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University of Oregon; Fall 2007

Physics 351 – Vibrations and Waves

List of things to study for the Final Exam

NOTE: This list is intended only as an approximate guide to the topics with which you should be familiar, in preparation for the upcoming exam. There will certainly be topics listed here that are not present on the exam. And of course, this list won't spell out exactly everything that will show up in the midterm – it is meant only as an approximate guide.

Format of the exam: The final exam (Friday. Dec. 7, 10^{15}am – 12^{15}pm, 30 Pacific) will be closed book / closed notes / no calculators. Some information will be supplied to you (see below).

General advice: Study your homework assignments, lecture notes, and the textbook. Be sure to study the posted solutions to homework problems and midterm exam problems that you didn't understand. Understand the *derivations* of everything, not just the results. Ask yourself: could I explain this to someone else? When taking the exam remember: setting up the problem correctly is *much* more important than solving the resulting algebra.

- Be familiar with Taylor expansions. Note their applicability when asked to consider any "small" parameter – e.g. small oscillations about equilibrium.
- Be familiar with basic trigonometry. You will be given any necessary trigonometric identities (sin(A+B) = ..., etc.). Be familiar with complex numbers and notation.
- Be familiar with dimensional analysis.
- Be able to derive the equations of motion of simple pendulum and mass-on-a-spring systems. Be familiar with basic properties of springs – extension, force, kinetic and potential energies, etc. Know how frequency, period, and angular frequency are related.
- Be able to analyze the vibrations of other oscillating systems covered in the course: electrical circuits, floating objects, physical pendulums, fluid in a tube. It is useful to be able to think about both "force" expressions (Newton's Laws) and kinetic/potential energy expressions. (Voltage drops across resistors, inductors, and capacitors will be given to you, if needed.)
- *Damped oscillators*. Understand the quality factor, Q (and how it is defined). Know how amplitude and energy decay with time. Know (remember) conditions for over-, under-, and critical-damping. Understand the derivation of $x(t)$. Know what the $x(t)$ curves "look like," though you don't have to remember their exact functional forms. (These will be given if needed.)

- Know properties of forced oscillators – e.g. what the amplitude and phase curves "look like." Equations for A(ω), δ(ω) will be given to you if needed; you don't have to memorize them.
- Know how to analyze the frequencies of oscillation about equilibrium for objects subject to arbitrary potential energy functions.
- Initial conditions – be able to determine x(t) for a system given the appropriate initial conditions.
- Coupled oscillators: Be able to write differential equations that describe coupled oscillator systems and analyze them to extract the normal modes of the system. You need not memorize normal mode wave functions or frequencies for the loaded string or coupled mass & spring systems; these will either be given to you, or will be derived from the differential equations you formulate as part of the problem(s).
- You will be given the following expressions for the determinants of 2×2 and 3×3 matrices:

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}; \det(A) = a_{11}a_{22} - a_{12}a_{21}$$

$$B = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}; \det(B) = b_{11}\left(b_{22}b_{33} - b_{23}b_{32}\right) - b_{12}\left(b_{21}b_{33} - b_{23}b_{31}\right) + b_{13}\left(b_{21}b_{32} - b_{22}b_{31}\right)$$

- Vibrations of continuous systems. Given the wave equation, be able to look for normal mode solutions, apply boundary conditions, and derive expressions for the normal mode vibrations and normal mode frequencies. You need not memorize normal mode wave functions or frequencies for strings, etc.; you should, however, remember "generic" properties – e.g. does normal mode frequency increase or decrease with mode number? ... with increasing tension in a string?
- Fourier Analysis: You will be given the formula for the coefficients of the Fourier Series expansion of an arbitrary function, if needed. Be familiar with how to use it.
- Be familiar with the concepts of phase velocity and group velocity of traveling waves. (You will be given the expressions $v_p = \omega/k$ and $v_g = d\omega/dk$, if needed.)