Nonlinear Optics
Homework 2
due Tuesday, 30 Jan 2007

- **Problem 1:**
  Following the calculations shown at the end of the crystal symmetries.nb notebook, calculate deff[θ, ϕ] for type I phase matching for the crystal KDP (see Table 1.5.3 and fig 1.5.2). You may also find the posted Midwinter reference useful.

- **Problem 2:**
  The impulse response for a classical damped harmonic oscillator is
  h[t] = Exp[- γ t] Sin[ω0s t] for t > 0, and h[t] = 0 for t<0
  where ω0s is a slightly shifted resonance frequency defined by
  $\omega 0s = \sqrt{\omega 0^2 - \gamma^2}$

  Use transform theorems to calculate the corresponding transfer function to show that you recover what is expected from the linear solution described in Chapter 1. You may check your result by doing the transform in *Mathematica*, but I want the work to be done analytically.

- **Problem 3:**
  Using the sample program convolution demo.nb as guide to the use of the numerical convolution routine ListConvolve, perform the following convolution numerically:
  fOut[t] = h[t] ⊗ fIn[t],
  where h[t] is defined above in problem 2, and $\text{fIn}[t] = \text{Exp}\left[-t^2/\text{tp}^2\right]\text{Cos}[\omega\, t]$

  Plot the input and output functions for the off resonant case and the nearly resonant case.

  This calculation illustrates the response of the system to a pulsed input.

- **Problem 4:**
  In the previous problem, the response shown is that of the individual induced dipole in the system. When a wave propagates through a material made up of these dipoles, the waveform itself is changed according to:

  Eout[ω] = Exp[$i\,\omega$ n[ω] L/c] Ein[ω]

  In this respect, Hsys[ω] = Exp[$i\,\omega$ n[ω] L/c] can be considered a transfer function. This transfer function is different from that in problems 2 and 3, though they are related since n[ω] = $\sqrt{1 + 4\pi\,\chi^{(1)}(\omega)}$.

Using the same input pulse as in the previous problem, calculate the output pulse in two different ways:
a) Calculate Eout[ω] through the product form shown above, then do a numeric Fourier transform to calculate Eout[t].

b) Calculate the impulse response hsys[t], then numerically do the convolution as in problem 3.

For help with the numeric Fourier transforms, look at the FFT demo.nb notebook.
You can also see examples in the non-perturbative response.nb notebook.

- **Problem 5:**
  Boyd problem 2.1