Edit Log for Spectral Theory PhL 2.24.13

Step 1: **Assemble** all 6 chapters into a new container doc. There are 6 chapters, and the doc is now 95 pages after doing this. Same length that Galois was! **DONE**

Step 1A: Open all field codes, otherwise the following things won't work inside them. This is just a Word option thing.

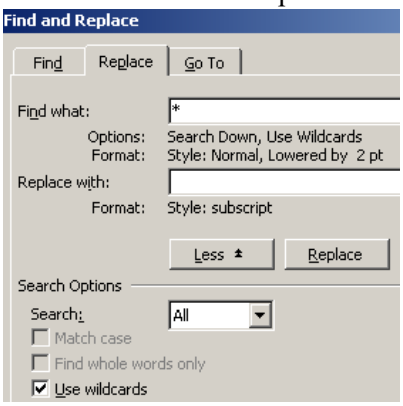
Step 2: **Subscripts and Superscripts**. Use Organizers to bring in ALL styles from normal.dot

After I do this, I find that

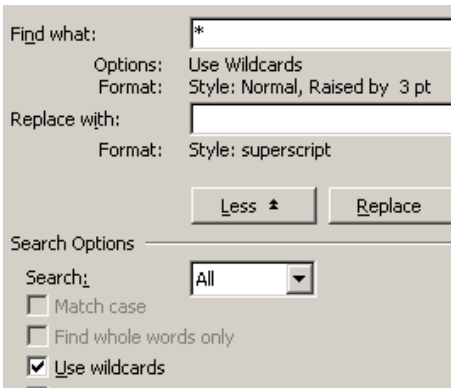
subscripts are: Normal + 9 pt, Lowered by 2 pt
superscripts are: Normal + 9 pt, Raised by 3 pt

So use the Replace function, turn on wild cards, look for * with style = normal and font = lowered by 2 points and replace by style = subscript, as shown below on the left. After testing a few, I did this globally and replaced 1761 + 465 occurrences. Then did 1350 superscripts as on the right below, again after testing a few.

subscripts:



superscripts:



Step 4: **Greek letters**. You have to do this for each symbol separately.

Item: ω replaced 900 of these. First, copy and paste the old symbol into the find what area. Then copy the new Greek letter and do replace with "from clipboard". Works just fine.
Item: π replaced 161 of these
Item: δ replaced 128 of these
Item: θ replaced 25 of these

Well, there are lots of problems but I think 98% of everything is fixed. In this entire doc, I put all my equation bodies inside field codes, I no longer do that but will retain it in this doc.

Step 5: Rough in some headings!

OK, this got me rolling along. I am now just reading through, changing to more modern integral notation and sticking with the Section numbering idea which differs from my other documents.

Mon 2.25.13

Resuming in Chapter 1.

Weds 2.27.13.

Got side tracked on Medicare, now we resume. I plowed ahead, but mostly I am doing cosmetic repairs on this pass so equations are at least readable. I got down to the start of Chapter 4. I am not sure what the focus of this paper is all about, and the title will be a challenge. It is all rather amazing stuff.

Thurs 2.28.13 starting 6:45AM

Today I renamed the last sections so that the doc has a uniform system. We now have 6 chapters, but the section numbers run 1 through 37, and equations are for example (33.2). For some reason, it was a hybrid of two different systems. This took a while.

I will not continue with "formula repairs" starting where I left off yesterday.

OK, I have finished all equation basic repairs for entire doc.

Decide on a summation form. This might take some PDF export work. I have never really been happy with what my symbol doc has offered. Here is some basic offerings:

$$\sum_{n=0}^{3} n^2 \qquad \sum_{n=0}^{3} n^2$$

These in the PDF look like

$$\sum_{n=0}^{3} n^2 \qquad \sum_{n=0}^{3} n^2$$

Not that much difference, and a lot of work to change them all to have smaller letters.

I think the 9 pt letters look best in the PDF because it gets more stuff directly under the Σ symbol, and the font is similar to the exponent size.

$$\sum_{n=-\infty}^{\infty} n^2 \qquad \sum_{n=-\infty}^{\infty} n^2 \qquad \sum_{n=-\infty}^{\infty} n^2$$

11 10 9

The old style integrals come out very bad so all need to be changed

$$c(\omega) \equiv (1/T_1)X_{pulse}(\omega) = (1/T_1)\int_{-\infty}^{\infty} dt\, x_{pulse}(t)\, e^{-i\omega t}$$

I have a ton of manual equation processing now to do, to extract integrands.

Is there a way to globally change the font size in case I decide later to change things? Suppose we open all field codes and we see something like this

$$\sum_{n=-\infty}^{\infty}$$

How can I search for maybe su(and some wild cards to change the right stuff?

Well, I might have to be specific. There are not that many cases.

change $n = -\infty,\infty$ to $n = -\infty,\infty$

Sum/integration repair is complete now through Section 24.
Now am through Section 32.
OK, got all the way through with equation repair and equation numbers all in right place.
Is now noon, this took abut 6 hours!

Lets do a PDF and just take a look around for problems. Done, things fixed. In general, the PDF presents a uniform appearance now for integrals and sums. I am publishing in PDF, not in Word, so the PDF is what I want to look good.

Let's now start all over and add pictures as needed. And do full equation checking.

Chapter 1
- Section 1 DONE
- Section 2 DONE, added lots of stuff re Sturm-Liouville theory
- Section 3 DONE
- Section 4 DONE
- Section 5 DONE
- Section 6 DONE
- Section 7 DONE
- Section 8 DONE
- Section 9 DONE
- Section 10 DONE

Stopping now at 8:45PM. I am doing a very careful reading and adding things as seems useful.

Fri 3.1.13 starting 6:45AM

Chapter 1
- Section 11 DONE
- Section 12 DONE
- Section 13 DONE
- Appendix A: DONE

Today I did a very complete rewrite of Appendix A. Things were wrong, the logic flow was terrible, it is now much better. I am still now sure how $\delta(0)$ is going to appear in later sections. Once again I am ready to start on Chapter 2. It has taken a long time to get things cosmetically OK, and to get the math preparation stuff in good order.

Sat 3.2.13

Chapter 2
- Section 14: DONE, added some pix, lots of edits.
- Section 15: DONE, improvements made!
- Section 16: DONE, picture added
- Section 17: DONE, many pictures added and updated, Maple and Excel used.
- Section 18: DONE, and short and simple. One picture added.
- Section 19: DONE, redid the plots, made it cleaner.

What to do about Figure labeling? Hold off.

Chapter 3
- Section 20: DONE, about image spectra and aliasing.
- Section 21: in progress

The logic concerning the digital filters is very hazy. I need some kind of block diagram that shows where the oversampled filter is in the picture. Very poor presentation. I am putting this issue on hold and will continue. I see that this subject comes up later in my doc, maybe by that time things will be clearer.

Sun 3.3.13

Chapter 3
- Section 21: DONE
- Section 22: DONE
- Section 23: DONE
- Section 24: DONE

New pictures, added material, web checking, it was a long day.

Mon 3.4.13

Chapter 3
- Section 25: DONE, improved the connections to earlier sections, it was fuzzy

Section 26: DONE, aperture correction.

I added Section 21 (b) on Group Delay, just so I could refer to it in Section 26.
I added comments on the notion of LTI filter.
Fixed up the missing (21.7) equation number.

Tues 3.5.13 // day after the break-in !

I got sidetracked a lot today, pretty much a loss. I lost stuff already entered. I need to go through each "box" and give references for each claimed equation. Then I can do Section 27. At least I got Appendix B written which derives a somewhat strange formula that is needed in Section 27. Manana!

Weds 3.6.13.

Simplified Appendix B, did Section 27 on Discrete Fourier Transform, could not take limits of result to obtain the Fourier Series Transform, and then realized that this entire section is WRONG! The DFT applies to a single pulse, not to a pulse train, and both sums are finite. So I am now pondering what to do about this.

(1) Can the DFT be applied to a pulse train, if so, how different from applied to a pulse
(2) Do I actually use the DFT in later document sections?

The answer to the second question, thankfully, is no. I must have just added Section 27 to get the DFT into my paper somehow. So let's ignore Section 27 for now and move on. Later I will come back and decide what to do about it.

Chapter 3
Section 28: FIR and linear phase. Did a complete Lam-based rewrite here.

Thu 3.7.13. flailed a bit this day, other matters required attention
added comparison between FIT and DiFT.

Fri 3.8.13.

Early start 5:30 AM. Question: What is wrong with my Discrete FT derivation with infinite time range?

OK, I have finally *battled my way* through the long DFT section. It was painful and the result is not all that great, but at least I see nothing grossly wrong anymore. So I finally have

Chapter 3
Section 27: DONE, forms of the DFT. 4 PM Friday.

Chapter 1: Section 6 on Laplace Transforms: Did a complete rewrite!

Wrote Appendix C in attempt to state all the transforms in one place and to show how some of the spectra are related. I am worn down at 7 PM.

Sat 3.9.13

Added a section on the Fourier Cosine and Fourier Sine transforms.
Added stuff in Appendix A about distributions as seen in Stak.

Sun 3.10.13

Tried to compare the Fourier Cosine/Sine with the series results, but gave up, not useful.
Starting now on "where do image spectra come from" which is Section 29.
Got a certain distance there, they realized I need to understand "energy in a delta function" and that led to yet another section on δ(0) in Appendix A. At least now I understand the meaning of energy in a voltage pulse of shape δ(t) and why + infinite. TBC manana.

Thurs 3.14.13

I lost several work days due to house security, shopping, and Jim Ball black PC work, continuing now trying to make Section 29 do something reasonable.

I just found an error in the main doc, however, which is that w(t) = y(t)x(t) is not true for any $x_{\mathbf{pulse}}$ in the pulse train x(t), it is only true for a delta pulse. So go clean that up right now in various places. OK, this turned out to be a very tiny problem since I never used it.

Reworked Section 29 on image spectra examples, as I now call it, but I don't see the point. So far my example just shows that if you shorten the aperture pulse, you make things worse because you create image spectra for the physical signal.

My mental block continues now at 6:30 PM. Why do we want to do the aperture thing? The answer to that lies in my oversampling and decimation section 30, but I cannot seem to understand my own writing there. There are no pictures of circuits,. time domain, or freq domain, so it is hard to comprehend, though it is probably perfectly correct. I would like to do a real world example including any digital filters required, and see why it is worth doing such a thing. I seem to be missing some major main point. A new feature since I wrote this is that I have Maple to simulate whatever I want to do.

Sat 3.16.13

Added three Examples in the Digital Fourier transform section. The first is my painful finite pulse train where it took all day to get the reconstructions to work right. The second is my single pulse so I could show the sinc sum rule. The third is an infinite pulse train where I reproduce a result found earlier. So this is where this stuff ended up. I then replaced "where do image spectra come from" with my digital brick wall filter section.

Sun 3.17.13

Today I added a comment about dimensions for the convolution theorem. Then I went through the brick wall section making small edits and adding equation and figure numbers. Then I finished the oversampling and decimation section using this filter.

Task: I now want to find some verification of my D/A filter scheme, just to make sure I am not miles off the mark. // I found a few things, and think I am OK. Integrated the oversample section 30 into the main doc. a few edits elsewhere, much more Maple work, it is going fine.

Mon 3.18.13

I think we are all roughed in now on Chapter 4 on Practical Topics, Sections 28,29,30, it took a long time to get there. Time now to clean up the "blue text" in Section 21.

I have now read Sections 20 and 21 one after the other a few times, and they are better correlated to each other. They both involve a form of image spectra and aliasing. I treat the filter on a slightly different footing from just a signal. These sections are I think pretty good. The concluding group delay section of Section 21 is also good, I just read it now. Read Section 22 and 23 on DFT.

I have now done massive edits on the Z Transform section 24, too many details to review here. I have the better function H"(z) to replace Δt G"(z) for example. I had to redo all the equation numbers, it is a mess and will require full proofing right now, all 14 pages of it.

Section 24 a,b,c,d,e,f,g, box. This took a long time, more errors found, it is done (for now).

I don't have the energy after 12 hours of staring at the monitor to continue now into Section 25. I think sections 25 through 30 are now at least OK and stable.

Tues 3.19.13

Skipping now to Section 32 on the autocorrelation function. DONE

Section 33

(a) DONE. I think my dealing with $\delta(0)$ here is just fine, and nice HP analyzer comment.

(b) DONE, we now have the power spectrum of a pulse train using c_m coefficients.

Section 34 DONE, Excellent, very clear.

Section 35. DONE, made lots of improvements in notation, I had it wrong before.

Section 36. DONE.

I would like to add some Maple work before going on to the standard line codes of Section 37.

Weds 3.20.13

This was a massive unbelievable day. I started out doing a lot of Maple stuff to make some random pulse trains with p = 1/2 and try to show that the spectrum matches the predictions I have made. They were not matching, and I then realized that I really need to know ALL RESULTS in the case of a finite pulse train, since that is the only kind of pulse train I can make in Maple!! This led to many changes

- Appendix A: made connection between δ_5 and sum of δ_4 which I failed to do earlier.
- Appendix A: introduced δ_6 as the square of δ_5 which lets me do my finite stuff correctly!
- Section 13: added the finite sum rule as equation (13.3)
- Section 14: added a closing section on finite length pulse trains. Need this later.
- Everywhere: used the word "simple" do mean no amplitude modulation
- Section 33: now has separate infinite and finite sections
- Section 34: now has separate infinite and finite sections
- Section 35: now has separate infinite and finite sections

This took an immense amount of fiddling. It is now 9 PM. Tomorrow I think I can finally do that Maple program and install it as a great example! That is what got this whole round of changes started.

Thurs 3.21.13

Wrote up my Maple example, and am now ready for first reading into the line code Section 37 which is the last of the doc. // Got Section 37 all done, the AMI stuff was very tough going but I got it. But some limits don't look right. I order the Data Transmission book on line for $4 total, I can perhaps check other of my results in there when it arrives. Meanwhile, I have plenty of editing to do!

Fri 3.22.13.

I have finally made it all the way through Spectral. There are some loose bolts right now.

- why did I always use $|\langle X(\omega)\rangle|^2/T$ in the original doc **DONE**
- how does this tie in with covariance of my Ng notes.. **DONE**
- why does the $p \to 1$ limit of my AMI result seem wrong? **DONE**
- Add graphs for the various line codes, maybe change the title of that section. **DONE**

I spent the entire morning on the Ng item on the above list and I ran aground. I don't know how to make the connection between the autocorrelation function of Spectral and the correlation function of my Ng notes. This is very bad, I should know this by now. Feeding time.

Resolution: In the evening session I realized that the Ng notes stuff involves correlation and covariance, defined either continuously or discretely, but neither of these concepts involves a function, at least in my Ng notes. A related topic is the cross-correlation function of two functions, and the cross-correlation of a function with itself is the auto-correlation function. This is the thing I was looking for.

So in this regard, I added subsection (f) to Section 32 on autocorrelation, and I added a small comment in Section 35 regarding the Ng type stuff for discrete correlation and covariance. I added the notion of a Hermitian function in Section 7.

So in a full day I accomplished just one item on the above list.

Sat 3.23.13.

Let's look into scary bullet 1 above. Review units carefully. I have done so and I now see that my old way was the correct way!

I have rewritten Section 33 (a).
I have rewritten Section 33 (b).
I have rewritten Section 33 (c), only had to change one $\mathcal{P}$ to $\mathcal{E}$
I have rewritten all of Section 34
Section 35 (a) stays as it was
Section 35 (b) has a few edits. End up with exact same result but P is power, not energy density
Section 35 (c) and (d) are now updated as well.
Section 35 (e) is all OK.
Section 36 is OK.

I then started anew in Section 37, reworking all the line codes, added bipolar NRZ. A lot of things have changed and I am adding plots, it is slow going, but no rocket science here, just hours. I stopped at a convenient spot at 9:15 PM.

Sun 3.24.13.

Sections 37 (a) (b) (c) (d) all done. I made many many passes through these sections, adding more graphs, fixing errors, giving the sections the exact labeled structure, and so on. It took a long time. Added sample pulse trains. I don't yet have good equation numbers.

I went through (e) quickly, adding sample pattern, imposing same structure.

I am now ready finally to deal with them mystery questions about AMI when p→ 1.

But in my debug doc on this, I run into errors in the main doc for supporting material, so I have do push down another stack level and deal with these errors.

OK, after cleaning up more messes, I am back to the AMI paradox in a separate doc. I wonder if I can find a web verification of the AMI spectrum?

I have resolved the paradox finally, but am off by factor of 2 somewhere. It was a long road, and it is now 9:15PM. Another slogging day!

Mon 3.25.13.

First added $\boldsymbol{\delta_7}$ **delta function** model to App A, so that I can use it from the AMI section. I have to redo the numbering in App A, so I decided I should review Chapter 5 (so far ignored) to make sure no further δ's will be needed from there.

Reviewed **dispersion relations** stuff, rewriting along the way. Had a big problem with the concluding coax section, but was finally able to state something reasonable after half a day. Got the original Konig article using Jim's access Cork2soaker.

Now I need to finalize App A, then fix whatever problems remain with the AMI section.

I next resolved the sign error I thought I had, so that AMI detail is fixed. Tomorrow I continue with AMI.

Tues 3.26.13.

In the AM I did a complete rewrite of Section 33 to bring in the X'(ω) and X"(z) transforms which were hidden in my previous version. I now have a problem. This entire Section 33 was supposed to be only about simple pulse trains, but in the last subsection I have some results that apply to general pulse trains, so that is a little out of place. Secondly, I am wondering why I never seem to have a section for general pulse train with y_n. I suspect that Section 34 is now about to also be completely rewritten!!!

Status 4PM. I have rewritten Sections 33, 34 and 35 and this is all done. I now have to do something with Section 36, whose first section is a bit strange.

After one hour of yardwork, I have updated Section 36 as well.

I will now install all four of these rewritten sections: DONE.

Bug: I then wanted to insert an example of an A/B wave in the power section but ran into the δ(0) problem again where the scaling is hazy. Scale one way get the right answer, another get the wrong answer. This needs to be repaired or if not fixable, I have to completely back it out of spectral doc.
Stopping at 9 PM.

Weds 3.27.13.

I think my bug got solved in bed, and I will add a detailed general pulse train example.

But first, I decided to reorder the pieces of Sections 32-36, changing a lot of titles. Now we have a more logical ordering: simple, general, then statistical pulse trains, each in separate Section.

I am now ready to add my fancy example and resolve the "bug". DONE, it is added, I think the pieces are all correct. I did it correctly without arm-waving.

Now back to the AMI limit. DONE! I got the a → -1 limit finally to work, and that was the last missing piece.

Status: Everything is "done" in the sense that I have no missing pieces in the doc other than the introduction. But much is in a messy state, bad equation numbers, too much detail, I feel the need to compress things somehow, at least in some places. It is sitting now at 199 pages!

Thurs 3.28.13.

I first repaired my Ng PDF bookmarks and reissued. Noted that GoDaddy is completely gone, I only got 20 days for my $8.99. Told Jeff and Jason.

Next, I edited Appendix A in several ways:

(1) added the exact form needed for the AMI limit as δ_8

(2) made each δ_n statement self contained

(3) redid and checked all equation numbers in Appendix A, rather painful.

Next, I need to edit all references to Appendix A in the entire document to make sure they are right and maybe redo some quoted equations: **DONE**.

Clean up equation numbers in the linecodes section. Did some, but have to go do this for a while:

Clean up the examples section that includes the square wave.

The question of W(ω) versus X(ω). My first use of W(ω) is Section 20.

Get rid of w and W in Section 20: DONE. This took a while, maybe 100 instances. I don't want to call my amplitude modulated pulse train x(t) some places and w(t) other places! **DONE**

Note: Need to update all quoted Maple code which uses W and replace with X: **DONE**

Replace all sum over odd with ± odd to make very clear. **DONE**

I have now added two methods to Section 34 to make sure my results are exactly right. Then I finally did the square wave special case stuff. Perhaps there are other special cases I should now try.

Something is chirping at me ??? It was the smoke alarm, new battery.

Did all the Special Cases now in Section 34 and then added little pictures so you can find the thing you want quickly. Then fixed up the linkage from the AMI section.

So worn out for today, but I am at least very sure that all my Section 34 repeat sequence results are correct, since not likely I will get verification anywhere.

Maybe get rid of Chapter 36 and make it be end of Ch 35. DONE

Pondered the NRZI idea a bit. Have a vague idea of how to do it.

Fri 3.29.13.

Note: In the AMI section, change from a_n to y_n I think **DONE**

I am working on the NRZI idea. Spent all day on this and finally got a result for my Change/Hold linecode that does the right thing in three interesting limits. Had to add still more to Appendix A. Tomorrow I will clean this up, and then do the NRZI special case!

Sat 3.30.13.

Did some general reading, I think X"(z) is adequately incorporated into the discussion.

Check equation numbers in the random code example **DONE**, it was OK.

Is the double pulse diphase or biphase? I will use biphase with parens diphase, based on web frequency. All done on this.

I have just reviewed the entire line code section, editing as needed, including AMI. I am now ready to update the Change/Hold line code section, then install it, then do the NRZI limit.

Change AMI to a separate Section.
Add Change/Hold as a new Section including NRZI.
It is all done. I think I am done adding content to the monster.

Time to do some file management, things have gotten out of hand really.
Did the docs and pdfs, now come the mws.

Time to get figures all numbered. This took a long time, at least now every figure has a number so I can at least refer to them.

Reformatted every figure and equation number line, that took a very long time!

Now go adjust figures to right since many are off. THAT also took a long time. Each pass it makes Word to its 100% CPU thing for a long time, it is repaginating all Sections that I touched.

What should I do about Figures which are old and have captions? Decided to replicate the figure number on the right, and leave as was with caption under the picture.

Did left right centering of all figures. Going off to the Millcreek place.

Maple review of spectral doc:

Section 8: sinc plot

Sun 3.31.13.

Will now to the Maple survey. **DONE**.

Completed some items listed above, so nothing still pending.

References: I can't find them, so will to this on the fly during proofing. Gave up on Reference Data for Radio Engineers, too many versions, mine is 1956!

Start Long Edit Cycle!

Right off the bat I have trouble. I talk about the FT of θ(t) but it is non-square integrable, so how can I claim that as an example? I cannot verify that θ(0) = 1/2 using the FT inversion formula for example.

I added section 9 (h) to show the 1/2 factor in a real world example rather than with θ(t).

Now what do we do about Section 8 (c) on the spectrum of the Heaviside function? The result (8.4) is never quoted except just below the equation statement, so I could kill it maybe.

Well, after several hours I got this all cleaned up and I made the connection to pf(1/ω) and Stakgold and I have the X(ω) = "1/iω" stated correctly, in agreement with Stak and the web. Good to get this issue taken care of.

Appendix A:

equation number sequence check: done
figure number sequence check: done
intro, done
(a) done, very good
(b) done, very good, found and fixed some small bugs.
(c) done, Maple cannot do my hand algebra! Few edits, all good.
(d) done, added a little wrap up statement.
(e) done, added bits here and there.
(f) done, this is the δ(0) coda, I stress undoing the limit when in doubt.

So finally I conclude one section's worth of editing. It will be a very long road! (3/31/13)

Appendix B.

equation number sequence check: done (one equation)
figure number sequence check: done (no figures)
done. It is very short, added comment that it is used in the DFT section.

Mon 4.1.13.

Don't forget overall spell check !! ********** DONE may 17

Section 1

equation number sequence check: done
figure number sequence check: done
(a) done, a new little section defining pulses and pulse trains
(b) done, and seems good to me
(c) done, and glad I added this, added comment on Fourier Sine Series Transform.

Section 2

equation number sequence check: done
figure number sequence check: done
(a) done, a new little section defining pulses and pulse trains
(b) done, and seems good to me

(c) done, and glad I added this, added comment on Fourier Sine Series Transform.

Section 3

equation number sequence check: done
figure number sequence check: done (no figures)
done, I like the dimensions and groups comments, and the full diagonalization proof

Section 4

equation number sequence check: done, a little strange
figure number sequence check: done (2 figures)
(a) done and good
(b) done and a very good example with scattering comments I like
(c) done and good, good comments I think.

Section 5

equation number sequence check: none
figure number sequence check: none
done, very short, good argument in favor of convention, mention of two books.

Section 6

equation number sequence check: 13
figure number sequence check: 2
done

Section 7

equation number sequence check: 3
figure number sequence check: 0
done

Section 8

equation number sequence check: 5
figure number sequence check: 1
done. It was good to get this stuff exposed in the document, pf(1/ω) for example.

Section 9

equation number sequence check: 5
figure number sequence check: 2
done, added the box recovery in full detail, as well as the 1/2 points on the sides.

Section 10

equation number sequence check: 8
figure number sequence check: 1
done, no changes needed.

Section 11

equation number sequence check: 2

figure number sequence check: 2
done, not a very exciting section, but the rule should be stated somewhere.

Section 12
equation number sequence check: 2
figure number sequence check: 0
done, a very short section!

Section 13
equation number sequence check: 3
figure number sequence check: 0
done, no problems, improved linkage to Appendix A

Chapter 2 intro: done

Section 14
equation number sequence check: 21
figure number sequence check: 2
(a) done, made a few changes, removing contradictory statements due to additions.
(b) done, the finite length simple pulse train, but no box for this. All clean so far.

Section 15
equation number sequence check: 12
figure number sequence check: 0
done

Section 16
equation number sequence check: 3
figure number sequence check: 1
done

Section 17
equation number sequence check: 11
figure number sequence check: 6
done: this is a tedious "practice" section with a square wave.

Section 18
equation number sequence check: 1
figure number sequence check: 1
done, this wins the prize for shortest section.

Section 19
equation number sequence check: 5
figure number sequence check: 4
done

Chapter 3 intro: done

Section 20
equation number sequence check: 7
figure number sequence check: 2
done, easy to read (compared to tedious 17)

Section 21
equation number sequence check: 20
figure number sequence check: 1
(a) done, long but good
(b) done, this is very good and I remember it took a while to derive it, group delay.

Section 22
equation number sequence check: 20
figure number sequence check: 1
done, think it is good, introducing the Digital Fourier Transform

Section 23
equation number sequence check: 5
figure number sequence check: 0
(a) done, all the A = BC forms in ω space.
(b) done, includes the DigFT summary box.

Tues 4.3.13.

Section 24 on Z transform
equation number sequence check: 37
figure number sequence check: 8
intro text: done, added a picture of the ω to z mapping which I found helpful
(a) done, short and clear
(b) done, clear
(c) done, short and clear. Maybe should not show the subsections in TOC?
(d) done, this really is "too short" a section, will review all this.
(e) done, this is first shot at the RC filter.
(f) done, and very very good I think.
(g) done, the better design for a digital RC filter.
(h) done.
(g) done, the summary box.

Section 25
equation number sequence check: 9
figure number sequence check: 7
done to Example 1
done to Example 2
done through end of section.

This was an interesting section, glad the big ugly last example is gone.

Section 26

equation number sequence check: 4
figure number sequence check: 2
done, a nice little section if I do say so myself....

Weds 4.4.13.

Section 27 on the DFT // needs a full rewrite

equation number sequence check: 15
figure number sequence check: 0
done, opening text
(a) done, good stuff is done here I think, stuff you won't find discussed elsewhere
(b) done, this was proof of DFT for a pulse train

STOP. I have decided that Section 27 needs to be completely rewritten, it is just too complicated and contrived. I will defer that task because nothing later depends on the DFT, I just wanted to work it into the document. The fact that it is presented in backwards order (train first) shows what a mess it really is.

In order to maintain continuity, I will continue with the editing process and "some day" return to the task of rewriting Section 27.

Chapter 4 into: done

Section 28 do filters have linear phase

equation number sequence check: 4
figure number sequence check: 0
Method 1: done and good
Method 2: done and OK, a little stilted

Section 29 simple low pass filter

equation number sequence check: 9
figure number sequence check: 5
done: this is a very clear practical example I think, very good

Section 30 the oversampled D/A thing

equation number sequence check: 9
figure number sequence check: 5
(a) done in figures get rid of w(t), DONE
(b) done
(c) done in plot code get rid of W DONE
(d) done , this is all good stuff I think

Thurs 4.4.14.

Added Hilbert Transform section as (e) in Section 31, shuffled things around

Fri 4.5.14.

Section 31 spectral dispersion relations

(a) through (f), done

(g) having sign problems here and other confusions

Mon 4.15.13

I have now written Appendix C, and have modified the examples of section 8, and have modified the end of the dispersion relation section. I just read through all of Section 31 and found some wrong local equation numbers and fixed them. so maybe need to review this entire section at some point. I think it has to do with my adding σ to the section.

Appendix C Fourier Integral Transform and the Hilbert Transform

equation number sequence check: 34

figure number sequence check: 1

(a) done, did some clean up, equation number fixes

(b) done, tiny edits.

(c) done, tiny edits

(d) done, pretty good I think

(e) done

(f) done, very fast, good enough

(g) done

(h) hold for manana. // DONE!

Tues 4.16.13

I worked on section (h) Hilbert transform today. I made Example 1 more general and verified it with Erdelyi, the sgn(β) is important. I then did Example 2 as a superposition of Example 1 and ended up with the reverse order thing $(f\hat{})^{h}$. I then verified this final result C.44 by direct calculation and installed that alternate derivation at the end of Appendix C.

This Appendix is now ready to be installed into the main doc! DONE!

This project is now on hold until return from East Coast. The DFT section still has to be rewritten, the references have to be done, and then production work. It is now sitting at a whopping 239 pages!

I would like to check the power densities against the Bennet Davey book and maybe look at that book a little bit.

Weds 4.17.13

Found a little extra time so can do a little today. Found missing factors of T_1 associated with δ(t) as a pulse and did repairs in Section 25.

Section 27 DFT

equation number sequence check: 21
figure number sequence check: 4
intro material: done, but reread when done and maybe improve
(a) done
(b) done.
(c) done, some repairs made, added more generic DFT.
(d) done and OK

This section is just a bit strange, but I no longer think it needs a complete rewrite. I do obtain the standard results, and I do things fully in the pulse train and pulse context used everywhere in my doc.

What still remains to be done?

- write an overview and summary
- overall spell check
- verify line code results against Bennet
- clean up the References -- **DONE**
- do pagination
- proof Sections 32 through 38 !!! I have not done this yet!

Weds 5.6.13

Well, about 3 weeks have passed and spectral theory has gotten cold. I am not sure where to start. I need to be familiar with all of it to write the introduction. So I guess I will just read the entire document, but without detailed equation number checks. I will look for grammar problems and flow.

Get accent mark on Erdelyi everywhere.

CHAPTER 1

1. The Fourier Integral and Sine/Cosine Transforms
(a) Pulses and Pulse Trains, Periodic and Aperiodic
(b) The Fourier Integral Transform X(ω)
refers to Appendix C which I will not digress to read now.
(c) The Fourier Sine and Cosine Transforms $X_S(\omega)$ and $X_C(\omega)$

2. Proof of the Fourier Integral Transform
refers to Appendix A, will not digress now.
Comments

3. The Convolution Theorem and its Derivation
The Convolution Theorem:
Comments
(1) Dimensions.
(2) Operators.

(3) Groups.

4. Applications of the Convolution Theorem
(a) General case
(b) A specific example: the RC filter section
(c) An even simpler example: $L_t = (d/dt)$
refers to Appendix C for subtleties of g(t) = θ(t)

5. Fourier Integral Transform Conventions
(a) Sign of Phase.
(b) j Versus i.
(c) Allocation of 2π.
(d) Comments.

6. The Generalized Fourier Integral Transform and the Laplace Transform $\mathcal{X}(s)$

7. Reflection Rules

8. Three simple examples of spectra
(a) The spectrum of x(t) = 1 :
(b) The spectrum of x(t) = δ(t - t_1) :
(c) The spectrum of x(t) = θ(t) :
ref to Appendix C. This section gives a hint of complexity, but reader is spared in main line text

9. Spectrum of an isolated square pulse

10. The Area Rules and Parseval's Formulas

11. Differentiation and Integration Rules with Examples

12. Time translation x(t) causes phase on X(ω).

13. Exponential Sum Rules

Chapter 2: Pulse Trains and the Fourier Series Connection

14. The Spectrum of a Simple Pulse Train

(a) Infinite Length Simple Pulse Train
Note on $x_{pulse}(t)$

(b) Finite Length Simple Pulse Train

15. Connection with the traditional Fourier Series

16. Fourier Series for a positive square wave pulse train

17. More about positive square-wave pulse trains

18. Non-positive pulse trains

19. Biphase pulse and pulse train

Chapter 3: Sampled Signals and Digital Transforms

20. Sampled signals and their Image Spectra

21. Digital Filters, Image Spectra and Group Delay

(a) A Digital Filter as an Approximation to an Analog Filter

(b) Filter Group Delay

22. The Digital Fourier Transform X'(ω) Part I

23. The Digital Fourier Transform X'(ω) Part II

(a) Relation between X'(ω) and X(ω)

(b) Summary of the Digital Fourier Transform

24. The Z Transform X"(z)

(a) Convolution Theorem

(b) Unit Impulse

(c) Time translation

(d) Derivative Limit

(e) Digital RC filter

(f) Poles in H"(z) imply feedback and infinite impulse response (IIR)

(g) The digital RC filter revisited

(h) Other circuits

(i) Z Transform Summary

25. Amplitude Modulated Pulse Trains

Example 1: A finite pulse train

Example 2: The unit impulse and the sinc sum rule

26. A simple application: aperture correction

27. The Discrete Fourier Transform

(a) The Discrete Fourier Transform for a Simple Pulse Train x(t)

(b) Proof of the Discrete Fourier Transform for a Simple Pulse Train x(t)

(c) The Discrete Fourier Transform for an Arbitrary Pulse

(d) Comments **on the Discrete Fourier Transform**

Chapter 4: Some Practical Topics

28. Do FIR filters have linear phase?
Method 1
Method 2

29. A Simple Digital Low-Pass Filter

30. Use of Oversampling in a D/A Converter Design

(a) A very simple D/A converter

(b) Oversampling just the D/A converter

(c) Add oversampling and zero-stuffing to reduce aperture

(d) Add an $\omega_1/2$ digital low-pass interpolation filter

---

Thurs May 9.

Today I reread Chapter 4 and did more edits, adjusting ending figure numbers. Unlike my impression yesterday, I think this really is an excellent section and the interested reader should enjoy it a lot. It takes the abstract math down to earth with precise Maple plots and hardware designs in the context of a practical circuit. It is not a D/A handbook, it is just a long example of the methods described earlier. I can now move on to Chapter 5.

Chapter 5: Some Theoretical Topics

31. Spectral Dispersion Relations

(a) A simple integral equation for X(ω) analytic in the upper half plane

(b) A simple integral equation for X(ω) analytic in the lower half plane

(c) dispersion relations for X(ω)

(d) dispersion relations for γ(ω)

(e) dispersion and attenuation

(f) application to coaxial cable

(g) The dispersion relation expressed in terms of the Hilbert Transform

---

Chapter 6: Power in Pulse Trains

32. The Autocorrelation Function

(a) Autocorrelation function for a Square Pulse.

(b) Energy in a finite signal x(t)

(c) The Spectral Density Connection: Wiener-Khintchine

(d) Verification of Wiener-Khintchine for a Square Pulse.

(e) Cross-correlation, convolution, and autocorrelation

33. Spectral Power Density of a Simple Pulse Train

(a) Infinite Simple Pulse Train

(b) Finite Simple Pulse Train

(c) Spectral Power Density of a Simple Pulse Train

(d) Average Power P of a Simple Pulse Train

34. Spectral Power Density of a General Pulse Train

(a) General Pulse Train results and connection with the Autocorrelation Function

(b) Spectral Power Density for a General Pulse Train

STOP!!! I realize that I have not proofed Sections 31 through 38 in terms of my full proofing check! I thought I had already done this, but the log above shows not so! So a lot of work still remains, and I just have to hunker down and do it. THEN I can do final readings and write overview sections. I have jumped the gun! In fact, I should start with Section 31. Start on this tomorrow!!

Fri May 10, 2013.

In my proofing pass halted above 3/31 I had the format used below. Was I checking every equation reference? I don't know, but I will do so starting now.

Section 31 dispersion relations
- equation number sequence check: 22
- figure number sequence check: 2
- (a) done
- (b) done
- (c) done
- (d) done
- (e) done
- (f) done
- (g) done

Section 32 power in pulse trains
- equation number sequence check: 15
- figure number sequence check: 1
- (a) done
- (b) done
- (c) done
- (d) done
- (e) done

Section 33 simple pulse train power

equation number sequence check: 32

figure number sequence check: 0

(a) done

(b) done

(c) done

(d) done

Section 34 general pulse train power

equation number sequence check: 31

figure number sequence check: 9

(a) done

(b) done

(c) done

Method 1: Brute Force Approach done

Method 2: Fourier Series Approach done

Special Case Group 1

Square wave pulse train with peak-to-peak = 2 units and period $2T_1$

Square wave pulse train with peak-to-peak = 1 units and period $2T_1$

Square wave pulse train with peak-to-peak = 2 units and period T_1 :

Square wave pulse train with peak-to-peak = 1 unit and period T_1 :

Special Case 2

Special Case 3 : Recovering the Simple Pulse Train Spectra

Pause here to write some overview stuff, since so much has happened! // Well, I forgot to do this and just continued.

Section 35 statistical pulse trains

equation number sequence check: 25

figure number sequence check: 6

(a) done, many eq nos were wrong.

(b) done.

(c) done

(d) done

(e) done, making progress in the flow I think

(f) done, my A+ numerical example for stat pulse train

(g) done, comment that autocorr not really needed.

(h) done

Done for 5/10/13.

May 11, 2013.

Before going on to Section 36 on those line code formulas, I decided to attempt verification of the formulas. To my surprise, I found that I got my formulas not from Bennet but from some other book by Smith which I don't have. This led to a Marriott visit, and that led to some new realizations, and I now have to ponder things a bit before I can resume the spectral doc proofing. These new things are all good new things.

May 12, 2013.

Based on the library trip of yesterday, I decided to expand my little statistics digression into Appendix D. That is now written, and I will proof it right now before doing an installation:

Appendix D statistical pulse trains

equation number sequence check: 32
figure number sequence check: 0
(a) done
(b) done
(c) done

I then attempted to tie this into Section 35. I deleted old subsection (b) and backed up all the other letters by one. Probably some internal letter references are now wrong within Section 35.

I got a match between my main spectrum result and that of Xiong and installed this verification just after equation (35.11). This is my ONLY connection to other authors! I thought some author used the α and β notation, but it is not Smith or B&D or anyone else I am aware of. I lost it if I ever had it. But Xiong has luckily filled the breach. I guess I need to re-proof Section 35 now and review my summary above in light of the μ and σ^2 parameters.

But first, let's go for verification of some of my line codes, that will be a major topic and I will do this in a separate doc. // Got almost all done, found various errors and fixed them, verification is always important to do!! Shutting down for today.

May 13, 2013

This AM I went through the line code sections of spectral doc and added equations with verification references for the reader. These are only for p = 1/2 generally speaking, but AMI from B&D is more general with its factor of 2 error issue. Everything including NRZI has verification I would say, so that is a definite improvement in things. I show tracing paths for everything.

So the proofing pass can now continue. I am going to redo section 35 since it got altered.

I just worked the Poisson Sum Formula into Section 13.

Section 35 statistical pulse trains

equation number sequence check: 25 plus some extras with a,b suffix
figure number sequence check: 6
(a) done

(b) done
(c) done
(d) done
(e) done
(f) done
(g) done

May 14, 2013

After proofing Section 35 yesterday, I updated its summary section above. Proofing continues:

Section 36 line codes

equation number sequence check: 14
figure number sequence check: 13
intro: OK
(a) done
(b) done
(c) done
(d) done
(e) done

1. My Manchester waveform picture is wrong, but I think everything else is correct. Where are these waveform pictures? They are taken from linecode samples.mws. I fixed it up.

2. With the corrected picture, it seems that $\mu = 0$ for any value of p, but I have $\alpha = (2p-1)^2$! Something is wrong here. The battle continues forever! Something is very wrong here, but now it is driver's license time and then TseRin lawn time. // I never got back to work this day. // Resolution: the mean of the waveform is not the same as the mean of the amplitudes y_n.

3. I just bit the bullet and replaced "spectral power density" with "power spectral density" since it wins by 3 to 1 on search. Similarly for energy. All done. // But then later I switched it back the way it was!

Section 37 the AMI Line Code

equation number sequence check: 14
figure number sequence check: 3
DONE. Made various fixes.

I am ready to proof Section 38, but am now worn down.

Section 38 Change Hold line codes

equation number sequence check: 33
figure number sequence check: 3
Pulse Shape: done
Coding: done
Coefficients: done (the long section!)
Spectrum: done (another long section!)
Lim A→B : done
Lim p→ 1: done, after fixing a factor of 2 error which took about 2 hours to deal with
Lim p→0: done, again had to fix errors, previous results were dead wrong!
Lim p→1/2: done
Box Shaped Pulse for general p: done
Box Shaped Pulse for p = 1/2: done
Example: Unipolar NRZI line code: done
Example: Bipolar NRZI line code: done

Hurray!! This Section 38 was in vary bad shape. Pictures wrong, numerical errors, equation numbers missing, etc.

Just did another read-through of Section 38, adding equation periods and a few other details. It is done.

Decision: I think I like "spectral power density" better than "power spectral density" so I am going to change it all back the way it was (also for energy) and add a comment about PSD. About 17 occurrences. Now same for energy. DONE.

I just wrote detailed summaries of the four Appendices, that took quite a while.

All that remains is the "Overview".

May 17, 2013

I wrote a short **overview** (one paragraph) and a **short summary** to go with it. I **installed** the detailed summary at the END because I know how confusing it is to have such a long section between the TOC and the main body. Maybe with bookmarks that is not such an issue, but I just prefer to have it be "out of the way". I have never seen a book with a separate summary like this.

So now everything is **fully assembled** for the very first time, and we are sitting at 267 pages. I certainly hope the PDF can be created OK.

I now want to **proof these added sections**.

Overview and Summary: done

I think this really does summarize what the paper is about.

A Detailed Summary of this Document

opening: done
Chapter 1: done
Chapter 2: done, punctuation fixes
Chapter 3: done
Chapter 4: done
Chapter 5: done
Chapter 6: done
Appendix A: done
Appendix B: done
Appendix C: done
Appendix D: done

Next: deal with capitalization of various section headings. I only use capitals on "special words and phrases", not ordinary words. Reflection Rule is a special phrase. Area Rules. It is a strange system I use, but I don't want to capitalize "of an isolated square pulse", for example.

Chapter 1: ok
Chapter 2: ok
Chapter 3: ok
Chapter 4: ok
Chapter 5: ok
Chapter 6: ok
App A: ok
App B: ok
App C: ok
App D: ok

Letter sequencing check: all OK, numbers and letters.

Section headings: done, took about 10 minutes, short title for each chapter.
Decided not to do section-level headings! Way too many.

Still pondering various titles for the doc. Digital filters and filters in general really do form a major part of things and should be mentioned.

References review: done. Want to add A&S but no real justification to do so. It is a very short ref list and has no references on Fourier Analysis!

Erdelyi accent mark: ***** DONE
What words in the doc should be bolded as eyecatchers? ******** I think I will let this just ride and be inconsistent. I bolded things where I thought it was important to do so.

Pagination:

TOC: comes out very nice, I add one page break but not really needed.

Overview: very nice, 2 pages
Section 1: ok
Section 2: ok
Section 3: ok
Section 4: ok
Section 5: ok
Section 6: ok, does not start with page break.
Section 7: ok
Section 8: ok, does not start with page break.
Section 9-13: all OK, one continuous short chunk of stuff
Chapter 2:
Section 14: I made a small change to make it end at a page bottom, all OK!
Section 15: ok
Section 16-19: ok (treat as a single group of sections)
Chapter 3:
Section 20: ok
Section 21: ok
Section 22: ok
Section 23: ok, the summary box cannot fit all on the first page, so OK.
Section 24: ok , a long section.
Section 25: ok
Section 26: ok, short section on aperture correction
Section 27: ok to start of section (c) , and then ok to the end
Chapter 4:
Section 28: ok, put Method 2 on separate page.
Section 29: ok
Section 30: ok
Chapter 5:
Section 31: ok
Chapter 6:
Section 32-33: ok as a pair
Section 34: ok
Section 35: ok
Section 36: ok to top of page 180, and throughout
Section 37: ok
Section 38: ok
Appendix A: ok
Appendix B: ok
Appendix C: ok
Appendix D: ok
Summary: ok
References: ok

Done paginating! Let's now fix Erdelyi and Erdélyi: DONE

What else?

Spell check: Have to copy out chunks and do in a separate word doc,

Spellcheck file 1: entire doc from start to start of Ch4, not a single spelling error noted! Probably this is because this is older material which I have already spell checked, though I am always adding new stuff. This was the first 106 pages, very tedious to do this task but it must be done.

// check paragraph above 24.1 "in Section 23". I overtyped it.

Spellcheck file 2: From start of Chap 4 to start of sec 36, about 66 pages. Found and corrected 6 misspelled words in this chunk.

Spellcheck file 3 is the rest of the doc.
Something wrong with the summary Chapte 2 heading at the end of the doc.
found about 3 words misspelled, all done!

What else? I think we are there.

Title is pretty long:

Fourier Analysis with Application to Digital Filters and PAM Signal Spectra

If I say "spectral theory", no one will ever find this thing. Same for "pulse trains". By adding PAM, I properly limit the documents scope, which is correct. Digital filters is probably a common search term, maybe PAM would be. Fourier Analysis has lots of competition. Fourier transform seems to imply that is the only transform, but analysis seems more general.

Fourier Analysis and its Application to Digital Filters and PAM Signal Spectra

Fourier Analysis and its Application to Digital Filters and Spectral Power Density

Fourier Analysis with Application to Digital Filters and Spectral Power Density

Fourier Analysis with Application to Digital Filters and PAM Signals

Fourier Analysis with Application to PAM Signals and Digital Filters

Fourier Analysis with Application to Pulse Trains and Digital Filters

This last one is the winner:
1) search on Fourier Analysis
2) search on Digital Filters
3) search on Fourier and PAM
4) suggests the fourier analysis is a separate topic that is treated on its own, then applied

I am now ready to attempt a 259 page PDF. Starting at 9:14, stop 9:18, a mere 4 minutes to process my largest document ever!

Review the bookmarks:
are any missing
are there alignment space problems?

The Chapter 2 book mark is missing. I noted a problem with that above!
Capitalize heading Pulse Train Ensemble in Appendix D (c) DONE
Chapter 2 heading also messed up in the summary at the end.
Otherwise all headings have good alignment.

So lets completely delete that Chapter 2 heading in both places, copy to notepad, copy back, and set heading types in both places. DONE.

Second shot! Note: it beeps once when it starts doing copy pages, benign. It then does a final set of pile driving in the scroll bar before being done. The Chapter 2 problem is fixed in both places.

I have been reading the start of the doc and already have some errata in an errata doc. Things are looking up for spectral doc! The entire PDF is only 2 MB, amazing! This is half the Word doc size. I have not yet studied the typography much.

Sat May 18.

Today I am just reading through spectral doc in the PDF, and making fixes in the DOC as I go, periods after equations and so on. I have tuned the overview a bit.

At 10 AM I am at the start of section 16. // Now at start of Chapter 3, and that is enough for now, I think I will do a cycle, do a quick check, and then upload and push.

General cleanup: while cleaning up, ran into a doc summarizing all the transforms and decided to add that list as Appendix E, it is pretty good and pretty long and good to gather then together.

Fourier Transforms and their Application to PAM Signals

Fourier Transforms with Application to Pulse Amplitude Modulated Signals

This is the new title. Plural transforms suggests not just the Fourier Transform. PAM is a bad abbreviation, don't use it. Digital filters falls out from the other two topics, and paper does both analog and digital anyway. So it is now a done deal!

Now releasing to Xmission: it is done. I also released a new Maple of this date. The last release was Jan 1, I fixed up some bookmark stuff and a misspelled word on the very first line! So two pdf's were released today.

Wrap Up

So, today I released my Spectral Theory "book" for the first time, it now has this title,

Fourier Transforms and their Application to Pulse Amplitude Modulated Signals

I see that I did some work thinking about converting spectral doc back in 2003, but I didn't get far. I found a folder on this subject which is a subfolder in the spectral theory folder. It contains just some of the 1991 files I was I guess practicing on.

The complete set of 1991 files continues to live on my E drive,

E:\Projects, Frozen 2004-\BTS Stuff 1991-1997\BTS 91\Spectral Book

At some earlier time, perhaps 1998, these files were converted from Mac to PC and acquired an extra number "6" in the file names.

How long was the original document? If I go to E drive, I can bring up the files one at a time:

chapter 1 6.doc	18 p	The Fourier Integral and Related Topics
chapter 2 6.doc	14	pulse trains and the Fourier Series Connection
chapter 3 6.doc	25	sampled signals
chapter 4 6.doc	8	Some Practical Topics
chapter 5 6.doc	5	Some Theoretical Topics
chapter 6 6.doc	16	Statistical Pulse Trains

In addition to this, there are 7 docs which just contain "contents" for each chapter and overall.

contents files	7 p

So the length of this document was 86+7 = 93 pages, quite substantial.

When I got done with this thing, it had expanded to 263 pages, about *triple* the original size. Perhaps that is why it took so long.

How long did I spend on this thing? It seems that I took a look at doing this task in 2003

Jan	none
Feb	started on Feb 25, so 4 days
Mar	all month basically 30 days
Apr	all month less White Rim (6) and less Cod (10), so call it 14 days
May	started may 6, done may 18, so another 13 days

Total days = 4 + 30 + 14 + 13 = **61 days**

The Galois paper only took 22 days!! So why so long to do Spectral?? I suppose with Galois I stuck to the script and just edited, added a little, the trees and all that, and then was done with it. This Spectral

story was quite different. The whole business of finite N and the δ_n models. I think it was basically a complete rewrite of every single section!

August 9 2013 Update.

This was a massive update on which I spent maybe 16 solid days (will count later). I created a separate area for doing this update called Work for Aug 2013 update. There is a separate log for all the work done in that folder. The log file itself is some 19 pages long! See that log file for details. The biggest changes are new fat appendices, and a completely rewritten Section 35 on statistical pulse trains with its implications carried through to other sections. This was pulse train work, nothing changed in the Fourier Transform sections before perhaps Section 32. The doc is now I think much improved in many ways. I think there were some errors that were fixed as well, and of course errata have been handled as well.