Universidad
Carlos III de Madrid
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COURSE: Communication Theory		
DEGREE: Bachelor in Telematics 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 1 - Introduction ▪ Presentation of the course contents ▪ Definition of a communication system ▪ Performance parameters in a communication system	X			No	Review of the concepts related with random variable, random processes and their statistical descriptions	1,66	3
1	2	Chapter 2 - Noise in communication systems ▪ Review of random variables and random processes ▪ Statistics in the time domain ▪ Stationarity, cyclostationarity and egodicity		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, and concepts of starionarity, cyclostationarity and ergodicity and their application in the modeling of communication systems	1,66	
2	3	Chapter 2 - 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 and time domain and frequency domain statistics at the output of linear systems	1,66	4
2	4	Chapter 2 - Noise in communication systems ▪ White processes ▪ Gaussian processes ▪ Examples of random processes	X		Extra Weakly class (29). Need for classroom with capacity for lecture group	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	1,66	
2	5	Chapter 2 - Noise in communication systems ▪ Model for thermal noise ▪ Power of thermal noise ▪ Signal to noise ratio		X		No	Analysis of the usual model for termal noise, understanding of the signal to noise ratio concept, and application of this concept to the transmission of a signal with additive white Gaussian noise where the receiver uses a filter to limit the noise power	1,66	

3	6	Chapter 3 - Modulation and detection in Gaussian channels - Analog vs. digital systems - Design criteria for a communication system - Model for a digital communication system - Hilbert spaces for the representations of signals in a vector space - Gram-Schmidt orthogonalization process	X			No	Determination of parameters conditionning the performance of commmunication systems, and understanding of basic functional modules of a digital communication system. Review of vector spaces and orthonormal bases. 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	1,66	
3	7	Chapter 2 - Noise in communication systems - Class for exercises		X		No	To work in the exercises to be solved at class	1,66	5
4	8	**Continuous evaluation** - Partial activity (Chapter 2) Chapter 3 - Modulation and detection in Gaussian channels - Design of digital transmitter - Definition of a symbol - Relationship between binary and symbol rates - Separation of transmitter in encoder and modulator	X			No	Understanding of the basic operation principle of a digital transmitter, of the symbol concept as an element allowing the transmission of a set of m bits, and of the relationship between binary rate and symbol rate. 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	
4	9	Chapter 3 - Modulation and detection in Gaussian channels - Presentation of the demodulator by means of the inner product - Implementation of the optimal demodulator - Correlators and matched filters - Properties of the matched filter - Definition of the equivalent discrete channel		X		No	Understanding of the role of a demodulatro to obtain a discrete representation of the received signal. Analysis of the possible structures implementing a demodulator, and understanding of the equivalent discrete channel concept in order to perform a discrete time bases study of a digital communication system	1,66	4
5	10	Chapter 3 - Modulation and detection in Gaussian channels - Distributions of the observatio at the demodulator output - Obtention of the optimal decoder - Minimizing the probability of error - Design criteria for the decoder: máximum a posteriori (MAP), maximum likelihood (ML) and minimum euclidean distance.	X			No	Obtention of conditional distributions at the output of the demodulator from the model given by que equivalent discrete channel, given each possible transmitted symbol, and from these distributions, design of the optimal decoder for different distributions of transmitted symbols and noise distributions	1,66	
5	11	Laboratory - Session 1		X	Computer Room. 2 slots per seminar group	No	Preparation of exercises for laboratory session 1	1,66	4
6	12	Chapter 3 - Modulation and detection in Gaussian channels - Calculation of probability of error for different constellations - Approximation for the probability of symbol error - Bounds for the probability of error: the union bound, and the loose bound	X			No	Performance evaluation, in terms of the probability of symbol error, for different cases, and determination of how performance is modified if non-optimal decision regions are used. Understanding of the approximations and bounds for the probability of error by means of the interpretation of probabilities as integrals over the conditional distributions	1,66	
6	13	Chapter 3 - Modulation and detection in Gaussian channels - Class for exercises		X		No	To work in the exercises to be solved in class	1,66	4

7	14	Chapter 3 - Modulation and detection in Gaussian channels ▪ Optimal desing for the encoder - Sphere packing technique ▪ Constellations used in practical communication systems ▪ Optimal binary assignmenta - Gray encoding ▪ Calculation of bit error rate (BER)	X			No	Design of optimal constellations, considering the tradeoff between energy and performace, in 1D and 2D spaces. Understanding of the practical constraints leading to the use of non-optimal constellations. Definition of optimal binary asignments for different types of constellations, and examples of calculation of BER and approximations used for high signal to noise ratios	1,66	
7	15	Chapter 3 - Modulation and detection in Gaussian channels ▪ Continuous symbol transmission ▪ Review of the relationship between symbol rate and bit rate ▪ Analysis of non-optimal receivers: characterization of conditional distributions of the observations and calculation of the probabilit of error		X		No	Extension of the functional modules of the digital communication model for the continuous transmission of a sequence of symbols. Review of the relationship between symbol rate and bit rate and particularization for different examples. Understanding of the methodology used to analyze an arbitrary receiver, not necessarily optimal, and statistical characterization of such a receiver to evaluate the probability of error	1,66	3
8	16	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	
8	17	Chapter 3 - Modulation and detection in Gaussian channels ▪ Class for exercisesSesión de ejercicios (II)		X		No	To work in the exercises to be solved in class	1,66	6
9	18	**Continuous evaluation** - Partial activity (Chapter 3) 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 binary source channels and discrete memoryless channels for different systems, and understanding of the statistical models they are representing and the assumptions that these models imply	1,66	
9	19	Laboratory - Session 2		X	Computer Room. 2 slots per seminar group	No	Preparation of exercises for laboratory session 2	1,66	5
10	20	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	
10	21	Chapter 4 - Fundamental limits in communications ▪ Class for exercises		X		No	To work in the exercises to be solved in class	1,66	5
11	22	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	
11	23	Laboratory - Session 3		X	4.2.B01A. 2 slots per reduced group	No	Preparation of exercises for laboratory session 3	1,66	4

12	24	Chapter 4 - Fundamental limits in communications • Calculus methodology for channel capacity for different cases • 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 Gaussin channeld 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	
12	25	Chapter 4 - Fundamental limits in communications • Class for exercises (II)		X		No	To work in the exercises to be solved in class	1,66	6
13	26	**Continuous evaluation** - Partial activity (Chapter 4) Chapter 5 - Analog modulations • Introduction to analog modulation • Amplitude modulations (AM)	X			No	Analysis of analog modulations in the time domain, in the frequncy domain, and comparison of required power and spectral efficiency for different variants of amplitud modulations	1,66	
13	27	Chapter 5 - Analog modulations • Angle modulations (phase and frequency) • Effect of noise in analog modulations		X		No	Analysis of angle modulations in the time domain and in the frequency domain. 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)	1,66	4
14	28	Chapter 5 - Analog modulations • Class for exercises	X			No	Work in the proposed exercises that will be solved a class	1,66	
14	29	Laboratory - Session 4		X	4.2.B01A. 2 slots per reduced group	No	Preparation of exercises for laboratory session 4	1,66	7
							Subtotal 1 - 112,33 hours	**48,33**	**64**

15		**Continuous evaluation** - Test (Chapter 5) Extra clases, tutoring class, homework handling in, etc.						0,5	1,5
16 17 18		Preparation for the evaluation and exam						3	21
							Subtotal 2 - 26 hours	**3,5**	**22,5**

TOTAL(Total 1 + Total 2. Maximum 180 hours)	**138,33 hours**