Midterm Exam No. 01 (2014 Summer)

PHYS 203B: College Physics

Date: 2014 Jun 23

Solutions

_____ (Name) _____ (Signature)

Total : 140 point

1. (**10 points.**) Four identical metal spheres have charges of $q_A = +Q$, $q_B = +\frac{1}{4}Q$, $q_C = -\frac{3}{4}Q$, and $q_D = -\frac{3}{2}Q$. Spheres A, B, and C, are brought together so they touch, and then they are separated. Then sphere C is touched to sphere D and separated. What is the resultant charge on sphere C?

2. (**10 points.**) What is the electric force between a glass ball with $3.0\,\mu$C of charge and a rubber ball with -4.0 μC of charge when their centers are separated by 5 cm?

3. (**20 points.**) Four point charges have equal magnitudes, all four being positive. These charges are fixed to the corners of a square. The magnitude of each of the charges is $4.0\,\mu$C, and the lengths of the sides of the square are 2.0 cm. Calculate the magnitude of the net force that each charge experiences.

4. (**10 points.**) An electric field of 246,500 N/C points due west at a certain spot. What are the magnitude and direction of the force that acts on a charge of $-6.8\,\mu$C at this spot?

5. (**20 points.**) Charges of $-q$ and $+2q$ are fixed in place, with a distance of $a = 2.0$ m between them. See Fig. 1. A dashed line is drawn through the negative charge, perpendicular to the line between the charges. On the dashed line, at a distance y from the negative charge, there is at least one spot where the total potential is zero. Find y.

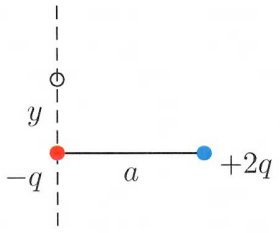


Figure 1: Problem 5

6. (**10 points.**) A proton and an electron are moving due east in a constant electric field that also points due east. The electric field has a magnitude of 4.3×10^5N/C. Determine the ratio of the magnitude of the acceleration of the proton to that of the electron.

MTE-01, Prob. 1

Step 1 : $q_A = +Q$ $\quad q_B = +\frac{1}{4}Q$ $\quad q_C = -\frac{3}{4}Q$ $\quad q_D = -\frac{3}{2}Q$

step 2 : $q_A = q_B = q_C = \frac{Q + \frac{1}{4}Q - \frac{3}{4}Q}{3} = +\frac{1}{6}Q$ $\quad q_D = -\frac{3}{2}Q$

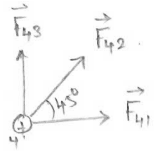
step 3 : $q_A = q_B = +\frac{1}{6}Q$ $\quad q_C = q_D = \frac{+\frac{1}{6}Q - \frac{3}{2}Q}{2} = -\frac{2}{3}Q$

Answer : $q_C = -\frac{2}{3}Q$

MTE-01, Prob. 2

$$F = \frac{kq_1q_2}{r^2} = \frac{(8.99\times10^9)\times(3\times10^{-6})\times(4\times10^{-6})}{(5\times10^{-2})^2} = 43.2\ N$$, attractive (toward each other)

MTE-01, Prob 3



$|\vec{F}_{41}| = |\vec{F}_{43}| = \frac{kq^2}{a^2}$

$|\vec{F}_{42}| = \frac{kq^2}{(\sqrt{2}a)^2} = \frac{kq^2}{2a^2}$

1 ④

a

↓ 2 ③ $\quad$ ③ 3

$$|\vec{F}_{tot}| = \frac{kq^2}{a^2}\cos45 + \frac{kq^2}{a^2}\cos45 + \frac{kq^2}{2a^2}$$

$$= \frac{kq^2}{a^2}\left(\sqrt{2} + \frac{1}{2}\right)$$

$$= \frac{(8.99\times10^9)\times(4\times10^{-6})^2}{(2\times10^{-2})^2}\left(\sqrt{2} + \frac{1}{2}\right)$$

$$= 688.4\ N$$

MTE-01, Prob 4

$$\vec{F} = q\vec{E} = (-6.8\times10^{-6})\times(2.465\times10^{5})\ N$$
$$= 1.68\ N \quad \text{to East}$$

MTE-01, Prob 5

$$V_1 + V_2 = 0 \qquad -\frac{kq}{y} + \frac{k2q}{\sqrt{a^2+y^2}} = 0 \Rightarrow 2y = \sqrt{a^2+y^2}$$
$$\Rightarrow 3y^2 = a^2 \Rightarrow y = \pm\frac{1}{\sqrt{3}}a = \pm 0.67\ m.$$
$$y = \frac{a}{\sqrt{3}} = \frac{2m}{\sqrt{3}} = 1.155\ m$$

MTE-01, Prob 6

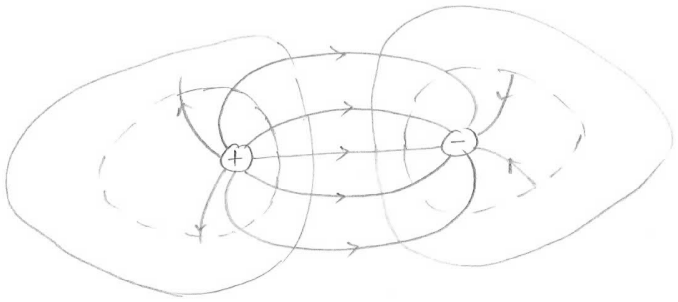
Proton accelerate, and electron decceleratu.

$$a_p = \frac{q_p E}{m_p} \qquad a_e = \frac{q_e E}{m_e}. \qquad \frac{a_p}{a_e} = \frac{m_e}{m_p} = 5.45\times10^{-4}$$

MTE-01, Prob 7

$$\Phi_E = \frac{Q_{enclosed}}{\epsilon_0} = \frac{+5e-5e}{\epsilon_0} = 0.$$

MTE-01, Prob 8



MTE-01, Prob 9

(a) $a = \frac{qE}{m} = \frac{1.6\times10^{-19} \times 620}{1.67\times10^{-27}} = 5.94\times10^{10}\ \frac{m}{s^2}$.

(b) $V_f = V_i + a\,\Delta t$

$1.4\times10^{6} = 0 + (5.94\times10^{10})\,\Delta t$

$\Delta t = \frac{1.4\times10^{6}}{5.94\times10^{10}} = 2.36\times10^{-5}$ sec.

(c) $\Delta x = \frac{V_f^2 - V_i^2}{2a} = \frac{(1.4\times10^{6})^2}{2\times(5.94\times10^{10})} = 16.50$ m

(d) $K_f = \frac{1}{2} m_p V_f^2 = \frac{1}{2} \times (1.67\times10^{-27}) \times (1.4\times10^{6})^2 = 1.64\times10^{-15}$ J

MTE-01, Prob 10

(a) $\frac{1}{R_{eq}} = \frac{3}{R}$ $\quad R_{eq} = \frac{R}{3} = \frac{300}{3} = 100\,\Omega$

(b) $V_1 = V_2 = V_3 = 10$ V

(c) $I_1 = \frac{V_1}{R_1} = \frac{10}{300} = 0.033$ A

$I_2 = \frac{V_2}{R_2} = \frac{10}{300} = 0.033$ A

$I_3 = \frac{V_3}{R_3} = \frac{10}{300} = 0.033$ A

$I_1 + I_2 + I_3 = 0.1$ A

(d) $P_1 = I_1 V_1 = (0.033)\,10 = 0.33$ W

$P_2 = I_2 V_2 = 0.33$ W

$P_3 = I_3 V_3 = 0.33$ W.