**Plan for reorganizing/improving electric potential labs**

**Matt Trawick, December 2016**

**How our labs on electric potential are organized now:**

Here is an outline of our current set of labs that deal with electric potential. In the outline below, the sub-parts are “activities” within each lab.

1. Existing Lab: The Electric Potential (This is from the original Dickinson College Workshop Physics. Hereafter, this lab is referred to as “the Dickinson lab”)
   1. Work in uniform field (introduces dot products, does not draw graphs). Then introduces potential energy.
   2. defined as . Discussion of potential difference for a point charge.
   3. Students derive V(r) for point charge.
   4. Potential due to charged ring (“numerical estimate” which turns out to be exact.)
   5. Potential due to charged ring (exact, with a trivial integral)
   6. Charged ring again, E-field method. (Calculating E, then integrating )
   7. Sketches of field lines and equipotentials.
2. Existing Lab: An Example Problem using Electric Potential. (A one page lab with an example of two point charges, by Matt. Nothing special here.)
3. Existing Lab: Fields and Equipotential Lines (the carbon paper lab).
4. Existing Lab: Finding V from E (By Matt, ~2015, several example scenarios using )
   1. Constant E
   2. Two different constant E
   3. + and – constant E
   4. Nonuniform E
5. Existing Lab: Field and Potential I (“Measuring” E & V for a point charge.) (These are the computer-based ones that use really old software. I personally don’t think these add much, and many of us have opted out of using these at all.)
6. Existing Lab: Field and Potential II
7. Existing Lab: Field and Potential III
8. Existing Lab: Field and Potential IV

Besides weaknesses in some of the individual labs, these labs don’t work very well together. First, there are gaps in coverage: none of these labs really address the idea of visualizing as a surface. There’s also not much made of the parallels between F&U and E&V. Finally, the main “Electric Potential” Dickinson lab (#1, above) covers so much ground that some of the other labs would actually fit better somewhere in the middle of it, rather than after it.

**What I want to do instead:**

I imagine retaining two labs mostly as they are now: the carbon paper lab and the relatively new “Finding Potential from electric Field” lab. I want to write a better introduction to electric potential that would build more intuition and a stronger connection to ideas of force and energy. I also want to do some things with 3D visualizations of for things like a dipole, or two positive charges. I want to retain some of the more advanced activities from the Dickinson lab (the uniformly charged ring, for example), but separate them from the other more introductory material. Finally, I want to end up with a series of shorter, more focused labs, making it easy to pick and choose, so you could reasonably skip any one lab, or decide to do activities 3 and 4 of some other lab as a lecture instead if you wanted to.

1. *New Lab:* Introduction to Electric Potential
   1. Review and motivate Force F, work W, and potential energy U. I’ll probably use examples of and a compressed spring . This will absolutely be review from 131, and this activity could even be assigned as pre-lab homework (though in my experience students need help remembering this, so we’d still need to spend some time on it in class. Also review of why work is , and why the dot product matters. (This is covered in the Dickinson lab, activity 1.)
   2. F:E as U:V.
   3. Contrived example problem showing why electric potential is useful. In the same way the shape of a series of hills and valleys are irrelevant if you know , we also don’t need to know the electric field everywhere if we just know .
   4. Do a lot with pictures showing relationship between E and V (and maybe F and U).
      1. Given 1D graph of E, draw V, and vice-versa, for Uniform E…
      2. …and Linear E, maybe
      3. Back and forth with representations of field lines and equipotential lines.
   5. V for a point charge. (Maybe this material is better at the start of lab 3?)
      1. General picture: high, low, etc.
      2. Work the integral to get kq/r (borrowing from original potential lab)
      3. Drawing graphs (Maybe also a 3D view, with Falstad or something else? Probably not yet.)
2. *Existing Lab:* The Carbon Paper lab. (Probably with a reduced introduction section.)
3. *New Lab:* Superposition.
   1. Review of V for a single point charge. Graph V(x,y) in 3D.
   2. V for a dipole, using 3D view of V(x,y). Ask questions like whether V=0 and E=0 at the center.
   3. V for two positive charges. Also with 3D viewing, questions about E and V.
4. *New Lab, with some recycled parts:* Potential for distributions of charge:
   1. Charged rod, solved numerically (like the ring in the Dickinson lab)
   2. Charged rod, solved exactly (This is harder…. Save this for last? Not sure about this part…)
   3. Charged Ring, done numerically, (from Dickinson lab)
   4. Charged Ring, as a (trivial) integral.
   5. Charged Ring, E-field method. (from Dickinson lab)
5. *Existing Lab:* Finding V from E (unchanged)
   1. Constant E
   2. Two different constant E
   3. + and – constant E
   4. Nonuniform E

Interestingly, it seems to me that there are a couple possible variations in the ordering of these labs. The carbon paper lab and the superposition lab (#2, #3) could be swapped, for instance. And the “Finding V from E” lab (#5) could be stuck much earlier, maybe even second.