Study Guide for Test 4

Gravity on the large scale

You should know the gravitational force law and energy formula,

$$|\vec{F}_g| = \frac{Gm_1m_2}{r^2}, \qquad U_g = -\frac{Gm_1m_2}{r}, \qquad G = 6.67 \times 10^{-11}\ \text{N-m}^2/\text{kg}^2,$$

and be able to use these formulas in constrained motion problems and in energy conservation problems. You should understand the concept of escape speed.

Oscillations

You should understand how Newton's second law for a mass on a spring predicts oscillatory motion:

$$\frac{d^2x}{dt^2} = -\frac{k_s}{m}\,x \quad \Rightarrow \quad x(t) = A\cos\omega t, \quad \text{with } \omega = \sqrt{\frac{k_s}{m}}.$$

You should know how the frequency ($f = \omega/2\pi$) and period ($T = 1/f$) are related to the angular frequency (ω). You should understand the correspondences to similar behavior in other oscillating systems such as a simple pendulum in the small-amplitude limit.

Waves

You should understand the following terms as applied to waves: transverse; longitudinal; amplitude; frequency; angular frequency; period; wavelength; angular wave number; speed; superposition.

Given a mathematical formula for a pulse or periodic wave traveling in one dimension (as on a string), you should be able to determine any of the relevant quantities (amplitude, frequency, etc.) in the preceding list. Given a sufficent number of these quantities, you should be able to write down a mathematical formula describing the pulse or wave.

You should know the formulas for the speed of a transverse wave on a taut string, or a sound wave, in terms of the elastic and inertial properties of the medium:

$$v_{\text{string}} = \sqrt{\frac{\text{tension}}{\text{mass/length}}}; \qquad v_{\text{sound}} = \sqrt{\frac{\text{bulk modulus}}{\text{density}}}.$$

You should also understand why these formulas make sense, qualitatively. You should memorize the approximate value of the speed of sound in air (340 m/s).

You should understand the principle of superposition, as applied to two waves in the same medium that overlap.

You should understand what sound waves are, in terms of displacement of molecules and variations in density and pressure. In particular, you should know that where the displacement is large, the density variation is zero, and vice-versa.

You should be able to draw standing-wave patterns and determine the various standing-wave wavelengths and frequencies for strings and pipes (with open and/or closed ends).