Physics 9HE, Fadley—Assignments for Winter Quarter, 2008-09:

Chapter | Reading | Questions/Problems, including Special labels S1, S2,...
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2—Special relativity | Section 2.10 only, review remaining sections from 9HB, 9HC, 9HC | Probs. in Chap. 2: 51, 54
3—Basic experiments leading to quantum theory | Section 3.5 only | Probs. in Chap. 3: 17,19,23: plus, Special part: If the emissivity of tungsten is 0.32 at this temperature, and the wire has a diameter of 0.01 cm, what length of wire would be necessary for a 60W bulb?
15—General relativity 15.1-15.4, 15.5--optional (relates to newspaper article in S.F. Chronicle of April 5, 2004 see lecture slides) | Probs. in Chap. 15: 2,4,9,11,17,24—plus: What is the frequency change due to velocity? Use equations in lecture for GPS.
5—Wave properties of matter Sections 5.1-5.3 for midterm, remaining sections after, plus supplementary reading on Fourier integrals | Probs. in Chap. 5: 1,3,10, 11, 12, 17, 19, 22, for midterm, then 26, 27, 28, 33, 40, 43, 45, 48 54, plus Special Problems:

S1—With reference to the website: http://www.falstad.com/fourier/index.html, calculate the first two non-zero Fourier coeffients in the cosine+sine series representing a square wave, and show that they agree with the numbers given at this site. Why are there no cosine terms?

S2—With reference to the supplementary reading on Fourier integrals, show that the final formula for g(ω) on p. 3 and plotted in 4.20 is correct.

6—Quantum theory Sections 6.1-6.4, then all remaining sections | Probs. in Chap. 6: S1-Show that the wave function for a free particle traveling to the right is an eigenfunction of the momentum operator \( \hat{\rho} \) and the kinetic energy operator \( \hat{K} \), 2, 5,7,8,9,11,15,20, 23,26,28,32,37, 40,41,47,54
7—The hydrogenic atom All, plus supplementary reading on electronic transitions and selection rules (see link at website). | Questions: 1,2

Probs. in Chap. 7: 1,3,5,8,11,13,15,16,19,20(But do for 4p instead of 4d).29,32,35,38,46, plus

S1: Show, using the full hydrogenic atom wave functions given in a lecture slide that, if you take the combinations 3d+2+3d-2 and 3d+2-3d-2, you get two of the real 3d orbitals, also shown in a lecture slide, and identify which ones.

8—Many-electron atoms & the periodic table Sections 8.1 and 8.2 only, plus supplementary reading on exchange symmetry & many-particle wave functions (see link at website) | Questions: 5

Probs. in Chap. 8: 1,2,4,5,7, 11,12,23 (Remember the dipole selection rules!),24

S1: Let \( \hat{P}_{12} \) be the permutation operator for the labelling of two identical particles that occupy the same region in space, which is defined from \( \hat{P}_{12} \psi(\vec{r}_1, \vec{r}_2) = \psi(\vec{r}_2, \vec{r}_1) \). Now let \( \hat{P}_{12} \) act on the following to determine which would be suitable choices for a wave function for two overlapping fermions (e.g. electrons, protons, or neutrons) or for two overlapping bosons (e.g., photons or pions) or for neither. Good wave functions must either be antisymmetric for fermions (-1 eigenvalue of \( \hat{P}_{12} \)) or symmetric for bosons (+1 eigenvalue of \( \hat{P}_{12} \)). Here, \( \psi^{+m_s}(\vec{r}_1) \) represents particle 1 in spatial wavefunction \( \psi^{n/m_{s}} \), and with spin up \( (m_s = +1/2) \), \( \psi^{-m_s}(\vec{r}_2) \) represents particle 2 in spatial wavefunction \( \psi^{n/m} \), and with spin down \( (m_s = -1/2) \), etc., etc. (See handout for further discussion.)

(a) \( \psi(\vec{r}_1, \vec{r}_2) = \psi_{100,+}(\vec{r}_1) \psi_{100,-}(\vec{r}_2) = \psi_{100,+}(\vec{r}_2) \psi_{100,-}(\vec{r}_1) \)
(b) \( \psi(\vec{r}_1, \vec{r}_2) = \psi_{100,+}(\vec{r}_1) \psi_{100,+}(\vec{r}_2) \)
(c) \( \psi(\vec{f}_1, \vec{r}_2) = \psi_{210,+}(\vec{f}_1) \psi_{21-1,-}(\vec{r}_2) - \psi_{21-1,-}(\vec{f}_1) \psi_{210,+}(\vec{r}_2) \)
(d) \( \psi(\vec{r}_1, \vec{r}_2) = \psi_{210,+}(\vec{r}_1) \psi_{21-1,-}(\vec{r}_2) \)

S2: Show that the simple two-electron wave function for the ground state of He introduced in lecture is in fact normalized.

9,10,11—Molecular and solid 9.5 and 9.6 only. All sections of both | Probs. in Chap. 9: 21, 27, 28, 38
### Questions in Chap. 10:

- 2, 6 (But do for H\textsubscript{2} and D\textsubscript{2})
- 3, 6, 18, 21

[Just make use of the result from Chap. 9 that the rms spread in emission frequency due to atomic motion relative to the observer will be given by:]

\[ \Delta f = f_0 \left( \frac{kT}{c^2 \gamma m} \right). \]

1. **Show that the selection rule for vibrational transitions in a diatomic molecule is valid for excitations from the v = 0 state to the v = 1 and v = 2 states by directly calculating the relevant integrals. Use symmetry in dealing with the integrands to simplify your work.**

### Questions in Chap. 11:

- 1, 9, 12, 14

### Probs. in Chap. 10:

- 2, 12, 16, 31

### Probs. in Chap. 11:

- 3, 14, 16, 17, 25, 26, 51

### Questions in Chap. 12:

- 2, 12

### Probs. in Chap. 12:

- 3, 14, 16, 17, 25, 26, 51

### Questions in Chap. 14:

- 1, 3 (See Ex. 14.1 & Eq. 14.4, and assume the nucleon moves at speed c), 4, 20, 31, 34, 40

### Probs. in Chap. 14:

- 1, 3 (See Ex. 14.1 & Eq. 14.4, and assume the nucleon moves at speed c), 4, 20, 31, 34, 40