**Transformed E&M I materials**

**Current Density**

**(Griffiths Chapter 5)**

**STUDENT DIFFICULTIES**

**Notes**

The idea of volume and surface currents J and K, and how they relate to I is difficult. It is slightly difficult to visualize J flowing through an area A and that integral gives you the total current, but it’s very difficult to visualize K flowing past a line element to give you I=2πR\*K. Prof. Pollock used the visual analogy of the Mississippi which seemed to stick with many students:

*I motivated J by thinking about the "flow of the Mississippi" compared to "flow of Boulder Creek", and characterizing flow as total current (Mississippi clearly vastly bigger) but what about "water flowing at me through this circle I am making with my fingers". Then perhaps Boulder Creek even wins - so there's some OTHER quantity to characterize flow, which motivates our definition of "current density" as current/area. (Then rotate the circle to show them that it's really perpendicular area needed to DEFINE this current density).*

**Common difficulties**

**Volume and surface current (\*\*\*)**

* After many weeks of dealing with surface and volume currents, even some of the best students did not realize that they had to integrate over the volume current *J* to get the current *I*. Some attempted to add *K* and *J* to get *I*, or to multiply *J\*A* to get *I*, even if *J* was not uniform. More students in the Transformed class seemed to understand J and K via their units, but students in both classes struggled.
* Most student had a fuzzy understanding of the distinction between I and J and K, and were not able to articulate their ideas clearly. They have trouble understanding a density that is *flowing* rather than static (as in charge density).
* Even among the best students, many saw K as *“I/L*” rather than *“dI/dl”* and this caused difficulties in calculations (and similarly for J) since it was then not obvious to them that I =∫K*•dl.*