Problems: Week 5

5-1. What is potential energy? [Do not write mgh] Hint: Read the notes from 121 and then formulate your answer

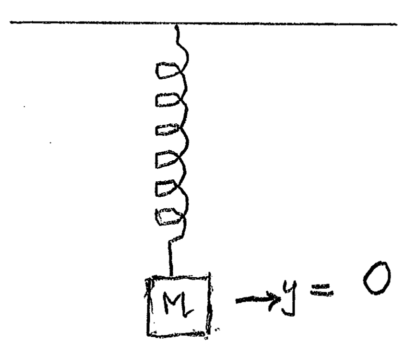
5-2. Why is there a minus sign on the right hand side of the equation for ΔU (the change of potential energy in an $\underset{\rightarrow}{E}$ field)

$$\Delta U = -\underset{\rightarrow}{F}_E \cdot \underset{\rightarrow}{\Delta S}$$

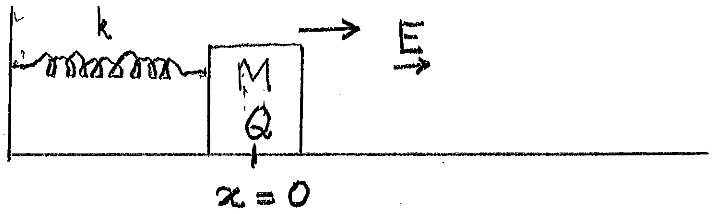
5-3. The following problem is the exact equivalent of a problem we did in Phys121. Recall: a mass M is suspended vertically as shown. At y = 0, M is at rest (you are holding it). The spring is un-stretched and the gravitational potential energy is set at zero. Show that if you let M go it will move by an amount

$$\Delta y = \frac{-2Mg}{k},$$

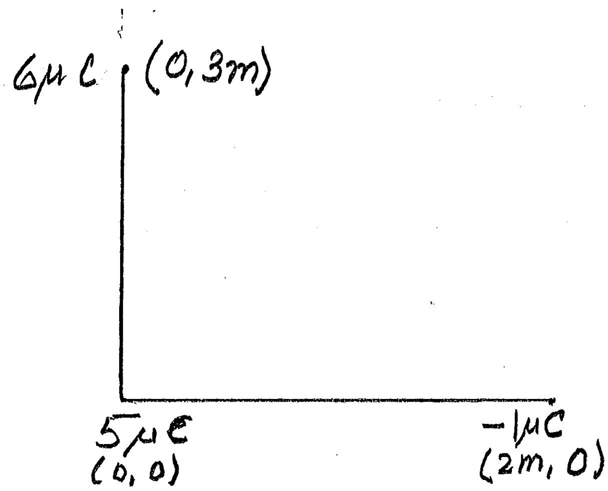
before rising again and will oscillate between y = 0 and $y = \frac{-2Mg}{k}$. (Here k is the spring constant)



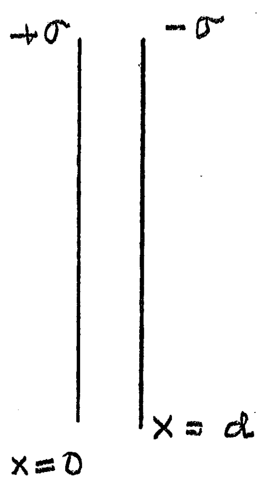
5-4. An object with mass M and charge Q is attached to a spring of constant k. The whole system is located in a uniform $\underset{\rightarrow}{E}$ field. The mass is released at rest at x = 0 when the spring is un-stretched and the electrical potential energy is set at zero.
(i) Calculate how far it will move before returning. Why? (ii) What is the value of x when mass is in equilibrium? Why? (iii) What is the period of the oscillation?



5-5. Calculate the potential energy of the three charge system shown in the figure.



5-6. Two large plates each (4m x 4m) carry charges $\pm 10\mu C$ and are separated by d = 1mm. (i) What is the charge density $\pm\sigma$ on the plates? (ii) What is the $\underset{\rightarrow}{E}$ field between the plates? (iii) What is the potential difference between the plates? (iv) If you want to move an electron from the left plate to the right plate how much work would be done?



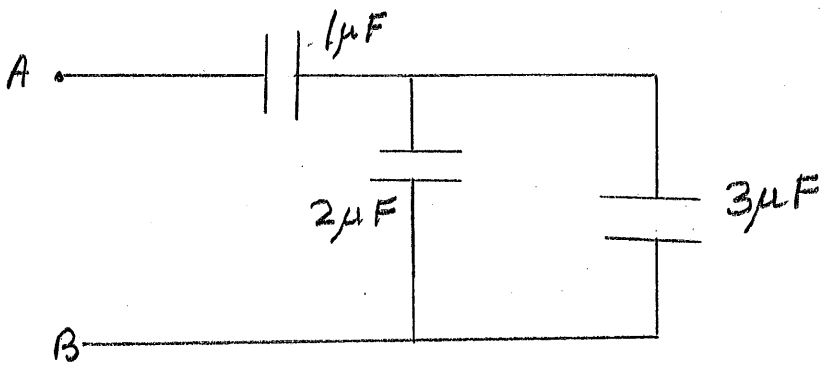
5-7. In the famous Rutherford Experiments which provided the first clue regarding the structure of atoms, (mass concentrated in a nucleus at the center) α -particles of mass $6.4\times10^{-27}\,kg$ and charge +2e were directed toward Au nuclei of charge 79e. If the α -particles had a velocity of about $10^{7}\,m/s\ \hat{x}$ directed toward an Au nucleus sitting at x = 0, how close would it get to the Au nucleus before turning around?

5-8. What are the differences between a battery and a capacitor? Explain in detail.

5-9. In a parallel plate capacitor the plates have area (0.5m x 0.5m) and are separated by 0.01m. What is the capacitance if (a) there is air between the plates, (b) there is a dielectric constant $\kappa = 2$ between the plates?

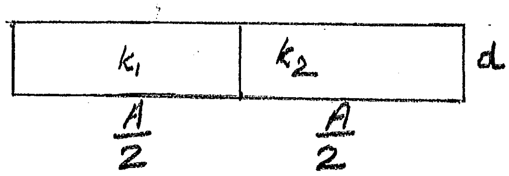
5-10. How many $1.0\mu F$ capacitors would you need to connect in parallel so that they can store a charge of 0.1C with a potential of 300V across the totally capacitance?

5-11. For the circuit shown, what is the equivalent capacitance across AB. If you attach a 12 volt Battery across AB what are the potential differences and charges on the capacitors?



5-12. As shown a parallel plate capacitor is filled with two dielectrics each occupying one half. Show that the equivalent capacitance is

$$C_{eq} = \frac{\varepsilon_0 A}{2d}(k_1 + k_2)$$



5-13. Now the two dielectrics have areas A but each is $\frac{d}{2}$ thick. Show that

$$C_{eq} = \frac{2\varepsilon_0 A}{d}\left(\frac{k_1 k_2}{k_1 + k_2}\right)$$