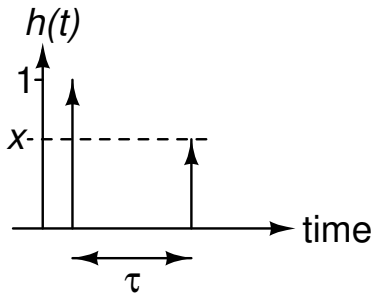
Assignment 2

Due Friday, November 4. Show your work. Submit your assignment using the appropriate dropbox on the course web site. Assignments submitted after the solutions are made available will be given a mark of zero.

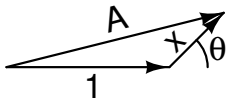
Question 1

A multipath channel consists of a direct path and a delayed path. The signal propagating along the delayed path is received τ ms later than the direct signal and at a level that is x times the level of the direct signal:



Graph the relative amplitude of the signal at the output of the channel as a function of frequency over the frequency range $f = 0$ to 1 kHz.

Hints: The direct and delayed components are at the same frequency so you can express each one as a complex number. The phase of each component is determined by the delay (τ) and frequency (f). The amplitude of each component is given in the question (1 and x). By adding the two complex values you can find the magnitude of the received signal (A below):

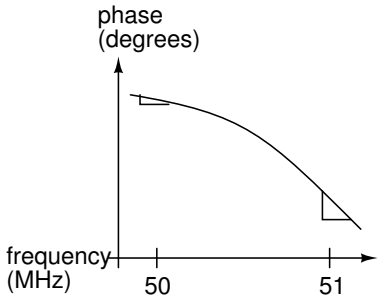


You can the produce the graph in any way you want (using manual calculation, a spreadsheet, C program, Matlab script, etc.) but you must show how you obtained your answer. If you are computing points to be plotted, make sure the points include the frequencies that result in the smallest received amplitude.

The values of x and τ are determined by your BCIT ID. If a and b are the fifth and sixth digits of your BCIT ID, then $x = 0.1 + 0.08a$ and $\tau = 2 + 0.5b$ ms. For example, if your student number is A00123456 then $a = 3$, $b = 4$, $x = 0.35$ and $\tau = 4$ ms.

Question 2

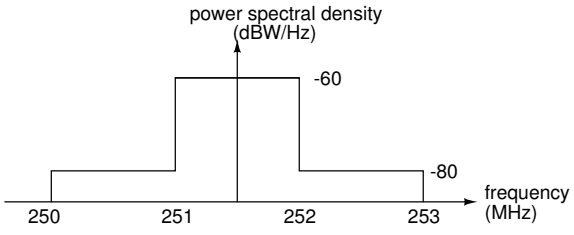
The following plot shows phase shift (degrees) versus frequency (MHz) for a communication channel (not to scale):



The slope of the curve at 50 MHz is -90 degrees/MHz and the slope at 51 MHz is -270 degrees/MHz. By how much will signal components at 51 MHz be delayed relative to components at 50 MHz?

Question 3

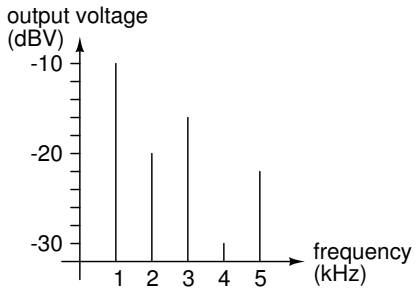
The diagram below shows the power spectrum of a signal. The power outside the range shown in negligible. What is the 99% power bandwidth of the signal?



Question 4

The diagram below shows the spectrum at the output of an amplifier when the input is a 1 kHz sine wave.

The display is calibrated in units of dBV (dB above 1 volt).



What is the THD in percent?

Question 5

Complex communication systems are often evaluated by simulating their operation in software rather than building prototypes. These simulations usually involve transmitting random data over channels with noise. Because the data and noise are random, these are often called "Monte-Carlo" simulations.

Write a C program that uses Monte-Carlo simulation to estimate the probability that a frame of 50 bits will have 3 or more errors assuming each bit has a 1×10^{-2} probability of being in error.

Your simulation should generate a million frames. Each frame should have 50 bits. For each bit use a random number generator function to determine if a bit is in error or not. Keep track of the number of errors in each frame and the number of frames with three or more errors. At the end of the program print the fraction of frames with errors.

Hint: Your program will probably have two loops (one for the frame number, one for the bit number) and two variables (one for the number of frames with 3 or more errors, one for the number of bits in error in the current frame). To determine if a bit is in error, you can use the rand() *function, defined in* `stdlib.h` *and test to see if the random value is less than the bit error rate* (1×10^{-2}) *times* `RAND_MAX`.

Question 6

The heights of children visiting an amusement park is normally distributed with a mean of 1.3 m and a standard deviation of 0.3 m. To go on the *GutBuster* roller coaster children must be over 1 m tall. What fraction of the children visiting the park are eligible to board this ride?