Gmail

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Follow-up: Radiation, Antennas, and Einstein Relativity

2 messages

Christian Ferko <cferko@alum.mit.edu> Sat, Nov 14, 2020 at 9:03 PM
To: S14332s1-students@esp.mit.edu
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Hi all,

Thanks for the excellent questions and productive discussion in the chat during the talk today. I had a lot of fun.

I owe you some comments and resources.

1. The slides from the talk are available as a PDF here, or on Overleaf here.

   I recorded a slightly longer version of the talk which goes a bit slower and includes all sections. The playlist is on YouTube here, or you can view individual acts (introduction, act 1, act 2, interlude, act 3, epilogue).

2. To get more intuition for divergence and curl, I highly recommend Grant's video here. Lots of people in the chat also seemed to be fans of his.

   One person asked about eigenvalues when I got on a tangent about the Hessian. If you have time, you can learn about this by going through Grant's linear algebra playlist, which is also fantastic.

3. A few remarks on textbooks:

   - Someone asked whether my figures were taken from a textbook. Most of the pretty ones (like the flux through the heart) are from Halliday and Resnick, which is available in PDF form here.

     This is a good introductory textbook -- I think it's perfect for learning physics at the high school level, but it won't explain much about the mathematical framework like divergence and curl.

   - The standard textbook for freshman electromagnetism (at MIT, UChicago, and elsewhere) is Purcell (PDF here). This is a beautiful textbook full of nice physical insights.

     See Appendix H for a nice treatment of the radiation from an accelerated charge, including an argument for why it goes like $\frac{1}{r}$ rather than $\frac{1}{r^2}$ (an important fact which I did not have time to mention in the talk).

   - Volume 2 of the Feynman lectures on physics is another classic undergrad-level book on electromagnetism. You can find it as a DJVU here (if you don't have a DJVU reader, you may need to download one).

   - Finally, if you aren't already aware, you can find PDF or DJVU versions of almost any textbook for free on libgen.

4. Someone rightly asked whether my definitions of divergence and curl are independent of the shapes of the limiting surface and loop, respectively. This can be immediately shown using some fancy theorems but here's a sketch of a simple proof using the squeeze theorem.

   Consider any sequence of surfaces S_i surrounding a point P such that the volumes of S_i go to zero as $i \to \infty$. For each fixed i, we can circumscribe S_i by a large rectangular prism R_i and inscribe it with a small rectangular prism r_i. For rectangular prisms, we can compute the limit defining the divergence exactly (see Section 3.3 of the Feynman lectures). So the limits for both the sequence of large prisms R_i and the sequence of small prisms r_i exist and are equal. But the surface S_i always lies entirely within the volume bounded by R_i and r_i, so the divergence limit for the S_i must lie between that of the R_i and that of the S_i, which means that it is equal to their common value (here I am sweeping some details under the rug). Since this is true for any family of surfaces S_i, they all produce the same divergence.

   Also see Figure 2.23 in Purcell, and the accompanying text, which sketches another proof that this limit is independent of the shapes of the surfaces. The proof for curl is similar by circumscribing/inscribing rectangles around your closed loops.

If I forgot to answer any questions or include any resources that I mentioned in the talk, or if you have any questions about physics or colleges, feel free to email me at this address (cferko@alum.mit.edu).

Best,
Christian

Christian Ferko <cferko@uchicago.edu> Sun, Nov 15, 2020 at 8:07 AM
To: Axel Greer <axelgreer815@gmail.com>

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