CpE 319 Assignment 2

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1 Problem 2.3

For a channel 6MHz wide with 4 levels and no noise, Nyquist's theorem gives us a maximum data rate of

$$C = 2 * 6\text{Mhz} * log_2 4 = 24\text{Mbps} \tag{1}$$

2 Problem 2.4

The Shannon capacity of a 3kHz channel with a 20 dB SNR is

$$M = \sqrt{1 + S/N} = \sqrt{1 + 10^{SNR/10}} = 10 \tag{2}$$

This means we can have an alphabet of up to 10 symbols without an excessive error rate.

The Nyquist theorem thus gives us a maximum data rate of

$$C = 2 * 3\text{kHz} * log_2 10 = 19.93\text{kbps} \tag{3}$$

3 Problem 2.8

We begin by calculating the necessary bit rate:

$$R = 2560 \times 1600 \times 24 \times 60 = 5625\text{Mbps} \approx 5.5\text{Gbps} \tag{4}$$

Using this desired bit rate, we can calculate the required bandwidth for the signal. Since an SNR is not provided, we will assume the medium is capable of transmitting 1 bps per Hz. This means we will require a frequency bandwidth $\delta f \approx 5.5$ GHz.

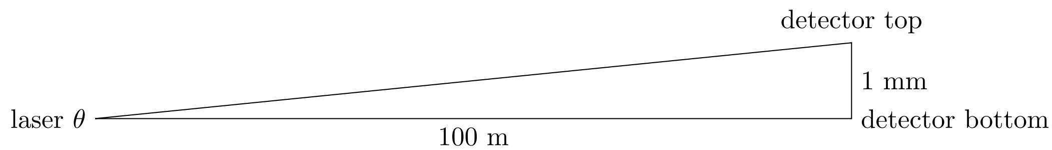
Our frequency spectrum will thus be $f_0 \pm 2.75$ GHz. Since we are given a wavelength, we must calculate f_0:

$$f_0 = \frac{v}{\lambda} = \frac{2.99 \times 10^8}{1.3 \times 10^{-6}} = 230\text{THz} \tag{5}$$

This gives a frequency band of $(2.2999735 \times 10^14, 2.3000275 \times 10^14)$ Hz, which is almost negligible on the order of magnitudes we are dealing with here. Nonetheless, converted back to wavelengths, we calculate a range of $(1.2998844 \times 10^{-6}, 1.30001554 \times 10^{-6})$ microns. This requires a total of 3.1×10^{-11} microns of wavelength.

4 Problem 2.11

This is a simple geometry problem:



While this diagram simplifies the issue somewhat, it is a correct representation of the issue. Since we have a right triangle with two known edges, we can solve for our angle:

$$\theta = tan^{-1} \frac{0.001}{100} = 5.73 \times 10^{-4} \text{degrees} \tag{6}$$