FREQUENTLY ASKED QUESTIONS

February 27, 2003

Administrative Questions

Can we put how-tos on our formula sheets?

Prof. Roland says no. Of course you can put the formulae from the how-tos on the sheets. I'd advise practising so you're as familiar with the steps as possible.

What will be on the quiz?

Prof. Roland's review slides on the course web page give an excellent guide of what to study. Here also are my notes on WUN2K (which I didn't quite get to in recitation today):
`http://cyclo.mit.edu/~schol/802x/handouts/wun2k.pdf`

What will be the level of difficulty of the problems? Will there be a problem as difficult as part c of the example problem in recitation?

The practice quizzes are a good guide to the difficulty of the problems. Part c of today's example problem would be on the most difficult end of the possible range of problems.

Content Questions

Why do weak, strong, electric and gravitational forces apply to different sizes?

The four fundamental forces act at on objects of any size; the issue is what distance scale the forces become *relatively important*. The strong force becomes very large at small distances. The gravitational force becomes relatively important for large objects at large distances, because macroscopic objects tend to be mostly neutral so don't have much electrical force.

Can you explain the charged slab CyberTutor problem?

These can be done with the Gauss' Law how-to; the trick is to pick the right surfaces. For part B: pick a Gaussian box which sticks out of the surface on either side, with end surfaces parallel to the slab surface. The electric field is perpendicular to the slab surface. The flux through the sides of the Gaussian box is therefore zero. The flux through each end of the box is EA, where A is the area of the Gaussian box. So the LHS of Gauss Law is $2EA$. The RHS of Gauss' Law is q_{in}/ϵ_0. q_{in}, the charge inside, is the charge density ρ times the volume of the slab which is inside the Gaussian box. This volume is Ad. Reuniting the LHS and RHS of Gauss' Law and solving for E, the A's cancel and you get $E = \frac{\rho d}{2\epsilon_0}$.

For part C: pick a Gaussian box with one end flush with the $x = 0$ side of the slab and the other end at x. The LHS of Gauss's Law is the flux through the end at $x = 0$ which is EA, where E can be taken from part B, *plus* the flux through the end at x, which is $E(x)A$. The RHS is the charge inside this box, which is ρAx. So we get $\frac{\rho d}{2\epsilon_0}A + E(x)A = \frac{\rho Ax}{\epsilon_0}$. Once again A cancels, and solving for $E(x)$ you get $\frac{\rho}{\epsilon_0}(x - \frac{d}{2})$.

Can you explain the torque on a dipole?

A dipole is just an positive and negative charge (of equal q) separated by a distance l. The dipole moment is defined to be $\vec{p} = q\vec{l}$ where $\vec{l}$ is the vector from the negative to the positive charge. Imagine you put this pair of charges in an electric field. The positive charge wants to go along the field lines, the negative charge wants to go the opposite way. This tries to *rotate* the dipole. So there is a *torque*, and the magnitude of the torque is $\vec{p} \times \vec{E}$. See section 21-11 in the text.

Can you explain the third to last and second to last slides on the web?

The third to last is just explaining the superposition principle for potential. At a point, you add potentials due to all charges; but unlike electric field, potential is a *scalar*, so you just add numbers. See section 22-3, 22-4 in the text. The second to last slide shows the potential from the uniform electric field you would get between two plates. Potential for constant $\vec{E}$ is then just -E times distance x ($-$work done by the field, divided by charge q). So V versus x is therefore a straight line with negative slope. Potential *energy*, on the other hand, is positive or negative depending on the sign of charge q. So two lines are plotted for potential energy U, one with positive slope for negative q (increasing potential energy– you have to push the charge, like lifting in a gravitational field), and one with negative slope for positive q (decreasing potential energy, for charge "falling" along field lines).

How do you find σ when doing a conductor/insulator problem?

Usually you can use the Gauss' Law how-to, except reverse the last couple of steps. Generally, you figure out $\vec{E}$ by some other means, and use Gauss' Law to *solve* for the charge inside. Using the charge inside some convenient Gaussian surface, you find σ, the charge per unit area on a surface (or λ, or ρ or whatever).

Where does potential flow from?

Potential doesn't really "flow" the way an electric field line does... potential is a *scalar*, unlike electric field, which is a *vector*. The best way to think of potential is by analogy with gravitation. It's a "property of space" that tells you how much potential energy an object has at some position.

What is an "equipotential surface"?

This is just a surface where the potential is the same everywhere on the surface. For instance, for a uniform electric field, equipotential surfaces are perpendicular to the field. For a spherical charge distribution, equipotential surfaces are spheres (at constant r.) See text section 23-5.

I didn't understand problem 4 of one of the practice exams (a charged ring). Is this similar to what we did in class today?

The idea behind this problem was really superposition. For the electric field, you add up electric forces vectorially (example 21-9 in the text); only the component along the axis of the ring counts; the perpendicular components cancel by symmetry. Potential, on the other hand, is a *scalar*. You just add up the potentials due to all the pieces of the ring. See example 23-8.

In $\Delta U = -\Delta W$, why is there a negative sign?

If the field does work – imagine a positive charge "falling" along field lines – the potential energy is *decreasing* (like for falling) so the change in potential energy is negative.

What exactly is V?

V is potential. It's a quantity, like electric field, which is a property of space for some distribution of charges. $V = U/q$, so it tells you how much potential energy a charge q would have at some point in space.

If the potential inside a conducting sphere is constant, what about the potential inside a non-conducting sphere?

The potential inside a non-conducting sphere depends on whether the non-conductor is charged or not. If it's uncharged, there's no field inside and potential is constant. If there's charge inside, you have to find the electric field, and integrate to find the potential.

When do you solve generally for $V(r)$, $E(r)$, as opposed to at a particular point?

It's usually best to solve as generally as you can.

In step 3 of the potential "how-to", how do you choose A and B? What is $d\vec{l}$? How do you evaluate the line integral? How do you choose $d\vec{l}$?

Choose A to be the point where you want to find V, *e.g.* $V(r)$. B is some point where you *know* V. This could be where V is zero, or just some other point where you know V. A and B should be connected by a region of space where you know E.

In a path integral, $d\vec{l}$ is a little piece of the line... you are moving along the line and adding up some quantity along it. When calculating the potential difference, you are adding up the work done along each piece $\vec{E} \cdot d\vec{l}$. You can choose whatever path you like. Since work done by the field is independent of path, you can pick a simple path. If $\vec{E}$ is parallel to $d\vec{l}$, then $\vec{E} \cdot d\vec{l}$ is just Edl. So pick a path where $\vec{E}$ is parallel to $d\vec{l}$. For instance, for spherical symmetry, you can choose a radial path. Then $d\vec{r}$ is just a radial piece of the radial path.

Then the integral can be just crunched through like any integral.

In today's charged sphere example problem, E was linear in r inside the surface. Why doesn't E change with respect to r outside the sphere?

It *does* change outside the sphere! Outside the sphere, it goes as $1/r^2$ (like a point charge).

In today's charged sphere example problem, why didn't we make a Gaussian surface for part a, but we did for part c?

We did make Gaussian surface for part a, too. This was a sphere with radius $r > R$.

In today's charged sphere example problem part a, how did you do the integral $V(r) = -\int_\infty^r \frac{Q}{4\pi\epsilon_0 r'^2} dr'$? And how did you choose r and ∞ to be the limits of integration?

It's just a normal integral (note the integration variable is a "dummy variable" r' to distinguish it from the r in the limits of integration.) The upper limit r is the point B from the how-to; it's where you want to find $V(r)$. The lower limit ∞ is the point A from the how-to; it's where you know V (it's zero, because you've chosen infinity as the zero potential point).

In today's charged sphere example problem part c, why did we choose V_A to be at the surface? Why couldn't we choose ∞?

Because the line integral is over *some region where you know E*. At the surface of the sphere, the functional form of E changes. You need to do the line integral from the surface to the point where you are at r (where you have found $E(r)$ in step 1). The start of this line integral is A, at the surface where you know $V(R)$ from part a of the problem.

In today's charged sphere example problem part c, why does $\frac{Q_{in}}{Q} =$

$\frac{V_{in}}{V}$?

The charge inside an inner sphere with radius r is just proportional to the volume inside, for uniform charge density.

In today's charged sphere example problem, what did the graphs you drew mean? How do you use these sorts of graphs?

I drew $E(r)$ and $V(r)$ to visually represent the field and potential. For $r < R$, $E(r)$ increases linearly with r. At the surface, where $r = R$, it starts to drop as $1/r^2$ for $r > R$. The potential has a parabolic shape for $r < R$, and at the surface drops as $1/r$ for $r > R$. Note that both field and potential look like those for point charges at $r > R$.

In today's charged sphere example problem, why was the potential on the surface of the charged sphere zero?

It *wasn't* zero on the surface of charged sphere. It was $V(R)$, which we got from plugging in $r = R$ to the answer from part a. Of course, you could *define* potential to be zero at the surface if you wanted, but we had already defined potential to be zero at infinity. You can't change your zero point in the middle of the problem!

If V is independent of charge, why was there a Q in the final answer of the example problem?

V (like $\vec{E}$) is independent of the *test* charge. It's not independent of *source* charge Q.

How do the LVPS and HVPS work?

Well, the answer to this question is rather long, and is explained in detail in your experiment handouts. I would like to point out that *you are not expected to understand all of this material* right away. Much of it involves concepts not yet introduced. Unfortunately, because you need these power supplies to do the experiments, you have to build them before we cover the concepts. I recommend that later in the course, after we've covered such topics as capacitors, electric circuits, inductors, etc., you go back and reread the LVPS and HVPS information. You will find that much of it makes a lot more sense!

Other

Why was the Sparkly Frog so unenthusiastic today?

You would be too if people kept increasing your potential energy, only to let you lose it again.

Tidbits

Best joke from today's questionnaires

Two guys walk into a bar. And the third one ducks!

(Hey, students... surely you can do better than this on the jokes? :))