1. Nonstandard Analysis . . . . . Dr. Forster

Description of Essay

Developments in C20 Logic have made possible a rigorous treatment of infinitesimals, and thereby opened the door to a natural rational reconstruction of C17 calculus. However the interest of this material is not just historical but emphatically mathematical. Although the C20 discoveries that started this renascence lie in Logic, the Logic involved is not terribly recondite, and the material is accessible to people in Logic or Analysis. This stuff deserves to be more widely known.
There is a variety of approaches, and a wealth of available literature, some of which is listed below.

Relevant Courses

Essential: Part II Logic and Set Theory or equivalent.
Familiarity with Undergraduate Analysis is essential.

References

[1] John Bell "A Primer of Infinitesimal Analysis" CUP
[2] H. Jerome Keisler "Elementary Calculus: An Infinitesimal approach". `http://www.math.wisc.edu/~keisler/calc.html`
[3] André Pétry "Analyse Infinitesimale—Une Presentation Nonstandard" Céfal 2010

Further suggestions from Prof Hyland (I'll nail down the bibliographixcal details later at my leisure but i want to get this out and visible NOW.

1. Abraham Robinson Non-standard analysis

2. Non-standard analysis is not the only modern treatment of infinitesimals: synthetic differential geometry.

3. I am wondering what really is non-standard analysis ... . One angle can be extracted from Edward Nelson's Internal set theory which is somewhere in the BAMS.

4. For applications there is a book by Albeverio, Fenstad and some others.

5. There is a collection which Nigel Cutland put together which I think at the right level also about applications.

6. There are intuitionistic versions pursued in particular by Palmgren. There's an interesting paper by Avigad and Helzner in Arch Math Logic. You could mention in case someone else wants to do the essay?

Hurd and Loeb.

Hope this helps.