Signal generation

- Write matlab code to generate different types of **discrete time signals**
- Learning objectives
  - Generate discrete time (1D) signals
  - Good coding practices

Signal generation

- Follow the example of the code **DATASCIENCE_COURSE/SIGNALS/crcbgenqcsig.m**
  - Do **git pull DATASCIENCE_COURSE** to get the latest update
  - Write your code in the same format as this function
  - Learn elements of good coding: Good documentation, Clean and understandable code
  - Script showing how to use the function: **DSP/testcrcbgenqcsig.m**
- Once your code is running well:
  - Use: **git pull → git add→ git commit → git push**
  - **Remember the advice**: Pull before Push

QUADRATIC CHIRP SIGNAL

$$f(t) = A\sin(2\pi\Phi(t))$$

Instantaneous phase:

$$\Phi(t) = a_1 t + a_2 t^2 + a_3 t^3$$

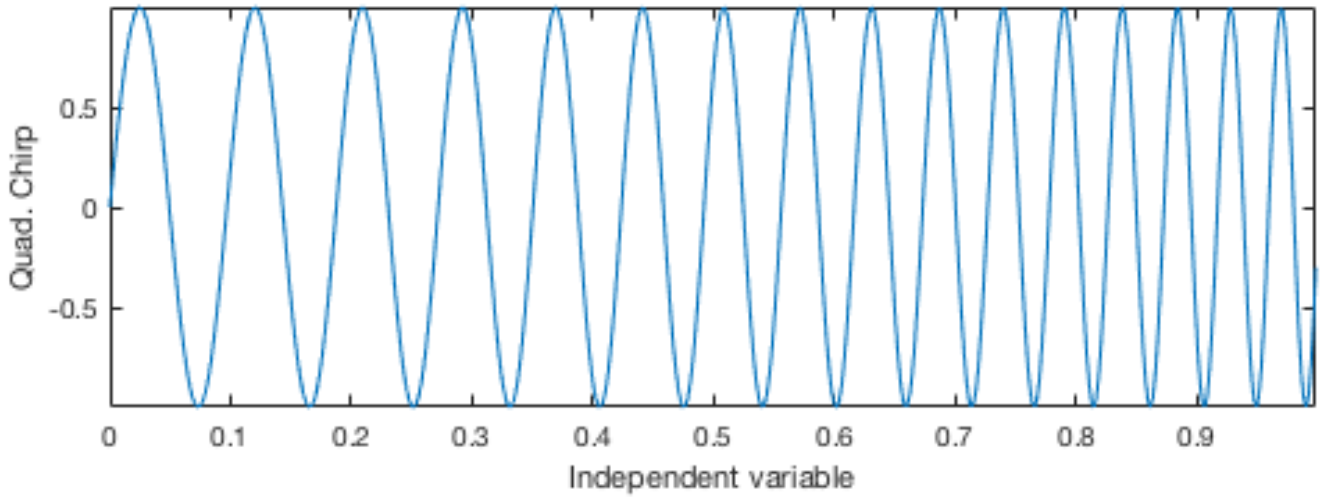
Parameters of the signal:

$$\mathrm{A}, a_1, a_2, a_3$$

Instantaneous frequency:

$$f(t) = \frac{d\Phi}{dt} = a_1 + 2a_2 t + 3a_3 t^2$$

$f(t)$ increases with t
$1/f(t)$ (Instantaneous period) decreases with t



Example taken from textbook ("Swarm intelligence methods for Statistical Regression", Chapter 1)

Format of a Matlab function definition

function <output arguments> = <function name>(Input arguments)

function sigVec = crcbgenqcsig(dataX,snr,qcCoefs)

- dataX : vector of time stamps $(t_0, t_1, \ldots, t_{M-1})$ at which the samples of the signal $s(t)$ are to be computed.
- qcCoefs: vector of three coefficients [a1, a2, a3] that parametrize the phase of the signal $\Phi(t) = a_1 t + a_2 t^2 + a_3 t^3$
- snr: A special way to define the parameter A

$$\Phi(t) = a_1 t + a_2 t^2 + a_3 t^3$$

```
phaseVec = qcCoefs(1)*dataX + qcCoefs(2)*dataX.^2 + qcCoefs(3)*dataX.^3;
```

$$\sin(2\pi\Phi(t))$$

```
sigVec = sin(2*pi*phaseVec);
```

$$A\sin(2\pi\Phi(t))$$

```
sigVec = snr*sigVec/norm(sigVec);
```

Elements of good coding

```
function sigVec = crcbgenqcsig(dataX,snr,qcCoefs)
% Generate a quadratic chirp signal
% S = CRCBGENQSIG(X,SNR,C)
% Generates a quadratic chirp signal S. X is the vector of
% time stamps at which the samples of the signal are to be computed. SNR is
% the matched filtering signal-to-noise ratio of S and C is the vector of
% three coefficients [a1, a2, a3] that parametrize the phase of the signal:
% a1*t+a2*t^2+a3*t^3.

%Soumya D. Mohanty, May 2018

phaseVec = qcCoefs(1)*dataX + qcCoefs(2)*dataX.^2 + qcCoefs(3)*dataX.^3;
sigVec = sin(2*pi*phaseVec);
sigVec = snr*sigVec/norm(sigVec);
```

Function name should be descriptive but short: CRCBook-Generate-Quadratic-Chirp-Signal

First comment is used by Matlab to generate Contents report

Second line shows usage format (input and output arguments); Displayed with command "help crcbgenqcsig'

Describe what the code does and what is the meaning of each input and output argument

Author of the code (add additional lines for multiple authors), Date of creation

Variable names should be descriptive.
C++ convention: thisIsAVariableName .
Quadratic Chirp Coefficients

Tasks

- Write functions to generate the following signals
- Each function should be accompanied by its own test script (‘test<function name>.m’) following the example of testcrcbgenqcsig.m
  - Note: in your function, the overall amplitude A should be interpreted as SNR (see **crcbgenqcsig.m**)
- Make a plot of each signal
  - You have to choose a **sampling interval (or period)** Δ

$$t_n = n\Delta, \qquad n = 0,1, \dots, N-1$$

  - **Sampling frequency** $= 1/\Delta$

List of signals

- Sinusoidal signal
  - $s(t) = A\sin(2\pi f_0 t + \phi_0)$
  - Parameters: A, f_0, ϕ_0
- Linear chirp signal
  - $s(t) = A\sin(2\pi(f_0 t + f_1 t^2) + \phi_0)$
  - Parameters: A, f_0, f_1, ϕ_0
- Sine-Gaussian signal
  - $s(t) = A\exp\left(-\frac{(t-t_0)^2}{2\sigma^2}\right)\sin(2\pi f_0 t + \phi_0)$
  - Parameters: $A, t_0, \sigma, f_0, \phi_0$

List of signals

- Frequency modulated (FM) sinusoid
  - $s(t) = A\sin(2\pi f_0 t + b\cos(2\pi f_1 t))$
  - Parameters: A, b, f_0, f_1
- Amplitude modulated (AM) sinusoid
  - $s(t) = A\cos(2\pi f_1 t) \times \sin(f_0\, t + \phi_0)$
  - Parameters: A, f_0, f_1, ϕ_0
- AM-FM sinusoid
  - $s(t) = A\cos(2\pi f_1 t) \times \sin(2\pi f_0 t + b\cos(2\pi f_1 t))$
  - Parameters: A, b, f_0, f_1

List of signals

- Linear transient chirp
  - $s(t) = \begin{cases} 0; \ \ t \notin [t_a, t_a + L] \\ A\sin(2\pi(f_0(t - t_a) + f_1(t - t_a)^2) + \phi_0) \end{cases}$
  - Parameters: $A, t_a, f_0, f_1, \phi_0, L$
- Exponentially damped sinusoid
  - $s(t) = \begin{cases} 0; \ \ t \notin [t_a, t_a + L] \\ A\,\mathrm{e}^{-(t-t_a)/\tau}\sin(2\pi f_0 t + \phi_0) \end{cases}$
  - Parameters: $A, t_a, f_0, \tau, \phi_0, L$
- Step FM
  - $s(t) = \begin{cases} A\sin(2\pi f_0 t)\,; \ \ t \le t_a \\ A\sin(2\pi f_1(t - t_a) + 2\pi f_0 t_a); t > t_a \end{cases}$
  - Parameters: A, t_a, f_0, f_1