Three problems out of the text.

Due Monday, 14 January, 2008.

1 Serway, Problem 23.7

This is the type of problem most likely to be asked on an exam covering Coulomb's Law. Remember what you learned in SP211 about summing vectors. Follow Serway's example of calculating the straight line forces between pairs of charges first, *then* breaking those forces into components so that they may be summed...

SOLUTION

The **repulsive** force exerted on the 7.00-μC charge by the 2.00-μC charge is

$$F_{21} = k\frac{|q_1||q_2|}{r^2} \tag{1}$$

$$= \frac{(9\times10^9)(7\times10^{-6})(2\times10^{-6})}{(0.5)^2} \tag{2}$$

$$= 0.5\,\mathrm{N}. \tag{3}$$

The **attractive** force exerted on the 7.00-μC charge by the -4.00-μC charge is

$$F_{31} = k\frac{|q_1||q_3|}{r^2} \tag{4}$$

$$= \frac{(9\times10^9)(7\times10^{-6})(4\times10^{-6})}{(0.5)^2} \tag{5}$$

$$= 1\,\mathrm{N}. \tag{6}$$

These forces sum vectorially as

$$\mathbf{F} = \mathbf{F}_{21} + \mathbf{F}_{31} \tag{7}$$

$$= F_{21}(\cos 60^\circ \mathbf{i} + \sin 60^\circ \mathbf{j}) + F_{31}(\cos 60^\circ \mathbf{i} - \sin 60^\circ \mathbf{j}) \tag{8}$$

$$= 0.25\mathbf{i} + 0.43\mathbf{j} + 0.5\mathbf{i} - 0.87\mathbf{j} \tag{9}$$

$$= \boxed{(0.75\mathbf{i} - 0.43\mathbf{j})\,\mathrm{N}}, \tag{10}$$

which is equivalent to 0.872 N at 30° below the x-axis.

2 Serway, Problem 23.9

Remember that *equilibrium* does not mean zero charge...

SOLUTION

The **attractive** electric force between the spheres is

$$\mathbf{F} = k\frac{|q_1||q_2|}{r^2} \tag{11}$$

$$= (9 \times 10^9)\frac{(1.2 \times 10{-}8)(1.9 \times 10^{-8})}{(0.3)^2} \tag{12}$$

$$= \boxed{2.3 \times 10^{-5}\mathrm{N}}. \tag{13}$$

After the spheres are connected, the net charge on the joined spheres is $q_1 + q_2 = -6\,\mathrm{nC}$. Since they are identical conductors, this charge will evenly distribute itself over both spheres resulting a charge of -3 nC on each sphere. The **repulsive** electric force between them is then

$$\mathbf{F} = k\frac{q^2}{r^2} \tag{14}$$

$$= (9 \times 10^9)\frac{(3 \times 10{-}9)^2}{(0.3)^2} \tag{15}$$

$$= \boxed{9 \times 10^{-7}\mathrm{N}}. \tag{16}$$

3 Serway, Problem 23.10

Just do part (a).

SOLUTION

To show that a system will exhibit simple harmonic motion, we must show that it obeys Hooke's law

$$F_x = -\kappa x \tag{17}$$

where κ is constant. In this problem, we find the straight-line forces on the particle of charge $-Q$ as usual. The y-components cancel, and we are left with the *attractive* (i.e. negative) force

$$\begin{aligned} F &= -2k\frac{qQ}{r^2}\cos\theta && (18)\\ &= -2k\frac{qQ}{\sqrt{\frac{d^2}{4}+x^2}}\frac{x}{r} && (19)\\ &= -2k\frac{qQx}{\left(\frac{d^2}{4}+x^2\right)^{3/2}} && (20)\\ &\approx \boxed{-\frac{16kqQ}{d^3}x}, \qquad \text{for small } x && (21)\\ &\equiv -\kappa x. && (22) \end{aligned}$$

The period of oscillation will then be

$$\begin{aligned} T &= 2\pi\sqrt{\frac{m}{\kappa}} && (23)\\ &= \boxed{8\pi\sqrt{\frac{md^3}{kqQ}}}. && (24) \end{aligned}$$