General Framework of Using Filters

- In practical, usually we do not know the statistic characteristics such as mean and variance(aka variables of interest, VoI) of the signal $\{X_n\}$, thus we need measurements
- If the signal generation process is wide-sense stationary yet ergodic[2] as well, then easy estimation of VoI methods exist:
  - if we measure a realization $\{x_n\}$, of the process $\{X_n\}$(e.g., one waveform from the ensemble of possible waveforms/ one(or a few) battery performance test to infer the general performance of this battery type, sort of to monitor/measure x_n for a period of time, such x_n is just one possible waveform of the ground truth)
- Wiener filter - linear estimator for stationary signals
- Kalman filter - non stationary signals estimator(not covered in 3F3)

[2] such as mean and variance ergodic

Extension of Wiener Filter

Wiener Filter can readily be extended to deal with cases outside the regular noise reduction:

- Prediction of a noisy signal $\{u_n\}$
- Smoothing of a noisy signal
- Deconvolution

$$R_X(k) = a^{|k|}\sigma_X^2, \quad k \in \mathbb{Z}$$

$$S_X(f) = \sum_{k=-\infty}^{\infty} R_X(k) e^{-j2\pi fk} = \sigma_X^2 \sum_{k=-\infty}^{\infty} a^{|k|} e^{-j2\pi fk} = \frac{\sigma^2}{1 + a^2 - 2a\cos(2\pi f)}$$