

University of Pennsylvania  
Department of Electrical and System Engineering  
Digital Signal Processing

HW7: GLP Systems, Windowing, and DFT

Tuesday, Apr. 2

**Due:** Tuesday, Apr 9, 11:59PM

- **Homework Problems:** All problems must be turned in and are not optional for full credit

1. Homework problems from the book: 5.38, 7.15, 8.10, 8.14
2. Matlab problem: Calculation of the DFT. In this problem you will measure the execution time of a direct calculation of the DFT using three different organizations of the algorithm. The definition of the DFT is given by:

$$X[k] = \sum_{n=0}^{N-1} x[n]W_N^{nk} \quad (1)$$

for

$$W_N = e^{-j2\pi/N} = \cos(2\pi/N) - j\sin(2\pi/N) \quad (2)$$

and  $k = 0, 1, \dots, N-1$ .

- (a) Two-Loop Program. Write a program (M-file) or a function in MATLAB to evaluate the DFT given above using two nested `for` loops with the inner loop summing over  $n$  and the outer loop indexing over  $k$ . Time the program for several lengths using the `clock` and `etime` commands. Compare the times of your DFT program with the built-in MATLAB command `fft` for the same lengths. Comment on the results.
  - (b) One-Loop Program. Write a DFT program using one loop which steps through each value of  $k$  and executes an inner product. Time the program as was done in (a). Explain the results obtained.
  - (c) No-Loop Program. Write a DFT program using a single matrix multiplication. Write your own DFT matrix rather than using the built-in `dftmtx`. Use the `exp` command with the exponent formed by an outer product of a vector of  $\mathbf{n} = 0:(N-1)$  and a vector of  $\mathbf{k} = 0:(N-1)$ . Time the program as you did for the previous programs.
  - (d) Comment on the differences and on the comparisons of the three implementations.
3. **Recommended Problems for Practice:** From the book: 7.27, 7.34, 8.11, 8.16