Problem Set Four: Receiver, Optical Amplification, and Coherent Detection

1) Basic Receiver Problem
Estimate the required average incident optical power at a receiver in order to assure an error rate of $1 \cdot 10^{-10}$.

The system components have the following characteristics and operating conditions:

- p-i-n photodiode quantum efficiency 60%
- effective load impedance of the diode 5kΩ
- preamplifier noise figure 4 dB
- operating wavelength 1.3 μm
- operating temperature 300 K
- receiver post detection bandwidth 10 GHz
- load capacitance 100fF

2) Optical Amplification
a) An optical amplifier can amplify a 10μW signal to the 1 mW level. What is the output power when a 1 mW signal is incident if the saturation power is 10 mW?
b) Deduce the SNR for an ideal amplifier including both signal shot noise and the signal-spontaneous beat noise. Show that the minimum noise figure is 3 dB. (i.e. that the noise factor is at best 2).
c) The optical amplifier is used in the link of problem 1 before the detector. For the same source power calculate the new B.E.R. Assume an optical bandwidth limited to the electrical bandwidth by a filter, and a spontaneous emission factor of 0.5.

3) Coherent Detection
Show that the quantum-limited sensitivity for a heterodyne FSK detection scheme is 36 photons per bit.