Week 6

Finishing an Experiment & Writing a Scientific Journal Article
FIVE STEPS TO COMPLETING AN EXPERIMENT

1. Frame your conclusions precisely; be sure you have experimental proofs
   - complete “Reverse Outline” form by last day of experiment - handwritten

2. Review Step 1 with your collaborator(s)
   - discussion of outline with instructor on last day
   - how will you convince your readership of your results?

3. Create a “forward outline” of the article (on your own)
   - paragraph-level bullets, typed
   - due 3 days after Step 2

4. Write your article (on your own)
   - concentrate on clarity and wordsmithing
   - due 2 weeks after Step 2

5. Submit article to the editor
   - formatting requirements must be fulfilled
   - returned with late penalties if not correct
**STEP 1: FRAME CONCLUSIONS**

- Decide what you can claim to have measured or proven in your work
- Think through the “logic” that leads to your conclusions
- A “Journal Article” for publication is NOT a “Lab Report”
  - **DO** convince the reader of your results; mention only things necessary to achieve that goal
  - **DON’T** dwell on extraneous details, mistakes you made along the way, data or results you ended up not using
IV. Conclusions
These are the conclusions of my experiment (usually you have only one or two):

1. ______________________________________________________
2. ______________________________________________________
3. ______________________________________________________
4. ______________________________________________________

Continue on a separate sheet, but are you sure that you have that many conclusions?

III. Results
These are the results that support my conclusions. If the results are numerical values, write them here. If they are in a graph, give a pointer to the graph in your notebook or attach a copy to this document.

SUPPORT FOR CONCLUSION 1:

a. ______________________________________________________

b. ______________________________________________________

c. ______________________________________________________

SUPPORT FOR CONCLUSION 2:

a. ______________________________________________________

b. ______________________________________________________

c. ______________________________________________________
SUPPORT FOR CONCLUSION 3:

a. 

b. 

c. 

SUPPORT FOR CONCLUSION 4:

a. 

b. 

c. 

II. Apparatus and Procedures
1. Attach the schematic diagram of your experiment that you will use in your article. Does it give the characteristics the reader needs so they will understand your results and be convinced of your conclusions and ONLY those characteristics?
2. Provide a list of the ideas you need in this section so the reader can understand your results and be convinced of your conclusions.

a. 

b. 

c. 

d. 

e. 

f. 

Continue on an attached sheet if you need more space.

I. Introduction
List ideas and concepts you need to present so the reader will both be motivated to read the rest of the article and will understand the rest of the article.

a. 

b. 

c. 

d. 

e. 

f. 

Continue on an attached sheet if you need more space.

Abstract
Make it terse and crystal clear. Give one or at most two sentences on each of the following:

What I did?

How did I do it?

What did I find (with key numerical values if only a few)?
STEP 2: SUMMARY DISCUSSION
Reviewing Your Logic

- Discuss conclusions/logic with an Instructor
  - done on the last day of the experiment
  - may be somewhat adversarial: “show me the evidence”

- Review completed reverse outline
  - often improves logic
  - verbal discussion uncovers any errors in logic

- Required part of finishing the experiment

- Scheduled for Tuesday during lab

Grade deduction if not done
**STEP 3: THE “FORWARD” OUTLINE**

*Turning Your Attention to the Reader*

**Purpose**
- Breaks writing process down into smaller pieces
- Refines content & ordering to convince the *reader* of your conclusions
  - presentation stream must guide the reader
  - gives reader confidence that you are competent

**Method**
- Force precise statement of conclusions
  - remove "wiggle room"
- Invert “reverse outline” order to normal forward sequence
  - make everything you say lead to the conclusions
- Include actual graphs
  - forces you to stare at the data you claim proves a point
- No sentences
  - do not hide soft logic behind lots of words
- Length
  - 1.5 to 2 pages of writing + figures and tables

*Grade deduction if not done*
STEP 4: WRITE THE ARTICLE

- **Scientific Article** for Publication
  - Written for a “scientific public”
  - Have a definite conclusion/message
  - Your scientific reputation is at stake
  - Present compelling evidence for your conclusion(s)
  - **Not** a chronology & give no extraneous details

- **Lab Report** for Internal Use
  - Written for your “boss”
  - Report all you did, whether successful or not
  - Your job or promotion is at stake
  - Discuss all you did/tryed, regardless of outcome
  - Often written as a chronology of your efforts
Abstract:

We

The goal of our experiment was to characterize the nuclear magnetic resonance properties of pure glycerin and to use our finding to test the accepted functional forms of the characteristic equations. We found $T_2$, the spin-spin relaxation time, to be $18.53 \pm 0.26$ ms and agreed with the functional form. For $T_1$, the spin-lattice relaxation time, we found the value $28.16 \pm 0.27$ ms; however we found very poor agreement on the predicted intercept ($4.1\sigma$) and unexplained behavior at delay times greater than $T_1$. The possibility of nonlinearity in the apparatus has not been ruled out.

great tells the whole story
Introduction:

Chaos is a topic that has developed through the study of dynamical systems. Such systems can have the appearance of unpredictability while actually being governed by precise deterministic laws. Systems in nature are often chaotic, displaying fractal growth patterns and extreme sensitivity to controlling parameters.¹ Present work is modeling natural systems and everyday problems, however, understanding these more complicated systems requires a re-investigation of the chaos inherent in simple classical mechanical systems.

Here we quantify the parameters controlling the motion of a damped driven metal reed in a symmetric double well potential and discuss the chaotic nature of its behavior. Such a system is governed by the equation:

\[ \dot{x} + \alpha x + c \dot{x} + (dx/dt) + d^2x/dt^2 = F_0 \cos(\omega t) \]  
(1)

where \( F_0 \) and \( \omega \) are the driving force and angular frequency of the driver, \( a \) and \( b \) describe the potential, and \( c \) is the decay constant.²

Section I will describe our apparatus and procedure for studying the behavior of this system. In Section II, our results will be presented in three subsections: II-A will discuss the characterization of the parameters governing our system and the steps leading up to chaotic motion; II-B discusses chaotic attractors and scale invariance; and II-C deals with the interpretation and superposition of fractal (Hausdorff) dimension. Section III presents our conclusions.

Equations:
- numbered
- symbols all defined

“Roadmap” to article at the end of Intro
Figure 4: Apparatus. The equations below the figure represent the two parameters used to adjust the magnets' position.

\[
\frac{x_1 + x_2}{2} = M_1 \\
x_1 - x_2 = M_2
\]

- \( R \) = Reed;
- \( M \) = Magnet;
- \( S \) = Strain Gauge;
- \( L \) = Loudspeaker

Block diagram: everything connected the correct way

Figures have: number, caption, tie-in to main text
mathematical prediction. However, beyond a certain critical value of \( k \), the separation between the resonance frequencies decreases, eventually becoming zero. We can interpret this behavior as evidence that the small-\( k \) approximation from which the mathematical predictions in the Introduction follow breaks down beyond this critical value of \( k \).

The specific shape of the envelope of the points cannot be taken too literally, as the frequency of maximum response is a resonance not just of the oscillator, but of all the mechanical components that make up the apparatus: the reed, the strain gauge, etc. Hence the 'true' shape, the shape reflecting only the properties of the Duffing oscillator, could be very different from that in Figure 5. Further, the frequency at which resonance is measured for each point is probably a slight underestimate: we observed that, having found a resonance, the frequency of resonance actually increases slightly in time (in magnitude \( \pm 2 \text{-} 3 \text{ error bars} \) for that point; this is most likely due to the magnetization of the reed. Hence all of the points in Figure 5 should be shifted slightly to the left.

Figure 6 is a phase plot of the oscillator's motion (for 2000 points) at a driving amplitude in the middle of the chaotic region in Figure 5. Data taken before difficulty later on, so subsequent phase plots only contained 500 points each. We superimposed three such plots (for better resolution) for widely varying \( k \) in Figure 7, and comparing with Figure 6 we see very similar patterns of 'holes' in the plots; this shows at least qualitatively that the chaotic motion has the same 'signature' regardless of the value of \( k \) and other initial conditions.

We did, however, make quantitative measurements of this 'signature', or fractal dimension, for each of the values of \( k \) in the phase plots. The software packages we used effectively returned a set of values which we plotted and fit a line to; the slope is the fractal dimension (c.f. Figure 8). Each data point may be understood as follows: the analysis program lays a \( 2^9 \times 2^9 \) grid over the phase space; then for a given value of \( r \), it takes the average number of points included in a box of side length \( 2^r \) around each data point in phase space and reports the log of this average as \( 'C(r)' \). The slope of the 'best fitting' the data (as in Figure 8) is the fractal dimension. Since we didn't really have a way to find the error on each individual point in Figure 8, we took several separate measurements of the fractal dimension for each value of \( k \) and used the mean and standard deviation to get an average fractal dimension. Hence one should understand that the results appearing in Table 1 represent averages taken over a large number of individual measurements of fractal dimension. All of the measured values of fractal dimension turn out to agree with one another within error, as evident from Table 1. This is an indication that the character of the chaos is inherent in the system and is irrespective of initial conditions. We could not get stable measurements for \( k < 2.65 \) (which corresponds to about half of the chaotic region) but considering the constant nature of the fractal dimension in the upper half of the chaotic region, we assume that the fractal dimension is the same here too.

IV. Summary
Graphs have axis labels, units,

Data points have error bars

Figures have: number, caption, tie-in to main text
Tables have:
- number,
- caption,
- tie-in to main text

Tables number and Figure number sequences are separate
CONCLUSION

The photoproduction differential cross section of the $\Lambda(1405)$ has been measured using the CLAS detector system at Jefferson Lab’s Hall B. Our lineshape results show strong differences between $\Sigma\pi$ decay channels, which has been predicted in the chiral unitary coupled channel approach, albeit with channel characteristics being interchanged with respect to the prediction. We hope to present our final results in the near future, which will include the lineshape measurements in each $\Sigma\pi$ channel, and the differential cross sections of the $\Lambda(1405)$, $\Sigma(1385)$, and $\Lambda(1520)$. Also of interest is our spin-parity analysis of the $\Lambda(1405)$, where for the first time it can be shown directly from experiment that the spin-parity of the $\Lambda(1405)$ is indeed $J^P = 1/2^-$. Our large data on the $\Lambda(1405)$ and closely hyperons will help shed light on the nature of the $\Lambda(1405)$ and its production mechanism.

ACKNOWLEDGMENTS

K. M. would like to thank the organizers of the PANIC11 conference for the opportunity to present results of our analysis, and also for financial support to attend the conference.

REFERENCES


References have:
- Number sequence in order of (first) text citation – no ”ibid.’s”
- Author(s), source, pages, year.
- NOT a bibliography
CHECKLIST

In recitation, we have provided you with a list of simple procedures we want you to practice. To insure you practice these procedures, we will use the check list below in grading your completion of the scientific reasoning, notebooks and scientific articles. This list does not include everything on which you will be graded. You need to produce summary notes, outlines, notebooks and scientific articles that fulfill the stated purposes of each. The deductions will be made first, and then the more qualitative aspects of your work will be taken into account in your grade.

Completing the Scientific Reasoning

<table>
<thead>
<tr>
<th>Preparation for Summary Talk</th>
<th>Deduct 1.0</th>
<th>Complete</th>
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</thead>
<tbody>
<tr>
<td>Outline Completed</td>
<td></td>
<td></td>
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</tbody>
</table>

Instructions for Notebooks and Articles

Look at this check list. Make corrections in your scientific article and notebook where you would incur a deduction.

When your notebook and article are ready to be turned in, fill in the check list as it applies to the final version of your article and notebook. Turn to the back page of this form. Fill in the last lines and sign the form. Turn this form in with your scientific article and notebook.

Notebooks

<table>
<thead>
<tr>
<th>Deduct 0.5</th>
<th>OK</th>
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<tbody>
<tr>
<td>1. No loose pages; pages numbered</td>
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<tr>
<td>2. Notes from lab discussions</td>
<td></td>
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<tr>
<td>3. Questions in handout answered in notebook</td>
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<td>4. Informative sketch of apparatus (for each step)</td>
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<td>5. Description of procedures (for each step)</td>
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<tr>
<td>6. Data tables with units and error bars (and description of how error bars were determined)</td>
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<tr>
<td>7. All graphs: title, axes (units), error bars</td>
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<tr>
<td>8. Analysis procedures and results recorded in notebook</td>
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<tr>
<td>9. All calculations, including spreadsheets and computer graphs in notebook</td>
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<tr>
<td>10. Progress reports each week</td>
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<td>11. Light cross out</td>
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<td>12. Delineate sections of work (headings, boxes, ...)</td>
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<tr>
<td>13. Cross referencing among data tables, analysis, graphs</td>
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<tr>
<td>14. Proper use of significant digits</td>
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<tr>
<td>15. When best fit curve produced a) show best fit curve on graph</td>
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<tr>
<td>b) state $\chi^2$</td>
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<tr>
<td>c) state if fit is good</td>
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<tr>
<td>16. Final conclusions in notebook</td>
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</table>

Scientific Articles

<table>
<thead>
<tr>
<th>Deduct 0.5</th>
<th>OK</th>
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</thead>
<tbody>
<tr>
<td>1. Pages double spaced, one column, single sided, numbered</td>
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<tr>
<td>2. Descriptive title</td>
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<tr>
<td>3. 5 sections with headings written out</td>
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<tr>
<td>a) Abstract (1 paragraph: What done; method; specific conclusions)</td>
<td></td>
</tr>
<tr>
<td>b) Introduction (with &quot;road map&quot; to article at end)</td>
<td></td>
</tr>
<tr>
<td>c) Apparatus and Procedures</td>
<td></td>
</tr>
<tr>
<td>d) Results</td>
<td></td>
</tr>
<tr>
<td>e) Conclusions</td>
<td></td>
</tr>
<tr>
<td>4. References (even to handout) in Physical Review style</td>
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<tr>
<td>5. Equations with more than a symbol and number appear in separate lines with equation number and all symbols defined</td>
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<tr>
<td>6. At least one, appropriate block diagram</td>
<td></td>
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<tr>
<td>7. Tables numbered separately in the order in which they appear in the text</td>
<td></td>
</tr>
<tr>
<td>8. All figures and graphs numbered consecutively as they are cited in text</td>
<td></td>
</tr>
<tr>
<td>9. Uncertainties, labels on axes, etc. on graphs. All figures have a title and caption. Cite sources if not original</td>
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</tr>
<tr>
<td>10. Proper significant digits and number format</td>
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<tr>
<td>11. Discussion of experimental uncertainties</td>
<td></td>
</tr>
<tr>
<td>12. Forceful statement of conclusions at end of article.</td>
<td></td>
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</tbody>
</table>

*If these items are not completed, your scientific article will be returned for reformatting before grading.

Present Article Title: ____________________________

Name: ____________________________

Signature ____________________________

Date: ____________________________

Pick up this checklist today, hand in with article and notebook in 2 weeks.
STEP 5: SUBMIT TO EDITOR

- Complete the Checklist of formatting demands
- Hand in:
  - Article
  - Notebook
  - Completed Checklist

- Editor checks required formats

- Returns work to you if corrections are needed
  - Late-work deduction applied if this delays completion
MPL PROCEDURES & FORMALITIES

Close-Out Talks
1) Complete all analysis before the summary talk.
2) Complete the reverse outline before the summary talk.
3) Have rough drafts of all graphs and values for all numbers that justify your conclusions available for the talk.

Article Outlines
1) Use your reverse outline as a guide.
2) Force precise statement of conclusions.
3) Keywords and phrases suffice: sentences not necessary
4) Include actual graphs.
5) 1.5 to 2 pages of writing.

Scientific Articles
1) Double spaced, single sided, with page numbers.
2) 5 sections with headings written out.
   a) Abstract (1 paragraph: What done; method; specific conclusions).
   b) Introduction (with “road map” at end).
   c) Apparatus and Procedures.
   d) Results.
   e) Conclusions.
3) References (even if only to MPL handout) in Physical Review style.
4) Equations with more than a symbol and number appear in separate lines with equation number.
5) All symbols defined.
6) At least one appropriate block diagram.
7) Tables numbered separately in the order in which they appear in the text.
8) All figures and graphs numbered consecutively as they are cited in text.
9) Uncertainties, labels on axes, etc. on graphs. All figures have a descriptive caption.
10) Proper treatment of significant digits and number format.
11) Discussion of experimental uncertainties, both random and systematic.
12) Forceful positive statement of conclusions at end of article.
**Modern Physics Lab Grading Standard**

Each experiment gets 3 scores, weighted as follows:

1) Doing the experiment & learning the physics  50%
2) Scientific Journal Article  25%
3) Notebook  25%

For items (1) and (2) the scale is:

10  - everything done exceptionally well, carrying all aspects of the work beyond typical expectations, no errors of any significance
9   - everything done very well and at least one thing done beyond typical expectations; no major errors
8   - everything done well; a few small errors but no major errors
7   - everything done well but one thing done not so well (but not terribly)
6   - everything done but one thing done not so well; some other small errors allowed
5   - everything done with some number of errors
4   - some major element missing or incorrect
3   - two or three major elements missing or incorrect
For the Notebook the scale is:

10 - everything done exceptionally well, no errors of any kind
9  - everything done very well; no significant errors
8  - everything done; a few small errors but no major errors
7  - everything done but one thing done not so well (but not terribly)
6  - one major element missing or incorrect
5  - two major elements missing or incorrect
≤ 4 - three or more major elements missing or incorrect

“Errors” above do not refer to the standardized deductions from the check-off list you will use. These standardized deductions (0.5 per instance) come off your score before the grading above is applied.

Final letter grades will be assigned using the following nominal cut-offs:

9, 10 → “A”
7, 8  → “B”
5, 6  → “C”
3, 4  → “D”
SUMMARY

1. Frame your conclusions precisely; be sure you have experimental proofs
   - complete “reverse outline” form by last day of experiment - handwritten

2. Review Step 1 with your collaborator(s)
   - discussion of outline with instructor on last day
   - how will you convince your readership of your results?

3. Create a “forward outline” of the article
   - paragraph-level bullets, typed
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   - concentrate on clarity and wordsmithing
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5. Submit article to the editor
   - formatting requirements must be fulfilled
   - returned with late penalties if not correct