6	Mon. 10/6 Wed. 10/8 Fri., 10/10	**A.3-.6** Linear Algebra **3.1-.2** Formalism: Hilbert Space & Observables (Q5.6, 6.2-3) **3.3-3.4** Formal: Hermitian Operator's Eigenstates & Statistical (Q11) Columbia Visitor 3pm AHoN 116	**Daily 6.M** **Daily 6.W** **Daily 6.F**

Equipment

- Griffith's text
- Printout of roster with what pictures I have
- Whiteboards and pens

Check dailies

Announcements:

- **Exam**
  - **Graded**: 3-A, 5-B, 2-C, 2-D, 3-F; Course: 4-a, 5-B, 3-C, 1-D 2-F
  - **Observation**: While there were some minor, doh-kind of errors, there were also ones that suggested to me that some folks weren't getting the basics like in $\int |\Psi|^2 dx$ that $|\Psi|^2 = \Psi^*\Psi$. My best guess with this kind of error is that while doing homework, one zeros in on the 'new' stuff and maybe piggy-backs on an example in the text and so doesn't get practice reinforcing that 'old' stuff that underlies everything.
  - **Opportunity**: Fix for HW points by next Wednesday. I've provided plenty of comments to get you started.
  - **Consider**: if you currently have a D or an F in this class, we should meet one on one sometime this week – before the drop deadline, in case that's an option to consider.
- **Columbia**
  - This Friday a representative from Columbia will visit to talk about / answer questions about the 3-2 program. There's no optimal time, but we've scheduled a session- presentation/open house for 3pm – as long as folks are dropping in in AHoN 116. The front end of this will overlap with some folk's classes – come to after; the back end will overlap with practices(?), leave early.

Daily 6.M Monday 10/6 Griffiths Appendix A.3-.6 Linear Algebra

Now for something (almost) completely different.

- **Talking the Talk**
  - From day-one, we've been using the vocabulary of linear algebra:
  - For example, we've been looking for (energy) **eignevectors** and casting wave functions in terms of them because those time-evolve in a simple way.

- We've observed that / taken advantage that these are often **orthogonal** and **normalizable**.
- So, conceptually, we've been working in a '**vector space'** where the energy eigenvectors are our **basis set**.

- **Walking the Wavey Walk**
  - All along, we've been working with Schrodinger's Wave Equation – solving this differential equation.
- **Wave & Matrix Mechanics**
  - Historically, Shrodinger wasn't the first to come up with a formulation of quantum mechanics, he was just the first to cast it in terms that were particularly familiar to classical physicists – in terms of a wave equation. A little before that Heisenberg had cast it in slightly less-familiar language, that of *matrix algebra.* Dirac later showed that the two approaches were completely equivalent – thus our use of linear-algebra lingo when working with a wave equation.
- **Today: Matrix Review/Prep**
  - we prepare for Chapter 3, on the formalism of Quantum Mechanics, by boning up on the formalism / mechanics of matrix algebra.
  - **Why bother?**
    - In classical mechanics you're familiar that you've got your choice of approaches, say force and energy, neither of which truly contains different physics, but the different approaches a) give us different conceptual pictures and b) are the easier tools to apply for specific types of problems.
    - The same is true for wave and matrix mechanics.

- **Team Up**
  - Now, I expect that matrix algebra is fresher for some of you (who've taken linear algebra) than it is for me (it's been a few years). So I'll provide structure and emphasize connections to what we've been doing in this class, but let's also pair you up – folks who *have* had linear algebra with folks who haven't
  - **Show of hands**: who *has* had linear algebra?

"I'd like to see briefly how the operators that we are currently familiar with are done in Linear Algebra terms, since operators are linear combinations of vectors."
Bradley W

A.3 Matrices

Linear transforms

$\mathbf{M}$

$\tilde{\mathbf{M}}$ **Transpose (flip across the diagonal)**

$\mathbf{M}^*$ **complex conjugate**

$\mathbf{M}^t = \tilde{\mathbf{M}}^*$ **Hermite conjugate, adjoint**

$[\mathbf{S},\mathbf{M}] = \mathbf{SM} - \mathbf{MS}$ **Comutator (order of operations matters)**

$\mathbf{M}^{-1}$ such that $\mathbf{M}^{-1}\mathbf{M} = \mathbf{I}$ **that Inverse**

$$\mathbf{M}^{-1} = \frac{1}{\det \mathbf{M}} \tilde{\mathbf{C}}$$

"Can we go over how to write the inverse for a non 2x2 matrix" MitchS

Dailys 1. Math: A.8

Starting Weekly HW: A.9

A.4 Change of Bases

If you think of the basis set as just another set of vectors, then transforming to a new basis set is simply transforming a vector; the same math applies.

If $\mathbf{T}$ transforms a vector within a given basis set (say, rotates a position vector by 60° relative to the x,y,z axes),

$$\vec{r}_f = \mathbf{T}\vec{r}_i$$

And if $\mathbf{S}$ takes a vector a from its representation in terms of one basis set to its representation in terms of another (primed),

$$\vec{r}_i{}' = \mathbf{S}\vec{r}_i$$

Then transforming (rotating) *and then* rephrasing in terms of the new basis set (coordinate system) would be

$$\vec{r}_f{}' = \mathbf{S}\mathbf{T}\vec{r}_i$$

Then again say you wanted to project in terms of the new basis set, then transform in terms of that basis set, and then project *back* again (say, it was easier to express a rotation relative to a rotated basis set, but then you want the expression back in terms of the old one) would be

$$\vec{r}_f = \mathbf{S}^{-1}\mathbf{T}\mathbf{S}\vec{r}_i$$

Or, the other way around,

$$\vec{r}_f{}' = \mathbf{S}\mathbf{T}\mathbf{S}^{-1}\vec{r}_i{}'$$

So, apparently

$$\mathbf{T}' = \mathbf{S}\mathbf{T}\mathbf{S}^{-1}$$

"I am really confused by changing bases in A.4. I lose track of what they are talking about and don't know how to read the notation. Can we go over what they are doing and how the notation works?" Anton

1. Dailys A.14
   "can we go over the matrix rotations in A.14, im not really sure how to go about constructing them." Jessica I too would like to go over this. Kyle B,

A.5 Eigenvectors and Eigenvalues

"Could we briefly go over diagonalizability and why it's important? Is there any difference between a matrix being diagonalizable and it being a basis set/set of independent vectors that spans a vector space?"
Spencer

I'm also finding diagonalizing confusing
Mark T,

I also would like to cover this.
Gigja

$\mathbf{M}\vec{a} = \lambda\vec{a}$

$\left(\mathbf{M} - \lambda\vec{I}\right)\vec{a} = 0$

But if a is not 0, this must be because the matrix combo is singular, that is ,

$\det\left(\mathbf{M} - \lambda\vec{I}\right) = 0$

1. Math A.19

A.6 Hermitian Transformations

1. Starting Weekly HW (A.25)