# ECE 447 Fall 2025

## Lesson 33

## GR2 Review Day

UNITED STATES
AIR FORCE
ACADEMY

# Schedule and Admin

- Schedule.
  - Lesson 33 - **Review Day**
  - Lesson 34 - GR2 (Thursday, 13 Nov)
  - Lessons 35-37 - Binary Digital System Performance, Error Correction
  - Lesson 38 - MATLAB Lab 7: Matched filters, multi-path, OFDM, BER (substitute for Lt Col TBD)
  - Lesson 39 - Advanced topics: OFDM, MIMO, CDMA
  - Lesson 40 - Course review
- Admin
  - **HW7**. Due 10 Nov (Lsn 33) to Gradescope.

# Chp 5 Review: Lessons 18-20, HWs 3 & 4

- **Sampling**
  - Impulse train in time ↔ impulse train in frequency
  - Creates copies of message spectrum in frequency
  - Sinc is ideal interpolator, if $f_s \geqslant 2B$
  - Non-ideal pulses have "filtering" effect on sampled signal - equalizers reverse the filtering to obtain original signal
  - What two requirements do we have for *distortionless* filtering?
  - $G(f)e^{-j2\pi f t_0} = E(f)\tilde{G}(f) = E(f)P(f)\frac{1}{T_s}\sum_n G(f - nf_s)$, so make equalizer transfer function

$$E(f) = \begin{cases} T_s e^{-j2\pi f t_0} \cdot |P(f)|^{-1}, & |f| \leqslant B \\ \text{Flexible}, & B < |f| < f_s - B \\ 0, & |f| \geqslant f_s - B \end{cases}$$

  - Just need to invert $P(f)$ and plug into $E(f)$! Example: 5.1-5a - find $E(f)$ if $p(t) = \Pi(\frac{t}{T_s} - \frac{1}{2})$

# CHP 5 REVIEW: LESSONS 18-20, HWS 3 & 4

- **PCM**
  - Just sample, quantize, and encode
  - Message peak at $\pm m_p$, so each bin is $2m_p/L$, where $L = 2^n$ levels, $n$ = number of bits
  - Each additional bit improves the SNR how much?
  - Max data rate per bandwidth is $\frac{2\text{bps}}{\text{Hz}}$ - assuming a noiseless channel w/ bandwidth $B$
  - **If sampling exactly at Nyquist,** $f_s = 2B$**,** then min req'd channel bandwidth is $B_T = nB$
  - **If sampling at greater than Nyquist,** $f_s > 2B$**,** then min req'd channel bandwidth is $B_T = \frac{nf_s}{2}$ or simply the data rate $nf_s$ divided by 2

  - Be able to solve problems like 5.2-3 or Example 5.2, where a max quantization error is given as a percentage of $m_p$ and $f_s$ is given as a percent of the Nyquist rate

# Chp 6 Review: Lessons 22-28, HWs 5 & 6

- **Digital Communications**
    - **Line codes**
    - Be able to plot $y(t) = \sum_k a_k p(t - kT_b)$, i.e., the baseband waveform
    - Be able to use generic PSD equation in (6.11c)? Maybe, but I'd provide values for $R_n$
    - Band-limited vs. time-limited
    - **ISI**
    - Nyquist's First Criterion for Zero ISI:

$$p(t) = \begin{cases} 1, & t = 0 \\ 0, & t = \pm nT_b \end{cases}$$

    - Excess bandwidth $f_x$, roll-off factor $r$
    - GR will **clearly** use $R_b$ for bit rate and $R_s$ for symbol rate/baud
    - How do we accomplish timing synchronization?
    - Parts of eye diagrams

# Chp 7 Review: Lessons 29-30, HW 7

- **Probability**
  - Bernoulli trials using bits
  - Conditional/total probability
  - Gaussian RV, Q function
  - Expected value, mean square, and variance
  - Central limit theorem