What do I need to know for 3.024 Midterm 2013?

The short answer – everything except:

1) Exact equations for dispersion relations for lattice vibrations

2) Equations for angular momentum and Hamiltonian operators in spherical coordinates

3) Exact equations for Hermite polynomials

4) Spherical harmonics and radial (Legendre) functions

5) Bohr radius (a_0) and ionization energy (E_I) exact expressions

6) Derivation of central equation

Long answer:

1) Fourier transform. Qualitative knowledge of Fourier transfor for a plane wave, sine, cosine, Gaussian.

2) Dispersion relations for lattice vibrations for mono- and diatomic lattices. Graphs with labels and what are the different values of ω at different points.

3) Phononic bandgap – graphic representation with labels, significance for sound transfer.

4) Connection between the materials properties, the speed of sound and Youngs modulus

5) Solving 2x2 eigenvalue problems.

6) Properties of observables (real eigennumbers, orthogonal eigenfunctions forming a complete basis)

7) Momentum operator and its eigenfunctions.

8) Schrodinger's equation – when can you use time-independent Schrodinger's equation

9) Particle in a box – everything.

10) Continuity of wavefunctions and their first derivatives at materials boundaries – piecewise potentials.

11) Harmonic oscillator – Hamiltonian operator, energy eigenvalues, general form of eigenfunctions (you do not need to memorize Hermite polynomials, but you need to know what they are), orthogonality of eigenfunctions, even and odd eigenfunctions. Eigenfunction shapes.

12) Measurements – how to predict the results of a measurement of a specific observable based on a wavefunction represented as a linear superposition of the observable eigenfunctions, how to represent a wavefunction based on knowing the measurement results of a specific observable.

13) Expectation values of observables – the two ways to calculate them (using integrals with a given particle wavefunction or the weighted average of the probable measurement results).

14) How to calculate commutators. Ehrenfest theorem.

15) Conservation - when is energy conserved, when is momentum conserved, when is angular momentum conserved.

16) Hydrogen atom – Hamiltonian operator in terms of momentum operators and Coulombic potentials. Conservation of angular momentum. Commutators between the different components of angular momentum vector and its length squared. General form of Hydrogen eigenfunctions (spherical harmonics vs radial parts), orthonormality of the eigenfunctions. Quantum numbers and what do they represent (yes the actual eigennumbers for L_z and L^2, energy). You do not need to memorize Bohr radius or ionization energy but expected to know how energy E_n and radius a_n depend on n.

17) Periodic potentials: what is and what is not conserved; eigenfunction form for periodic potentials.

18) Graphic representation of simple periodic potentials (finite number of sines and cosines)

19) Band diagram shapes E vs k within the Brillouine Zone - Qualitative

20) Periodic potential eigenfunctions at the band edge (when $k = \pm g/2$) - Qualitative

21) Band gap vs height of the periodic potential (quantitative), bandgap vs. size of atoms – Qualitative.

22) Direct vs Indirect band gap – qualitative.

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