FREQUENTLY ASKED QUESTIONS

March 13, 2003

Administrative Questions

Can we have our formula sheets back from the last quiz?

Please ask Prof. Roland; I assume he kept them.

Content Questions

In the pset problem, what's that resistor with the arrow through it? What do we do with that?

That's just a variable resistor. It means you can modify the resistance. It's like the potentiometer ("pot") in your LVPS.

What happens when you partially remove dielectric from between capacitor plates?

Dielectric increases capacitance. So you can store more charge for the same potential difference if there's dielectric inside capacitor plates. Suppose you have a charged capacitor which is disconnected from a battery (constant Q). If you remove dielectric from it (even partially), the capacitance decreases, so V, the potential difference between the plates, increases. Since $U = \frac{1}{2}QV$, energy stored increases. This energy comes from the work you did to remove the dielectric (which is attracted to the plates).

In the resistor network practice problem, can you redraw it all in one diagram, as 369 in parallel with 5, and that in series with 2 and 8, and then that in parallel with 4, and then that in series with 1 and 7? I got a different answer.

Yes, you can draw the equivalent circuit all at once the way you describe (rather than doing it step-by-step as we did in class) and you should get the same answer: 369 in parallel with 5 is $3R/4$; that in series with 2 and 8 is $2R + 3R/4 = 11/4R$; that in parallel with 4 is $11R/15$; that in series with 1 and 7 is $2R + 11R/15 = 41/15R$.

In the resistor network practice problem, can't you just have 369 in series, in parallel with 258 in series, in parallel with 147 in series?

No, this won't work. Remember, "in parallel" means "has the same potential difference across". The 369 group and the 258 group don't have the same potential difference across them! Also remember that "series" means "back-to-back", with nothing else drawing current away. The resistors 3, 6, and 9 are in series, but 2, 5 and 8 are not!

In resistor network problems, how do you know where to start for simplifying them?

Mostly, it's just practice... try to identify a grouping which is in series or in parallel. Sometimes you cannot make an equivalent resistance at all and you have to use Kirchoff's Rules– for instance, often if there is more than one battery in the circuit, you need to do this. We will see examples.

What are the effects of open and closed switches?

An open switch is an "open circuit": charges have no way of getting across, so there is no current in that branch of the circuit. When a switch is closed, it allows current to flow through in that branch of the circuit.

Can you clarify the loop rule gravitational analogy?

A battery "pumps" charge: it does work to separate charges from each other to maintain a given potential difference. This is analogous to lifting in a gravitational field: when you lift something, you do work to give it some potential energy. Similarly, the battery does work to give charges potential energy. In our fish analogy, the battery lifts buckets of fish up a hill. The potential decreases across resistors in the direction of the current, according to Ohm's Law, $V = IR$. The mechanical analog to a resistor is a hill full of boulders. Imagine the bucket of fish getting poured down the hill... their gravitational potential energy decreases down the hill. But if you lift them back to the top of the hill, their net change in potential is zero. Similarly, the net change in potential of charges going around the circuit loop is zero.

What's a "voltage drop"?

It's just a decrease of potential across some object like a resistor (it's a decreasing potential difference). It's called that due to the gravitational analogy.

What was that demon you were talking about?

This was just a fanciful way of describing how a battery works. A battery does whatever it has to do to make a constant potential difference across its terminals. You can imagine an obsessed little demon inside working hard to pump charge across to make the potential difference right. Of course, batteries don't *really* have little demons inside them– they have goblins.

Can you review the algebra for solving the differential equation for charging the capacitor?

See text p. 670 (for charging a capacitor) and p. 672 (for discharging). It's written out in detail there.

Can we see more applications of Kirchoff's Rules?

Yes, I think we will be seeing some. I've put a how-to on the howto page, and as we do examples I'll add them in.

What's an "edge effect"?

We've been assuming that the parallel plates of the capacitor are infinite, so that the field inside is uniform. Of course they are not really infinite, and near the edges the approximation that they are infinite gets worse, and the field is not uniform. Mostly we ignore that though. See for example Fig 23-1 of your text.

In the experiment problem, what happens to the charge density if you have washers as opposed to disks?

Think about the potential difference: does that change if there's a hole in the disk? Does the electric field change, if $V = Ed$? How is E related to σ (assuming an infinite sheet)? If you have less area due to a hole, do you have more or less charge? Do you have more or less capacitance? As for the factor f which describes the fact there's extra charge on the edges: if there's a hole, will there be more or less charge on edges?

Can we have some hints for the problem set?

- Problem 2: The first one is an 8.01X problem. How is power used by the car related to force and velocity? (Note that horsepower is just a unit of power, see the inside cover of your text). For the second problem: 52 Ah just means that one battery can provide 52 A for one hour at 12 V. If the battery is providing 52 A at 12 V, what is the power? How much total energy can the 26 batteries provide? How long can the car run using that energy? How far can the car go during that time?

- Problem 3: This one is much harder than was intended. Let me try to give some hints. You can use Ohm's law, and Kirchoff's Loop Rule for most of these.
  - a., e. Remember what a battery's obsession is.
  - b. If the ammeter and battery have internal resistances, imagine little resistances in series with an ideal battery and ammeter. Use the loop rule to find V_{AE}. If R_7 increases, what happens to the total equivalent resistance of the circuit? Then what happens to the total current? Then what happens to to V_{AE}?
  - c., d., e., g. What happens to R_{eq}? Then what happens to total current? What happens to other currents and voltage drops?
  - f. This one is tricky. There are actually competing effects: if R_2 decreases, total equivalent resistance decreases, so total current through the circuit increases... but if R_2 decreases, current prefers to go through R_2 instead of R_3. To decide which effect is more important, ask the question: what if R_2 went to zero? Would current through R_3 increase or decrease?
  - h. Use the Loop Rule.

- Problem 4: When the switch first closes, the bulb is non-conducting, so it's as if it's not there. You can use the expression for the voltage across a capacitor that's charging up that I derived in class today: $V(t) = V_0(1 - e^{-t/RC})$. (Be careful: what does V_0 mean in this expression?) When the potential difference across the capacitor hits 90 V, the bulb acts like a conducting wire: it shorts out the capacitor (i.e. drops to zero potential difference). So the voltage drops very fast. But when it hits 70 V, it stops conducting... the capacitor starts charging again, following the same expression for $V(t)$. You can use this equation to solve for times needed. For part b: find the difference between the time it takes to get to 70 V and the time it takes to get to 90 V, and add that in.

Tidbits

Why is hamburger the lowest in energy of all kinds of meat?

Because it's in the ground state.