

# 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

$$C = 2 * 6MHz * \log_2 4 = 24Mbps \quad (1)$$

## 2 Problem 2.4

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

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

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

$$C = 2 * 3kHz * \log_2 10 = 19.93kbps \quad (3)$$

## 3 Problem 2.8

We begin by calculating the necessary bit rate:

$$R = 2560 \times 1600 \times 24 \times 60 = 5625Mbps \approx 5.5Gbps \quad (4)$$

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  $\delta f \approx 5.5GHz$ .

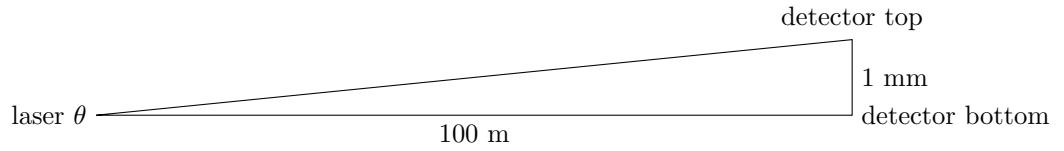
Our frequency spectrum will thus be  $f_0 \pm 2.75GHz$ . Since we are given a wavelength, we must calculate  $f_0$ :

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

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  $3.1 \times 10^{-11}$  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:

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