1. (6pt) In an optical parametric oscillator, a pump photon at frequency $\omega_p$ generates signal and idler photons at frequencies $\omega_s$ and $\omega_i$ such that $\omega_p = \omega_s + \omega_i$. Assuming the pump wavelength is 0.53$\mu$m (2-nd harmonic of Nd$^{3+}$-YAG laser), and the signal is tunable from 1.2$\mu$m to 1.8$\mu$m, find the range of wavelengths for idler photons.

2. (6pt) Maximal acceptance angle of a graded-index plastic multimode fiber with cladding index $n = 1.55$ was measured to be $10^\circ$ with respect to the fiber axis. Assuming optimal index profile, find the inter-modal dispersion of the fiber and estimate the bit rate-length product. Assume the tolerance factor to be $\varepsilon = \frac{1}{2}$.

3. (6pt) A train of chirp Gaussian pulses with width parameter $T_0 = 10$ps is launched into a 3km long fiber with dispersion $\beta_2 = 20$ ps$^2$/km. At the fiber output, the pulses were found to be of the same duration as at the input. Find possible values of the chirp factor.

4. (6pt) Two Fabry-Perot filters with identical full width at half maximum of 20GHz and resonant frequencies shifted with respect to one of the ITU grid frequency $f_0$ by +10GHz and -10GHz are used in sequence so that transmission spectrum of the combined filter is equal to the product of transmission spectra of individual filters. For the combined filter, find transmission at $f_0$, transmission at $f_0+100$GHz, and full width at half maximum.

5. (6pt) A receiver provides bit error rate of $BER = 10^{-9}$. Assume that the bit errors are mainly caused by the shot noise of the photodetector (not a typical case, though). How much stronger input (in dB) would be required to achieve $BER = 10^{-12}$?