Date: November 5, 2015.

Name: ______________________________

Instructions:

- Submit your solutions on standard letter-size paper (8 1/2 by 11 inch).
- Hand in the completed exam by 4:00 P.M. on Friday, November 6, 2015 to Dr. Kassas in his office.
- No collaboration or consultation is allowed with any other person besides Dr. Kassas. He is willing to talk about problems if he is available.
- You may use non-human outside sources (e.g., books). If you use such sources, then list them.
- Submit *all* your source code.

1. [**12 points**]. Homework Assignment 1, Problem 2, except instead of trying to determine the values of `xObs` and `dObs` by matching your horn output to an audio file, determine these by matching your output to the received horn frequency time history in the MATLAB file `trainData.mat`. Loading this file into MATLAB will put two vectors in your workspace. The units of `fApparentVec` are Hz and the units of `tVec` are seconds. Estimate `xObs` and `dObs` to 0.1 meters.

2. [**12 points**]. In Homework Assignment 1, Problem 3, we examined the effect of a sampling clock frequency bias on Doppler estimation. This problem will examine the effects of clock frequency bias on Doppler derived from frequency downconversion and sampling.

Usually, we don't measure signal properties directly at the signal's incoming frequency. Instead, we convert incoming signals to a lower center frequency by a process called frequency conversion. To understand frequency conversion, recall that

$$\cos(x)\cos(y) = \frac{1}{2}\left[\cos(x-y) + \cos(x+y)\right].$$

Hence, by multiplying an incoming signal $x(t) = \cos(2\pi f_c t)$ by a local signal $x_l(t) = 2\cos(2\pi f_l t)$ and then low-pass filtering the result to eliminate the high frequency $f_c + f_l$ component, we convert the high frequency signal down to a lower frequency $f_b \triangleq f_c - f_l$. Figure 1 shows a diagram of the frequency conversion process.

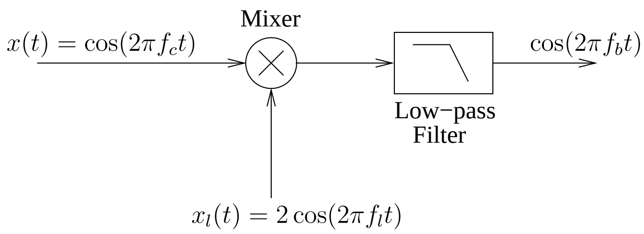

Figure 1: A single-stage frequency conversion (mixing) operation.

Assume that some oscillator with a perfect clock produces a pure sinusoid of the form $x(t) = \cos(2\pi f_c t)$. Suppose that we receive this signal and make a measurement f_m of the signal's frequency by (1) performing frequency conversion to translate the signal to a nominal center frequency $f_b = 0$ Hz and then (2) sampling the signal with nominal sampling interval Δt and observing the number of samples per period, where the assumed period is $T = 1/f_c$. Assume there is no motion between our receiver and the signal transmitter. Suppose that the local clock we are using to perform frequency conversion and sampling has a fractional frequency error of $\Delta f/f$.

Derive an expression for the apparent Doppler f_D resulting from frequency conversion and sampling with a clock that has this fractional frequency error. Express your result in terms of f_c and $\Delta f/f$. How does this expression differ from the one derived in Homework Assignment 1, Problem 3?

3. [**10 points**] Homework Assignment 1, Problem 6.

4. [**10 points**] Homework Assignment 2, Problem 1.

5. [**12 points**] Homework Assignment 2, Problem 2.

6. [**12 points**] This problem is an extension of Homework Assignment 2, Problem 5. Use the `generateLfsrSequence` function you wrote to answer the following questions.

Which of the following characteristic polynomials correspond to maximal length sequences for a 9-stage linear feedback shift register? Of those that do, which pairs of polynomials correspond to so-called *preferred pairs* of m-sequences, i.e., m-sequences that can be shifted and summed (modulo 2) to generate a family of Gold codes?

$$
\begin{aligned}
f_1(D) &= 1 + D^4 + D^9 \\
f_2(D) &= 1 + D^3 + D^5 + D^8 + D^9 \\
f_3(D) &= 1 + D^3 + D^5 + D^6 + D^9 \\
f_4(D) &= 1 + D^3 + D^4 + D^6 + D^9 \\
f_5(D) &= 1 + D^3 + D^7 + D^8 + D^9 \\
f_6(D) &= 1 + D^2 + D^9
\end{aligned}
$$

7. [**10 points**] Homework Assignment 3, Problem 1.

8. [**12 points**] Homework Assignment 3, Problem 4. Express your output `delTauG` in seconds. Test your function with the following input arguments:

```
ionoData =
    alpha0: 1.1176e-008
    alpha1: 7.4506e-009
    alpha2: -5.9605e-008
    alpha3: -5.9605e-008
     beta0: 90112
     beta1: 0
     beta2: -196610
     beta3: -65536
fc = 1575.42e6
rAntRx =
       -742005.851560607
      -5462223.38476596
       3198008.7346792
rSvTx =
       20847329.7083373
      -15185642.4780402
        6205281.68907901
tGPS =
    week: 1575
 seconds: 518201.501
model = 'broadcast'
```

9. [**10 points**] Homework Assignment 3, Problem 6, except use scintillation data from the file `scintDat2.mat`. Turn in the values you computed for S_4 and τ_0.