49. Course Specification of Information Theory and Coding

I. Course Identification and General Information:

1.	Course Title:	Information Theory and Coding				
2.	Course Code & Number:	CCE454				
3.	Credit hours:	C.H				TOTAL
		Th.	Tu.	Pr.	Tr.	
		2	2	-	-	3
4.	Study level/ semester at which this course is offered:	5^{th} Year - 1^{st} Semester				
5.	Pre –requisite (if any):	Probability and Statistics for Engineers (BR131), Digital Communications (CNE323).				
6.	Co –requisite (if any):	None				
7.	Program (s) in which the course is offered:	Communication Engineering and Networks				
8.	Language of teaching the course:	English				
9.	Location of teaching the course:	Faculty of Engineering - Electrical Department				
10.	Prepared By:	Asst. Prof. Dr. Mohammed Abdul Karim Al-Suraby				
11.	Date of Approval	April 2020				

II. Course Description:

This course provides students with basic concepts and applied mathematics required to the field of information theory and coding, which is widely applied in modern wireless communications systems. Course topics include an introduction to information theory and coding, measure of information, channel capacity, discrete and continuous channels, source coding (data compression), channel coding for error-detection and correction (block and cyclic codes) and the convolutional coding. Throughout tutorial work and self-study, students will develop the problem-solving skills related to the design and the implementation of some

channel coding to different wireless communications systems using engineering tools such as MATLAB environment and/or Python.

	III. Course Intended learning outcomes (CILOs) of the course	Referenced PILOs
a1	Define the principles of information and coding theory with reference to the application in modern communication and computer systems.	A1
a2	Recognize the principles of coding design techniques used in telecommunications systems.	A1 and A2
b1	Evaluate the information capacity and possible code rates of discrete memoryless channels for performance evaluation of various coding techniques over fading channels.	B2
b2	Analyze different channel encoding and decoding techniques used in wireless communication systems.	B3
c1	Calculate the information content of a random variable from its probability distribution based on Shannon-Hartley theorem for information transmission on Gaussian channels.	C1 and C4
c2	Implement different coding/decoding schemes to variant digital communication applications.	C1, C2 and C4
d1	Work in an interdisciplinary team, contributing in project work pragmatically & responsibly and making commitments in view of the resources that are available.	D1
d2	Search Web and information technology resources for software simulation tools and modern methods used in information & coding problem-solving.	D5

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a1 - Define the principles of information and coding theory with reference to the application in modern communication and computer systems. .	Active lectures, Interactive class discussions and Tutorials	Homework Assignments Quizzes Written Exam
a2 - Recognize the principles of coding design techniques used in telecommunications systems.	Active lectures, Interactive class discussions and Tutorials	Homework Assignments Quizzes Written Exam

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1 - Evaluate the information capacity and possible code rates of discrete memoryless channels for performance evaluation of various coding techniques over fading channels.	Active lectures, Interactive class discussions, Tutorials and Exercises	Homework Assignments
b2 - Analyze different channel encoding and decoding techniques used in wireless communication systems.	Active lectures, Interactive class discussions, Tutorials, Self-Learning and Exercises	Homework Assignments

© Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
c1 - Calculate the information content of a random variable from its probability distribution based on Shannon-	Active lectures, Interactive class	Homework Assignments

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Hartley theorem for information transmission on Gaussian channels.	discussions, Tutorials and Exercises.	
c2 - Implement different coding/decoding schemes to variant digital communication applications.	Active lectures, Interactive class discussions, Tutorials, Self-Learning and Exercises.	Homework Assignments

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1 Work in an interdisciplinary team, contributing in project work pragmatically & responsibly and making commitments in view of the resources that are available.	Tutorials and Exercises	Homework Assignments
d2 Search Web and information technology resources for software simulation tools and modern methods used in information & coding problem-solving.	Tutorials, Exercises and Self-Learning.	Homework Assignments

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact hours
1.	An Introduction to Information Theory	a1, b1, c1	• Course Orientation, Introduction to information theory and coding, • Definition and measure of information (self-information, entropy, relative information, and mutual information). • Channel capacity, redundancy and efficiency of channels.	3	6
2.	Discrete and Continuous Channels	a1, b1,c1	• Symmetric channels, binary Symmetric channel. • Binary erasure channel, cascaded channels, repetition of symbols. • Binary asymmetric channel, Shannon theorem	3	6
3.	Source Encoding	a1, a2,b1, b2, c2	• Source Encoding techniques, purpose of encoding, instantaneous codes, construction of instantaneous codes, Kraft's Inequality. • Coding efficiency and redundancy, noiseless coding theorem. • Construction of basic source codes: Shannon-Fano algorithm, Huffman coding, arithmetic coding.	2	4
4.	Codes for Error	a1, a2, b1, b2, c2	• Block Coding: Parity check coding, linear block codes,	3	6

	Detection and Correction		error detecting and correcting capabilities, generator and parity check matrices, standard array and syndrome decoding. • Hamming codes, encoding and decoding of systematic and unsystematic codes, • Applied Mathematical, Number Theory, Prime Numbers Generation, Galois Fields, Euler function, $\varphi(q)$, • Cyclic codes: generator polynomial, generator and parity check matrices, encoding of cyclic codes, syndrome computation and error detection.		
5.	Convolutional Coding	a1, a2, b1, b2, c2	• Binary convolution codes, tree and trellis diagram, decoding convolution codes. • The Viterbi algorithm.	3	6
Number of Weeks /and Units Per Semester				**14**	**28**

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B - Tutorial Aspect:				
Order	**Tutorial Skills List**	**Number of Weeks**	**Contact Hours**	**Learning Outcomes**
1.	An Introduction to Information Theory • Definition and measure of information (self-information, entropy, relative information, and mutual information). • Channel capacity, redundancy and efficiency of channels.	**2**	**4**	**a1, b1, c1, d1 and d2.**
2.	Discrete and Continuous Channels • Symmetric channels, binary symmetric channel. • Binary erasure channel, cascaded channels, repetition of symbols. • Binary asymmetric channel, Shannon theorem	**2**	**4**	**a1, b1, c1, d1 and d2.**
3.	Source Encoding • Encoding techniques, purpose of encoding, instantaneous codes, construction of instantaneous codes, Kraft's Inequality. • Coding efficiency and redundancy, noiseless coding theorem. • Construction of basic source codes: Shannon-Fano algorithm, Huffman coding, arithmetic coding.	**3**	**6**	**a1, a2, b1, b2, c2, d1 and d2.**
4.	Block Codes • Parity check coding, linear block codes, error detecting and correcting capabilities. • Generator and parity check matrices, standard array and syndrome decoding. • Hamming codes.	**3**	**6**	**a1, a2, b1, b2, c2, d1 and d2.**
5.	Cyclic Codes • Generator polynomial, generator and parity check matrices. • Encoding of cyclic codes, syndrome computation and error detection.	**2**	**4**	**a1, a2, b1, b2, c2, d1 and d2.**

6.	Convolutional Codes • Binary convolution codes, tree and trellis diagram, decoding convolution codes. • The Viterbi Algorithm.	**2**	**4**	**a1, a2, b1, b2, c2, d1 and d2.**
Number of Weeks /and Units Per Semester		**14**	**28**	

V. Teaching strategies of the course:

- Active Lectures.
- Interactive class discussions.
- Tutorials.
- Exercises and Homework,
- Self-Learning.

VI. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1.	**An Introduction to Information Theory** ▪ Definition and measure of information (self-information, entropy, relative information, and mutual information). ▪ Channel capacity, redundancy and efficiency of channels.	a1, b1, c1, d1 and d2.	2nd and 3rd	1.5
2.	**Discrete and Continuous Channels** ▪ Symmetric channels, Binary Symmetric Channel. ▪ Binary Erasure Channel, Cascaded channels, repetition of symbols. ▪ Binary asymmetric channel, Shannon theorem	a1, b1, c1, d1 and d2.	4th to 6th	3
3.	**Source Encoding** ▪ Encoding techniques, purpose of encoding, instantaneous codes, construction of instantaneous codes, Kraft's Inequality. ▪ Coding efficiency and redundancy, noiseless coding theorem. ▪ Construction of basic source codes: Shannon-Fano	a1, a2,b1, b2, c2,d1 and d2.	7th and 8th	3

	▪ algorithm, Huffman coding, arithmetic coding.			
4.	**Block Codes** ▪ Parity check coding, linear block codes, error detecting and correcting capabilities. ▪ Generator and parity check matrices, standard array and syndrome decoding. ▪ Hamming codes.	a1, a2, b1, b2, c2, d1 and d2.	10th and 11th	3
5.	**Cyclic Codes** ▪ Generator polynomial, generator and parity check matrices. ▪ Encoding of cyclic codes, syndrome computation and error detection. ▪ Search on the Web and preparing report on the implementation of Cyclic codes to different Tele-communications systems.	a1, a2, b1, b2, c2, d1 and d2.	12th	3
6.	**Convolutional Codes** ▪ Binary convolution codes, tree and trellis diagram, decoding convolution codes. ▪ The Viterbi Algorithm.	a1, a2, b1, b2, c2, d1 and d2.	13th and 14th	1.5
Total Marks				**15**

VII. Research:

No	Research	Aligned CILOs(symbols)	Week Due	Mark
1.	**Research 1: (Students work in small groups of 2 or 3 members)** ▪ Short report on simulation tools & programming languages used in solving of problems related to information measurements and channel coding techniques implementations.	a1, b1, c1, d1 & d2.	3rd to 4th	2
2.	**Research 2: (Students work in small groups of 2 or 3 members)** ▪ Short report on Binary Symmetric & Asymmetric channel, Shannon theorem applications, ▪ Short report on Source coding implementation such as Huff-man and another modern source coding applied to variant channels for performance evaluation.	a1, b1, c1, d1 & d2.	4th and 7th	5
3.	**Research 2: (Students work in small groups of 2 or 3 members)** ▪ Short report on different channel coding techniques, ▪ Short report on Cyclic, Convolutional and Turbo channels codding implementation & performance evaluation when applied to variant channels such as White-Gaussian & Fading channels.	a2, b2, c2, d1 & d2.	9th to 14th	8
Total Marks				**15**

VIII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1.	Assignments	2nd to 14th	15	10%	a1, a2, b1, b2, c1, c2, d1 and d2

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2.	Searches	3rd to 14th	15	10%	a1, a2, b1, b2, c1, c2, d1 & d2
3.	Quizzes	4th, 8th and 13th	15	10%	a1, a2, b1, b2, c1
4.	Mid -Term Exam	9th	30	20%	a1, b1 and c1
5.	Final Exam	16th	75	50%	a1, a2, b1, b2, c1 and c2
Total Marks/ Percentage			**150**	**100%**	

IX. Learning Resources:

- *Written in the following order: (Author - Year of publication – Title – Edition – Place of publication – Publisher).*

1- Required Textbook(s) (maximum two).

1- Thomas M Cover, Joy A Thomas (2013), Elements of Information Theory – 3nd Edition, USA, John Wiley & Sons.
2- Gareth A Jones, J Mary Jones (2002), Information and Coding Theory - 2th Edition Great Britain, Springer.

2- Essential References.

1- Robert J. McEliece, (2002), The Theory of Information and Coding, 2nd Edition, U Cambridge University Press.
2- R. W. Hamming (1980), Coding and Information Theory, USA, Prentice Hall.

3- Electronic Materials and Web Sites *etc*.

X. Course Policies:

1.	**Class Attendance:** -A student should attend not less than 75 % of total hours of the subject; otherwise he will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic
2.	**Tardy:** - For late in attending the class, the student will be initially notified. If he repeated lateness in attending class he will be considered as absent.
3.	**Exam Attendance/Punctuality:** - A student should attend the exam on time. He is Permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam.
4.	**Assignments & Projects:**

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	- The assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time.
5.	**Cheating**: - For cheating in exam, a student will be considered as failure. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty.
6.	**Plagiarism**: Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proved a plagiarism of a student, he will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university.
7.	**Other policies:** - Mobile phones are not allowed to use during a class lecture. It must be closed, otherwise the student will be asked to leave the lecture room - Mobile phones are not allowed in class during the examination. Lecture notes and assignments my given directly to students using soft or hard copy

Reviewed By	**Vice Dean for Academic Affairs and Post Graduate Studies: Asst. Prof. Dr. Tarek A. Barakat** **President of Quality Assurance Unit: Assoc. Prof. Dr. Mohammed Algorafi** **Name of Reviewer from the Department: Assoc. Prof. Dr. Farouk Al-Fuhaidy**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed** **Asst. Prof. Dr. Munasar Alsubri**

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