Workshop 1

PHY142: Honors Introductory E&M

09-11-2013

"From a long view of the history of mankind – seen from, say, ten thousand years from now – there can be little doubt that the most significant event of the 19th century will be judged as Maxwell's discovery of the laws of electrodynamics. The American Civil War will pale into provincial insignificance in comparison with this important scientific event of the same decade."
- Richard Feynman, The Feynman Lectures on Physics, Vol. II (1964)

Objective: Introduction to how workshops will be run, getting to know one another. We'll cover the basics: Coulomb's law, continuous charge distributions, electric fields, preparation for vector calculus review with Professor Orr (mainly working with curvilinear coordinate systems). Going to go over problems 3 & 4, mini-lecture on vector calculus. If there are left over problems we will complete them next week.

Electrostatics Problems:

1 Two small charged spheres hang from cords of equal length ℓ and make small angles θ_1 and θ_2 with a vertical.

a If $Q_1 = Q$, $Q_2 = 2Q$, and $m_1 = m_2 = m$, determine the ratio $\frac{\theta_1}{\theta_2}$.

b If $Q_1 = Q$, $Q_2 = 2Q$, $m_1 = m$, and $m_2 = 2m$, determine the ratio $\frac{\theta_1}{\theta_2}$.

c Estimate the distance between the spheres for each case.

2 A thin rod bent into the shape of an arc of a circle of radius R carries a uniform charge per unit length λ. The arc subtends a total angle of $2\theta_0$, symmetric about the x-axis. Determine the electric field $\mathbf{E}$ at the origin, 0.

3 Long line of charge. Determine the magnitude of the electric field at a point P a distance x away from the midpoint 0 of a very long line (a wire, say) of uniformly distributed positive charge. Assume x is much smaller than the length of the wire, and let λ be the charge per unit length (C/m).

4 Uniformly charged disk. Charge is distributed uniformly over a thin circular disk of radius R. The charge per unit are (C/m^2) is σ. Calculate the electric field at a point P on the axis of the disk, a distance z above its center.

Math Problems:

5 Find the gradient of each of the following functions:

a $f(x, y, z) = x^2 + y^2 + z^2$

b $f(x, y, z) = 10x^4y^9z^{10}$

a $f(x, y, z) = e^{i2x}\sin(y)\ln(z)$

6 Find the divergence of each of the following vector functions:

a $\mathbf{v}_1 = x^2\hat{\mathbf{i}} + 3xz^2\hat{\mathbf{j}} - 2xz\hat{\mathbf{k}}$

b $\mathbf{v}_2 = xy\hat{\mathbf{i}} + 2yz\hat{\mathbf{j}} + 3zx\hat{\mathbf{k}}$

a $\mathbf{v}_3 = y^2\hat{\mathbf{i}} + (2xy + z^2)\hat{\mathbf{j}} + 2yz\hat{\mathbf{k}}$

7 Find the curl of the vector function $\mathbf{v}_3 = -y\hat{\mathbf{i}} + x\hat{\mathbf{j}}$. Sketch the curl, what direction does the curl of $\mathbf{v}_3$ point? Intuitively speaking, what do you expect the divergence to be? Then calculate the curls of problems 6(a-c).

8 Find the volume of a sphere of radius R using integration.

9 Find the formulas for r, θ, ϕ in terms of x, y, z – the inverse, in other words, of spherical polar coordinates.