% Tune-Up #7

% Working part of Exercise 1.1 of Mini-Project #2. Mini-Project #2 assignment,
% hints, and code are available on the homework page.
% The exercises for Mini-Project #2 are from Chapter 10 of the book
% *Computer-Based Exercises for Signal Processing in Matlab*, 1994.

% Wireless Localization

% The project involves estimating distance to an object in the environment.
% using wireless signals. This problem simulates a radar system that sends a
% signal and then listens for the return signal that bounced off the object.
% Using the round-trip time T_d and speed of propagation in the environment *c*,
% the distance can be determined as $d = (1/2)\ T_d\ c$.
% Methods for finding the direction (angle) to the object include
% (a) Directional beams
% (b) Triangulation
% For an overview of radar signals, please see
% https://en.wikipedia.org/wiki/Radar_signal_characteristics

% Complex-Valued Chirp Signals

% In a chirp signal, the principal frequency increases or decreases over time.
% When chirp signals propagate in an environment, they are resistant to
% frequency distortion and thermal noise. You'll evaluate this in Mini-Project #2.

% **Part (a) Write Matlab code to generate and plot a complex-valued chirp**
% pulse that sweeps frequencies from -W/2 to W/2:
% s(t) = exp(j pi (W t^2) / T) for -T/2 <= t <= T/2.
% Parameters from Table 10.1 in the excerpt of Chapter 10:
%   T pulse length   25 us
%   W swept bandwidth 2 MHz
%   fs sampling frequency 20 MHz
%   TW time-bandwidth product 50 [dimensionless]
% The oversampling factor is p where fs = p W.

```
T = 25E-6;
```

```
W = 2E6;
fs = 20E6;
Ts = 1/fs;
t = (-T/2) : Ts : (T/2);
s = exp(j*pi*W*(t.^2)/T);
```

% Time-domain plot. We have to be careful at plotting s(t)

% because it is complex-valued. We'll plot the real part.

```
figure;
plot(t, real(s));
xlabel( 't' );
```

% Question: Describe the chirp signal.

% ***Answer:*** The chirp signal is a finite-length signal that last from -T/2 to T/2 seconds.

% The principal frequency decreases from -T/2 to 0 seconds and increases

% from 0 to T/2 seconds.

% (b) Write a Matlab function to generate a discrete-time version of the

% complex-valued chirp following the Mini-Project #2 guidance:

% s[n] = exp(j 2 pi alpha $(n - N/2)^2$) for for $0 \leq n \leq N-1$

% We'll need to connect s(t) for $-T/2 \leq t \leq T/2$ via s[n] = s(n T_s) where

% T_s is the sampling time. N samples would correspond to T seconds of

% continuous time i.e. T = N T_s. The Matlab function will take two parameters

% TW time-bandwidth product

% p oversampling factor

% The sampling rate fs is p W. Using the hints for Mini-Project #2, we can

% express the parameters alpha and N in terms of p and TW:

% N = p TW

% alpha = TW / (2 N^2)

% Question: Verify the formulas for *N* and *alpha* using the code from part (a).

% ***Answer:*** The formulas for *N* and *alpha* can be obtained by equating the first

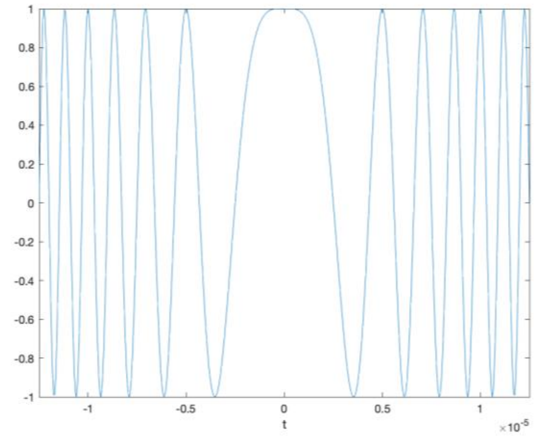
% value of the complex-valued chirp *s*(-*T*/2) and the first sample of the

% discrete-time chirp *s*[0].

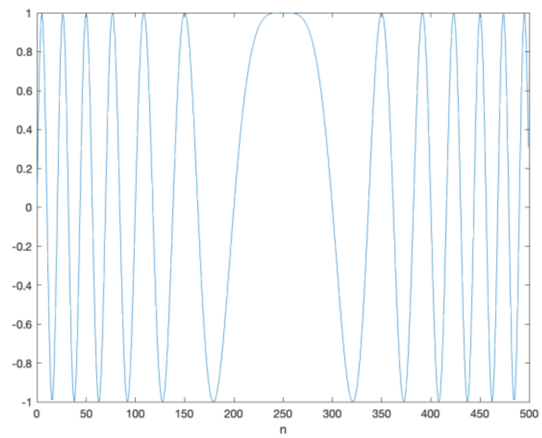
% For this Tune-Up, we'll plot *s*(*t*) and

% *s*[*n*] to see if *s*[*n*] are samples of *s*(*t*).

```
%% Plot real part of s(t)
T = 25E-6;
W = 2E6;
fs = 20E6;
Ts = 1/fs;
t = (-T/2) : Ts : (T/2);
soft = exp(j*pi*W*(t.^2)/T);
figure;
plot(t, real(soft));
xlabel( 't' );
xlim( [-T/2 T/2] );
```




```
%% Plot real part of s[n]
TW = T*W;
p = fs / W;
N = p * TW;
alpha = TW / (2*N^2);
n = 0 : N-1;
sofn = exp(j*2*pi*alpha*(n - N/2).^2);
figure;
plot(n, real(sofn));
xlabel( 'n' );
```



% Yes, as seen on the right, s[n] are samples of s(t).

% Question: Write a MATLAB function to generate the discrete-time chirp

% called dchirp and place it in a file called dchirp.m.

% ***Answer***: See the code below.

```
function s = dchirp( TW, p )
% DCHIRP   generate a sampled chirp signal
%   usage  s = dchirp( TW, p )
%          s : samples of a discrete-time "chirp" signal
%              exp(j pi (W/T) t^2 )   for -T/2 <= t <= T/2
%          TW : time-bandwidth product
%          p : sample at p times the Nyquist rate (W)
N = p*TW;
alpha = TW / (2*N^2);
n = 0 : N-1;
s = exp(j*2*pi*alpha*(n - N/2).^2);
```