Problems: Week 3

3-1. The human ear has a "drum" which is roughly circular with a diameter of 1cm. If a 60dB sound wave lands on you ear how much power (energy/sec) does it deliver? Why? What is the pressure amplitude of this wave if frequency is 440Hz?

3-2. You are standing on the platform when a train travelling at 30mph passes by. If the engineer blows a horn at 300Hz what is the change in the frequency of the sound perceived by you as the engine goes by. [assume that speed of sound is 330m/sec]

3-3. Suppose you are driving toward a hill at 60mph and you blow your horn at 500Hz. What is the frequency of the "echo" you will perceive as the reflected wave gets back to you? Why?

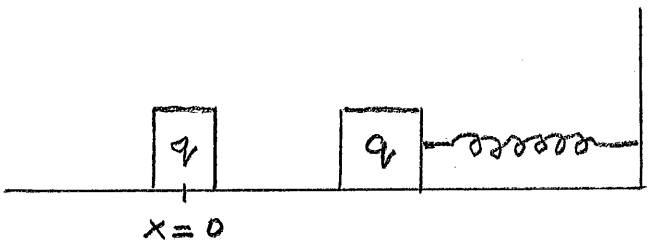
3-4. A piano tuner uses a tuning fork to set the wire tension for a chosen string. Initially, she tunes the "A" string by ear and sounding it along with her 440Hz fork perceives 4 beats. What are the frequencies of the sound from the string? She then tightens the string very slightly and now hears 6 beats. What was the frequency after the initial tuning? Why?

3-5. Consider the copper penny in your pocket. How many electrons must you remove from it so it will acquire a charge of $+10^{-9}$C?
($e = -1.6 \times 10^{-19}\, C$)

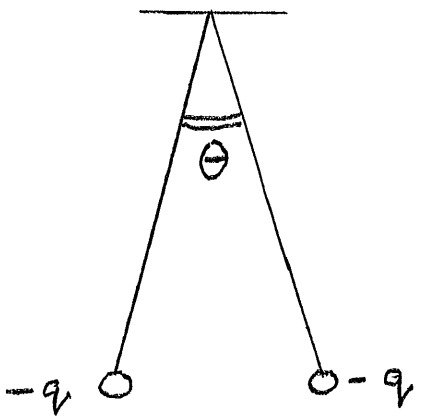
3-6. Cu has a molar mass of 64gm and a density of 8.95gm/cm^3. We are told that it is a conductor because each Cu atom contributes one electron which is free to move. How many mobile electrons would you estimate in one m^3 of Cu?

3-7. In the Bohr model of the hydrogen atom the electron is in uniform circular motion around the proton, the centripetal force being due to the Coulomb force. If so, what must be the speed of the electron if the orbit radius is $0.5\times10^{-10}\,m$.
($m_e = 9\times10^{-31}\,kg$)

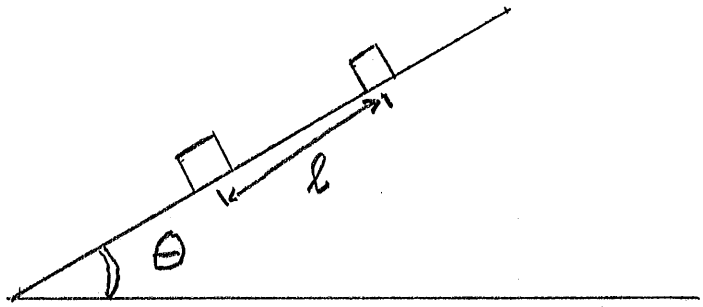
3-8. The picture shows two equal positive charges q. One of them is fixed at x = 0 and the other is attached to a spring and free to slide on a smooth frictionless surface. At equilibrium the separation between the charges is 2mm, the spring length is changed by 1mm and the spring constant is 10^3N/m
(i) Is the spring squeezed or stretched? Why? (ii) Calculate q.



3-9. Two equal negative charges are suspended by two l = 1m long strings. At equilibrium the angle Θ is 5°. If their masses are 10^{-3}kg, what is q?

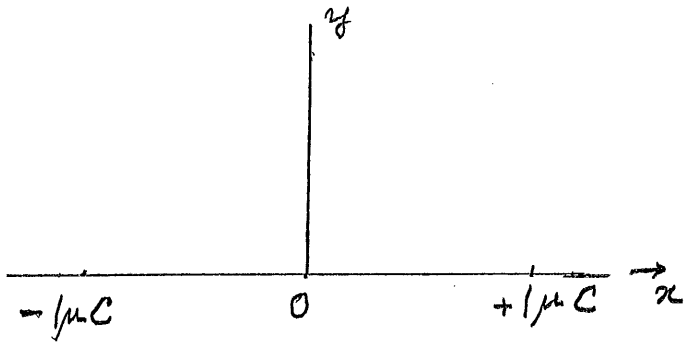


3-10. Two equal positive charges of 5μC each of mass 0.05kg, are lying on a smooth frictionless inclined plane, $\Theta = 30°$. The lower charge is fixed. What must be their separation l if the upper charge is to be at equilibrium?



3-11. Two charges, 1μC and 16μC are fixed at x = 0 and x = 5m. Where would you place a charge of -5μC so that it experiences no force? Why?

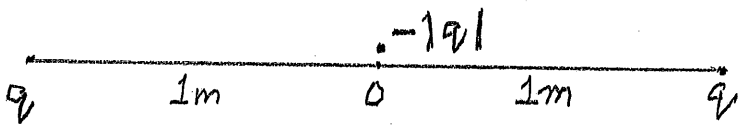
3-12. A dipole consists of two equal and opposite charges $\pm 1\mu C$ located at $x = \mp 0.01$m. Calculate the force, magnitude and direction experienced by a charge located at (i) x = 1m, (ii) y =1m. [Express your result in terms of the dipole moment vector $\underrightarrow{p} = q\underrightarrow{l}$ where magnitude of l is the charge separation, and the direction of l is from negative to positive q.]



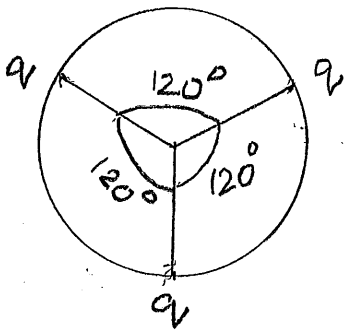
3-13. Two equal charges q are located at $x = -a$ and $x = +a$. Show that if you place a charge –q on the y-axis at y << a it will experience a force

$$\underrightarrow{F_E} = \frac{-2k_e q^2 y}{a^3}\hat{y}$$

If you let the negative charge go it will exhibit linear harmonic motion
(i) Calculate the frequency of this motion $q = 1\mu C$ if, a = 1m and mass $=10^{-4} kg$ $\left(k_e = 9\times10^9 \frac{N-m^2}{C^2}\right)$. (ii) Calculate the length of a simple pendulum which will have the same period.



3-14. Three equal charges are symmetrically located on the circumference of a circle, as shown. What is the force experienced by a charge placed at the center? Why?



3-15. Sketch the $\underrightarrow{E}$ - field lines for charges of $+/\mu C$ and $-2\mu C$ placed at x = 0 and x = 1m respectively.