Physics 1B
HW #1 Solutions
Chap 15 Conceptual Questions: 3, 4, 8, 10, 15, and 16
For Questions or Errors please email Morgan at mjbrown@ucsd.edu

3. As it is, the two rods are in unstable equilibrium. When released, the rods will only stay in the position they are currently in if *perfectly* aligned. Since there is a good chance they are just slightly misaligned when released, we expect the rods to rotate.

   We know the positive side of one rod will be attracted to the negative side of the other rod, but there are two configurations that have the plus and negative close together. Although there will probably be oscillations before the system settles into equilibrium, the final configuration will have *either* the rod on the left or the rod on the right rotated180 degrees. The final configuration will be stable; this is because if you move a rod slightly, the system will tend to go back the way it was.

4. In an atom, the nucleus is at the center, and the electrons are traveling around it. Sometimes a few of these electrons can be removed (this process is called ionization) from the atom. Once free, these electrons can move about, and that is what we call current. Thus, it makes sense that the mobile electrons are the charge carriers. (Note, we often talk about "positive" current. In reality, no positive charges are usually moving. Just think as the positive current as going in the opposite direction as the electrons.)

8. The electric field is caused by charged particles. Thus, if the test charge itself had a large charge, it would have its own electric field, and that would change the field you are trying to measure.

10. The student will not receive a shock in this case. Since the student is insulated from the ground, the charge that is accumulated on the top of the Van de Graaff generator and in her body has nowhere to go. You only feel a shock when charge is transferred, not when it is just building up in one place. (Note, as the charge builds up in your body, it often causes your hair to stand on end since the like charges are trying to repel each other and get as far away as possible.)

15. The answer is the same for all three cases. Gauss's law only works when you have a great deal of symmetry in the problem. It is usually used for spherical symmetry or rotational plus translational symmetry. The reason is because you must have a constant electric field on the Gaussian surface that you draw. In all three of the examples, there is no way to draw a Gaussian surface that has a constant electric field.

16. Grounding the television antenna is important to protect your equipment in the case of a lightning storm as well as to reduce electromagnetic interference. See http://www.tvantenna.com/support/tutorials/emi.html for more details.

Physics 1B Winter 2007

HW # 1 Solutions

Problems: 3, 9, 11, 16, 17, 15, 30

[3]

alpha particle $= q_1 = +2.0e$

gold nucleus $= q_2 = +79e$

dist $= 2.0 \times 10^{-14}\,m = r_{12}$

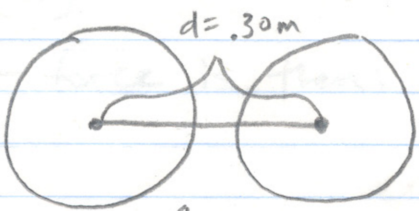
Coulomb's Force Law: $F_{12} = \dfrac{K q_1 q_2}{(r_{12})^2}$

$$F = \left(9\times10^{9}\,\frac{Nm^2}{c^2}\right)\frac{(2)(79)(1.6\times10^{-19}\,c)^2}{(2.0\times10^{-14}\,m)^2} = \boxed{91\,N}$$

(repulsive)

[9]

a)

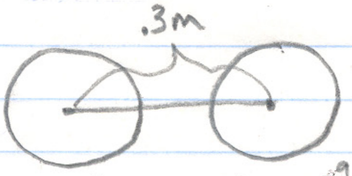


$q_1 = 12\times10^{-9}C$; $q_2 = -18\times10^{-9}C$

as above, $F = \dfrac{Kq_1q_2}{r^2} = $ $\boxed{2.2\times10^{-5}\,N}$ attractive because opposite charge

b) When connected some charge cancels. Net charge is $+12\times10^{-9}C - 18\times10^{-9}C = -6\times10^{-9}C$

so



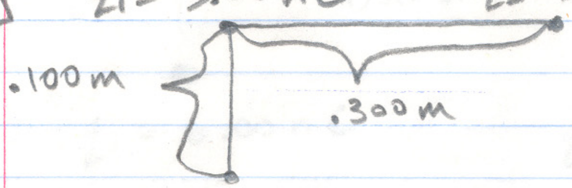
$q_1 = -3\times10^{-9}c$, / $q_2 = -3\times10^{-9}c$

$F = \dfrac{Kq_1q_2}{r^2} = $ $9\times10^{-7}\,N$ repulsive b/c same charge

Physics 1B Winter 2007

HW # 1 Solutions Page 2

11

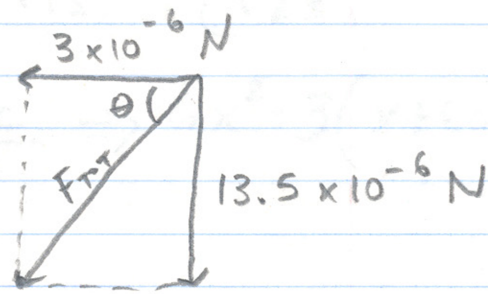


We solve for the force of the two other charges on q_1 and then combine the results.

$$F_{21} = \frac{k q_1 q_2}{(r_{12})^2} = 3 \times 10^{-6}\ N \quad \text{to the left}$$

$$F_{31} = \frac{k q_1 q_3}{(r_{13})^2} = 1.35 \times 10^{-5}\ N \quad \text{to the bottom}$$

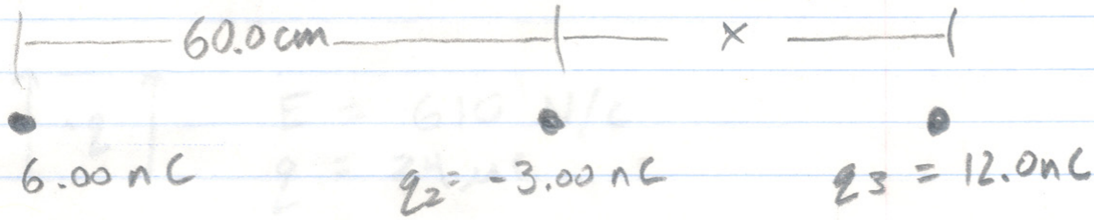
The net force is then:



$$F_{TOT} = \sqrt{(F_{21})^2 + (F_{31})^2} = \boxed{1.38 \times 10^{-5}\ N}$$

with $\theta = \tan^{-1}\left(\frac{13.5}{3}\right) = \boxed{77.5^\circ \text{ (see diagram)}}$

16



Since we put in a positive charge, it must be on the right side of both q_1 & q_2. We need to figure out how far to the right it is.

We balance the forces: $|F_{13}| = |F_{23}|$

$$\frac{k q_1 q_3}{(r_{13})^2} = \frac{k q_2 q_3}{(r_{23})^2} \Rightarrow \frac{q_1}{(r_{13})^2} = \frac{q_2}{(r_{23})^2}$$

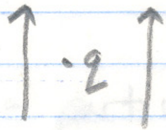
$$\frac{6.00\,\text{nC}}{(x + 60\,\text{cm})^2} = \frac{3.00\,\text{nC}}{x^2} \Rightarrow 6x^2 = 3(x+60)^2$$

$$\left(\frac{6}{3} x^2\right)^{1/2} = \left((x+60)^2\right)^{1/2} \Rightarrow \sqrt{2}\, x = x + 60$$

$$(\sqrt{2} - 1)\, x = 60 \rightarrow x = \frac{60}{\sqrt{2} - 1} = \boxed{145 \text{ cm right of } q_2}$$

Note: If you drop units when doing a calculation, always remember to put them back on correctly at the end.

17



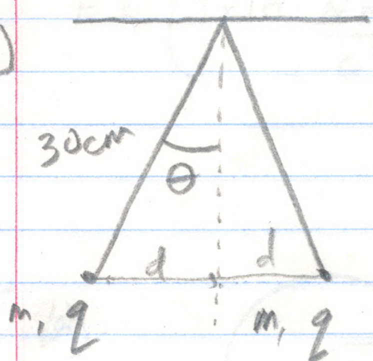
$E = 610\ N/C$

$q = 24\ \mu C$

To float $F_{elec} = F_{grav}$

$$qE = mg \implies m = \frac{qE}{g} = \frac{(24\mu C)(610\frac{N}{C})}{(9.8 m/s^2)} = \boxed{.0015\ kg}$$

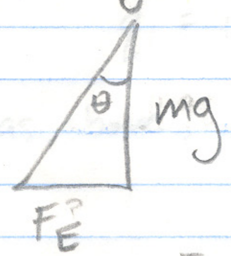
15



$\theta = 5°$

$d = (30cm)\sin\theta = 2.61\ cm$
$= .0261\ m$

$m = .20g \rightarrow F_g = mg$



$$\tan\theta = \frac{F_E}{mg} \rightarrow \boxed{F_E = mg\tan\theta}$$

$$F_E = \frac{kq^2}{(2d)^2} \rightarrow q = \sqrt{\frac{4d^2 mg\tan\theta}{k}} = \boxed{7.2\times10^{-9}\ C}$$

30