uc3m | Universidad Carlos III de Madrid

COURSE: Communication Theory		
DEGREE: Bachelor's Degree in Telecommunication Technologies Engineering / Bachero's Degree in Audiovisual System Engineering	YEAR: 2^{nd}	TERM: 2^{nd}

WEEKLY PROGRAMMING

Week	Session	DESCRIPTION OF CONTENTS	GROUPS (mark X) LECTURE	SEMINAR	Special room for session (computer class room, audio-visual class room, etc.)	Indicate YES/NO if the session needs 2 teachers	WEEKLY PROGRAMMING FOR STUDENTS: DESCRIPTION	CLASS HOURS	HOMEWORK HOURS (Max. 7h)
1	1	Chapter 0 - Introduction ▪ Presentation of the course: objectives and contents ▪ Definition of a communication system ▪ Classification of communication systems ▪ Performance parameters in a communication system	X			No	Review of the concepts related with random variables, random processes and their statistical descriptions.	1,66	3
1	2	Chapter 1 - Noise in communication systems ▪ Review of random variables and random processes ▪ Statistical characterization in the time domain ▪ Stationarity, cyclostationarity and ergodicity		X		No	Review of properties of probability density functions, and evaluation of probabilities from this function. Review of statistics used to characterize a random process in the time domain (mean and autocorrelation function), and concepts of stationarity, cyclostationarity and ergodicity and their application in the modeling of communication systems.	1,66	
2	3	Chapter 1 - Noise in communication systems ▪ Random processes in the frequency domain ▪ Power spectral density ▪ Random processes through linear systems ▪ Addition of random processes	X			No	Examples of calculation of power spectral densities for different kinds of random processes. Understanding of the relationship of time domain and frequency domain statistics between the input and output of linear systems. Analysis of the characteristics of addition of random processes, and the particular application to the model of a communication signal and noise.	1,66	3
2	4	Chapter 1 - Noise in communication systems ▪ White and Gaussian random processes ▪ Statistical model for thermal noise ▪ Power of the thermal noise and of the filtered noise ▪ Noise equivalent bandwidth ▪ Signal to noise ratio		X		No	Analysis of characteristics of white and Gaussian processes, behavior of such processes through linear systems, and calculation of power of these processes at the output of a linear system. Understanding of the statistical model used to characterize the thermal noise in a communication system. Definition of noise equivalent bandwidth and signal to noise ratio.	1,66	

3	5	Chapter 2 - Analog modulations ▪ Introduction to analog modulation ▪ Amplitude modulations (AM) • General concepts • Amplitude modulation (AM) • Double-sideband modulation	X			No	Understanding the need of modulation for transmission of analog sygnals. Analysis of analog modulations in the time domain, in the frequncy domain, and comparison of required power and spectral efficiency for different variants of amplitude modulations.	1,66	
3	6	Chapter 1 - Noise in communication systems ▪ Class for solving exercises		X		No	To work in the exercises to be solved at class.	1,66	4
4	7	Chapter 2 - Analog modulations ▪ Double-sideband modulation ▪ Vestigial-sideband modulation ▪ Coherent receivers for amplitude modulations	X			No	Analysis of new variants of amplitude modulations, and of the structure of a coherent receiver for amplitude modulations	1,66	
4	8	**Laboratory** - Session 1		X	Computer Room. 2 slots per seminar group	No	Preparation of exercises for laboratory session 1.	1,66	6
5	9	Chapter 2 - Analog modulations ▪ Angle modulations (phase and frequency) ▪ Joint description of PM and FM modulations • Time domain description • Frequency response of angle modulations ▪ Effecto of noise in analog modulations ▪ Analysis of the signal to noise ratio at the receiver	X			No	Analysis of angle modulations in the time domain. Understanding of main characteristics, parameters, and simplified analysis of the frequency response. Analysis of the behavior of analog modulations, both amplitude and angle modulations, with respect to noise, and comparison with a baseband transmission of the message signal (unmodulated) in terms of the signal to noise ratio at the output of each receiver.	1,66	
5	10	Chapter 2 - Analog modulations ▪ Class for solving exercises		X		No	Work in the proposed exercises that will be solved a class.	1,66	4
6	11	Chapter 3 - Modulation and detection in Gaussian channels ▪ Introduction to digital communication systems ▪ Basic model for a digital communication system • Functions of transmitter and receiver ▪ Design criteria for a communication system	X			No	Understanding of basic functional modules of a digital communication system, and of the factor to be considered in the system design: performance, energy and channel characteristics. Review of vector spaces and orthonormal bases.	1,66	
6	12	**Laboratory** - Session 2		X	4.2.B01A. 2 slots per reduced group	No	Preparation of exercises for laboratory session 2, and partial exam of the next week.	1,66	5

7	13	Chapter 3 - Modulation and detection in Gaussian channels ▪ Hilbert spaces for the representations of signals in a vector space ▪ Gram-Schmidt orthogonalization process ▪ Advantages of the vectorial representation for signals ▪ Digital communication model based on vectorial representation	X			No	Understanding of the representation of signals in a vector space, and definitions of the inner product that are interesting for continuous and discrete time signals. Application of the Gram-Schmidt method to obtain an orthonormal base to represent a set of signals. Understanding of the convenience of a separation of the transmitter in two functional modules (encoder + modulator), and identification of the parameters and factors that constraint the design of each module.	1,66	
7	14	Chapter 3 - Modulation and detection in Gaussian channels ▪ Design of the demodulator • Implementation using correlators • Implementation using matched filters ▪ Property of the maximum signal to noise ration		X		No	Design of a demodulator to obtain a vectorial representation of the received signal: structures based on correlators and matched filters. Analysis of the maximum signal to noise ratio at the output of a matched filter and its implications.	1,66	7
8	15	Chapter 3 - Modulation and detection in Gaussian channels ▪ Statistical characterization of the demodulator • Definition of the equivalent discrete-time channel ▪ Review of contents of the chapter.	X			No	Analysis of the conditional distribution of the output of the demodulator for each possible transmitted symbol: equivalent discrete channel.	1,66	
8	16	Chapter 3 - Modulation and detection in Gaussian channels ▪ Class for solving exercises		X		No	To work in the exercises to be solved in class.	1,66	4
9	17	Chapter 3 - Modulation and detection in Gaussian channels ▪ Design of the decoder: decision regions and probability of error ▪ Design criteria for minimum probability of error: máximum a posteriori (MAP), maximum likelihood (ML) and minimum euclidean distance	X			No	Understanding of the decoder design and its relationship with the probability of error. Optimal design from conditional distributions of the demodulator output.	1,66	
9	18	Chapter 3 - Modulation and detection in Gaussian channels ▪ Calculation of probability of error for different constellations ▪ Approximations and bounds for the probability of error ▪ Optimal desing for the encoder - Sphere packing technique ▪ Constellations used in practical communication systems ▪ Optimal binary assignmenta - Gray encoding		X		No	Performance evaluation, in terms of the probability of symbol error. Understanding of the approximations and bounds for the probability of error and their application to different practical examples. Design of optimal constellations, considering the tradeoff between energy and performace, in one-dimensional and two-dimensional spaces. Understanding of the practical constraints leading to the use of non-optimal constellations. Definition of optimal binary asignments for different types of constellations.	1,66	3

10	19	Chapter 3 - Modulation and detection in Gaussian channels ▪ Calculation of bit error rate (BER) ▪ Design of the modulator considering the channel characteristics ▪ Review of the relationship between symbol rate and bit rate	X			No	Examples of calculation of BER and approximations used for high signal to noise ratios. Understanding of how the channel response determines the modulator design. Review of the relationship between symbol rate and bit rate and particularization for different examples.	1,66	4
10	20	Chapter 3 - Modulation and detection in Gaussian channels ▪ Class for solving exercises (II)		X		No	To work in the exercises to be solved in class.	1,66	
11	21	Chapter 4 - Fundamental limits in communications ▪ Introduction: analysis of fundamental communication limits in communication systems by using *Information Theory* ▪ Probabilistic source models ▪ Probabilistic channel models	X			No	Obtention and understanding of statistical models used to characterize the behavior of sources in communication systems, and statistical models used to characterize a communication systems at different abstraction levels: modeling the effect of the communication channel, the process of transmitting a symbol (for soft and hard decisions), and the process of transmitting a bit.	1,66	6
11	22	**Laboratory** - Session 3		X	4.2.B01A. 2 slots per reduced group	No	Preparation of exercises for laboratory session 3.	1,66	
12	23	Chapter 4 - Fundamental limits in communications ▪ Probabilistic source and channel models usualy employed in the analysis of communication systems ▪ Examples of calculation of discrete memoryless channels (DMC) for different communication systems	X			No	Development of examples of memoryless binary symmetric source (BSS's) and discrete memoryless channels (DMC's) for different systems, and understanding of the statistical models they are representing and the assumptions that these models imply.	1,66	4
12	24	Chapter 4 - Fundamental limits in communications ▪ Quantitative information measures: entropy, joint and conditional entropies, and mutual information		X		No	Understanding of the quantitative information measures, their characteristics and properties, and how the modification of the distributions for the underlying involved variables affect to these measures.	1,66	
13	25	Chapter 4 - Fundamental limits in communications ▪ Introduction to coding for error protection ▪ Channel coding theorem (Shannon) ▪ Definition of channel capacity through the mutual information	X			No	Understanding of the coding mechanism, through the definition of extended symbols as groups of symbols, as alternative allowing a reliable communication through inherently unreliable channels, and of the implication of channel coding in the system efficiency. Analysis of channel capacity and of factors affecting it.	1,66	5
13	26	Chapter 4 - Fundamental limits in communications ▪ Class for solving exercises (I)		X		No	To work in the exercises to be solved in class.	1,66	

14	27	Chapter 4 - Fundamental limits in communications ▪ Methodology for the evaluation of channel capacity ▪ Definition of channel capacity for Gaussian channels ▪ Performance limits transmitting through Gaussian channels	X			No	Calculation of channel capacity for different kinds of DMC's, by using different techniques to obtain the maximum of the mutual information. Extension of the channel capacity concept to Gaussian channels and obtention of essential limits for the transmission through these channels. Understanding of the effect of parameters such as transmitted power, noise power, or bandwidth in such limits, and of the concept of spectral efficiency from the binary spectral rate.	1,66	
14	28	**Laboratory** - Session 4		X	4.2.B01A. 2 slots per reduced group	No	Preparation of exercises for laboratory session 4.	1,66	
14	29	Chapter 4 - Fundamental limits in communications ▪ Class for solving exercises (II)		X		No	To work in the exercises to be solved in class.	1,66	7
							Subtotal 1 - 112,33 hours	**48,33**	**64**
15		**Continuous Assessment** - Exam (Chapters 3 and 4) Tutoring, extra-classes, etc..						0,5	1,5
16 17 18		Preparation of the exam						3	21
							Subtotal 2 - 26 hours	**3,5**	**22,5**

TOTAL(Total 1 + Total 2. Maximum 160 hours)	**138,33 hours**