1: Calculate the carrier frequency for optical communication systems operating at 0.88, 1.3, and 1.55 μm. What is the photon energy (in eV) in each case? (at 0.88 μm, the photon energy = 1.41 eV)

2: Calculate the transmission distance over which the optical power will attenuate by a factor of 10 for three fibers with losses of 0.2, 20, and 2000 dB/km. Assuming that the optical power decreases as exp(−αL), calculate α (in cm−1) for the three fibers. (with loss of 0.2 dB/km, αp = 4.61 x 10−7 per cm & L = 50 km)

3: Assume that a digital communication system can be operated at a bit rate of up to 1% of the carrier frequency. How many audio channels at 64 kb/s can be transmitted over a microwave carrier at 5 GHz and an optical carrier at 1.55 μm? (N = 781, at 5 GHz)

4: A 1-hour lecture script is stored on the computer hard disk in the ASCII format. Estimate the total number of bits assuming a delivery rate of 200 words per minute and on average 5 letters per word. How long will it take to transmit the script at a bit rate of 1 Gb/s? (0.5 mSec)

5: A 1.55 μm digital communication system operating at 1 Gb/s receives an average power of −40 dBm at the detector. Assuming that 1 and 0 bits are equally likely to occur, calculate the number of photons received within each 1 bit. (Np = 1560)

6: An analog voice signal that can vary over the range 0.50 mA is digitized by sampling it at 8 kHz. The first four sample values are 10, 21, 36, and 16 mA. Write the corresponding digital signal (a string of 1 and 0 bits) by using a 4-bit representation for each sample. (0011 0110 1011 0101)

7: Sketch the variation of optical power with time for a digital NRZ bit stream 01011101110 by assuming a bit rate of 2.5 Gb/s. What is the duration of the shortest and widest optical pulse? (Duration of the shortest pulse = 0.4 nSec)
8: A 1.55-μm fiber-optic communication system is transmitting digital signals over 100 km at 2 Gb/s. The transmitter launches 2 mW of average power into the fiber cable, having a net loss of 0.3 dB/km. How many photons are incident on the receiver during a single 1 bit? Assume that 0 bits carry no power, while 1 bits are in the form of a rectangular pulse occupying the entire bit slot (NRZ format). \( N_p = 15625 \)

9: A 0.8-μm optical receiver needs at least 1000 photons to detect the 1 bits accurately. What is the maximum possible length of the fiber link for a 100-Mb/s optical communication system designed to transmit –10 dBm of average power? The fiber loss is 2 dB/km at 0.8 mm. Assume the NRZ format and a rectangular pulse shape. \( 19.535 \text{ km} \)

10: A 1.3-μm optical transmitter is used to obtain a digital bit stream at a bit rate of 2 Gb/s. Calculate the number of photons contained in a single 1 bit when the average power emitted by the transmitter is 4 mW. Assume that the 0 bits carry no energy. \( N_p = 2.62 \times 10^7 \)

11: A 50-km fiber link requires at least 0.3 μW at the receiver. The fiber loss is 0.5 dB/km. Fiber is spliced every 5 km and has two connectors of 1–dB loss at both ends. Splice loss is only 0.2 dB. Determine the minimum power that must be launched into the fiber. \( 0.3 \mu W = -35.23 \text{ dBm} \Leftrightarrow P_m = 0.227 \text{ mW} \)

12: A typical sheet of paper is 0.003 in. thick. How many wavelengths of 820 nm light will fit into this distance? How does this compare 50 μm – dia optical fiber?

13: A wave is specified by \( y = 8 \cos 2 \pi (2t - 0.8z) \mu m \). Find the amplitude, angular frequency and the displacement at \( t = 0 \) and \( z = 4 \mu m \)