Work the Projects and Questions in Chapter 2 of the course laboratory manual, including the “optional” parts.

For your report, use the file LABEX2.doc from the course web site.

Here is a list of important errata, clarifications, and notes; it also tells you which questions you can SKIP (omit):

- You should be familiar with the discrete-time unit step sequence. It is equal to zero on the negative integers and one on the rest. You probably wrote $u[n]$ for it. In the text and lab manual, Mitra writes $\mu[n]$.

- In the text and lab manual, the symbol $\ast$ is used to indicate linear convolution (the kind you’re used to). However, this is not standard – as noted in the footnote on page 53 of the text, most authors use the asterisk “*” alone to indicate linear convolution. Moreover, you should be aware that many authors use the symbol $\ast$ to indicate circular convolution, which is something different that we’ll talk about later (it’s discussed in Section 5.4 of the text beginning on page 211). In the text and lab manual, Mitra uses the symbol $\bigcirc$ for circular convolution, by the way.

  The moral of the story is: when you run into the symbol $\ast$, always make sure you know what the author means by it!

- Eq. (2.10) on page 17 is missing the “=” mark. It should read

$$\sum_{k=0}^{N} d_k y[n - k] = \sum_{k=0}^{M} p_k x[n - k].$$

  Note that this equation also implies that the system is causal. For a non-causal system, the sum on the right-hand side would also include one or more nontrivial terms for negative values of the index $k$ (implying that future values of the input such as $x[n+1]$, $x[n+2]$, etc., would be needed to calculate the current value of the output $y[n]$).

- In Section 2.4 on page 19, another “=” mark is missing in the sentence immediately below the display equations for “num” and “den.” It should read “... that is, $y[-1] = y[-2] = \ldots = y[-N] = 0.$”

- Yet another “=” mark is missing in the last sentence of this same paragraph. It should read “Access to final conditions is obtained using $[y,fc] = \text{filter}(\text{num,den,x,ic}).$” The vector $fc$ of final conditions is related to the state space representation of the system. We haven’t covered that yet. Don’t worry – it won’t show up again until Chapter 8 of the lab manual.
Another “=” mark is missing in Q2.2 on page 20. It should read “If the LTI system is changed from $y[n] = 0.5(x[n] + x[n-1])$ to...”.

For Q2.3, run the following cases:
- $f_1=0.05; f_2=0.47; M=15$
- $f_1=0.03; f_2=0.47; M=4$
- $f_1=0.05; f_2=0.10; M=3$.

In Q2.4, the input signal is a “chirp.” It is like a sinusoid where the argument of the cosine (the phase) is quadratic in $n$. The frequency of the sinusoid is the derivative of the phase with respect to $n$, which is linear in $n$. In other words, the frequency increases linearly with time. For the parts of the input signal where the frequency is low (in the filter passband), you should not see any attenuation at the output. For bigger $n$, the input frequency rises. As it rises to the edge of the filter passband and into the stopband, you should start to see attenuation.

- SKIP Project 2.2, Q2.5, and Q2.6.

For Q2.8, use
- $a=1; b=-1; f_1=0.05; f_2=0.4$
- $a=10; b=2; f_1=0.10; f_2=0.25$
- $a=2; b=10; f_1=0.15; f_2=0.20$.

For Q2.9, use $ic = [5 10]$ for the initial conditions. You should see that this makes the system appear to behave nonlinearly. To preserve the linear behavior, you would have to make the initial conditions for the input signal $x$ equal to $(a+b)$ times $[5 10]$. But that's not what the program does here – hence the apparently nonlinear behavior.

- SKIP Q2.10.

For Q2.11, keep $a$, $b$, and the cosine frequencies the same as they were in Q2.7 and in the original program P2.3. You will have to replace lines 9-14 of the program with new code to simulate the system $y[n] = x[n]x[n-1]$. Because this is nonlinear, you can’t use the Matlab `filter` command for Q2.11.

There are some things about Project 2.4 on p. 23 that may seem confusing. The main idea is to do an experiment to test if the system is time invariant.

- Line 5 of Program P2.4 makes the first input signal $x$. This is called $x[n]$ in the paragraph above Program P2.4.
- Line 6 of the program makes the second input $xd$, which is called $x[n-D]$ in the paragraph above the program. It is a delayed version of $x[n]$ that is shifted to the right by $D$ samples.
- Line 11 of the program makes the output $y$ for input $x$. Line 13 makes the output $yd$ for the delayed input $xd$.
- If the system is time invariant, then $yd$ should be the same as a delayed version of $y$ (up to numerical roundoff errors, which should be tiny). That is, $yd$ should be the same as a version of $y$ that has been shifted to the right by $D$ samples.
- The test for this is done in line 15 of the program, where the difference signal $d$ is calculated. This is the confusing part.
– Instead of shifting y to the right to do the comparison, the program actually shifts yd to the left. This is the reason that you have y - yd(1+D:41+D) in line 15.
– It would be easier to understand if you instead had y(1-D:41-D) - yd in line 15. But this would make negative array index values and cause a Matlab error: for D=10, you would have y(-9:31). So it is programmed by shifting yd to the left instead of shifting y to the right.
– This is also the reason that the last sentence above P2.4 says “the difference y1[n] - y2[n + D]” instead of “the difference y1[n - D] - y2[n].”

• For Q2.13, use D=2, D=6, and D=8.
• SKIP Q2.14, Q2.15, and Q2.16.
• For Q2.17, use D=10.
• SKIP Q2.25.
• SKIP Q2.27.
• For Q2.32, to answer the question “What is the discrete-time system whose impulse response is being determined...” you can simply give the input/output relation (difference equation).

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