The Trouble with Triboelectricity

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Where we are going

- The Issue
- Common Ideas after Instruction
- Examples

The Issue

Electrostatics is:

- fundamental to developing an understanding of concepts to follow, in particular:
  - charge
  - fields
  - current
- helpful in developing a charge model to help student reasoning about electric phenomena.

The Issue (cont.)

"Older" (nth edition) textbooks typically

- have presentations consisting of one or two terse sections of definitions and jump quickly to Coulomb's Law.
- make limited (if at all) references to this initial material in subsequent sections/chapters.
- present examples in more of a traditional "demo mode."
- give a feeling of being tailored to the lecture mode of delivery (personal bias?).

The brevity of coverage implies it is trivial and perhaps even unimportant.

This material is often covered in one class period (or less!). As a result, students tend to not grasp the deeper significance and underlying subtleties of electrostatics.

Soapbox Slide

- Has this lead to student "compartmentalization of knowledge" often referred to?
- Has this lead to students' lack of ability to make connections between concepts?
- Has this lead to students' attitudes about the disconnectedness of physics from just about everything else?

Common Student Ideas about Electrostatics

- Insulators cannot be charged.
- No distinction between an object (conductor or insulator) and its charged state (charged or uncharged).
- "Charge" is an object/substance, not a property of matter.
- "Positively charged" is an excess of protons; protons are as mobile as electrons.
- "Neutral" is a third type of charge (from observing the interaction with any charged object).
- Others (e.g., charge-current distinction, charge conservation) that are deeper than this paper proposes to plumb.

A Remedy?

Textbooks by Etkina and Knight, having a strong reliance on Physics Education Research, tend to

- have more, and deeper, discussion of common electrostatic examples and applications.
- make repeated references to initial ideas (i.e., explicit connections and cycling back!) in later text sections and discussions through:
  - repeated use of words/phrases.
  - similar diagrams with similar design elements.
- encourage discussion between students and with the instructor.
- utilize tactile experiences (experiments!) that students can do in their seats, at home or in the typical lab setting.

Experiments

- Many (traditional) labs still use glass rods and cat fur (PC?), i.e., typical "physics stuff."
- While there are still advantages to some rods/apparatus, variations using common materials are easily found.
  - See the Triboelectric series.
- Common materials provide versatility in that activities can be designed for various venues:
  - in the lecture hall.
  - in the student lab.
  - outside traditional boundaries – home, dorm, apartment, student union, etc.
  - outreach programs (school visits/workshops).

Experiments

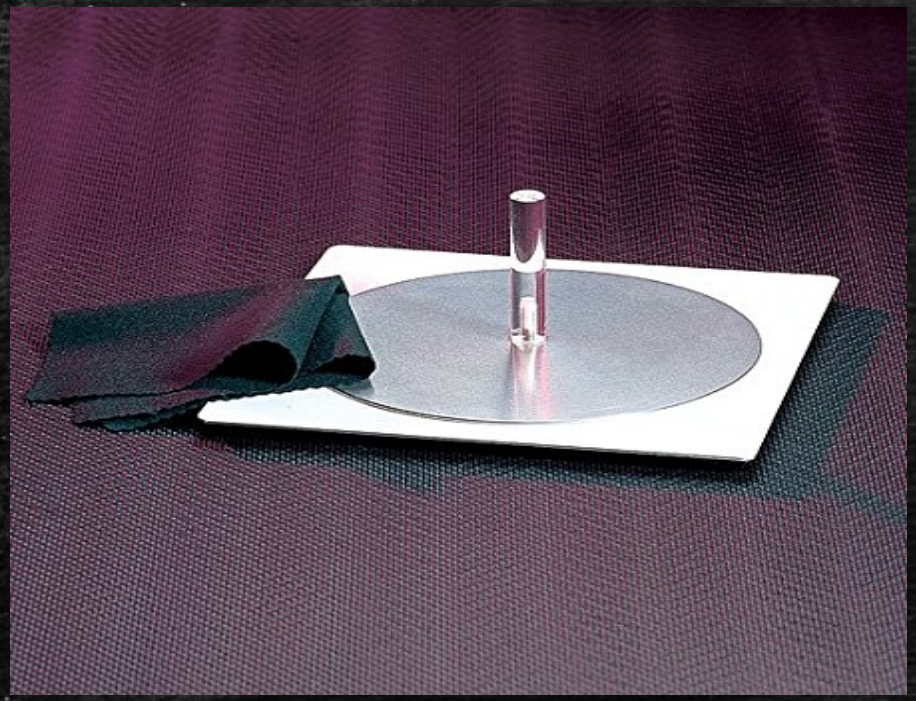
- Following Franklin's program has several advantages:
  - Develops a good model for charge.
  - Illustrates good scientific processes.
  - Develops (hopefully) a proper mindset for scientific investigations.
- Following Chabay and Sherwood's program, using scotch tape, also has similar advantages.

Example -
Commercial electroscopes versus homemade

$13 – 30 versus $2 – 5.

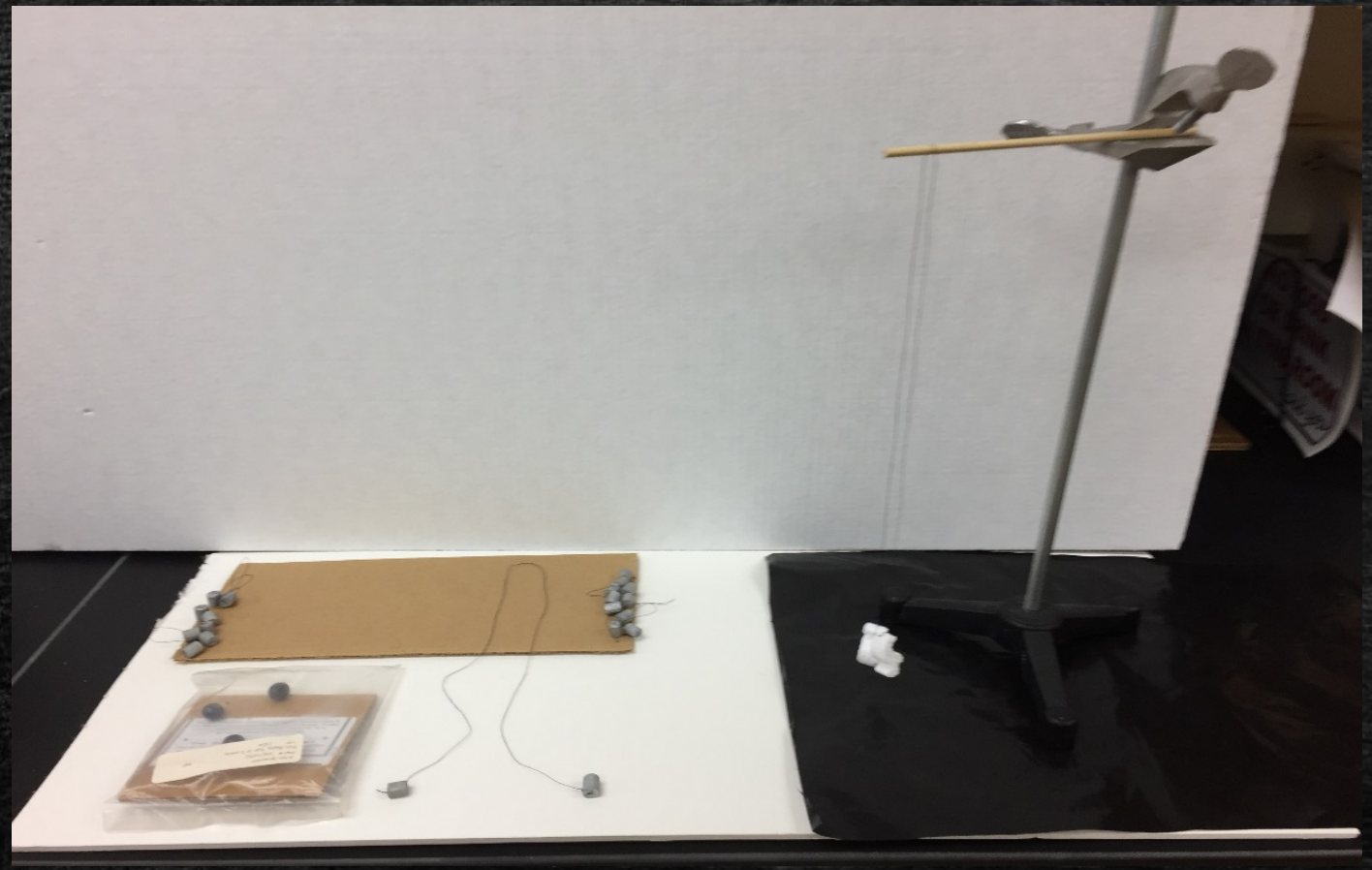
Example – Electrophorus

$12 - $60



$2 - $3 per pack

Example –
“Pith”-balls versus Styrofoam chips



$3 – 6 versus cents.

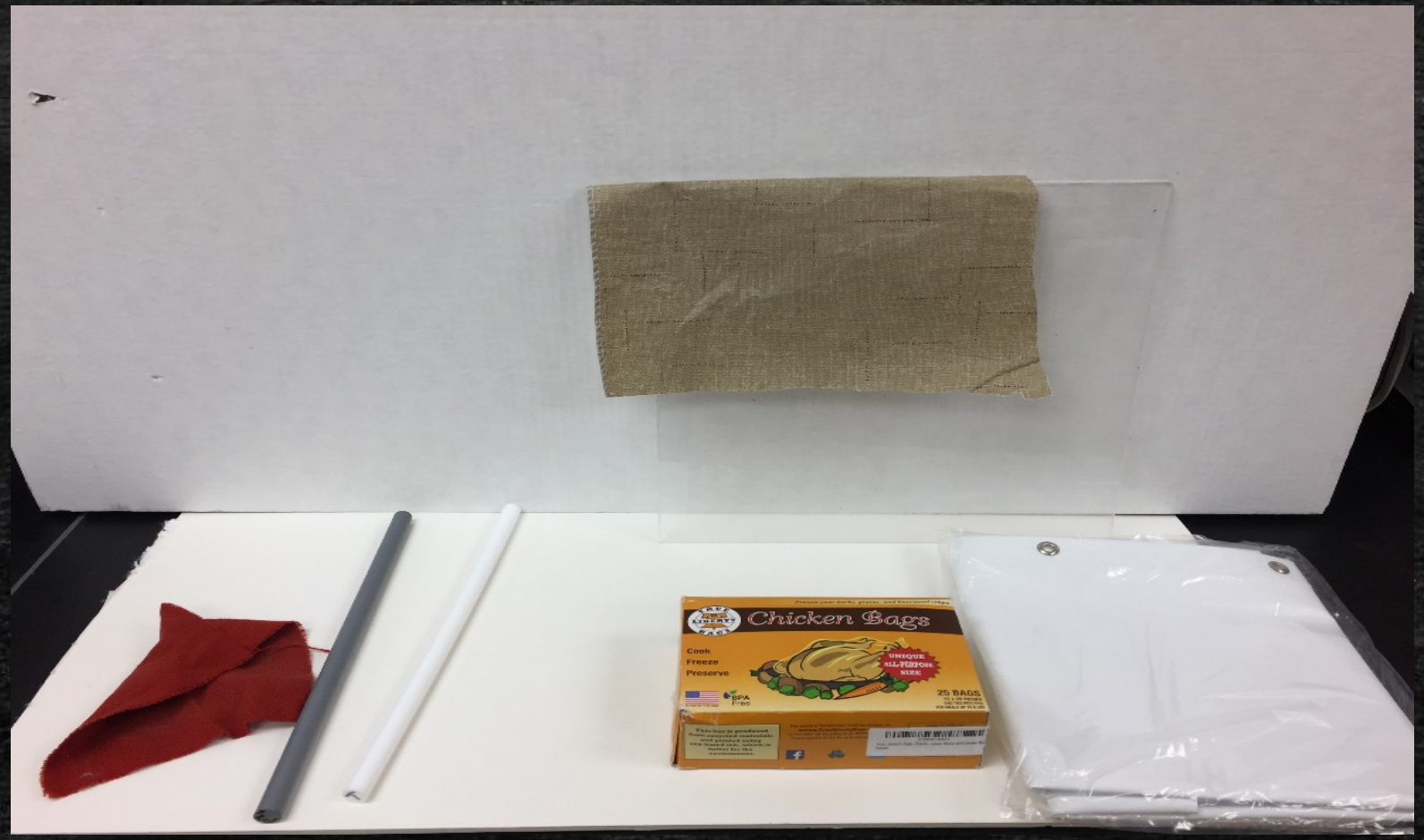
Example – Positive things

- Set of rods (glass, nylon, Teflon, PVC) - $12 - $15
- Silk - $5 - $65/yard
- Flannel - $2 - $3/yard

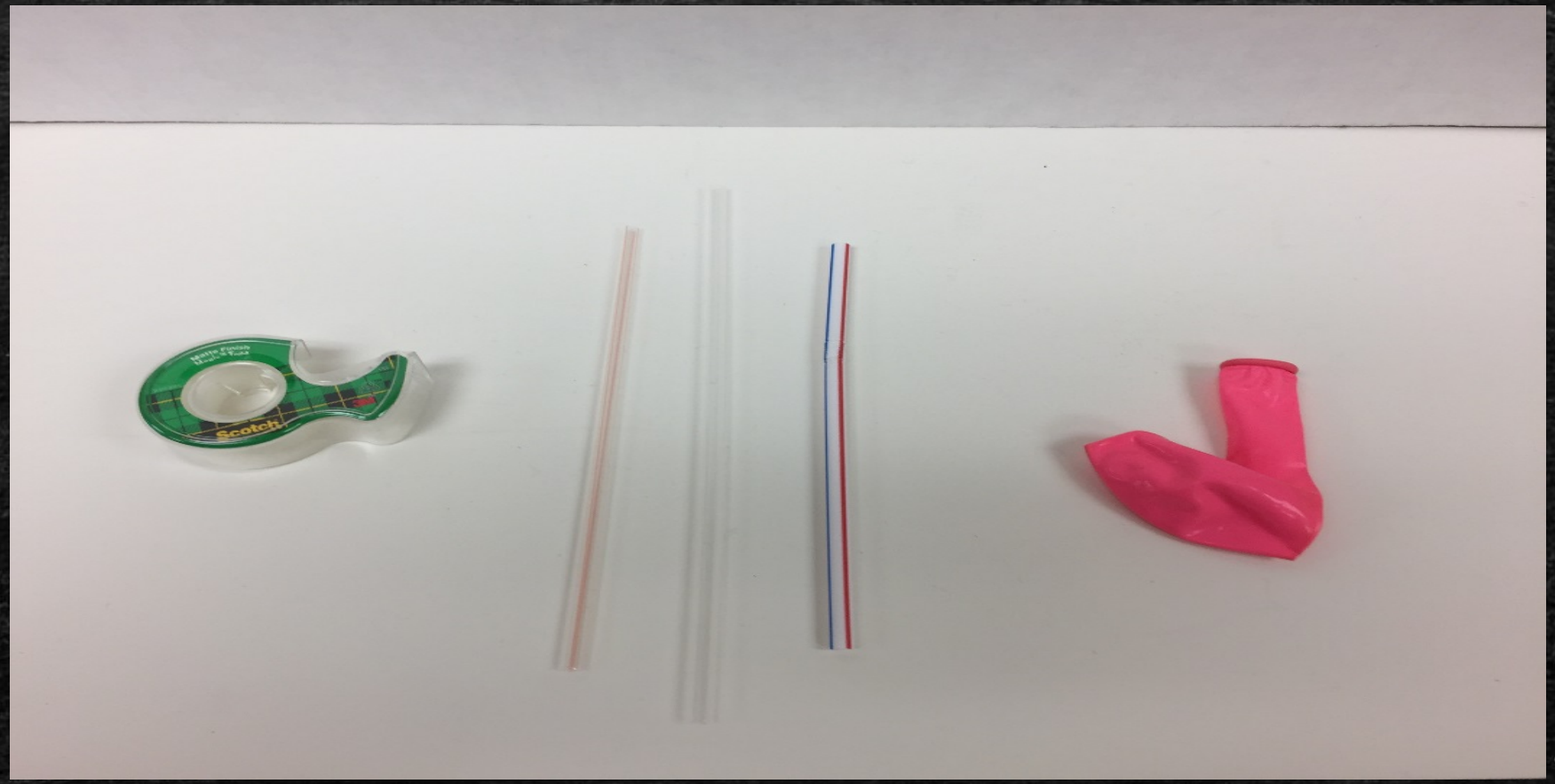
Versus

- Oven bags - $1.50 - $5
- Golf club divider - $2 - $3
- Large cable ties - $5 - $7/50
- Shower curtain/table cloth - $3 - $6

Example –
Negative Things



Example – Miscellaneous



Caveats

- Humidity
  - **Blow dryer**
  - **Dessicator box**
  - **“Hot box” (enclosed light bulb; careful!)**
  - **Set AC colder (last resort?)**
- Housekeeping (cleaning)
  - **Remove skin oils from handling**
  - **Remove accumulated dust, lint, etc.**
- Uniformity
  - **Ensure no rough edges or sharp points**

Conclusions

- In general, it is important to:
  - cover this material in more detail than may be "typical."
  - incorporate results from Physics Education Research.
  - whenever possible, make clear and explicit connections between the physics concepts and their actual applications
    - in latter portions of the course.
    - in students' career paths.

- AND provide a variety of student experiences, preferably tactile.

References

- **College Physics**, Eugenia Etkina, Rutgers University, Michael Gentile, Rutgers University, Alan Van Heuvelen, Rutgers University, Pearson, 2014

- "Facilitating model-building of electrostatics concepts related to conductors," Ryan L. C. Hazelton, Peter S. Shaffer, and Paula R. L. Heron, Department of Physics, University of Washington, Box 351560, Seattle, WA 98195

- **Five Easy Lessons: Strategies for Successful Physics Teaching** Randall D. Knight, (Professor Emeritus), California Polytechnic State University-San Luis Obispo, Pearson, 2003

References (cont.)

- "Improving Students' Conceptual Understanding of Conductors and Insulators," Joshua Bilak and Chandralekha Singh, Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, PA, 15260
- "Investigating Student Ability To Apply Basic Electrostatics Concepts To Conductors," Ryan L. C. Hazelton* , MacKenzie R. Stetzer† , Paula R. L. Heron* , Peter S. Shaffer* AIP Conference Proceedings **1513**, 166, 2013
  * Department of Physics, University of Washington, Seattle, WA 98195
  † Department of Physics, University of Maine, Orono, ME 04469
- "Novice use of qualitative versus quantitative problem solving in electrostatics," C. McMillan III and M. Swadener, J. Res. Sci. Teach. 28, 661–670, 1991

References (cont.)

- **Physics for Scientists and Engineers: A Strategic Approach with Modern Physics**, 4th Edition, Randall D. Knight, (Professor Emeritus), California Polytechnic State University-San Luis Obispo, Pearson, 2017
- "Students' understanding of the transfer of charge between conductors," C. Guraswamy, M. D. Somers, and R. G. Hussey, Phys. Educ. 32, 91–96, 1997