

Chapter 21

→ Electric Charge.

Any object has a negative charge, gains electrons.

Any object has a positive charge, loses electrons.

① Quantization of charge:

$$q = ne$$

الشحنة

$$n = \pm 1, \pm 2, \pm 3, \dots$$

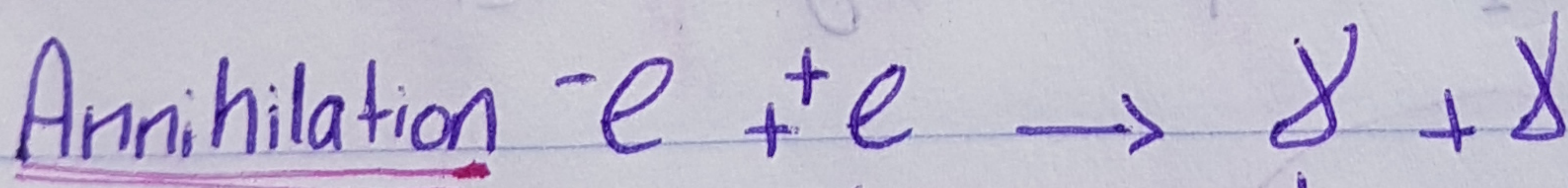
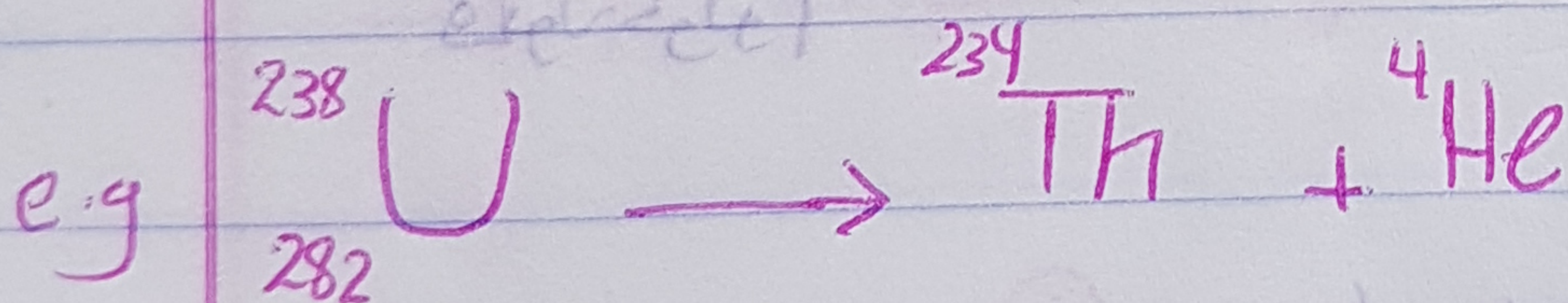
$$e = 1.6 \times 10^{-19} \text{ C}$$

مبدأ كمومية الشحنة

② Conservation of charge:

$$|q| \text{ before reaction} = |q| \text{ After reaction.}$$

مبدأ حفظ الشحنة

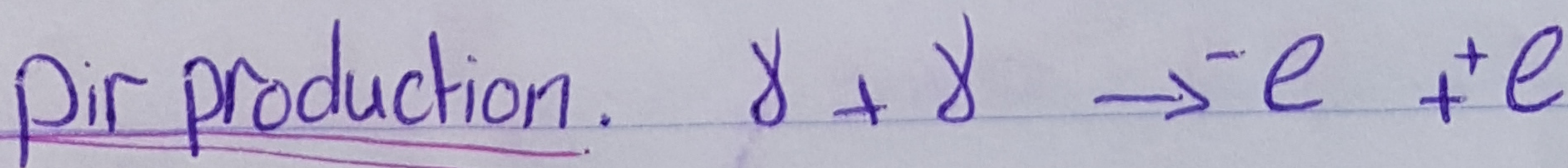


إلكترون

positron

electromagnetic wave

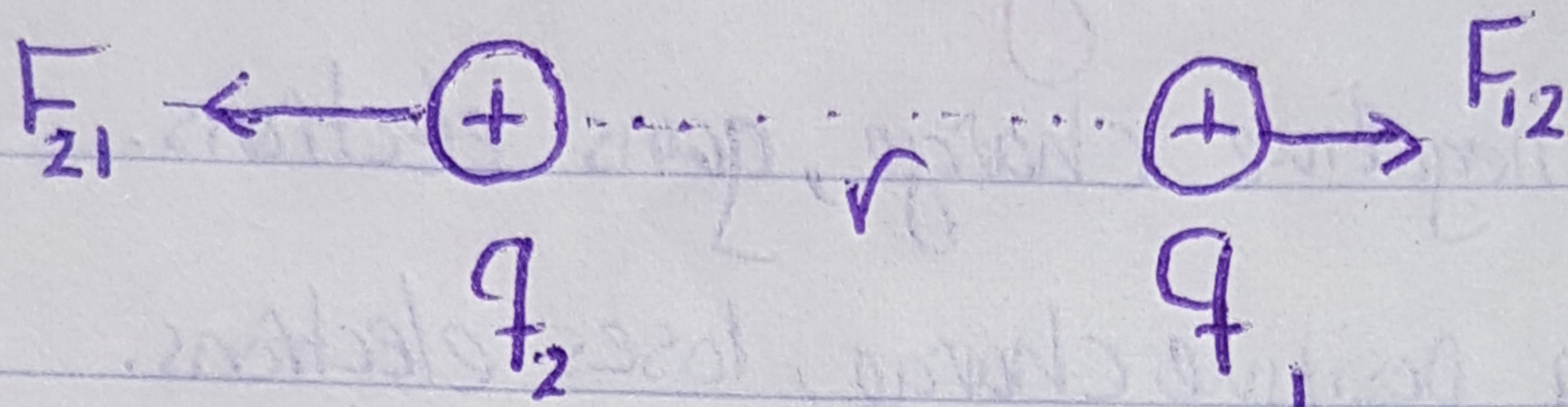
الكتلة تتحول إلى طاقة



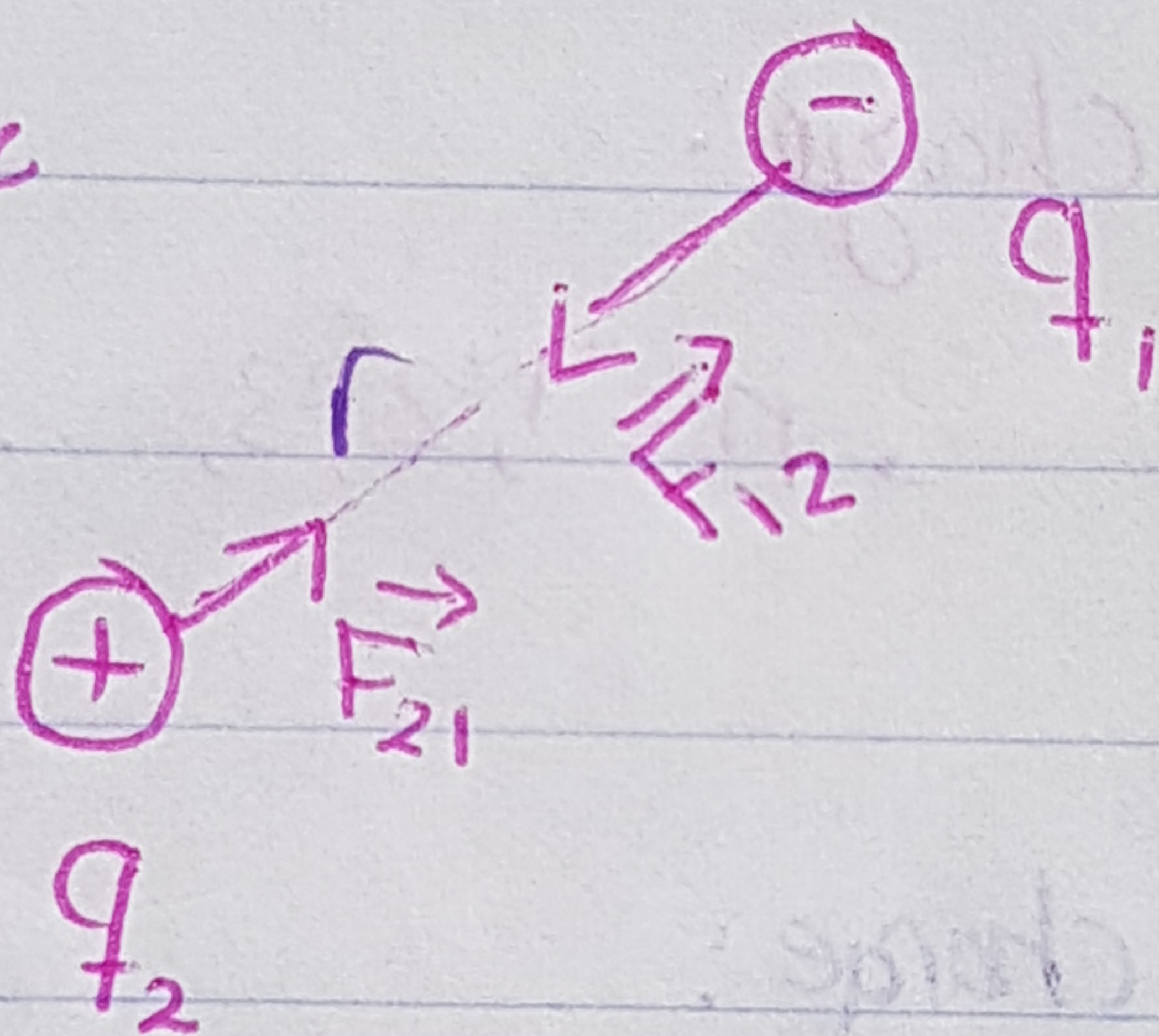
الطاقة تتحول إلى مادة

Coulomb's law :

Repulsive force



Attractive force



$$\Rightarrow F \propto \frac{q_1 q_2}{r^2}$$

قانون كولوم

q_1, q_2 is point charges شحنات نقطية

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

لانضغ الشحنات
(الموجبة والسالبة)

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

k → properties of the medium between q_1 & q_2
 تقسيم
 → Units of F & q

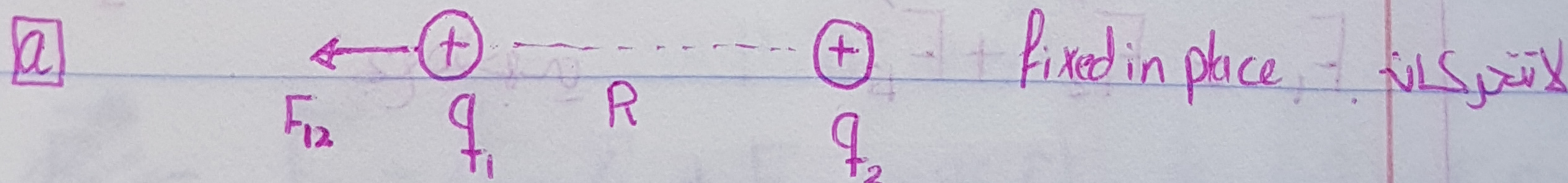
$$\Rightarrow k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N.m}^2/\text{C}^2 \text{ in air}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N.m}^2$$

(permittivity constant)

ثابت العازلية للوسط

Sample problem page 567:..



$$F_{12} = \frac{k q_1 q_2}{R^2} = \frac{9 \times 10^9 \times 1.6 \times 10^{-19} \times 3.2 \times 10^{-19}}{(0.021)^2}$$

$$\vec{F}_{12} = 1.15 \times 10^{-24} \text{ N in } -x$$

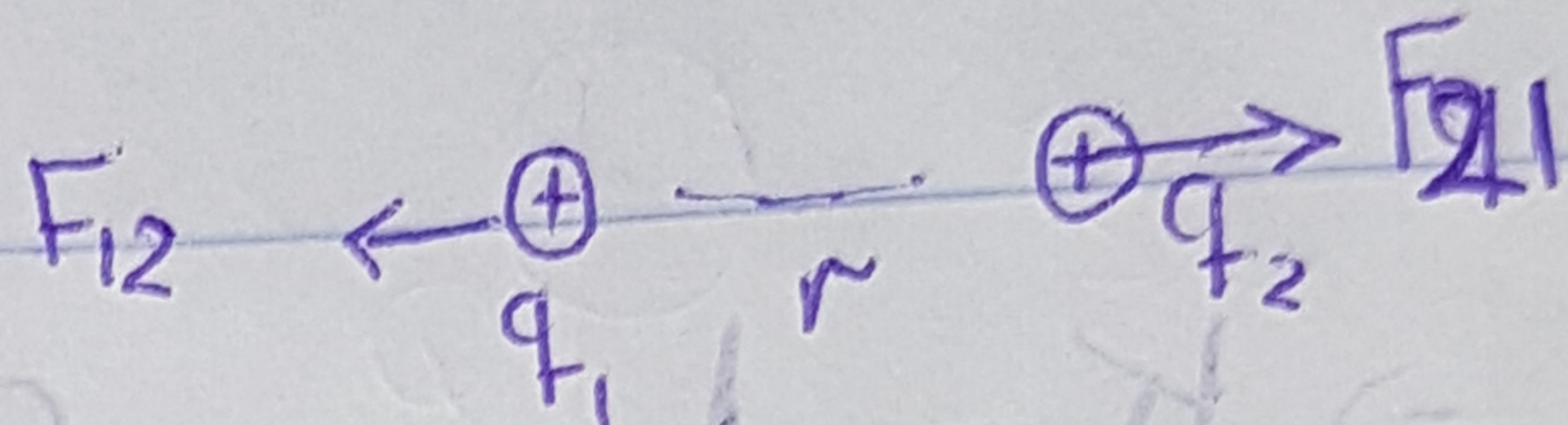
$$\vec{F}_{12} = -1.15 \times 10^{-24} \hat{x} \text{ N}$$

Review:

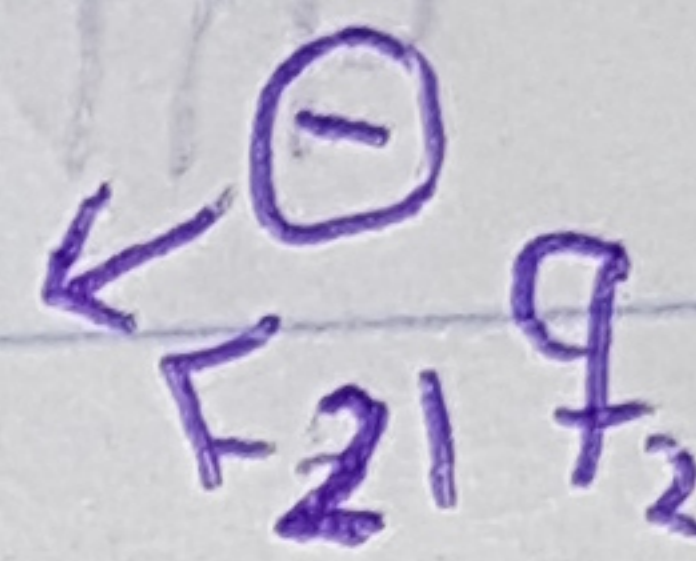
$$e = 1.6 \times 10^{-19} \text{ C}$$

$$q = \pm ne, \quad n = 1, 2, 3, \dots$$

$$F = \frac{k q_1 q_2}{r_{12}^2}$$



القوة المتبادلة على الشحنتين
تفصلهما.

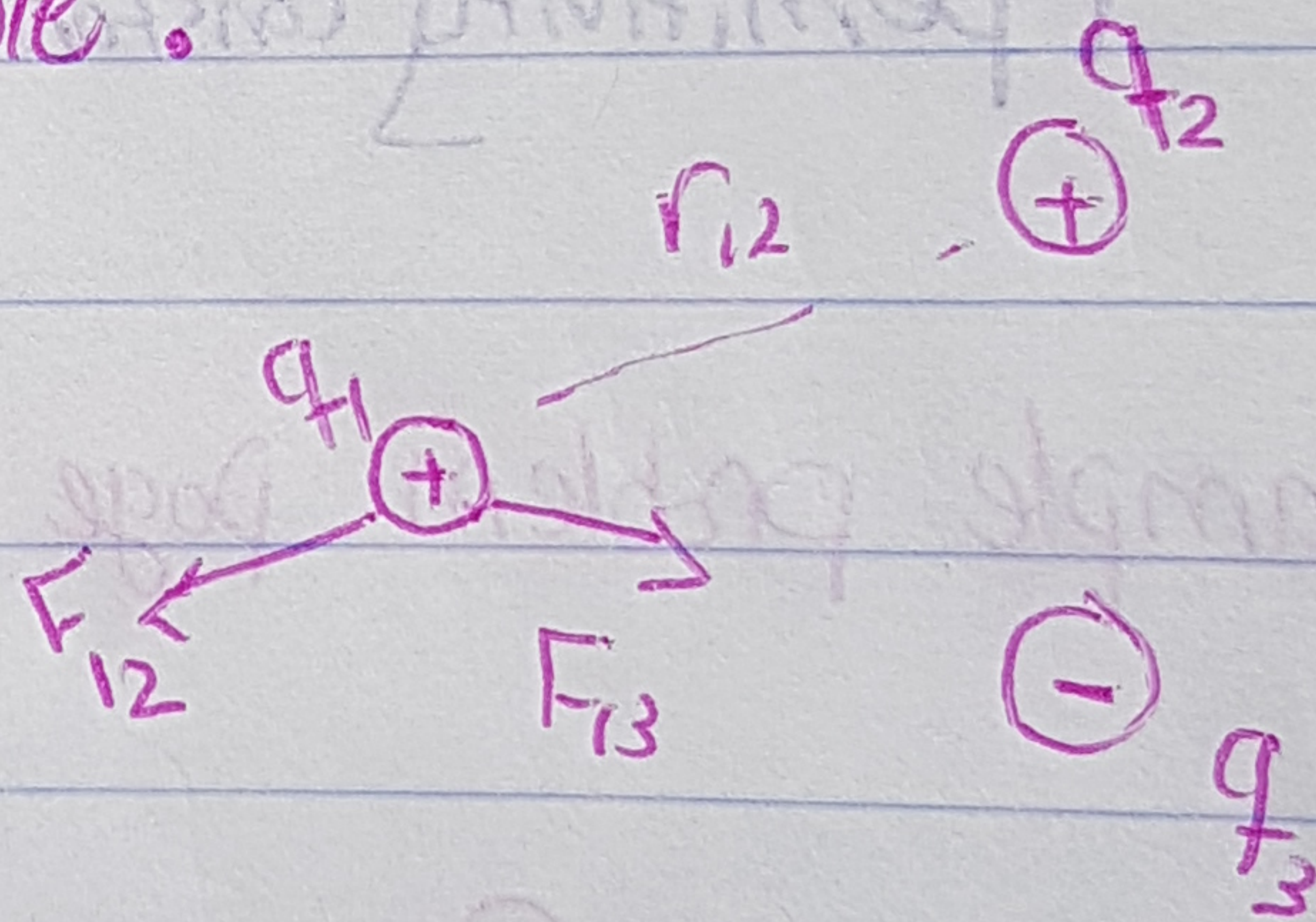


(+)

q1

Superposition Principle.

$$\vec{F}_1 = ?$$



$$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13}$$

جمع متجهي

[21-11]

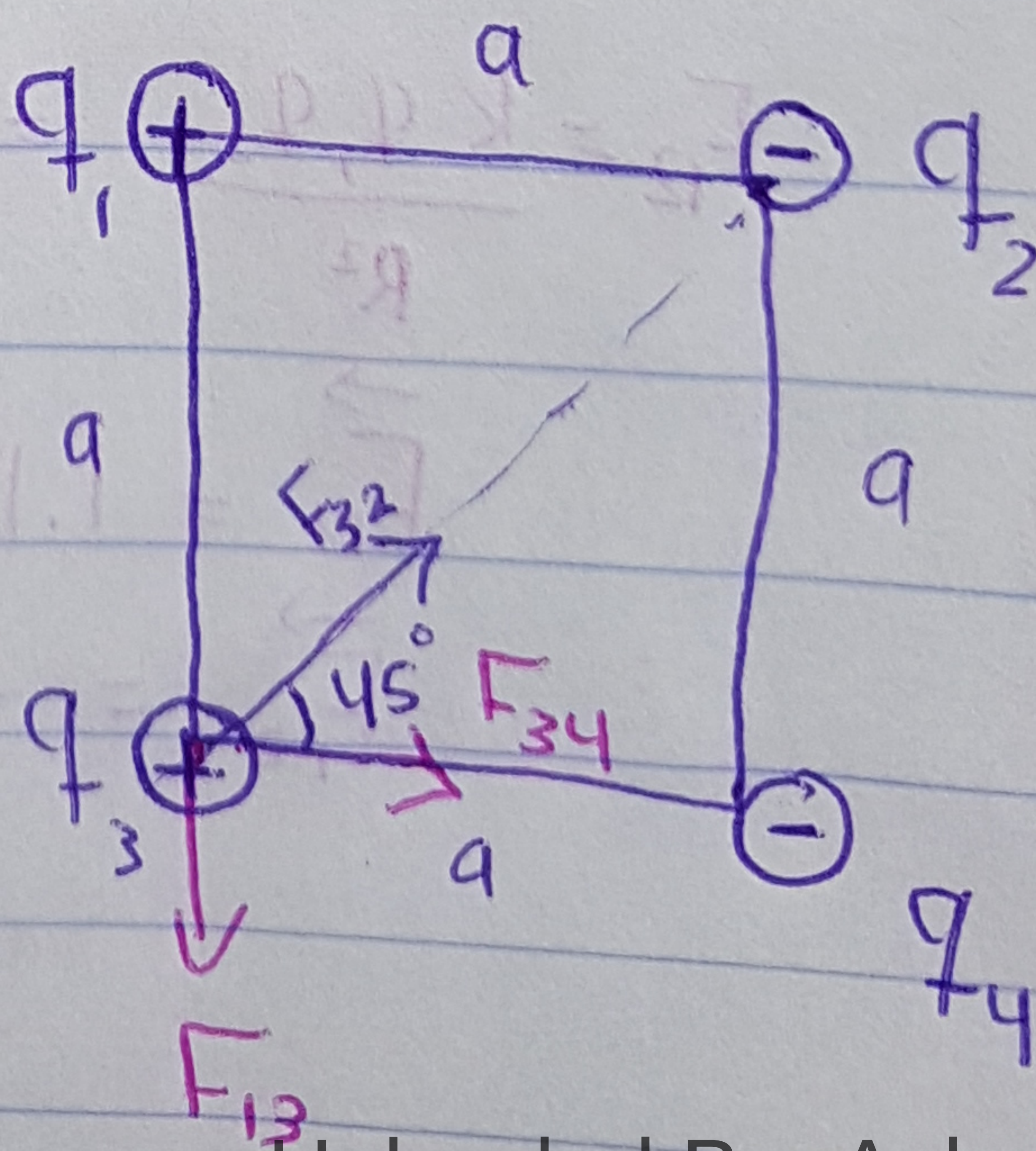
$$q_1 = +100 \text{ nC}$$

$$q_2 = -100 \text{ nC}$$

$$q_3 = 200 \text{ nC}$$

$$q_4 = -200 \text{ nC}$$

$$a = 5 \text{ cm}$$



Solve problem (10)

$$\vec{F}_3 = ?$$

$$F_{31} = \frac{9 \times 10^9 \times 100 \times 10^{-9} \times 200 \times 10^{-9}}{(5 \times 10^{-2})^2}$$

$$= 0.072 \text{ N}$$

$$F_{32} = \frac{9 \times 10^9 \times 100 \times 10^{-9} \times 200 \times 10^{-9}}{(5\sqrt{2} \times 10^{-2})^2}$$

$$F_{34} = \frac{9 \times 10^9 \times 200 \times 10^{-9} \times 200 \times 10^{-9}}{(5 \times 10^{-2})^2}$$

$$= 0.144 \text{ N}$$

$$\begin{aligned} \vec{F}_3 &= (F_{34} \hat{c} + F_{32} \cos 45 \hat{c}) + (F_{31} (-\hat{j}) + F_{32} \sin 45 \hat{j}) \\ &= 0.144 \hat{c} + (0.036)(0.71) \hat{j} \\ &\quad - 0.072 \hat{j} + (0.036)(0.71) \hat{c} \end{aligned}$$

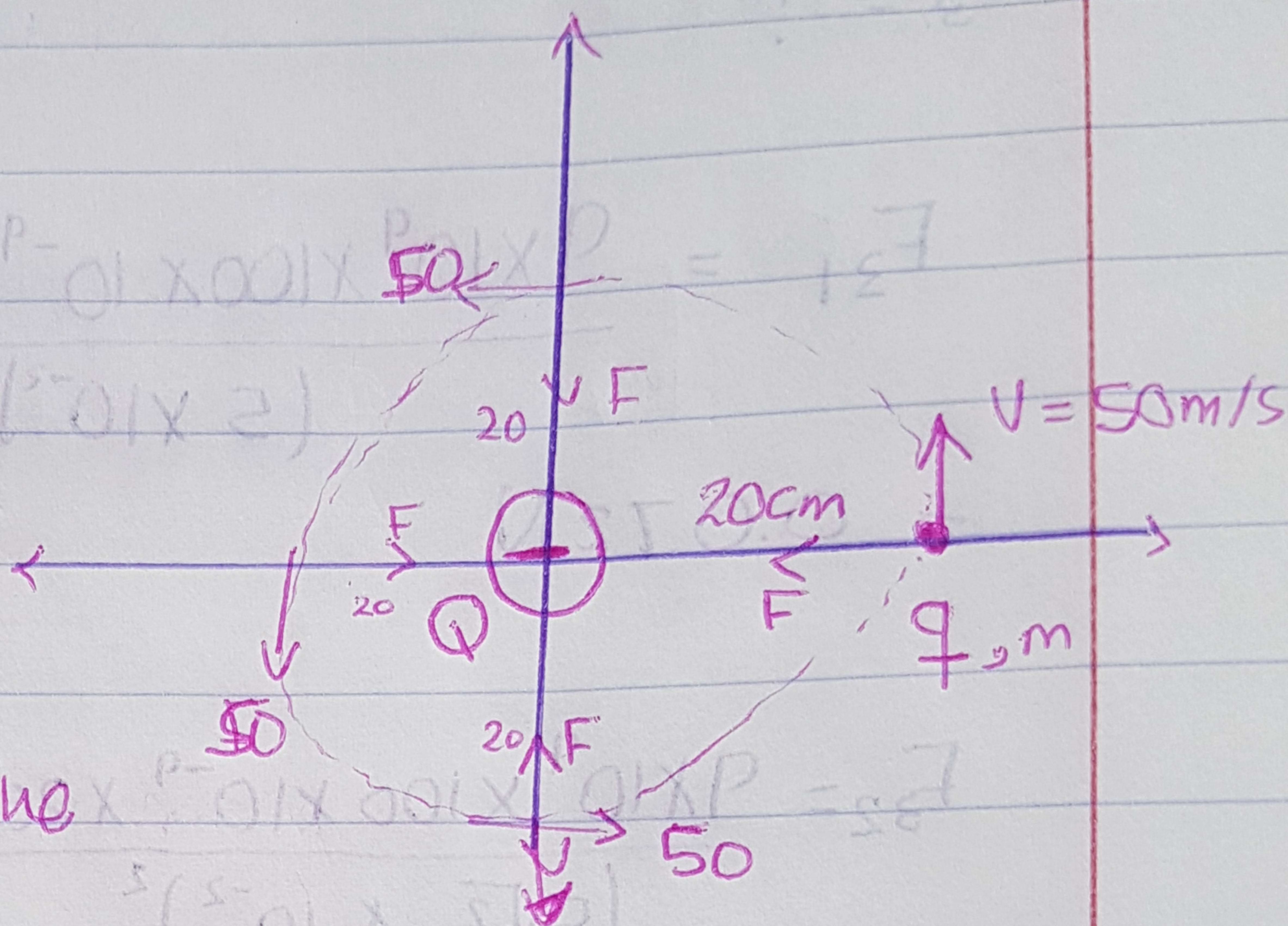
21-52

$$m = .5g$$

$$q = +4\mu C$$

Circular motion

Q must be negative



$$F = \frac{kQq}{r^2} = \frac{mv^2}{r}$$

$$Q = \frac{r m v^2}{k q} \Rightarrow \frac{(0.5 \times 10^{-3})(50)^2 (0.2)}{9 \times 10^9 \times 4 \times 10^{-6}}$$

$$Q = -6.9\mu C$$

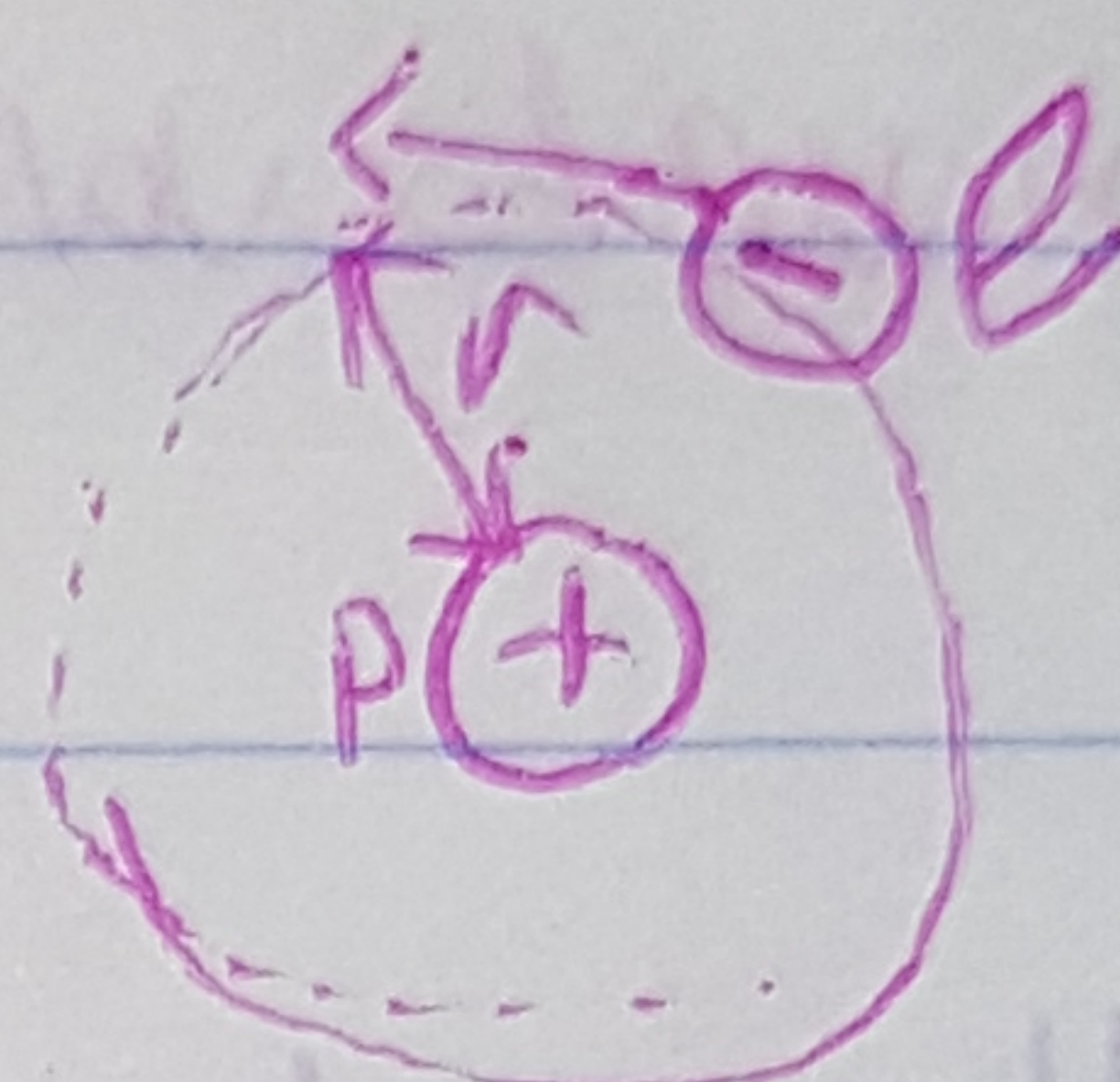
Problem H.W : Bohr's model for H-atom

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

$$r = 5.29 \times 10^{-11} \text{ m}$$

$$q_p = 1.6 \times 10^{-19}$$

$$e = -1.6 \times 10^{-19}$$



⇒ Find Kinetic energy for the circulating electron.

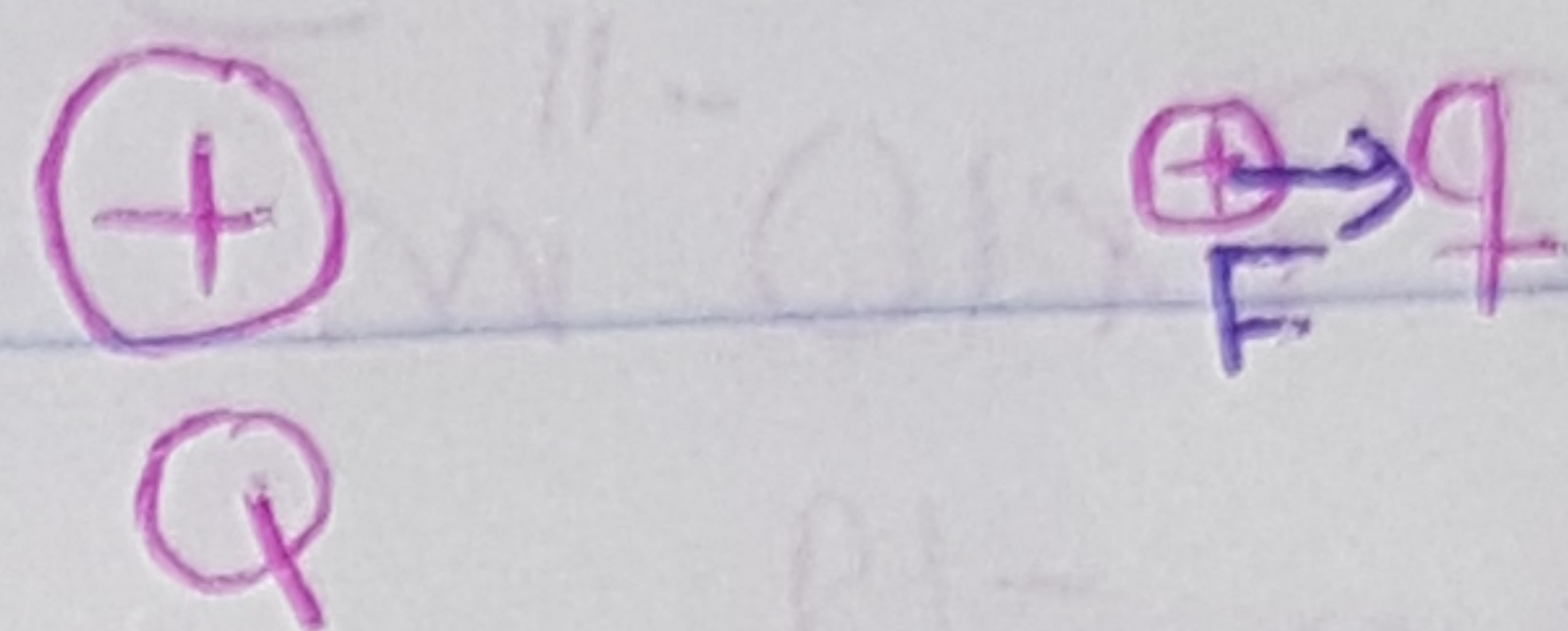
$$F = \frac{MV^2}{r} = \frac{kpe}{r^2}$$

$$\frac{1}{2} MV^2 = \frac{1}{2} \frac{(9 \times 10^9 \times (1.6 \times 10^{-19})^2)}{5.29 \times 10^{-11}}$$

$$K_E = 1.44 \times 10^{-10} \text{ Joul.}$$

eg q is free to move
 Q is fixed

q will move toward $+x$

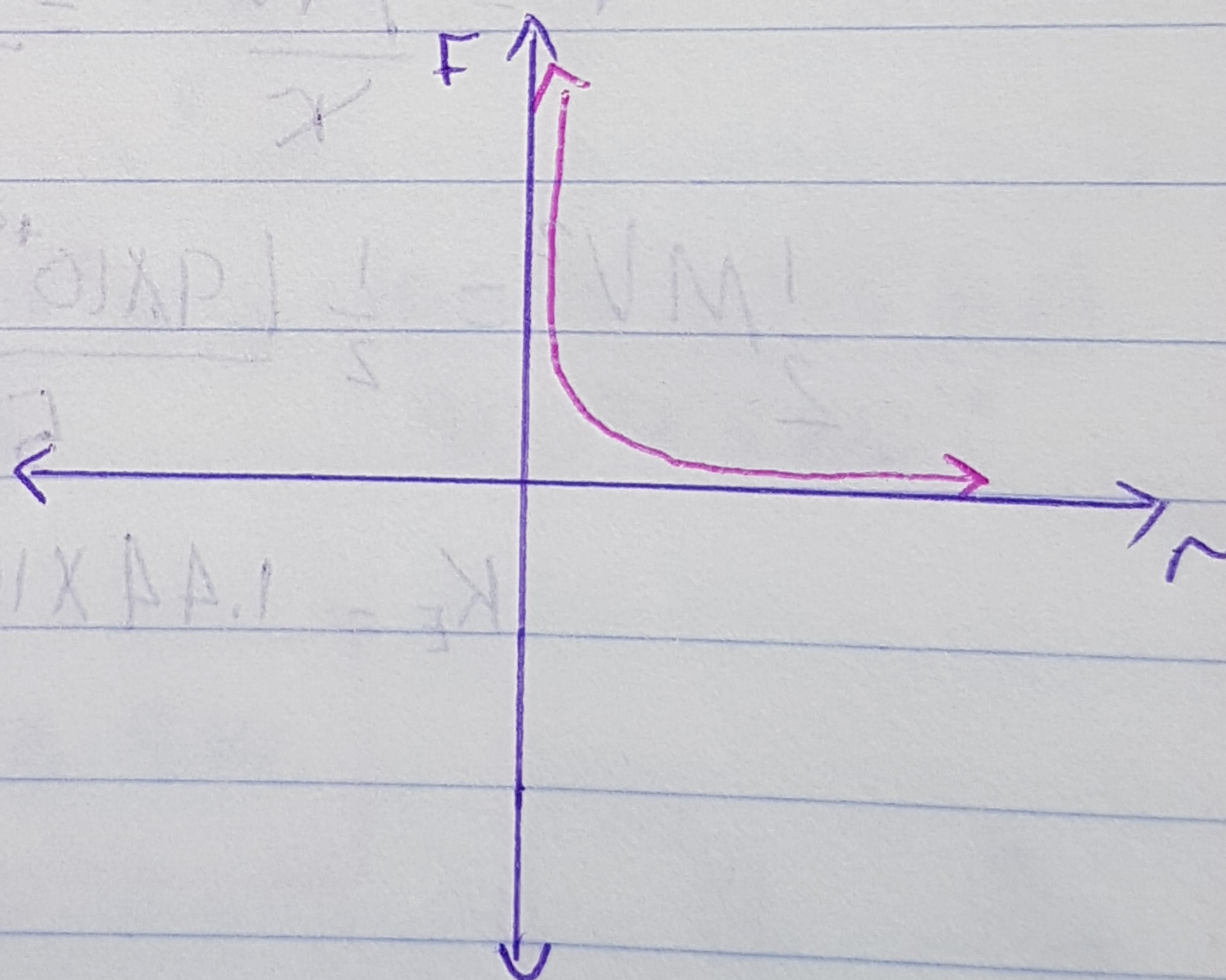


During this motion:

1. F is decreasing
2. acceleration is decreasing
3. speed is increasing.

$$F \propto \frac{1}{r^2}$$

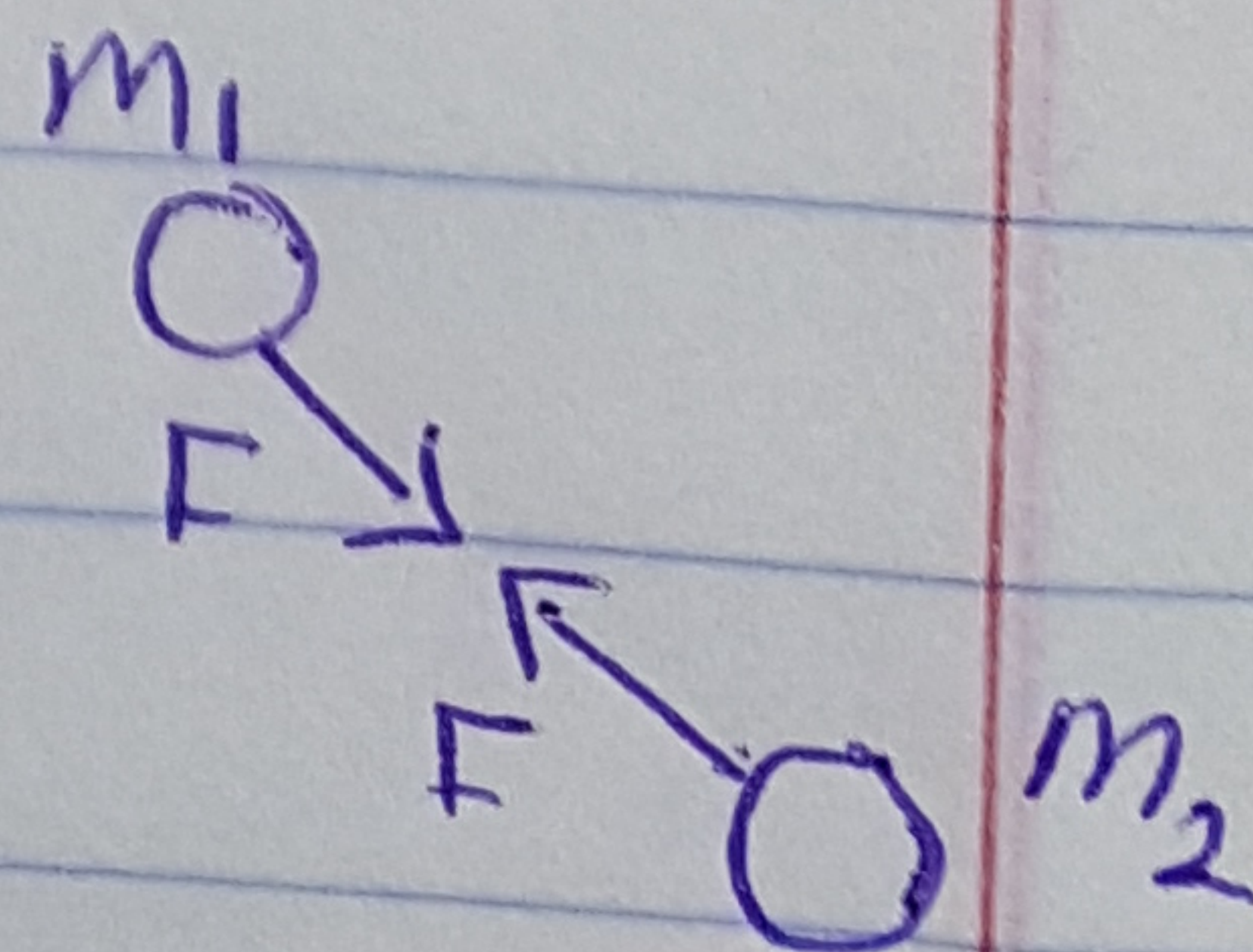
inverse square
law.



Note: Newton's gravitational force is an inverse square law.

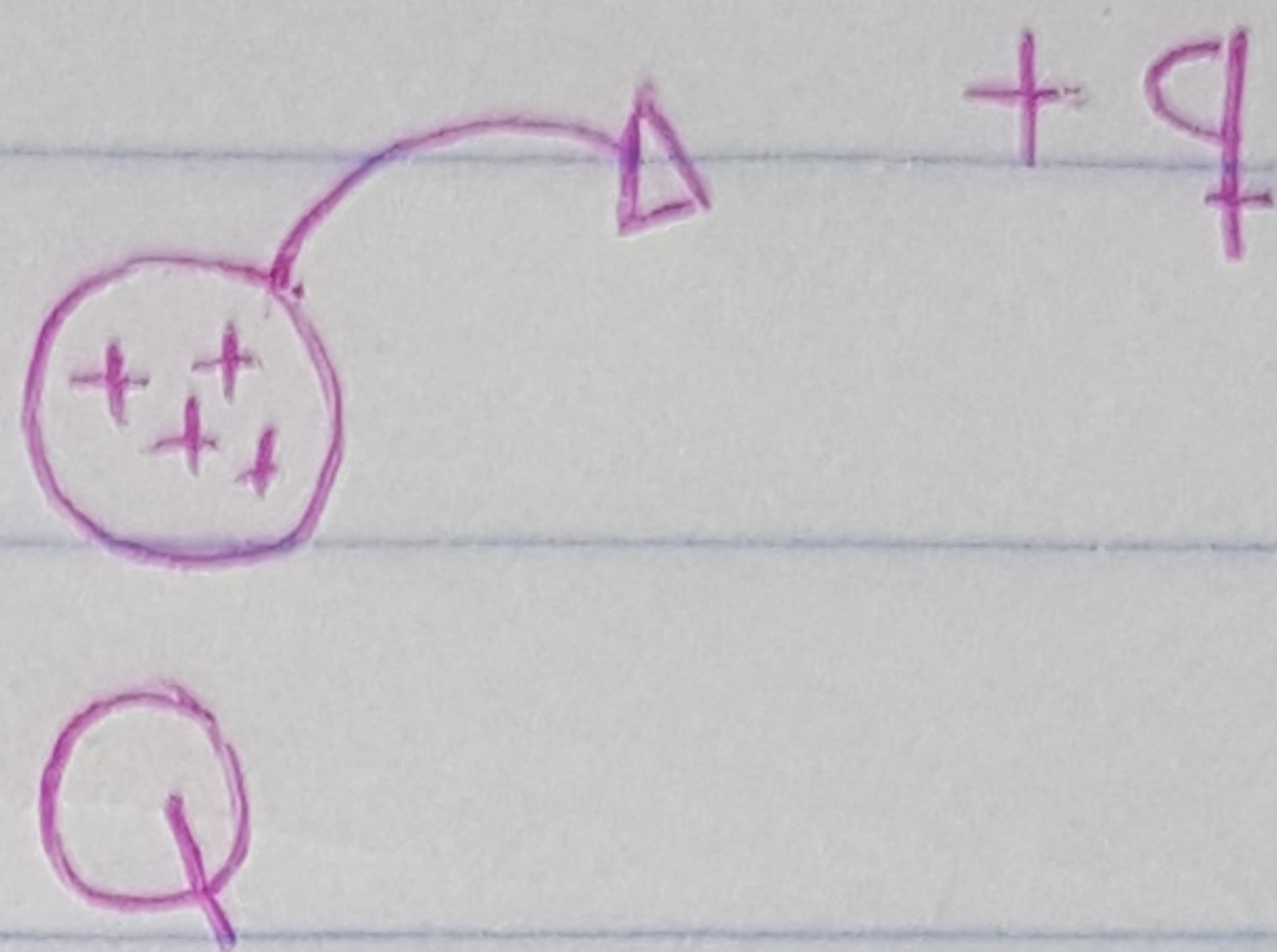
$$F = G \frac{m_1 m_2}{r^2}$$

$$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$$

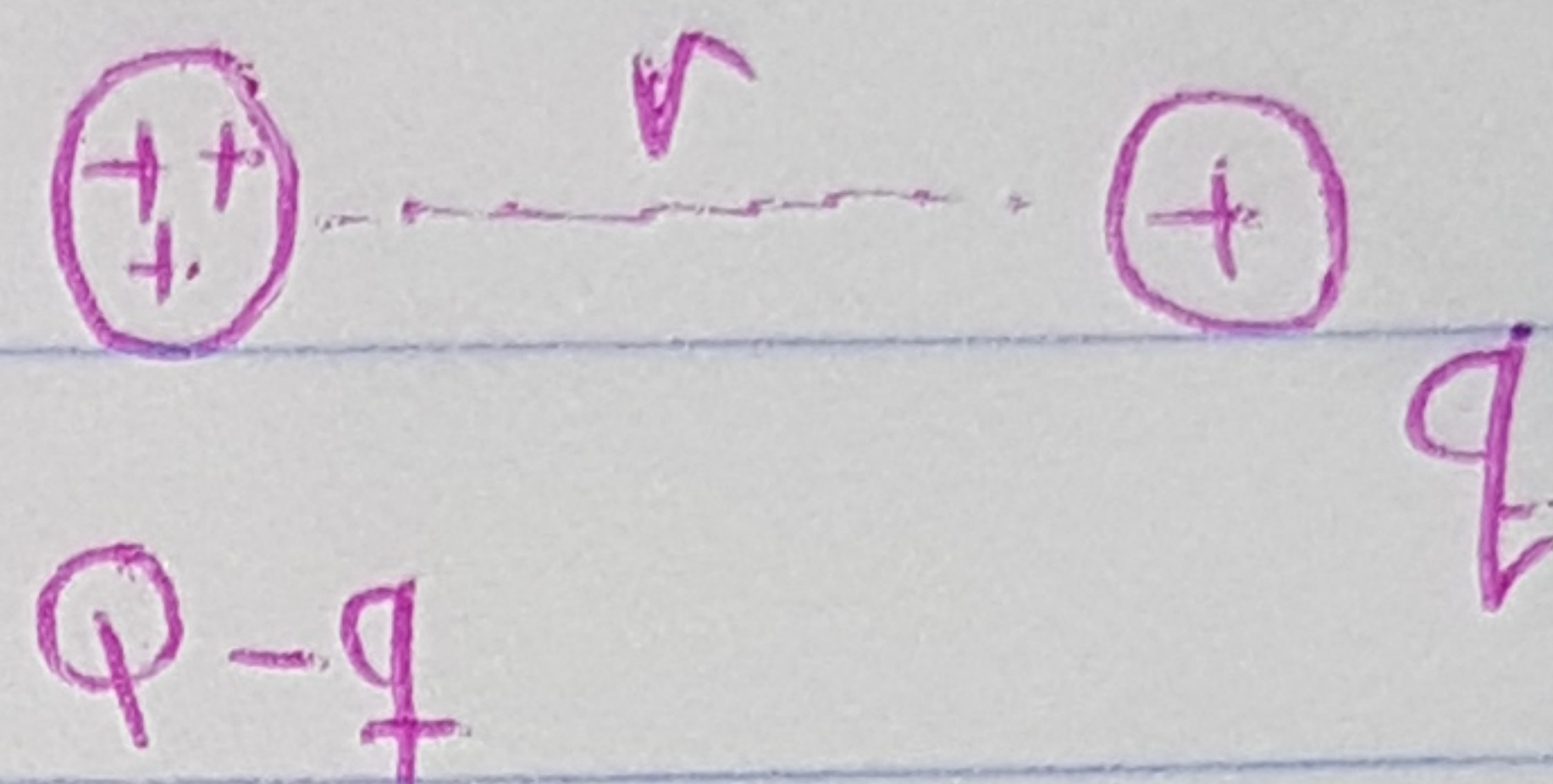


21-1

q ? for to be
maximum



$$F = \frac{k(Q-q)(q)}{r^2}$$



for $F_{\max}$ $\frac{dF}{dq} = 0$

$$F = \frac{k}{r^2} [Qq - q^2]$$

$$\frac{dF}{dq} = \frac{k}{r^2} [Q - 2q] = 0$$

$$Q - 2q = 0$$

$$q = \frac{1}{2}Q$$

Solve 54, 55