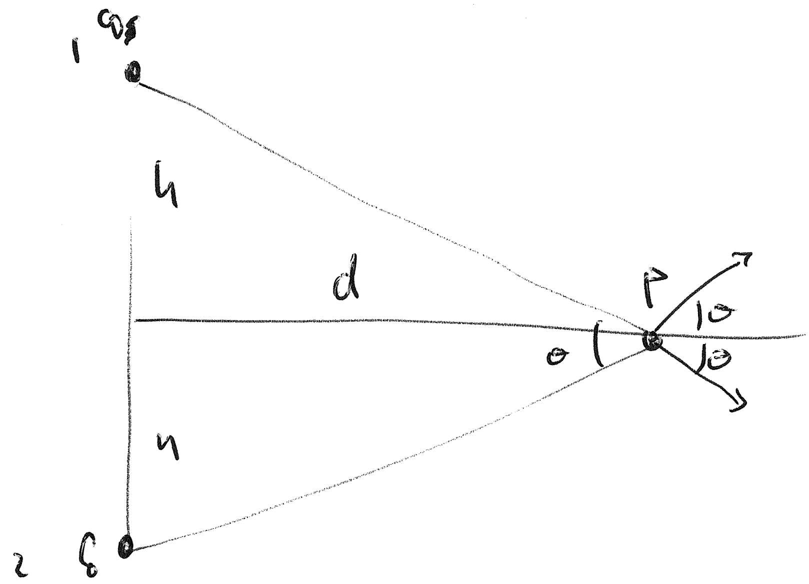
INFINITELY CHARGED LINE



CHARGE PER UNIT LENGTH = λ

ASIDE





$$\vec{E}_T = E_1 + E_2$$

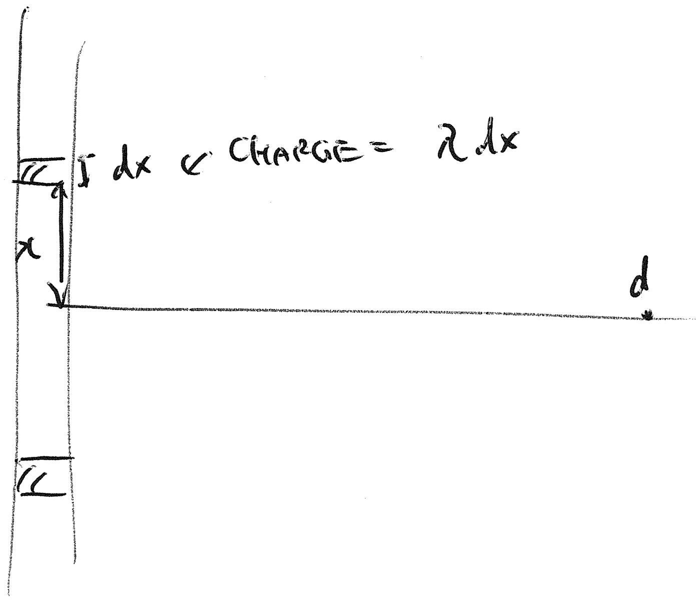
$$= 2E_x \hat{x}$$

$$E_{1x} = \frac{1}{4\pi\varepsilon_0} \frac{q}{\sqrt{d^2+h^2}^{\,2}} \times \cos\theta$$

$$E_{2x} = \frac{1}{4\pi\varepsilon_0} \frac{q}{\sqrt{d^2+h^2}^{\,2}} \times \cos\theta$$

$$\cos\theta = \frac{d}{\sqrt{d^2+h^2}}$$

$$E_T = \frac{1}{2\pi\varepsilon_0} \frac{qd}{(d^2+h^2)^{3/2}}$$



$$dE = \frac{1}{2\pi\varepsilon_0}\,\frac{d\,\lambda\,dx}{(d^2+h^2)^{3/2}}$$

$$E = \int_0^{\infty} \frac{1}{2\pi\varepsilon_0}\,\frac{d\,\lambda\,dx}{(d^2+h^2)^{3/2}}$$

$$= \frac{\lambda d}{2\pi\varepsilon_0}\left[\frac{1}{d^2}\,\frac{x}{(d^2+x^2)^{1/2}}\right]_0^{\infty}$$

$$E = \frac{1}{2\pi\varepsilon_0}\,\frac{\lambda}{d}$$