ASSIGNED: Jan. 20, 2006. **READ:** Part 3ab of Official Lecture Notes (available online).
DUE DATE: Jan. 27, 2006. **TOPICS:** Line spectra, sums of sinusoids at different freqs.

Show work on separate sheets of paper. Include all hand and Matlab plots and code.

[50] 1. For each of the two line spectra shown below, compute the following ([5] each):
    [10] (a) Expressions for the signals in terms of complex exponentials only.
    [10] (b) Expressions for the signals in terms of sinusoids (amplitudes and phases).
    [10] (c) The average powers of the signals.   [10] (d) The periods of the signals.
    [10] (e) The two signals are related by $y(t) = ax(bt + c) + d$. Compute constants a, b, c, d.

[30] 2. *Drawing line spectra of signals specified as functions of time:*
    [10] (a) Draw the line spectrum of the signal $1 + 2\cos(3t+1) + 4\cos(5t-1) + 6\cos(7t+2)$.
    [10] (b) A *square-law device* outputs a signal that is the square of the input signal.
           Thermocouples and EM radiation detectors are square law devices.
           $x(t) = \cos(t)$ is a square-law device input. Draw line spectrum of $y(t) = x(t)^2$.
    [10] (c) Draw the line spectrum of $16\cos^4(t)$. HINT: $\cos(\theta) = \frac{1}{2}(e^{j\theta} + e^{-j\theta})$.

[20] 3. *You Can Tune a Piano, But You Can't Tuna Fish*–REO Speedwagon's first album.
    We wish to tune the leftmost key (AAA) on a piano to a pure sinuosid at 27 Hz.
    We have a tuning fork at 27 Hz exactly. But the piano is really tuned to 28 Hz.
    We strike the piano key and tuning fork simultaneously, and listen to the result.
    For simplicity, assume both amplitudes=1 and both phases=0 (for less algebra).

    [05] (a) Using Matlab, plot $\cos(2\pi 27t) + \cos(2\pi 28t)$ for $0 \le t \le 2$ (use `linspace`).
           If possible, try listening to this using `sound`. How would you describe the signal?
    [10] (b) Derive identity $2\cos(\frac{x+y}{2})\cos(\frac{x-y}{2}) = \cos x + \cos y$ using $\cos(\theta) = \frac{1}{2}(e^{j\theta} + e^{-j\theta})$.
           Could you have proved that formula without complex exponentials?
    [05] (c) Use (b) to explain what you observed in (a). Explain how to tune a piano.

"A chicken is an egg's way of making another egg"–Anonymous