Some Guide to the Final Exam

(Monday, June 9, 4-6 PM; Optionally till later; Classroom)

UCSC, Phys 139A, Spring 2008
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1. Couple of important topics that were already covered in midterm will be included (e.g. harmonic oscillator and free particle). Note that the free particle problem is a good example of the "continuum basis" in QM [Example 4.18 of L8], and has been the basis of many problems [HW 5.1, 5.2, Quiz 6.1].

2. The parity of a stationary bound state, tunneling, and the oscillation frequency of a non-stationary state. [HW 5.3, Quiz 5] [(The later part of) Example 3.5 of L12 is an optional reading for a very advanced student. This example will enrich the understanding how the symmetry, the tunneling amplitude, and the degeneracy are all intertwined with one another.]

   For 3-8, you would need to go over the underlined titles in L8, to familiarize yourself with necessary concepts and facts.

3. You should feel comforable with the Dirac notation. Schrödinger equation in the Dirac notation?

4. Definitions: Hilbert space. Vector. State. Physical State. QM Operator. Unitary operator. Hermitian operator. Observable.

5. Properties of eigenvalues and eigenvectors of an observable: eigenvalues are real and eigenvectors can be made into a complete orthonormal basis – a natural basis – for the Hilbert space.

6. Law of measurement.

7. Time evolution of $\langle \hat{O} \rangle$, and its rich ramifications – Ehrenfest theorem and conservation rules. [HW 6.2]

8. Notion of compatible and incompatible observables. The generalized uncertainty principle.

9. Bohr theory of the Hydrogen problem, and its results. [Boxed items in pages 2,3 of L9] Scales: $\alpha = 1/137$, $a_B \approx 0.5$ Å, Rydberg $= 13.6$ eV, the ground state energy $=$ -1 Rydberg.

10. Given the wave functions in the hydrogen problem [*including spin!* – see number 15 below], you should be able to calculate things, interpret probabilistically, and also time dependence. [HW 8.1, 8.3; Section 4 of L8; End of Section 4 of L9]

11. Degeneracy in the Hydrogen problem. The relationships between n, l, m_l quantum numbers. You need to understand the table presented in page 2 of L10, and the discussion preceding it, starting from $n = j_{max} + l + 1$.

12. Fundamental commutation relations for angular momentum. Commutation relations between $\hat{J}^2, \hat{J}_z, \hat{J}_\pm$? Know how to express $\hat{J}_x$ and $\hat{J}_y$ in terms of $\hat{J}_\pm$? Know how to express any function of $\hat{\vec{J}}$ in terms of $\hat{J}^2, \hat{J}_z, \hat{J}_\pm$? [Eqs. 2.1-2.6 of L11]

13. Know the properties of the general angular momentum eigenstate $|jm\rangle$? [Box in page 4 and Eq. 2.7 of L11]

14. Spin – what is it? [Definition 2.1 of L11] Spin 1/2 – no need to memorize $\sigma_x, \sigma_y, \sigma_z$, but need to be familiar with their properties. Larmor precession. [HW 7]

15. The complete wave function of the Hydrogen problem. [Note 4.1 of L11] *[The last lecture with example wave functions, $A(\theta, \phi)$ and $B(\theta, \phi)$. Bonus HW, #1.]*

16. Angular momentum addition [Box in page 11, and Eq. 5.7 of L11]. Clebsh-Gordan coefficients – you should be able to use Table 4.8 of Griffiths, if presented with it.

17. *[Correction: You will not be required to understand the table in page 14 of L11, which I did not have time to cover in class. Zeeman and spin orbit are more like topics of 139B, in any case. In terms of the angular momentum conservation, you would be required to understand the following two points only: (1) in the Hydrogen problem, the energy is independent of orbital angular momentum and (2) in the spin case, the Larmor precession problem (HW 07) conserves S_z but not $S_{x,y}$.]* Conservation of angular momentum [Table in page 14 of L11]

18. Definitions of fermions, bosons [Def. 2.1 of L11]. Law of exchange symmetry for many particle wave function [Page 2 of L12]. You need to know how to write down wave functions for two particles/electrons with spin 0, 1. [Def. 2.1, Examples 2.2,2.3 of L12.]

19. Definitely NOT to be included in the final, although most of these are important to know "eventually": Heisenberg picture. S matrix. Coherent state. How to solve the angular differential equations for orbital angular momenta $\hat{L}^2, \hat{L}_z$. Representations of $\hat{L}^2$ in terms of θ and ϕ. You only need to be aware that spherical harmonics Y_{lm} are simultaneous eigenstates of $\hat{L}^2, \hat{L}_z$. How to solve the radial differential equation. Periodic table. Examples 3.2,3.3 of L11. Perturbation theory. Exchange Interaction. I.e., everything beyond page 4 of L12 will not be directly relevant to the final.

20. In regards to the textbook, Sections 4.1.1-4.1.3, and 4.3.2, can be skimmed over for the purpose of the final. Also, Sections 5.1.2 and after will not be directly relevant for the final.