1. *Course number and name*

**ENGR 449: Communication Systems**

1. *Credits and contact hours*

3 credit hours; three 50-minute lecture sessions/week, or two 1-hr-15-minute lecture sessions/week, depending on semester

1. *Instructor’s or course coordinator’s name*

Instructor: Dr. Hajiaboli, Instructor

Course coordinator: Tom Holton, Ph.D.

1. *Text book, title, author, and year*

Bernard Sklar, Digital Communications: Fundamentals and Applications, Third Edition, Prentice Hall, 2021.

* 1. *Other supplemental materials*

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* 1. Carlson, A. B. *Communication Systems,* 3 ed. McGraw Hill, 1986.
  2. Couch, L. W. *Digital and Analog Communication Systems.* Macmillan, 1987.

1. B.P. Lathi, Modern Digital and Analog Communication Systems, Fourth Edition, Oxford, 2009

1. *Specific course information* 
   1. *Brief description of the content of the course (catalog description)*

Review of analog signal and system analysis in the time and frequency domains. AM, FM, and PM modulation and demodulation techniques. Pulse modulation techniques. Digital modulation systems. Error-correcting coding: Block and convolutional codes. Advanced communications technologies.

* 1. *Prerequisites or co-requisites*  A grade of C- or better in ENGR 305

* 1. *Indicate whether a required, elective, or selected elective course in the program*

Required for Electrical Engineering

Elective for Computer Engineering

1. *Specific goals for the course* 
   1. *specific outcomes of instruction, ex. The student will be able to explain the significance of current research about a particular topic.*
   * The student can sketch signal waveforms before and after amplitude modulation both in the time and frequency domains.
   * Students understand signal characteristics and statistics, autocorrelation, energy/power spectral density, and their relations
   * The student can design a demodulator given a modulator.
   * The student understands SSB, VSB, and QAM.
   * The student can compare modulation schemes regarding their power and bandwidth efficiencies.
   * The student understands mathematics associated with frequency and phase modulation, and demodulation.
   * The student can sketch signal waveforms before and after frequency modulation both in the time and frequency domains.
   * The student can design a PM, AM, and FM demodulator.
   * The student demonstrates an understanding of how sampling rate is related to aliasing in converting analog signals to discrete samples and quantization noise.
   * The student understands the advantages of digital communications over analog communications.
   * The student understands how PCM is encoded and the reasons behind the resulting bit rate.
   * The student understands why digital data are line-coded and pulse shaped before transmission.
   * The student understands why ISI is caused by pulse shaping and what the Nyquist filter is.
   * The student understands equalization and can design a linear equalizer. The student understands digital modulation.
   * The student can sketch the waveforms of digitally modulated signals for ASK, PSK, FSK, and digital QAM.
   * The student can draw the constellation diagrams for M-PAM, M-PSK, DPSK, M-QAM, and M-FSK.
   * The student knows the cumulative distribution and probability density functions and their properties.
   * The student can analyze the performance of the binary symmetric channel.
   * The student can analyze the performance of digital modulation (e.g., BPSK) in an AWGN channel.
   * The student understands the calculation of channel capacity and average information per symbol.
   * The student demonstrates an understanding of mathematics associated with amplitude modulation and demodulation.
   * The student will demonstrate the ability to design an optimal system for AWGN channels.

* 1. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.*

Course addresses ABET Student Outcome(s): a, b, c, e. (1, 2, 6)

1. *Brief list of topics to be covered* 
   * Amplitude, phase, and frequency modulation/demodulation
   * Sampling theorem, quantization noise, PAM, PCM, and PPM coding
   * Line coding and pulse shaping. ISI effect and minimum bandwidth requirements in baseband and passband communication.
   * Vectorial space representation of signals and orthogonal spaces
   * Digital modulation techniques: PSK, QAM and FSK, ASK, PAM
   * Probability and random processes. Gaussian and uniform distributions.
   * Probability of bit/symbol error calculation for digital communication techniques.
   * Optimal receiver design for AWGN channels in both baseband and passband systems (Match filter/correlator)
   * Link budget design (power-limited and bandwidth-limited communication systems)
   * Channel Capacity, Entropy, and average information per symbol.