Physics 106b – 2011 Assignment 1

Due: Fri., Jan. 28, 4 pm (turn in to envelope on windowsill across from my office)
Reading: Chapters 23 and 24, plus sections 25-1, and 25-2
Assigned exercises
To encourage you to start from the basic premises as much as possible, you may only use basic definitions (such as $v \equiv \frac{dx}{dt}$), mathematics, equations from physics 105 or an equivalent mechanics course ($\mathbf{F} = m\mathbf{a}$, $s = \Delta x = v_0 t + \frac{1}{2}at^2$, etc.), principles which are not ordinarily expressed in equations (*e.g.* "Electric fields superpose." or "The electric field inside a conductor is zero."), and the following equations as starting points for these problems:

Definition of electric field: $\mathbf{E} = \frac{\mathbf{F}}{q}$ **Field of a point charge:** $\mathbf{E}_{\substack{\text{point}\\\text{charge}}} = \frac{kq}{r^2}\hat{\mathbf{r}}$

Field of an extended object: $\mathbf{E} = \int \frac{k\,dq}{r^2}\hat{\mathbf{r}}$

Gauss's Law: $\oint \mathbf{E}\cdot\hat{\mathbf{n}}\,dA = \frac{q_{\text{net, enclosed}}}{\varepsilon_0}$ $k = \frac{1}{4\pi\varepsilon_0}$

Definition of flux: $\phi_E \equiv \int \mathbf{E}\cdot\hat{\mathbf{n}}\,dA$.

If field is uniform and angle between field and area is constant, $\phi_E = EA\cos\theta$

$E_{\substack{\text{due to}\\\text{sheet}\\\text{charge}}} = \frac{\sigma}{2\varepsilon_0}$ $E_{\substack{\text{total,}\\\text{at metal}\\\text{surface}}} = \frac{\sigma}{\varepsilon_0}$

Definition of voltage: $V \equiv \frac{U_{\text{Elec}}}{q}$

Connections between *V* and E: $\Delta V_{AB} = -\int_A^B \mathbf{E}\cdot d\ell$ $\mathbf{E} = -\nabla V$, where $\vec{\nabla} \equiv \hat{\mathbf{i}}\frac{\partial}{\partial x} + \hat{\mathbf{j}}\frac{\partial}{\partial y} + \hat{\mathbf{k}}\frac{\partial}{\partial z}$

<u>If</u> field is uniform: $\Delta V_{AB} = -\mathbf{E}\cdot\ell$ $E = -\frac{dV}{dx}$

Assigned exercises appear on the next page.

These are all group problems, i.e. after spending at least ten minutes for each problem attempting them on your own, you are encouraged to work in small groups (2-5 students) together on them. What you turn in must be your own, i.e. do not blindly copy from one of your group members. (For a problem that you've had difficulty understanding, get one of the other group members to explain to you how to do it, rather than just copying without understanding.)

Ch. 23: Questions 4 (assume the charges shown in the figure are fixed in place), 5, 16, 22
Problems 10, 48, 76
Ch. 25: Questions 16, 21

Here is the solution to the related problem 23-75: Suppose the ink droplets enter the field region perpendicular to the field, as in the geometry of example 23-10. Then the analysis of that example shows that

$$\frac{v_x}{v_y} = \tan\theta = \frac{qE_y\,\Delta x}{mv_x^2} \Rightarrow \Delta x = \frac{mv_x^2\tan\theta}{qE_y} = \frac{(0.11\,\mu\text{g})(12\text{ m/s})^2\tan\theta}{(2.1\,\text{pC})(97\text{ kN/C})} = 1.37\text{ cm}$$

Plus problem 1A below:

1A. Two positive point charges +q are fixed on the y-axis at $y = +a$ and $y = -a$. A bead of mass m carrying a charge $-q$ slides without friction along a thread that runs along the x-axis.
Show that for small displacements of $x << a$, the bead experiences a restoring force that is proportional to x and therefore undergoes simple harmonic motion, and find the period of the motion.*Hint: Work by analogy with a mass on a spring – you should know the form of the force for this, and the equation for the resulting period from last semester. Correct answer:*

$$2\pi\sqrt{\frac{ma^3}{2kq^2}}$$

Code of Conduct in Classes:
Advice from Faculty in Physics and Astronomy

In the interest of encouraging all students in our classes to do their best, we request that each of you carefully adhere to the following standards:

Do

Ask questions even if you think you're the only one unsure.
Give positive reinforcement to others during and after class.
Help other students to feel comfortable in class.
Let your instructor know about problems affecting classroom morale.
Recognize that backgrounds and rates of development can vary from one person to another in science.

Don't

Ridicule others either during or after class.
Express frustration with the different levels of experience of your classmates.
Use classroom interactions as a way to impress people.