PHYS 143 Physics for Engineers

4 Modules

Each module is 4-6 chapters

Each week is about 1-2 chapters

First two weeks are harder than last two

Assessments

Saturday Mornings

Not comprehensive; each exam covers only one module

4 exams; one for each module

↳ 65% weightage

Labs

20% weightage

1 Report and Lab Quiz per week

Quiz

Every Sunday except exam week

6 online quiz

Opens on 11 AM

10 MCQs

15% weightage

Electric Fields

Electric Charge

+ve — proton

-ve — electron

⊕ ⊕ repel Unit Coulomb (C)

$\oplus$ $\oplus$ repel

$\ominus$ $\ominus$ repel

$\oplus$ $\ominus$ attract

e	-1.6×10^{-19} C
p	1.6×10^{-19} C

$m_p > m_e$

neutron – no charge
neutral

$m_n = m_p$

charge is quantized
↳ charge is a multiple of e/p

$Q = Ne$

N ↓ arbitrary integer

e ↳ charge of electron

charge is conserved ⇒ cannot be created or destroyed
(isolated system)

Materials

Conductors	Insulators	Semiconductors
free electrons	no free electrons	in between – they can be good conductors or insulators depending on doping
copper	rubber / glass	silicon / germanium

Electrostatic Force (Coulomb's Law)

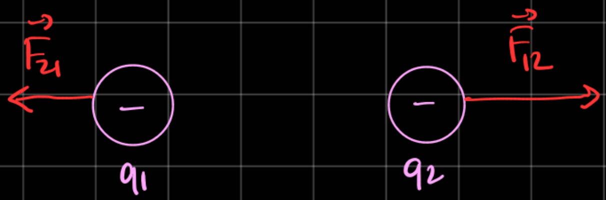
Electrostatic Force — F_e

Electric charges — q_1 q_2

Coulomb's Constant 8.89×10^9 — K_e

Distance b/w charges — r

$$\boxed{F_e = \frac{K_e q_1 q_2}{r^2}}$$



$$|\vec{F}_{12}| = |\vec{F}_{21}|$$

Question

$r = 5.3 \times 10^{-11}\ m$

$K_e = 8.9 \times 10^9$

$$F_e = \frac{8.9 \times 10^9 \times 1.6 \times 10^{-19} \times 1.6 \times 10^{-19}}{(5.3 \times 10^{-11})^2}$$

$F_e = 8.11 \times 10^{-8}\ N$

$\mu C = 10^{-6}\ C$

$q_1 = 5\mu C$ $\qquad r_{q_1 q_3} = a\sqrt{2} = 0.1 \times \sqrt{2}$

$q_3 = 5\mu C$ $\qquad r_{q_1 q_2} = a = 0.1$

$q_2 = -2\mu C$

$$\vec{F}_{13} = \frac{K_e q_1 q_3}{r^2} = \frac{8.9 \times 10^9 \times 5 \times 5 \times 10^{-6} \times 10^{-6}}{(0.1 \times \sqrt{2})^2}$$

$= 11.125\ N$

$F_{13x} = F_{13} \cos\theta$

$F_{13y} = F_{13} \sin\theta$

$$\vec{F}_{23} = \frac{K_e q_2 q_3}{r^2} = \frac{8.9 \times 10^9 \times 5 \times 10^{-6} \times (-2) \times 10^{-6}}{0.01}$$

$$= -8.9 \text{ N}$$

$$F_{13x} = \frac{11.125}{\sqrt{2}} = 7.87 \text{ N}$$

$$F_{13y} = \frac{11.125}{\sqrt{2}} = 7.87 \text{ N}$$

$$F = (F_{13x} + F_{23})\hat{i} + F_{13y}\,\hat{j}$$

$$F = -1.04\,\hat{i} + 7.94\,\hat{j} \text{ N}$$

$$F_{23} = F_{13}$$

$$\frac{\cancel{K_e} q_2 \cancel{q_3}}{x^2} = \frac{\cancel{K_e} q_1 \cancel{q_3}}{(2-x)^2}$$

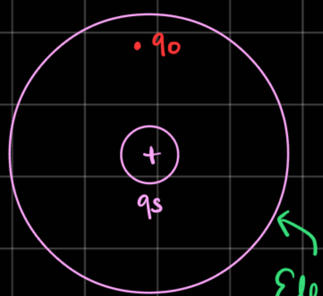
$$q_2 (2-x)^2 = q_1 x^2$$

$$q_2(x^2 - 2x + 4) = q_1 x^2$$

Electric Field

A force that can affect an object without touching it

All charged particles have electric field



Electric Field
(Area of influence)

$$\vec{E} = \frac{\vec{F}_e}{q_0}$$

q_s Source of electric field

q_0 Test charge

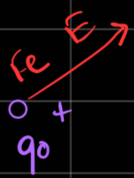
$\vec{F_e}$ Electrostatic Force

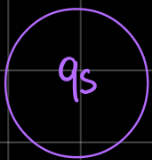
E Electric field

Test charge is used to check for existence of field.

If test charge +ve
then $\vec{F_e}$ and $\vec{E}$ have same direction.

If test charge -ve
then $\vec{F_e}$ and $\vec{E}$ have opp. direction

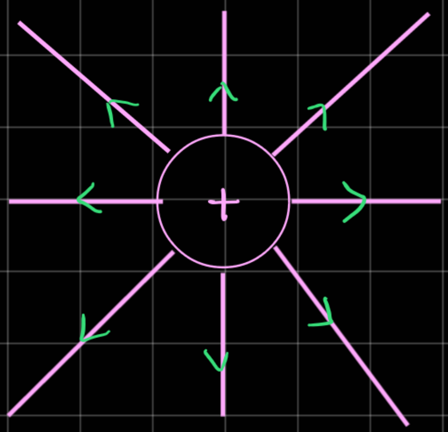


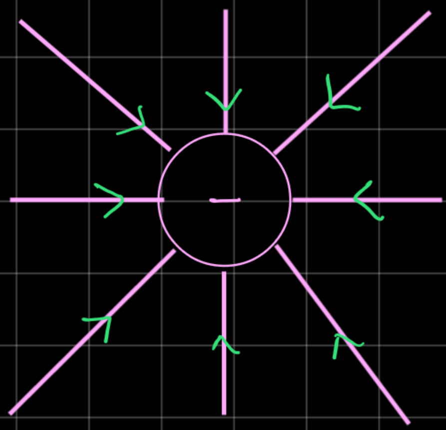


• q_0 $\vec{E} = ?$

$$\vec{E} = \frac{\vec{F_e}}{q_0} = \frac{K_e\, q_s\, \cancel{q_0}}{r^2\, \cancel{q_0}}$$

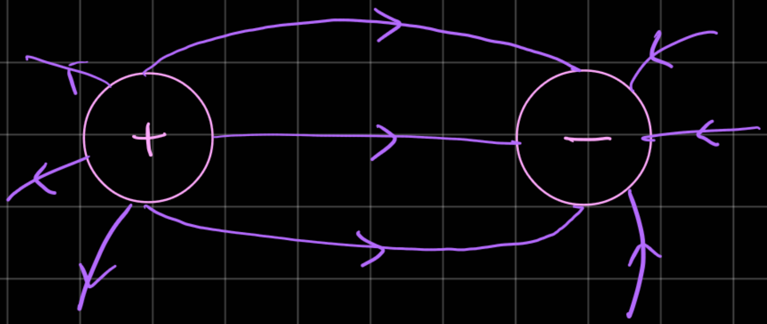
$$= \boxed{\frac{K_e\, q_s}{r^2}}$$





↑Q ↑ lines

Field lines do not cross each other



Density of field lines $\propto$ Electric Force

$$\vec{E} = \frac{\vec{F_e}}{q_0} \Rightarrow \vec{F_e} = \vec{E} q_0 = m\vec{a}$$

$$\vec{a} = \frac{\vec{E} q_0}{m}$$

If charge is put into electric field, it will accelerate

If E is uniform, then $\vec{a}$ is constant

↓

same magnitude

and direction

at all points

Particle under constant acceleration

$$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$$

x_f → Displacement

t → Time

a → Acceleration

$V_i = 3 \times 10^6$ m/s $E = 200$ N/C

$m_e = 9.11 \times 10^{-31}$ kg

If charge is $-ve$, then particle goes opposite to $\vec{E}$
$+ve$ towards $\vec{E}$

$$a = \frac{E q_0}{m}$$

$$= \frac{200 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}}$$

$$= -3.2 \times 10^{14} \hat{j}$$

Linear Charge Density $\lambda = Q / l$

Surface σ Q / A

Volume $\rho = Q / V$