GPN2-L01

Problem 1

A particle of charge $+3 \times 10^{-6} C$ is 12.0cm distant from a second particle of charge $-1.5 \times 10^{-6} C$. Calculate the magnitude of the electrostatic force between the particles. (01小題)

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the electrostatic force $F =$ ___(N)

01: **ANS:=2.81**

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

$$= (8.99 \times 10^9\, N \times m^2/C^2)\frac{(3 \times 10^{-6}\, C)(1.5 \times 10^{-6}\, C)}{(0.120\, m)^2}$$

$$= 2.81\, N$$

Problem 2

Of the charge Q initially on a tiny sphere, a portion q is to be transferred to a second, nearby sphere. Both spheres can be treated as particles. For what value of q/Q will the electrostatic force between the two spheres be maximized? (01小題)

$\frac{q}{Q} =$_____

02: **ANS:=0.5**

$$F = \frac{1}{4\pi\epsilon_0}\frac{q(Q-q)}{r^2}$$

$$f(q) = q(Q-q)$$

$$\frac{dF}{dq} = 0$$

$$Q - 2q = 0$$

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

Problem 3

Two identical conducting spheres, fixed in place, attract each other with an electrostatic force of 0.108 N when their center-to-center separation is 50.0 cm. The spheres are then connected by a thin conducting wire. When the wire is removed, the spheres repel each other with an electrostatic force of 0.0360 N. Of the initial charges on the spheres, with a positive net charge, what was (a) the negative charge(q_2) on one of them and (b) the positive charge(q_1) on the other? Assume $q_1 > |q_2|$.

兩個相同的導電球固定在適當的位置，當它們的中心距為 50.0 cm 時，它們以 0.108 N 的靜電力相互吸引。 然後通過細導線連接球體。 當電線被移除時，球體以 0.0360 N 的靜電力相互排斥。在球體上的初始電荷中，帶有正淨電荷，（a）負電荷（q_2）是多少？ 其中一個和（b）另一個正電荷（q_1）？ 假設 $|q_1| > |q_2|$。 (02小題)

(a) q_1 =_____C

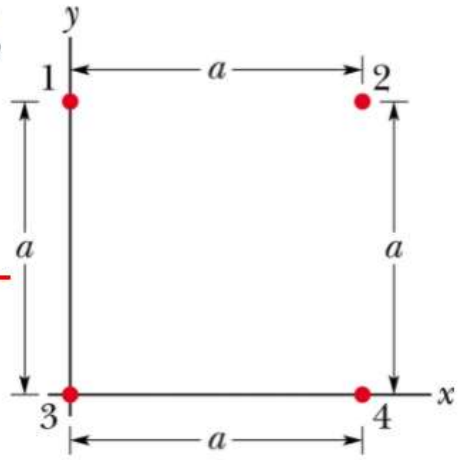
03: **ANS:=3e-6**

(b) q_2 =_____C

04: **ANS:=-1e-6**

Problem 4

In the figure, the particles have charges $q_1 = -q_2 = 100nC$ and $q_3 = -q_4 = 200nC$, and distance $a = 5cm$. What are the (a) x and (b) y components of the net electrostatic force on particle3?



(02小題)

(a)F_x=____(N)

05: **ANS:=0.17**

(b)F_y=____(N)

06: **ANS:=-0.046**

$$\vec{F}_3 = \vec{F}_{31} + \vec{F}_{32} + \vec{F}_{34}$$

$$= \frac{1}{4\pi\epsilon_0}\left(-\frac{|q_3||q_1|}{a^2}\hat{j} + \frac{|q_3||q_2|}{(\sqrt{2}a)^2}(\cos 45^\circ \hat{i} + \sin 45^\circ \hat{j}) + \frac{|q_3||q_4|}{a^2}\hat{i}\right)$$

$$(a)F_{3x} = \frac{|q_3|}{4\pi\epsilon_0 a^2}\left(\frac{|q_2|}{2\sqrt{2}} + |q_4|\right) = (8.99\times 10^9\, Nm^2/C^2)\frac{2(1.0\times 10^{-7})^2}{(0.05\,m)^2}\left(\frac{1}{2\sqrt{2}} + 2\right) = 0.17\,N$$

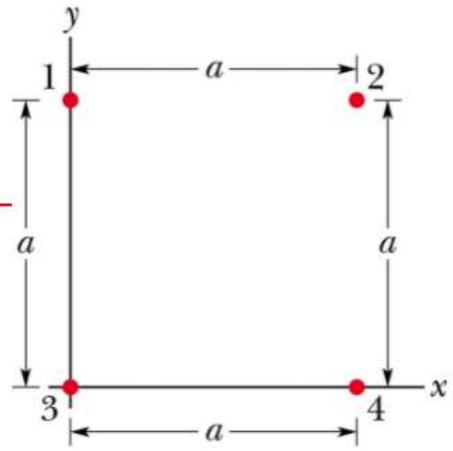
$$(b)F_{3y} = \frac{|q_3|}{4\pi\epsilon_0 a^2}\left(-|q_1| + \frac{|q_2|}{2\sqrt{2}}\right)$$

$$= (8.99\times 10^9\, Nm^2/C^2)\frac{2(1.0\times 10^{-7})^2}{(0.05m)^2}\left(-1 + \frac{1}{2\sqrt{2}}\right)$$

$$= -0.046\,N$$

Problem 5

In the figure, four particles form a square. The charges are $q_1 = +Q, q_2 = q_3 = q,$ and $q_4 = -2Q$. What is q/Q if the net electrostatic force on particle 1 is zero? (01小題)



$\frac{q}{Q} =$_____

07: **ANS:=0.707**

Solution:

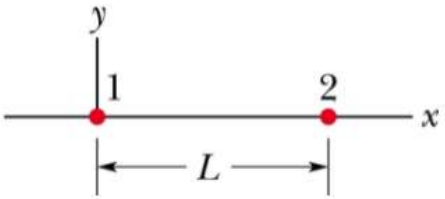
62. For the net force on $q_1 = +Q$ to vanish, the x force component due to $q_2 = q$ must exactly cancel the force of attraction caused by $q_4 = -2Q$. Consequently,

$$\frac{Qq}{4\pi\varepsilon_0 a^2} = \frac{Q|2Q|}{4\pi\varepsilon_0(\sqrt{2}a)^2}\cos 45^\circ = \frac{Q^2}{4\pi\varepsilon_0\sqrt{2}a^2}$$

or $q = Q/\sqrt{2}$. This implies that $q/Q = 1/\sqrt{2} = 0.707$.

Problem 6

In the figure, particle 1 of charge $+1.0\mu C$ and particle 2 of charge $-3.0\mu C$ are held at separation $L = 10cm$ on an x axis. If particle 3 of unknown charge q_3 is to be located such that the net electrostatic force on it from particles 1 and 2 is zero, what must be the (a) x and (b) y coordinates of particle 3? (02小題)



(a)x =_____ cm

08: **ANS:=-14**

(b)y =_____ cm

09: **ANS:=0**

(a) There is no equilibrium position for q_3 *between* the two fixed charges. It should also be clear that off-axi there are no equilibrium positions.

$$\frac{|q_1|}{L_0^2} - \frac{|q_2|}{(L+L_0)^2} = 0 \Rightarrow \left(\frac{L+L_0}{L_0}\right)^2 = \left|\frac{q_2}{q_1}\right| = \left|\frac{-3.0\ \mu C}{+1.0\ \mu C}\right| = 3.0$$

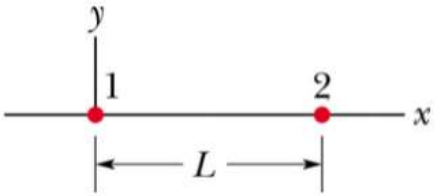
$$\frac{L+L_0}{L_0} = \sqrt{3} \Rightarrow L_0 = \frac{L}{\sqrt{3}-1} = \frac{10\ \text{cm}}{\sqrt{3}-1} \approx 14\,\text{cm}$$

(b) $y = 0$.

That is, q_3 should be placed at $x = -14$ cm

Problem 7

In the figure, particle 1 of charge +q and particle 2 of charge +4.00q are held at separation $L = 9.00cm$ on an x axis. If particle 3 of charge q_3 is to be located such that the three particles remain in place when released, what must be the (a) x and (b) y coordinates of particle 3, and (c) the ratio $\frac{q_3}{q}$? (03小題)



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x =_____ cm

10: **ANS:=3**

y =_____ cm

11: **ANS:=0**

q_3/q =_____

12: **ANS:=-0.444**

The third charge q_3 must lie between the other two

Suppose q_3 is at a distance x from q, and $L - x$ from $4.00q$.

$$F_3 = \frac{1}{4\pi\varepsilon_0}\left(\frac{qq_3}{x^2} - \frac{4qq_3}{(L-x)^2}\right)$$

We require $F_3 = 0$ and solve for x. $1/x^2 = 4/(L-x)^2$

The solution is $x = L/3$. With $L = 9.00$ cm, we have $x = 3.00$ cm.

(b) Similarly, the y coordinate of q_3 is $y = 0$.

(c) The force on q is $$F_q = \frac{-1}{4\pi\varepsilon_0}\left(\frac{qq_3}{x^2} + \frac{4.00q^2}{L^2}\right).$$

$F_q = 0$ and solve for q_3: $$q_3 = -\frac{4qx^2}{L^2} = -\frac{4}{9}q \quad \Rightarrow \quad \frac{q_3}{q} = -\frac{4}{9} = -0.444$$

where $x = L/3$ is used.

$$F_{4q} = \frac{1}{4\pi\varepsilon_0}\left(\frac{4q^2}{L^2} + \frac{4qq_0}{(L-x)^2}\right) = \frac{1}{4\pi\varepsilon_0}\left(\frac{4q^2}{L^2} + \frac{4(-4/9)q^2}{(4/9)L^2}\right) = \frac{1}{4\pi\varepsilon_0}\left(\frac{4q^2}{L^2} - \frac{4q^2}{L^2}\right) = 0.$$

Problem 8

The magnitude of the electrostatic force between two identical ions that are separated by a distance of 5.0×10^{-10}m is 3.7×10^{-9} N. (a) What is the charge of each ion? (b) How many electrons are "missing" from each ion (thus giving the ion its charge imbalance)? (02小題)

(a) $q =$_____C

13: **ANS:=3.2e-19**

(b) $n =$_____

14: **ANS:=2**

(a)

$$F = \frac{(q)(q)}{4\pi\epsilon_0 r^2} = k\frac{q^2}{r^2}$$

$$q = r\sqrt{\frac{F}{k}}$$

$$= (5 \times 10^{-10} m)\sqrt{\frac{3.7 \times 10^{-9} N}{8.99 \times 10^9 \, Nm^2/C^2}}$$

$$= 3.2 \times 10^{-19} \, C$$

$$(b) ne = qn = \frac{q}{e} = \frac{3.2 \times 10^{-19} \, C}{1.6 * 10^{-19} \, C} = 2$$

Problem 9

Earth's atmosphere is constantly bombarded by cosmic ray protons that originate somewhere in space. If the protons all passed through the atmosphere, each square meter of Earth's surface would intercept protons at the average rate of 1500 protons per second. What would be the electric current intercepted by the total surface area of the planet? (01小題)

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the electric current$i$ =_____A

15: **ANS:=0.122**

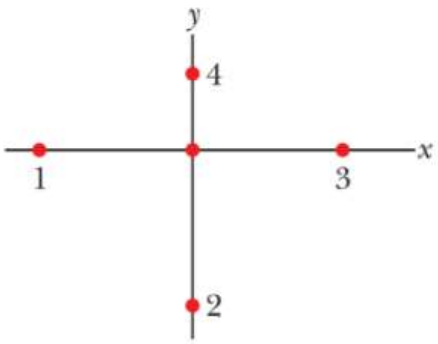
Solution:

$4\pi R^2 = 4\pi(6.37 \times 10^6 m)^2 = 5.1 \times 10^{14} m^2$

$i = (5.1 \times 10^{14} m^2)(1500)(1.6 \times 10^{-19}) = 0.122 A$

Problem 10

The figure shows electrons 1 and 2 on an x axis and charged ions 3 and 4 of identical charge $-q$ and at identical angles θ. Electron 2 is free to move; the other three particles are fixed in place at horizontal distances R from electron 2 and are intended to hold electron 2 in place. For physically possible values of $q \leq 5e$, what are the (a) smallest, (b) second smallest, and (c) third smallest values of θ for which electron 2 is held in place? (03小題)



(a) smallest: θ=_____ degree

16: **ANS:=37.5**

(b) second smallest: θ=_____ degree

17: **ANS:=50.95**

(c) third smallest: θ=_____ degree

18: **ANS:=56.6**

(a) The smallest value of angle is

$\theta_1 = 37.5°$ (or 0.654 rad).

(b) The second smallest value of angle is

$\theta_2 = 50.95°$ (or 0.889 rad).

(c) The third smallest value of angle is

$\theta_3 = 56.6°$ (or 0.988 rad).

$\tan\theta = d/R$ and $\cos\theta = R/r$ r is the dashed line

the net x force caused by q_3 and q_4 on the y axis

$$2\frac{qe}{4\pi\varepsilon_0 r^2}\cos\theta = \frac{2qe\cos\theta}{4\pi\varepsilon_0 (R/\cos\theta)^2} = \frac{2qe\cos^3\theta}{4\pi\varepsilon_0 R^2}.$$

equal the magnitude of the repulsive force exerted on q_2 by $q_1 = -e$.

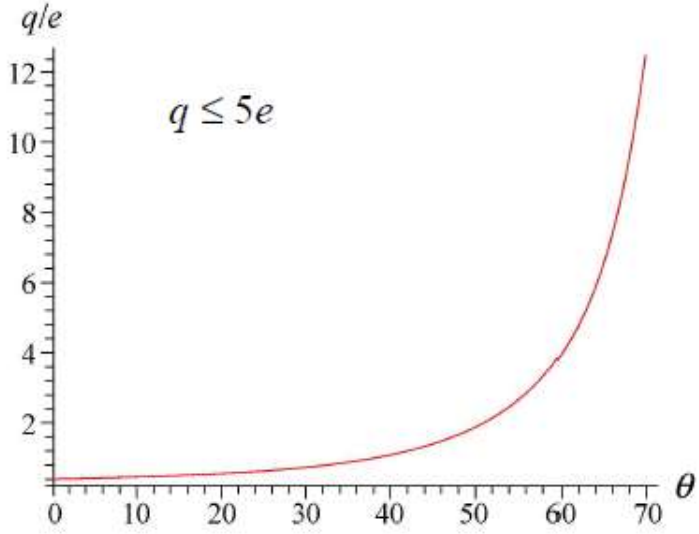
$$\frac{2qe\cos^3\theta}{4\pi\varepsilon_0 R^2} = \frac{e^2}{4\pi\varepsilon_0 R^2}$$

$$\Rightarrow \quad q = \frac{e}{2\cos^3\theta}.$$

$$\frac{e}{2\cos^3\theta} \leq 5e$$

$$\Rightarrow \quad \frac{1}{(10)^{1/3}} \leq \cos\theta$$

$$\theta \leq 62.34°.$$



Problem 11

Coulomb's law:有兩個正電荷帶電量分別是q_1, q_2，兩者之間存在的一個互相排斥的庫侖力，兩個電荷相隔的距離r，力量的大小F=?(不計無窮遠處。) (01小題)

兩電荷間的距離F=_____ [q_1, q_2, r, e_0], π=pi, ϵ_0=e_0 。

19: **ANS:=(q_1*q_2)/(4*pi*e_0*r**2)** (q_1*q_2)/(4*pi*e_0*r**2)

Coulomb force:有兩個正電荷帶電量分別是q_1, q_2，兩者之間存在的一個互相排斥的庫侖力，力量的大小是F，請計算這兩個電荷相隔的距離。(不計無窮遠處。) (01小題)

兩電荷間的距離r=_____ [q_1, q_2, F, e_0], π=pi, ϵ_0=e_0 。

20: **ANS:=sqrt((q_1*q_2)/(4*pi*e_0*F))** sqrt((q_1*q_2)/(4*pi*e_0*F))

有兩個電荷固定在x軸上，兩電荷相隔的距離是d，兩者的電荷量分別是$q_1(x_1 = 0), q_2(x_2 = d)$，$q_1 > q_2 > 0$。在x軸上放置另外一個電荷Q，該電荷要放置在哪一個座標(x_Q)所獲得的合力最小。 (01小題)

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x_Q=_____ [k, q_1, q_2, d], k=庫倫常數，q_1=q_1, q_2=q_2。

21: **ANS:=d/(1+sqrt(q_2/q_1))**

Solution:

d/(1+sqrt(q_2/q_1))

__B__ 22 可嘗試次數= 1 分數= 1　金屬之所以能導電是由於下列何者能自由運動 (A)金屬原子 (B)電子 (C)質子 (D)原子核 (E)離子。

__C__ 23 可嘗試次數= 1 分數= 1　質子與電子帶的電量何者較大？ (A)質子 (B)電子 (C)相同。

__A__ 24 可嘗試次數= 1 分數= 1　兩個電子之間的庫倫排斥力與重力的吸引力做比較，何者的力量較大? (A)電力 (B)重力 (C)相同

__E__ 25 可嘗試次數= 1 分數= 1　考慮電子-電子間的排斥力與電子-質子間的吸引力下列敘述何者正確？ (A)距離相同時吸引力比較大 (B)距離相同時吸引力比較小 (C)電子與電子間的距離增加一倍，排斥力增加一倍 (D)電子與電子間的距離增加一倍，排斥力減少為二分之一 (E)電子與電子間的距離增加一倍，排斥力減少為四分之一

__H__ 26 可嘗試次數= 1 分數= 1　一個物體被傳導上電荷之後，由於同性電荷之間的排斥力會使得電荷重新排列，直到穩定為止，這種重新排列達到穩定所需的時間被稱為弛豫時間(relaxation time)，請問對金屬而言這個時間大約為若干秒? (A) 1 (B) 10 (C) 50 (D)100 (E)10^{6} (F)10^{12} (G)10^{-6} (H)10^{-12}

__D__ 27 可嘗試次數= 1 分數= 1　在陰極射線管中，用來控制電子偏離中心的兩組裝置為？ (A)電子槍 (B)同軸心的遮板 (C)金屬球 (D)平行電板 (E)微波產生器

__A__ 28 可嘗試次數= 1 分數= 1　陰極射線管中運動的電子向下彎曲的軌跡是下列何種曲線? (A)拋物線 (B)雙曲線 (C)圓 (D)橢圓 (E)螺旋

__B__ 29 可嘗試次數= 1 分數= 1　承上題,電子之所以向下彎曲是受到哪一種力量的影響? (A)萬有引力 (B)平行板的電力 (C)電子槍射出的角度 (D)原子核的強交互作用力 (E)電子與電子之間的庫倫力

__A__ 30 可嘗試次數= 1 分數= 1 陰極射線管顯示器所發出的螢光是如何造成的? (A)被電子擊中的螢光材料所發出 (B)沒有被電子擊中的區域會發出螢光 (C)陰極所發出的高溫熱氣驅使螢光材料發光 (D)高壓的氣體撞擊螢光材料使之發光

__B__ 31 可嘗試次數= 1 分數= 1 控制噴墨式印表機的墨水滴飛行方向的性質為？ (A)墨水滴的質量 (B)墨水滴的電量 (C)墨水滴的速度 (D)墨水滴的密度 (E)平行板的電場 (F)墨水匣的壓力

__A__ 32 可嘗試次數= 1 分數= 1 噴墨式印表機的墨水滴運動軌跡是下列何種曲線? (A)拋物線 (B)雙曲線 (C)圓 (D)橢圓 (E)螺旋

__E__ 33 可嘗試次數= 1 分數= 1 電子的帶電量為_____庫倫? (A) 1.6 (B) 10 (C) -3.2 (D) 3.2×10^{-19} (E) -1.6×10^{-19} (F) 3.2×10^{-9}

__H__ 34 可嘗試次數= 1 分數= 1 α粒子是氦原子的原子核，其中有兩個質子和兩個中子，則α粒子的帶電量為_____庫倫? (A) 1.6 (B) 0 (C) -3.2 (D) -3.2×10^{-19} (E) -1.6×10^{19} (F) 3.2×10^{-9} (G) 1.6×10^{-19} (H) 3.2×10^{-19} (I) 6.4×10^{-19}

__A__ 35 可嘗試次數= 1 分數= 1 一庫侖的電量相當於多少個電子所帶的電量？ (A)6.2×10^{18} (B) 3.1×10^{18} (C)1.2×10^{20} (D)6.2×10^{19} (E)4.2×10^{20}

__C__ 36 可嘗試次數= 1 分數= 1 若電子所帶的電量為e，下列何者是油滴實驗中不可能出現的油滴帶電量？ (A)e (B)2e (C)2.5e (D)3e (E)4e (F)10e

__A__ 37 可嘗試次數= 1 分數= 1 一氣球經摩擦後向一水龍頭流出的水柱靠近，則會發現？ (A)水柱偏向氣球 (B)水柱偏離氣球 (C)水柱不受氣球影響 (D)與水滴的流速有關 (E)與水滴的大小有關

__A__ 38 可嘗試次數= 1 分數= 1 水分子中的電荷傾向分布為正負電荷分離的狀態，其中氫原子形成帶何種電性? (A)正電 (B)負電 (C)電中性 (D)與氧原子的距離有關。