

Electrical and Computer Engineering

Deidra Hodges – Associate Professor, and Chair

Malek Adjouadi, Ware Professor

Mohammad Shah Alam, Assistant Teaching Professor

Elias Alwan, Assistant Professor

Jean Andrian, Associate Professor

Wilmer Arellano, Associate Teaching Professor

Ou Bai, Associate Professor

Mandrita Banerjee, Assistant Teaching Professor

Armando Barreto, Professor

Shekhar Bhansali, Distinguished University Professor

Amaury Caballero, Teaching Professor

Mercedes Cabrerizo, Associate Professor

Gustavo Chaparro-Baquero, Assistant Teaching Professor

Hai Deng, Associate Professor and Graduate Program Director of the Master's Programs

Yu Du, Assistant Teaching Professor

Luis Galarza, Assistant Teaching Professor

Stavros Georgakopoulos, Professor

Mehdi Hatamian, Distinguished University Professor

Ahmed S. Ibrahim, Associate Professor

Shafiul Islam, Assistant Teaching Professor

Aleksandr Krasnok, Assistant Professor

Grover Larkins, Professor

Arjuna Madanayake, Associate Professor, and Graduate Program Director of the Ph.D. Program

Osama Mohammed, Distinguished University Professor, Associate Dean of Research, and School Director

Nonnarit O-Larnnithipong, Assistant Teaching Professor

Nezih Pala, Professor

Sumit Paudyal, Associate Professor

Alexander Perez-Pons, Associate Professor

Vladimir Pozdin, Assistant Professor

Gang Quan, Professor

Mohammad Ashiqur Rahman, Assistant Professor

Md Tauhidur Rahman, Assistant Professor

Pulugurtha Markondeya Raj, Associate Professor

Gustavo Roig, Professor

Mario Sanchez, Associate Director for Undergraduate Advising

Arif Sarwat, Professor

Mst Shamim Ara Shawkat, Assistant Professor

Atoussa Tehrani, Associate Teaching Professor

Himanshu Upadhyay, Associate Professor

Frank Urban, Associate Professor

Rafael Soltero Venegas, Associate Teaching Professor

Satheesh Bojja Venkatakrishnan, Assistant Professor

Yuri Vlasov, Associate Teaching Professor

John Volakis, Dean, College of Engineering and Computing & Professor

Herman Watson, Assistant Teaching Professor, and Undergraduate Program Director

Subbarao Wunnava, Professor Emeritus Distinguished

Kang Yen, Professor, Assistant Provost, and Graduate Program Director of the China Program

Konstantinos Zekios, Assistant Professor

Bachelor of Science in Electrical Engineering

Program Educational Objectives

The Electrical Engineering Educational Objectives are:

1. That our graduates are employed and have career advancement as electrical engineers, or in another profession using their electrical engineering skills,
2. That our graduates stay current in their field of expertise,
3. That our graduates attain supervisory/leadership positions in their respective organizations.

Student Learning Outcomes

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. an ability to communicate effectively with a range of audiences.
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Degree Program Hours: 128

Common Prerequisite Courses

CHM 1045	General Chemistry
CHM 1045L	General Chemistry Lab I
MAC 2281	Calculus I for Engineering
MAC 2282	Calculus II for Engineering
MAC 2283	Calculus III for Engineering
MAP 2302	Differential Equations
PHY 2048 ¹	Physics with Calculus I
PHY 2049	Physics with Calculus II
PHY 2049L	General Physics Lab II

¹PHY2048L is not required at FIU

For a list of all state-approved common prerequisites, including alternatives, visit <https://cpm.flvc.org>.

Additional lower division courses required:

EEL 2880	C Programming for Embedded Systems
----------	------------------------------------

Academic Progression Standards

Students who are unsuccessful in passing common prerequisites after two attempts will be advised to change their major into an area where they can be successful. Drops after the add/drop period, which result in a DR grade, are considered an attempt in the course and count as an unsuccessful enrollment.

Students applying to Electrical Engineering should have good communication skills in English (verbal and written) and exhibit logical thinking, creativity, imagination, and persistence. They should have proven academic background in mathematics, chemistry, and physics. First time in college at FIU and eligible to enroll in Calculus I

can declare Electrical Engineering as a major. All others will be admitted to Electrical Engineering after successfully registering for Calculus II. Missing courses may be taken at FIU, with advisor approval.

At the undergraduate level, the basic required program of instruction in fundamental theory and laboratory practice is balanced by a broad range of electives in such fields as bioengineering, communication systems, control systems, energy, and power. Students, with the counsel and guidance of faculty advisers, design their electives program around their own special interests and career objectives. Students are allowed to take ECE electives when they complete the University core and start taking degree core. Students must choose elective classes from an approved concentration list. Students may choose any class from any concentration as long as they fulfill the prerequisite(s) and corequisite(s). Students are required to choose at least two concentrations, at least nine credits from each of these two concentrations.

Any course taken without the required prerequisites and corequisites will be dropped automatically before the end of the term, resulting in a grade of "DR" or "DF". The student will not be eligible for a refund.

Students must earn a minimum grade of "C" and a minimum GPA of 2.0 in all EEE, EEL, and elective courses required for graduation.

Students, who have been dismissed for the first time from the University due to low grades, may appeal to the department for reinstatement. A second dismissal results in no possibility of reinstatement.

Students are required to take "SPC 2608 Public Speaking (for Engineers)". Students who have taken Public Speaking (or equivalent) at a Community College/University and have satisfied the UCC through courses other than Public Speaking may use the course toward concentration elective credits required for the program.

Lower-Division Preparation

Lower-division requirements include at least 50 credit hours of pre-engineering courses (see the Undergraduate Studies portion of this catalog for specific requirements). These courses include common prerequisite courses, 2 semesters of English composition and 2 other Gordon rule writing courses. A minimum grade of "C" is required in all writing courses, all calculus courses, differential equations, both physics classes, and chemistry. In addition, both transfer students and FIU freshman must take a combination of social sciences and humanities that fulfill the FIU University Core Curriculum requirements and those topics also complement the goals and objectives of the College of Engineering and Computing (including economic, environmental, political, and/or social issues. See semester-by-semester sample program for courses that fulfill this requirement). Students who have not satisfactorily met the social science/humanities requirements will be required to take additional (advanced) humanities/social science course(s).

In addition, students may transfer a pre-approved engineering Statics course if it meets the proper prerequisites for the course (speak to an FIU engineering advisor to see if your community college offers an acceptable statics course). Students must make up any missing prerequisites before they are allowed to begin taking certain engineering courses (see the course listing

on the following page for the complete list of required courses. Required pre/corequisites are listed in the section on Course Descriptions).

University Core (Total: 50 Credits)

Any student entering Florida International University as a first-time college student (Summer 2003 or after) or transferring in without an Associates in Arts (AA) degree from a Florida public institution (Fall 2003 or after) is required to fulfill the University Core Curriculum requirements.

SLS 1501	First Year Experience	1
<i>(Communications)</i>		
ENC 1101	Writing and Rhetoric I	3
ENC 1102	Writing and Rhetoric II	3
<i>(Humanities)</i>		
Humanities Group 1		3*
Humanities Group 2		3*
<i>(Mathematics)</i>		
MAC 2281	Calculus I for Engineering	4
MAC 2282	Calculus II for Engineering	4
MAC 2283	Calculus III for Engineering	4
MAP 2302	Differential Equations	3
Social Science Group 1		3*
Social Science Group 2		3*
<i>(Natural Sciences)</i>		
Natural Science Group 1		
CHM 1045	General Chemistry I	3
Or		
BSC 2010	General Biology	3
CHM 1045L	General Chemistry I Lab	1
Or		
BSC 2010L	General Biology Lab	1
PHY 2048	Physics with Calculus I	4
Natural Science Group 2		
PHY 2049	Physics with Calculus II	4
PHY 2049L	General Physics Lab II	1
<i>(Arts)</i>		
SPC 2608	Public Speaking	3

*Please check all approved courses from Academic Advising Center:

<http://undergrad.fiu.edu/advising/curriculum.html>.

Other Requirements

Students must meet the University Foreign Language Requirement, must have a minimum 2.0 GPA, must complete all required classes, and must otherwise meet all the state and university requirements in order to graduate. Students who enter the university with fewer than 60 transferred credits must take 9 summer credits. Also see the Undergraduate Studies portion of this catalog for additional information.

Electrical Engineering students must take:

Engineering Breadth and Elective (Total: 8 Credits)

EGN 1002	Engineering Orientation	2
ESI 3215	Evaluation of Engineering Data I	3
EGN 3613	Engineering Economy	3

ECE Core (Total: 21 credits)

EEL 2880	C Programming for Embedded Systems	3
EEL 3110C	Circuit Analysis and Lab	4
EEL 3120	Introduction to Linear Systems in Engineering	3
EEL 3135	Signals and Systems	3
EEL 3712	Logic Design I	3

EEL 3712L	Logic Design I Lab	1
EEL 4920	Senior Design I: Ethics, Communications and Constraints – <i>GL</i>	2**
EEL 4921C	Senior Design II: Project Implementation – <i>GL</i>	2**

**EEL 4920 and EEL 4921C are intended to be taken in the last 2 semesters of the undergraduate experience. Students are required to complete at least 100 credits, other ECE core courses, and Electrical Engineering Degree Core before EEL 4920 registration. ‡

Electrical Engineering Degree Core (Total: 10 credits)

EEE 3303C	Electronics I & Lab	4
EEL 3200	Electrical Energy Systems	3
EEL 4410	Introduction to Fields and Waves	3

Electrical Engineering Electives (Total: 39 credits)

(Selected from Areas of Concentration offered by ECE Department)

Plan of Study

Electrical Engineering Program Freshman to Senior

First Semester: (18)

CHM 1045	General Chemistry I	3
	Or	
BSC 2010	General Biology	3
CHM 1045L	General Chemistry I Lab	1
	Or	
BSC 2010L	General Biology Lab	1
ENC 1101	Writing and Rhetoric I	3
SLS 1501	First Year Experience	1
MAC 2281	Calculus I for Engineering	4
	(Social Science Group 1)	
ECO 2013	Principles of Macroeconomics	3
	or	
AMH 2020	American History Introductory Survey Since 1877 – <i>GRW/GL</i>	3
	or	
PSY 2012	Introductory Psychology	3
	or	
ANT 2000	Introduction to Anthropology – <i>GL</i>	3
	or	
POS 2041	American Government	3
	or	
SYG 2010	Social Problems – <i>GL</i>	3
	(Arts)	
SPC 2608	Public Speaking	3

Second Semester: (16)

EGN 1002	Engineering Orientation	2
ENC 1102	Writing and Rhetoric II	3
PHY 2048	Physics with Calculus I	4
MAC 2282	Calculus II for Engineering	4
	(Social Science Group 2)	
EG	Technology, Humans, and Society – <i>GL</i>	3

Third Semester: (15)

PHY 2049	Physics with Calculus II	4
PHY 2049L	General Physics Lab II	1
MAC 2283	Calculus III for Engineering	4
EEL 2880	C Programming for Embedded Systems	3
	Humanities Group 1	3**

Fourth Semester: (17)

MAP 2302	Differential Equations	3
EEL 3110C	Circuit Analysis and Lab	4

EEL 3120	Introduction to Linear Systems in Engineering	3
ESI 3215	Evaluation of Engineering Data I	3
EEL 3712	Logic Design I	3
EEL 3712L	Logic Design I Lab	1

Fifth Semester: (16)

EEL 3135	Signals and Systems	3
EEE 3303C	Electronics I & Lab	4
EGN 3613	Engineering Economy	3
EEL 4410	Introduction to Fields and Waves	3
	Humanities Group 2	3**

Sixth Semester: (18)

ECE Electives		15
EEL 3200	Electrical Energy Systems	3

Seventh Semester: (14)

EEL 4920	Senior Design I: Ethics, Communications and Constraints – <i>GL</i>	2
ECE Electives		12

Eighth Semester: (14)

EEL 4921C	Senior Design II: Project Implementation – <i>GL</i>	2
ECE Electives		12

**At least 9 credit hours must be taken in one or more summers.

Bachelor of Science in Internet of Things

Program Educational Outcomes:

IoT students should demonstrate that they have knowledge when evaluated under the following outcomes:

- Demonstrate practical hands-on expertise in selection, installation, customizing and maintenance of the state-of-the-art IoT devices and networks;
- Demonstrate a general understanding of at least one field where IoT plays a central role;
- Demonstrate the ability to utilize and understand contemporary IoT applications and protocols common-place to the industry;
- Demonstrate the ability to effectively communicate ideas in oral, written, and graphical form;
- Demonstrate ability to, and experience in, collaboratively working with teams and small group settings;
- Explain the legal and ethical implications of their work and an awareness of the impact of their actions and decision-making on individuals, society, and the environment.

Common Prerequisite Courses and Equivalencies

<u>FIU Course(s)</u>	<u>Equivalent Course(s)</u>
MAC 1105	MACX105
MAC 1114	MACX114 or MACX147
PHY 2053, PHY 2048L	PHYX053/PHYX048L
	PHYX053/PHYX053L
	PHYX004/X004L
	PHYX053C
PHY 2054, PHY 2049L	PHYX054/PHYX049L
	PHYX054/PHYX054L
	PHYX005/X005L

PHYX054C

Academic Progression Standards

Students who are unsuccessful in passing common pre-requisites after two attempts will be advised to change their major into an area where they can be successful. Drops after the add/drop period, which result in a DR grade, are considered an attempt in the course and count as an unsuccessful enrollment.

Degree Program Hours: 120

Required Courses from the FIU Core (the rest can be any from the list) Total: 50 credits

MAC 1105	College Algebra	3
CGS 2518	Data Analysis	3
COP 2250	Programming in Java	3
CHM 1045	General Chemistry I	3
PHY 2053	Physics without Calculus	4
EGS 1041	Technology, Human and Society – GL	3
IDS 3315	Gaining Global Perspectives	3

IoT Core Courses (40 credits):

TCN 2720	Introduction to IoT	3
CTS 1120	Fundamentals of Cybersecurity	3
EGR 2271	Introduction to Circuits & Electronic Hardware	3
CDA 3104	Introduction to Computer Design	3
CNT 3142	Microcontrollers for IoT Devices	3
CNT 3162	Wireless Communications for IoT	3
EEL 2880	C Programming for Embedded Systems	3
EEL 4730	Programming Embedded Systems	3
EEL 4734	Embedded Operating Systems	3
TCN 4211	Telecommunications Networks	3
EEE 4717	Introduction to IoT Security	3
CGS 3767	Computer Operating Systems	3
CEN 3721	Introduction to Human-Computer Interaction	3

Electives (30 credits)**Elective Courses from ECE (at least 9 credits):**

Existing Courses:

1. TCN 4081 Telecommunication Network Security (3)
(Prereq: TCN 4211)

New Courses:

2. IoT Privacy (3) (Prereq: EEL 2880)
3. Network Protocols for IoT (3) (Prereq: TCN 4211)
4. IoT Forensics (3) (Prereq: Embedded Programming for IoT)

Elective Courses from Other Departments in CEC (Up to 9 credits): As long as the prerequisites are met, up to 9 credits can be taken from other engineering departments.

Elective Courses from other Colleges (12 credits): As long as the prerequisites are met, 12 credits can be taken from other Colleges. Out of 12, up to 6 credits are acceptable/transferrable from other FL universities' online programs.

Combined BS/MS in Electrical Engineering Degree Pathway

This five-year pathway seamlessly combines a baccalaureate degree in Electrical Engineering with the Master's in Electrical Engineering. To be considered for admission to the combined bachelor's/master's degree

pathway, students must have completed at least 75 credits required for the bachelor's degree program at FIU, have earned at least a 3.2 GPA on both overall and upper-division courses, and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree pathway; the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree pathway will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships. Students enrolled in the pathway may count up to 9 hours of graduate-level courses (i.e., 5000 level or higher) as credits for both the undergraduate and graduate degree programs. For each of the courses counted as credits for both BS and MS degree, a minimum grade of 'B' is required. Upon completion of the combined BS/MS pathway, students must have accumulated a minimum of 24 hours of credits at the graduate (5000+) level. Students enrolled in the pathway are encouraged to seek employment with a department faculty member to work as a student assistant on a sponsored research project.

Combined BS in Electrical Engineering/MS in Biomedical Engineering Pathway

This five-year pathway seamlessly combines a baccalaureate degree in electrical engineering with the Master's in biomedical engineering. To be considered for admission to the combined bachelor's/master's degree pathway, students must have completed 75 credits in the bachelor's degree program at FIU, have earned at least a 3.25 GPA on both overall and upper division courses, and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree program; the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree pathway will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships. Students enrolled in the pathway may count up to 9 hours of graduate level courses (i.e., 5000 level or higher) as credits for both the undergraduate and graduate degree programs. For each of the courses counted as credits for both BS and MS degree, a minimum grade of 'B' is required. Upon completion of the combined BS/MS pathway, students must have accumulated a minimum of 24 hours of credits at the graduate (5000+) level. Students enrolled in the pathway are encouraged to seek employment with a department faculty member to work as student assistants on sponsored research projects.

Combined BS in Electrical Engineering/MS in Engineering Management

(BSEE/MSEM) Degree Pathway

Students, who are pursuing a Bachelor of Science degree in Electrical Engineering and have completed at least 75 credits with a minimum of a 3.2 overall GPA on both overall and upper division courses may, upon recommendation from three ECE faculty members, apply to enroll in the combined BSEE/MSEM pathway. Students need only apply once to the combined degree pathway; the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. In addition to the admission requirements of the MSEM program, students must meet all the admission requirements of the University Graduate School.

Students enrolled in the combined degree pathway could count up to two Electrical Engineering graduate courses for both the BSEE electives and the MSEM electives, for a total saving of 6 credit hours. A minimum grade of "B" is required graduate courses counted as credits for both BSEE and MSEM degrees. Only 5000-level or higher courses may be applied toward both degrees. Only graduate courses with formal lecture can be counted for both degrees.

The combined BSEE/MSEM pathway has been designed to be a continuous enrollment pathway. Students will receive their BSEE degree upon completion of all the requirements of the BSEE program. A student admitted to the combined degree pathway will be considered to have undergraduate status until the student applies for graduation from his/her bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships.

Students may elect to permanently leave the combined pathway and earn only the BSEE degree. Students who elect to leave the combined pathway and earn only the BS degree will have the same access requirements to regular graduate programs as any other student but will not be able to use the 6 credit hours in both the BSEE and MSEM degrees.

Students interested in the combined pathway should consult with their undergraduate advisor on their eligibility to the pathway. The student should also meet the MSEM Program Director to learn about the graduate program and available tracks/courses before completing the application form and submitting it to their undergraduate advisor. Final decision for admission to the MSEM program will be made by the University Graduate School upon recommendation by the Engineering Management program director. Applicants will be notified by the Engineering Management Program and the University Graduate School of the decision on their applications.

Combined BS in Electrical Engineering/MS in Telecommunications and Networking Pathway

Students who pursue a BS degree and are in their junior year, with at least a 3.3 GPA on both overall and upper division courses may apply to enroll in the combined BS/MS pathway. To be considered for admission to the combined bachelor's/master's degree pathway, students must have completed at least 75 credits in the bachelor's degree program at FIU and meet the admissions criteria

for the graduate degree program to which they are applying. Students need only apply once to the combined degree pathway; the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree pathway will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships. Only 5000-level or higher courses, and no more than the number of credits specified by the program catalog, may be applied toward both degrees. In addition to the admission requirements of the combined BS/MS pathway, students must meet all the of the University's graduate admissions requirements.

Students enrolled in the pathway may count up to six credit hours of Telecommunications and Networking graduate courses as credits for both the BS and MS degrees. The combined BS/MS pathway has been designed to be a continuous enrollment pathway. During this combined BS/MS pathway, upon completion of all the requirements of the undergraduate program, students will receive their BS degrees. Students in this pathway have one year to complete the master's degree after receipt of the bachelor's degree. Students who fail to meet this one year post B.S. requirement or who elect to leave the combined pathway at any time and earn only the BS degree will have the same access requirements to regular graduate programs as any other student, but will not be able to use the six credits in both the bachelor's and master's degrees.

For each of the graduate courses counted as credits for both BS and MS degree, a minimum grade of "B" is required. Students enrolled in the pathway may count up to six credit hours of Telecommunications and Networking graduate courses toward the elective BSEE requirements as well as toward the MS in Telecommunications and Networking degree. Only graduate courses with formal lectures can be counted for both degrees. The students are responsible for confirming the eligibility of each course with the undergraduate advisor.

Students interested in the pathway should consult with the undergraduate advisor on their eligibility to the pathway. The students should also meet the graduate advisor to learn about the graduate program and available courses before completing the application form and submitting it to the undergraduate advisor. Applicants will be notified by the department and the University Graduate School of the decision on their applications.

Bachelor of Science in Computer Engineering

Program Educational Objectives

The Computer Engineering Educational Objectives are:

1. That our graduates are employed and have career advancement as computer engineers, or in another profession using their computer engineering skills,
2. That our graduates stay current in their field of expertise,
3. That our graduates attain supervisory/leadership positions in their respective organizations.

Student Learning Outcomes

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. an ability to communicate effectively with a range of audiences.
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Degree Program Hours: 128

Common Prerequisite Courses **

CHM 1045	General Chemistry I
CHM 1045L	General Chemistry Lab I
MAC 2281	Calculus I for Engineering
MAC 2282	Calculus II for Engineering
MAC 2283	Calculus III for Engineering
MAP 2302	Differential Equations
PHY 2048	Physics with Calculus I
PHY 2049	Physics with Calculus II
PHY 2049L	General Physics Lab II

For a list of all state-approved common prerequisites, including alternatives, visit <https://cpm.flvc.org>.

Additional lower-division courses required:

EEL 2880	C Programming for Embedded Systems
MAD 2104	Discrete Mathematics ³
	or
COT 3100	Discrete Structures

**PHY 2048L is not a requirement for this program.

³Or equivalent fulfilling Discrete Mathematics requirements

Academic Progression Standards

Students who are unsuccessful in passing common prerequisites after two attempts will be advised to change their major into an area where they can be successful. Drops after the add/drop period, which result in a DR grade, are considered an attempt in the course and count as an unsuccessful enrollment.

Students applying to Computer Engineering should have good communication skills in English (verbal and written) and exhibit logical thinking, creativity, imagination, and persistence. They should have proven academic background in mathematics, chemistry, and physics. First time in college at FIU and eligible to enroll in Calculus I can declare Computer Engineering as a major. All others will be admitted to Computer Engineering after successfully registering for Calculus II. Missing courses may be taken at FIU, with advisor approval.

At the undergraduate level, the basic required program of instruction in fundamental theory and laboratory practice is balanced by a broad range of electives in such fields as bioengineering, communication systems, control systems, energy and power. Students, with the counsel and guidance of faculty advisers, design their electives program around their own special interests and career objectives. Students are allowed to take ECE electives when they complete the University core and start taking degree core. Students must choose elective classes from an approved concentration list. Students may choose any class from any concentration as long as they fulfill the prerequisite(s) and corequisite(s). Students are required to choose at least two concentrations, at least nine credits from each of these two concentrations.

Any course taken without the required prerequisites and corequisites will be automatically dropped before the end of the term, resulting in a grade of "DR" or "DF". The student will not be eligible for a refund.

Students must earn a minimum grade of "C" and a minimum GPA of 2.0 in all EEE, EEL, and elective courses required for graduation.

Students, who have been dismissed for the first time from the University due to low grades, may appeal to the department for reinstatement. A second dismissal results in no possibility of reinstatement.

Students are required to take "SPC 2608 Public Speaking (for Engineers)". Students who have taken Public Speaking (or equivalent) at a Community College/University and have satisfied the UCC through courses other than Public Speaking may use the course toward concentration elective credits required for the program.

Sections titled "Other Requirements" and "Lower Division Preparation" in the Electrical Engineering section is also requirements for the Computer Engineering students.

University Core (Total: 50 Credits)

Any student entering Florida International University as a first-time college student (Summer 2003 or after) or transferring in without an Associates in Arts (AA) degree from a Florida public institution (Fall 2003 or after) is required to fulfill the University Core Curriculum requirements.

SLS 1501	First Year Experience (Communications)	1
ENC 1101	Writing and Rhetoric I	3
ENC 1102	Writing and Rhetoric II (Humanities)	3
	Humanities Group 1	3*
	Humanities Group 2 (Mathematics)	3*
MAC 2281	Calculus I for Engineering	4
MAC 2282	Calculus II for Engineering	4
MAC 2283	Calculus III for Engineering	4
MAP 2302	Differential Equations (Social Sciences)	3
	Social Science Group 1	3*
	Social Science Group 2 (Natural Sciences)	3*
	Natural Science Group 1	
CHM 1045	General Chemistry I	3
	Or	
BSC 2010	General Biology I	3
CHM 1045L	General Chemistry I Lab	1
	Or	

BSC 2010L	General Biology I Lab	1
PHY 2048	Physics with Calculus I	4
Natural Science Group 2		
PHY 2049	Physics with Calculus II	4
PHY 2049L	General Physics Lab II	1
<i>(Arts)</i>		
SPC 2608	Public Speaking	3

*Please check all approved courses from Academic Advising Center:

<http://undergrad.fiu.edu/advising/curriculum.html>.

Computer Engineering students must take:

Engineering Breadth and Elective (Total: 8 Credits)

EGN 1002	Engineering Orientation	2
ESI 3215	Evaluation of Engineering Data I	3
EGN 3613	Engineering Economy	3

ECE Core (Total: 21 credits)

EEL 2880	C Programming for Embedded Systems	3
EEL 3110C	Circuit Analysis and Lab	4
EEL 3120	Introduction to Linear Systems in Engineering	3
EEL 3135	Signals and Systems	3
EEL 3712	Logic Design I	3
EEL 3712L	Logic Design I Lab	1
EEL 4920	Senior Design I: Ethics, Communications and Constraints – GL	2**
EEL 4921C	Senior Design II: Project Implementation – GL	2**

**EEL 4920 and EEL 4921C are intended to be taken in the last 2 semesters of the undergraduate experience. Students are required to complete at least 100 credits, other ECE core courses, and Electrical Engineering Degree Core before EEL 4920 registration.

Computer Engineering Degree Core (Total: 15 credits)

EEL 3370	C++ Programming for Embedded Systems	3
EEL 4709C	Computer Design	3
EEL 4730	Programming Embedded Systems	3
EEL 4740	Embedded Computing Systems	3
MAD 2104	Discrete Mathematics	3
or		
COT 3100	Discrete Structures	3

Computer Engineering Electives (Total: 34 credits)

(Selected from Areas of Concentration offered by ECE Department)

Plan of Study

Computer Engineering Program Freshman to Senior

First Semester: (18)

CHM 1045	General Chemistry I	3
Or		
BSC 2010	General Biology I	3
CHM 1045L	General Chemistry Lab I	1
Or		
BSC 2010L	General Biology I Lab	1
ENC 1101	Writing and Rhetoric I	3
SLS 1501	First Year Experience	1
MAC 2281	Calculus I for Engineering	4
<i>(Social Science Group 1)</i>		
ECO 2013	Principles of Macroeconomics	3
or		
AMH 2020	American History Introductory Survey	

	Since 1877 – GRW/GL	3
or		
PSY 2012	Introductory Psychology	3
or		
ANT 2000	Introduction to Anthropology – GL	3
or		
POS 2041	American Government	3
or		
SYG 2010	Social Problems – GL	3
<i>(Arts)</i>		
SPC 2608	Public Speaking	3

Second Semester: (16)

EGN 1002	Engineering Orientation	2
ENC 1102	Writing and Rhetoric II	3
PHY 2048	Physics with Calculus I	4
MAC 2282	Calculus II for Engineering	4
<i>(Social Science Group 2)</i>		
EGS 1041	Technology, Humans, and Society – GL	3

Third Semester: (18)

PHY 2049	Physics with Calculus II	4
PHY 2049L	General Physics Lab II	1
MAC 2283	Calculus III for Engineering	4
EEL 2880	C Programming for Embedded Systems	3
MAD 2104	Discrete Mathematics	3
or		
COT 3100	Discrete Structures	3
Humanities Group 1		3**

Fourth Semester: (17)

MAP 2302	Differential Equations	3
EEL 3110C	Circuit Analysis and Lab	4
EEL 3120	Introduction to Linear Systems in Engineering	3
ESI 3215	Evaluation of Engineering Data I	3
EEL 3712	Logic Design I	3
EEL 3712L	Logic Design I Lab	1

Fifth Semester: (18)

EEL 3135	Signals and Systems	3
EEL 3370	C++ Programming for Embedded Systems	3
EGN 3613	Engineering Economy	3
EEL 4709C	Computer Design	3
EEL 4730	Programming Embedded Systems	3
Humanities Group 2		3**

Sixth Semester: (13)

EEL 4740	Embedded Computing Systems	3
ECE Electives		10

Seventh Semester: (14)

EEL 4920	Senior Design I: Ethics, Communications, and Constraints – GL	2
ECE Electives		12

Eighth Semester: (14)

EEL 4921C	Senior Design II: Project Implementation – GL	2
ECE Electives		12

**At least 9 credit hours must be taken in one or more summers.

Any exception to the program requires the department's approval.

Combined BS/MS in Computer Engineering Degree Pathway

This five-year pathway seamlessly combines a baccalaureate degree in Computer Engineering with the Master's in Computer Engineering. To be considered for admission to the combined bachelor's/master's degree pathway, students must have completed at least 75 credits required for the bachelor's degree program at FIU, have earned at least a 3.2 GPA on both overall and upper-division courses, and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree pathway; the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree pathway will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships. Students enrolled in the pathway may count up to 9 hours of graduate-level courses (i.e., 5000 level or higher) as credits for both the undergraduate and graduate degree programs. For each of the courses counted as credits for both BS and MS degree, a minimum grade of 'B' is required. Upon completion of the combined BS/MS pathway, students must have accumulated a minimum of 24 hours of credits at the graduate (5000+) level. Students enrolled in the pathway are encouraged to seek employment with a department faculty member to work as a student assistant on a sponsored research project.

Combined BS in Computer Engineering/MS in Engineering Management (BSCpE/MSEM) Degree Pathway

Students, who are pursuing a Bachelor of Science degree in Computer Engineering and have completed at least 75 credits with a minimum of a 3.2 overall GPA on both lower and upper division courses may, upon recommendation from three ECE faculty members, apply to enroll in the combined BSCpE/MSEM pathway. Students need only apply once to the combined degree pathway; the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. In addition to the admission requirements of the MSEM program, students must meet all the admission requirements of the University Graduate School.

Students enrolled in the combined degree pathway could count up to two Electrical Engineering graduate courses for both the BSCpE electives and the MSEM electives, for a total saving of 6 credit hours. A minimum grade of "B" is required graduate courses counted as credits for both BSCpE and MSEM degrees. Only 5000-level or higher courses may be applied toward both degrees. Only graduate courses with formal lecture can be counted for both degrees.

The combined BSCpE/MSEM pathway has been designed to be a continuous pathway enrollment. Students will receive their BSCpE degree upon completion of all the requirements of the BSCpE program. A student admitted to the combined degree pathway will be considered to have undergraduate status until the student

applies for graduation from his/her bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships.

Students may elect to permanently leave the combined pathway and earn only the BSCpE degree. Students who elect to leave the combined pathway and earn only the BS degree will have the same access requirements to regular graduate programs as any other student but will not be able to use the 6 credit hours in both the BSCpE and MSEM degrees.

Students interested in the combined pathway should consult with their undergraduate advisor on their eligibility to the pathway. The student should also meet the MSEM Program Director to learn about the graduate program and available tracks/courses before completing the application form and submitting it to their undergraduate advisor. Final decision for admission to the MSEM program will be made by the University Graduate School upon recommendation by the Engineering Management program director. Applicants will be notified by the Engineering Management Program and the University Graduate School of the decision on their applications.

Areas of Concentration offered by the ECE

Department:

(Applied to all Department degree programs)

Electrical Engineering and Computer Engineering students must choose elective classes from an area of concentration from the following list and take the corresponding courses as their Electives. Students may choose any class from any concentration as long as they fulfill the prerequisite(s) and corequisite(s). Students must choose at least two concentrations, and complete at least nine credits from each of those two concentrations.

Bioengineering:

EEE 3303C	Electronics I & Lab	4
EEL 4140	Filter Design	3
EEE 4393C	Wearable Electronics	3
BME 4503C	Medical Instrumentation: Application and Design	4
EEE 4510	Introduction to Digital Signal Processing	3
EEE 4421C	Introduction to Nanofabrication	3

Communications:

EEL 3514	Communication Systems	3
EEL 3514L	Communication Systems Lab	1
EEL 4413	Wave-Propagation for Wireless Communication	3
EEL 4421	Introduction to RF Circuit Design	3
EEL 4461C	Antennas	3
EEE 4510	Introduction to Digital Signal Processing	3
EEL 4515	Advanced Communication Systems	3
EEE 4550	Introduction to Radar Systems	3
EEL 4583	Basics of RF Systems	3
EEL 4595C	Introduction to Wireless Digital Communications with USRP Applications	4

Autonomous Systems, Control and Robotics:

EEL 3657	Control Systems I	3
EEL 3664	Introduction to Autonomous Systems	3
EEL 4611	Control Systems II	3
EEL 4611L	Systems Laboratory	1
EEL 4658	Industrial Control Systems	3

EEL 4664	Sensors, Perception, and Robotic Manipulation	3	Digital Forensics:		
			EEL 4806	Ethical Hacking and Countermeasures	3
			EEL 4802	Introduction to Digital Forensics Engineering	3
Integrated Nano-technology:			EEE 4754	Introduction to Mobile Forensics	3
EEE 3303C	Electronics I & Lab	4	EEE 4750	Introduction to Image and Video Forensics	3
EEE 3396	Introduction to Solid State Devices	3	EEE 4752	Introduction to Network Forensics and Incident Response	3
EEL 4005	Measurements and Instrumentation in Engineering	3			
EEL 4304C	Electronics II and Lab	4	Internet of Things:		
EEE 4314	Integrated Circuits and Systems	3	TCN 4211	Telecommunication Networks	3
EEE 4314L	Integrated Circuits Laboratory	1	EEE 4510	Introduction to Digital Signal Processing	3
EEE 4393C	Wearable Electronics	3	COP 4610	Operating Systems Principles	3
EEE 4421C	Introduction to Nanofabrication	3	COP 4655	Mobile Application Development	3
			EEE 4717	Introduction to IoT Security	3
Power/Energy:			EEL 4740	Embedded Computing Systems	3
EEL 4005	Measurements and Instrumentation in Engineering	3	TCN 4271	Ubiquitous and Embedded Sensor Network-Centric Telecommunications	3
EEL 4212	High Voltage Engineering	3			
EEL 4213	Power Systems I	3	Entrepreneurship:		
EEL 4213L	Energy Conversion Lab	1	EEL 4933	Engineering Entrepreneurship	3
EEL 4214	Power Systems II	3	EEL 4062	Engineering Business Plan Development	3
EEL 4215	Power Systems III	3	EEL 4063	Introduction to Business Decisions	3
EEL 4241	Power Electronics	3			
EEL 4495	Introduction to Applied Electromagnetics for Safety Analysis	3	Artificial Intelligence and Big Data		
			CNT 4147	Big Data Analytics in ECE	3
Computer Architecture and Microprocessor Design:			CNT 4151	Data Visualization in ECE	3
EEE 4343	Introduction to Digital Electronics	3	CNT 4155	Python Programming in ECE	3
EEL 4709C	Computer Design	3	CNT 3143	Analytics with Cloud Services in ECE	3
EEL 4746	Microcomputers I	3	CNT 4153	Machine Learning in ECE	3
EEL 4746L	Microcomputers I Lab	1	CNT 4149	Deep Learning in ECE	3
EEL 4747	Reduced Instruction Set Computing Processors	3	CNT 4145	Sensor IoT Analytics	3
EEL 4747L	Microcomputers II (RISC) Lab	1			
			Cyber Defense:		
Data System Software (CS Oriented):			TCN 4211	Telecommunication Networks	3
MAD 2104	Discrete Mathematics	3	TCN 4081	Telecommunication Network Security	3
COP 2210	Programming I	4	EEL 4802	Introduction to Digital Forensics	3
COP 3337	Computer Programming II	3	EEL 4804	Introduction to Malware Reverse Engineering	3
COP 3530	Data Structures	3	EEL 4806	Ethical Hacking and Countermeasures	3
COP 4338	Systems Programming	3	EEL 4730	Programming Embedded Systems	3
COP 4610	Operating Systems Principles	3	EEL 4734	Embedded Operating Systems	3
COP 4655	Mobile Application Development	3			
			Pre-Medical Concentration for B.S. in Electrical and Computer Engineering		
Embedded System Software:			The B.S. in Electrical or Computer Engineering Pre-Med Concentration is designed for motivated students who have dual interests in engineering and medical careers.		
EEL 3370	C++ Programming for Embedded Systems	3	Student are required to complete all the courses in this concentration plus the core requirements for a B.S. degree in Electrical or Computer Engineering and other ECE engineering concentration credits.		
EEL 4730	Programming Embedded Systems	3			
EEL 4734	Embedded Operating Systems	3	Biology		
EEL 4740	Embedded Computing Systems	3	BSC 2010	General Biology I	3
EEL 4831	Embedded GUI Programming	3	BSC 2010L	General Biology I Lab	1
			BSC 2011	General Biology II	3
Networking and Security:			BSC 2011L	General Biology Lab II	1
TCN 4081	Telecommunication Network Security	3			
TCN 4211	Telecommunication Networks	3	General Chemistry		
TCN 4212	Telecommunication Network Analysis and Design	3	CHM 1046	General Chemistry II	3
TCN 4431	Principles of Network Management and Control Standards	3	CHM 1046L	General Chemistry Lab II	1
EEL 4xxx	Data Computer Communications	3			
EEL 4717	Introduction to Security of Internet of Things and Cyber-Physical Systems	3	Organic Chemistry		
			CHM 2210	Organic Chemistry I	4
Cybersecurity:			CHM 2210L	Organic Chemistry Lab I	1
EEL 4806	Ethical Hacking and Countermeasures	3	CHM 2211	Organic Chemistry II	3
EEL 4802	Introduction to Digital Forensics Engineering	3	CHM 2211L	Organic Chemistry Lab II	1
EEL 4804	Introduction Malware Reverse Engineering	3			

Pre-Medical Student Must Take

BCH 3033	General Biochemistry	3
	or	
CHM 4304	Biological Chemistry I	3

Physics Concentration for B.S. in Electrical or Computer Engineering

The B.S. in Electrical or Computer Engineering Physics Concentration is designed for motivated students who have dual interests in engineering and physics.

PHY 1033	Physics Pathways	1
PHY 3106	Modern Physics	3
PHY 3802L	Intermediate Physics Lab	3
PHY 3513	Thermodynamics	3
PHY 4221	Introduction to Classical Mechanics	4
PHY 4323	Intermediate Electromagnetism I	3
PHY 4604	Quantum Mechanics I	3
PHY 4821L	Advanced Physics Lab	3

Within Arts, Sciences and Education, any undergraduate student who elects to do so may carry two majors and work to fulfill the requirements of both concurrently. Upon successful completion of the requirements of two majors, the student will be awarded one degree and a notation denoting both majors will be entered on the transcript.

Students are required to complete all the courses in this concentration plus the core requirements for a B.S. degree in Electrical or Computer Engineering and other ECE engineering concentration credits.

Course Descriptions**Definition of Prefixes**

CDA - Computer Design/Architecture; CTS-Computer Technology and Skills; EGN - Engineering: General; EEE - Engineering: Electrical and Electronics; EEL--Engineering: Electrical; TCN - Telecommunications/Networks

Courses that meet the University's Global Learning requirement are identified as GL.

CDA 3104 Introduction to Computer Design (3). Computer architecture and design, CPU, memory systems, caches, data, input/output devices, bus architecture, and computer control. Processor types, instruction set and assembly language programming. Prerequisite: EGN 2271

CDA 4400 Computer Hardware Analysis (3). The study of hardware functions of a basic computer. Topics include logic elements, arithmetic logic units, control units, memory devices, organization, and I/O devices (for non-EE majors only). Prerequisites: CDA 4101 and MAD 2104.

CNT 3007 Introduction to Networking and Cybersecurity for Engineers (3). Introduction to fundamentals of computer networks and cybersecurity for Engineering students. Main principles of networking protocols and cybersecurity aspects. Design issues, network appliances, and security techniques. Prerequisite: EEL 2880

CNT 3122 Sensors for Internet of Things (3). This course introduces sensors and sensor design for IoT devices. Topics include history of IoT-enabled sensors, design and fabrication of smart sensors, theory and case studies of important smart sen. Prerequisite: EGN 2271

CNT 3142 Microcontrollers for Internet of Things (3). Overview of embedded systems and microcontrollers with a comprehensive in-depth look at the MSP43Q. Students will learn about this powerful mixed-signal, low power consumption microcontroller. Prerequisite: EGN 2271.

CNT 3143 Analytics with Cloud Services in ECE (3). This course will focus on how data is collected, stored and processed on the cloud. Students will learn to use machine learning on the cloud as a service to develop models and perform predictions. Prerequisites: EEL 2880 or COP 2210 or COP 2250 or equivalent or permission of the instructor.

CNT 3162 Wireless Communications for IoT (3). This course will cover source coding for data compression, channel coding for error correction, digital transmission and reception, wireless channels, and the narrow-band IoT communication system.

CNT 4145 Sensor IoT Analytics (3). This course examines the ingestion, storage, analysis and reporting of massive quantities of IoT data collected from distributed devices for processing using IoT cloud and edge computing. Prerequisite: EEL 4730

CNT 4147 Big Data Analytics in ECE (3). This course examines the ingestion, storage, analysis and reporting of massive quantities of data collected from distributed data sources and processed using streaming and big data technologies. Prerequisites: EEL 2880 or COP 2210 or COP 2250 or equivalent or permission of the instructor.

CNT 4149 Deep Learning in ECE (3). This course will focus on the application of deep learning techniques and algorithms on structured and unstructured data. Deep learning frameworks are applied to create models from large datasets. Prerequisites: CNT 4153 or permission from the instructor.

CNT 4151 Data Visualization in ECE (3). This course will focus on visualization frameworks and libraries to get insight from large volumes of data. Students will learn about various visualization techniques available on premise and cloud. Prerequisites: EEL 2880 or COP 2210 or COP 2250 or equivalent or instructor permission

CNT 4153 Machine Learning in ECE (3). This course will focus on the application of traditional machine learning algorithms and popular framework to large datasets. Students will learn to build machine learning models. Prerequisites: EEL 2880 or COP 2210 or COP 2250 or equivalent or instructor permission

CNT 4155 Python Programming in ECE (3). The course introduces the Python programming language as it applies to its interaction with various systems. Python is prominent within many areas for its reach libraries and easy of programming. Prerequisites: EEL 2880 or COP 2210 or COP 2250 or equivalent or permission of the instructor.

CNT 4165 Network Protocols for Internet of Things (3). This course introduces the underlying network protocols for IoT communications. Protocols at the medium access and network layers are discussed. Prerequisite: TCN 4211.

CNT 4185 Internet of Things Privacy (3). Introduces the privacy issues related to IoT technologies. Focuses on privacy preserving technologies regarding IoT user data,

access to such data and privacy law around such personal data. Prerequisite: EEE 4717.

CNT 4188 Internet of Things Forensics (3). This course examines the existing Digital Forensics models and methodologies for their applicability within the IoT domain. Various tools and techniques will provide access within these devices. Prerequisite: EEL 4730.

CTS 1120 Fundamentals of Cybersecurity (3). Don't get hacked, be safe, and protect your digital footprint. Actions taken can have a lasting impact on your personal, financial and professional life. Recognize and prevent threats.

EGN 1002 Engineering Orientation (2). Introduction to aspects of the engineering profession. Computer tools and basic engineering science. Team-based engineering projects.

EEE 3303C Electronics I & Lab (4). Introductory course dealing with basic electronic devices such as diodes, BJTs, FETs, Op-Amps, and their circuit applications. Hands on Lab with weekly activities are included. Prerequisite: EEL 3110C

EEE 3394 Electrical Engineering Science I - Electronic Materials (3). The course covers fundamental science topics in electrical engineering. This course addresses material science and quantum physics concepts, thermal and electrical conductivity, and semiconductors. Prerequisite: PHY 2048 Corequisite: MAC 2312

EEE 3396 Introduction to Solid State Devices (3). Introduction to the physics of semiconductors; charge carrier statistics and charge transport in crystalline solids. Basic operations of solid-state devices including p-n junction diode, the bipolar junction transistor and field-effect transistors. Prerequisites: PHY 2049, ESI 3215. Corequisite: MAP 2302, EEL 3110C.

EEE 4202C Medical Instrumentation Design (4). Concepts of transducers and instrumentation systems; origins of bio-potentials; electrical safety; therapeutic and prosthetic devices. Prerequisite: EEL 3110C.

EEE 4262 IoT Design of Embedded Sensing, Network, and Signal Processing (3). This course will provide hands-on experience on the software design and implementation of a typical IoT system/device on a customer-made IoT education platform of CyberSens-EDU. Prerequisites: COP 2210 or permission from the instructor (Basic programming experience is required)

EEE 4304C Electronics II & Lab (4). Second course in electronics with emphasis on equivalent circuit representation and analysis of electronic analog circuits and systems, their frequency response, and behavior under feedback control. Hands-on Lab with weekly activities is included. Prerequisite: EEE 3303C

EEE 4314 Integrated Circuits and Systems (3). Continuation of Electronics II with major emphasis on applications of integrated circuits and design of analog, control, communication and digital electronic systems. Prerequisite: EEL 4304C. Corequisite: EEE 4314L.

EEE 4314L Integrated Circuits Laboratory (1). Laboratory experiments in integrated circuits. Includes design of filters, analog systems, A/D and D/A systems.. Corequisite: EEE 4314.

EEE 4343 Introduction to Digital Electronics (3). This course focuses on digital electronics. BJT as a switch, CMOS and other advanced logic-gate circuits, data converters, switched-capacitor filters, semiconductor memories. Prerequisites: EEL 3712 and EEL 3712L.

EEE 4393C Wearable Electronics (3). Introduction to charge transport in inorganic and organic semiconductors and low-dimensional carbon. Design of devices and sensors using different classes of materials for wearable electronics. Prerequisite: EEL 3110C or EEL 3110 or EEE 3396 or permission of the instructor.

EEE 4421C Introduction to Nanofabrication (3). This course will give the students an introduction to micro/nanofabrication tools and techniques. It includes lab sessions where the students design, fabricate and test selected micro-scale devices. Prerequisites: EEE 3396 or permission of the instructor.

EEE 4423 Introduction to Quantum Computers (3). This course provides the foundations of quantum computers and quantum information systems with an emphasis on physical implementations. Prerequisites: EEL 3120, EEL 3135.

EEE 4510 Introduction to Digital Signal Processing (3). Modeling of DSP systems, Z transform, Algorithms for convolution, correlation functions, DFT, and FFT computation. Digital filters design, and engineering applications. Prerequisites: EEL 3135 or permission of the instructor.

EEE 4550 Introduction to Radar Systems (3). Radar equation, MTI and pulse-Doppler radar, tracking radar, signal detection in noise, radar clutter, propagation of radar waves, radar antenna, radar transmitters, and radar receivers. Prerequisites: EEL 3514 or permission of the instructor.

EEE 4717 Introduction to IoT Security (3). In this class, the students will learn the introductory topics related to the security of IoT by gaining hands-on experience on real IoT devices. This class involves significant programming. Prerequisites: EEL 2880 or COP 2210 or COP 2250 or equivalent

EEE 4750 Introduction to Image and Video Forensics (3). The course covers the theoretical and practical aspects and principles of forensic image and video analysis and their application to digital forensics. Prerequisite: EEL 4802

EEE 4752 Introduction to Network Forensics and Incident Response (3). The course covers the theoretical and practical aspects of the foundations of computer network security, incident response tools and techniques. Prerequisite: Senior Standing.

EEE 4754 Introduction to Mobile Forensics (3). The course covers the theoretical and practical aspects of Mobile device forensics focusing on the identification, preservation, collection, analysis, and reporting techniques and tools. Prerequisite: EEL 4802

EEE 4761 Embedded Systems Design and Implementation for IoT applications (3). This course will provide hands-on experience on the hardware design and implementation of a typical IoT system/device using Eagle/Autodesk PCB design software. Prerequisites: EEL

3110C or permission from instructor (No hardware design experience is required)

EEE 4762 Platform Design and Implementation for IoT Applications (3). This course will provide hands-on experience on the hardware design and implementation of a typical IoT system/device using Eagle/Autodesk PCB design software. Prerequisite: EEL 3110C or permission from instructor (No hardware design experience is required)

EEE 4763 Embedded Programming for IoT Sensing, Network, Control, and Applications (3). This course will provide hands-on experience on the software design and implementation of a typical IoT system/device on a customer-made IoT education platform of CyberSens-EDU. Prerequisite: COP 2210 or Permission of the Instructor (Basic programming experience is required)

EEE 4775 Massive Storage and I/O for Big Data Computing (3). This course provides a broad introduction to the fundamentals of massive file storage systems and I/O architecture in big data computing and its enabling systems infrastructure. Prerequisites: EEL 4709C or permission of the instructor.

EEL 2880 C Programming for Embedded Systems (3). Engineering problem-solving process, an overview of a generalized computing system, software development, real-life engineering applications, computational implications.

EEL 3003 Electrical Engineering I (3). For non-EE majors. Basic principles of DC and AC circuit analysis, electronic devices and amplifiers, digital circuits, and power systems. Prerequisites: MAC 2312, PHY 2049. Corequisite: MAP 2302.

EEL 3110C Circuit Analysis and Lab (4). Introductory circuit analysis dealing with DC, AC, and transient electrical circuit analysis and the general excitation of circuits using the Laplace transform. Hands on Lab with weekly activities are included. Prerequisites: MAC 2312 or MAC 2282, PHY 2049, (EGN 1002 or EGS 1006). Corequisites: MAP 2302, and for EE or CpE Engineering students, EEL 2880.

EEL 3112 Circuits II (3). Application of operational methods to the solution of electrical circuits. Effect of poles and zeroes on the response. Transfer function of electrical networks. Laplace and Fourier transform; network parameters. Prerequisites: MAP 2302, EEL 3110C, and EEL 3135.

EEL 3120 Introduction to Linear Systems in Engineering (3). Introductory course on linear systems, deals with the use of linear algebra to analyze resistive and dynamic electric circuits. Prerequisites: MAC 2312 or MAC 2282, PHY 2049, and EGN 1002.

EEL 3135 Signals and Systems (3). Use of Fourier analysis in electrical and electronic systems. Introduction to probability theory, linear algebra and complex variables. Prerequisite: EEL 3120 or BME 2740 for BME students Corequisite: MAP2302

EEL 3200 Electrical Energy Systems (3). Introductory course on topics related to electrical energy systems. Energy requirements, resources, and sustainability. Conversion of non-renewable and renewable energy sources to electric energy. Principles of electric power delivery. Principles of electric energy processing and conversion. Prerequisite: EEL 3110C

EEL 3370 C++ Programming for Embedded Systems (3). Object-oriented programming in C++ with emphasis on evaluation of alternative program design strategies. Class design, recursion, linked and dynamically allocated structures. This class will also include data structure concepts and applications. Prerequisites: EEL 2880 or permission of the instructor.

EEL 3472 Electrical Engineering Science II (3). The course covers fundamental science topics in electrical engineering. This course addresses electromagnetic field theory, including charge distributions, electromagnetic fields, transmission lines. Prerequisites: PHY 2048, Corequisites: MAP 2302

EEL 3514 Communication Systems (3). An introductory course in the field of analog communication systems. Transmitters, receivers, and different modulation and demodulation techniques are studied. Basic treatment of noise is also included. Prerequisites: EEL 3110C, EEL 3135, ESI 3215.

EEL 3514L Communication Systems Lab (1). This is a web-accessible hardware laboratory on analog and digital communication systems. Students will perform all the experiments remotely through the internet. Lab reports will be submitted for every remote lab. Prerequisite: EEL 3135.

EEL 3580 Introduction to Wireless Communication Systems (3). This course covers the fundamentals of wireless communication systems using software-defined radio toolkits, state-of-the-art design software, and hands-on learning approaches. Prerequisite: EEL 3110C or permission of the instructor.

EEL 3657 Control Systems I (3). Analysis of linear time-invariant feedback control systems. System modeling, time and frequency-domain response, stability and accuracy. Analysis by use of Root-Locus, Bode plots, Nyquist diagram. Prerequisites: EEL 3110C and EEL 3135.

EEL 3664 Introduction to Autonomous Systems (3). This course provides a comprehensive introduction to the components of autonomous systems and exposes the students to the concept of autonomous systems from the perspective of autonomous mobile robotic. Prerequisite: EEL 2880.s

EEL 3712 Logic Design I (3). Boolean Algebra. Binary number systems. Combinational logic design using SSI, MSI and LSI. Sequential logic design. Corequisites: EEL 3712L or EEL 3110C.

EEL 3712L Logic Design I Lab (1). Laboratory experiments, using gates, combinational networks, SSI, MSI, LSI. Sequential logic design. Corequisites: EEL 3712.

EEL 4005 Measurements and Instrumentation in Electrical Engineering (3). Course applies introduction to various measurements, data acquisition and control using the software packages commonly used in the electrical engineering practice and research. Prerequisites: EEL 3110C, EEL 2880.

EEL 4006 Development of Dynamic Web Sites (3). Techniques for the development of dynamic web sites, which will generate individualized web pages, according to data supplied by the user or retrieved from data stores available to the webserver. Prerequisites: EEL 2880 or permission of instructor.

EEL 4015 Electrical Design in Buildings I (3). Application of electrical codes and regulations. Design of loads, circuits, surge protectors, feeders, panels, and breakers. Prerequisite: EEL 3110C.

EEL 4016 Electrical Design in Buildings II (3). Electrical design of industrial buildings, size and design of distribution rooms, switchboards, transformers, bus ducts, motor control centers, starters, voltage drop calculations, and lighting distribution. Prerequisite: EEL 4015.

EEL 4062 Engineering Business Plan Development (3). This course is designed to help students develop an effective implementation plan for a new business venture. Prerequisites: EEL 4933.

EEL 4063 Introduction to Business Decisions (3). Fundamental concepts of industrial financial decisions, financial planning and analysis tools, justification for industrial capital investments, and intermediate and long-term financing options. Prerequisite: EGN 3613.

EEL 4090C Technical Sales for Engineers (3). Development of effective technical sales skills, including listening, questioning, presenting, objection handling, and closing. Emphasis on practical application of selling skills developed.

EEL 4140 Filter Design (3). Approximation techniques. Active RC second-order modules. Low pass filters, band-pass filters, high pass filters, notch filters are studied in detail. Sensitivity and high order filters. Design and laboratory implementation. Prerequisites: EEE 3303C

EEL 4212 High Voltage Engineering (3). Introduction to concepts of high voltage engineering, various measurements used in characterizing electrical insulation materials and systems for power engineering applications. Prerequisites: EEL 3110C, EEL 4213.

EEL 4213 Power Systems I (3). Introductory course to power systems components; transformers, induction machines, synchronous machines, direct current machines, and special machines. Prerequisite: EEL 4410. Corequisite: EEL 4213L.

EEL 4213L Energy Conversion Lab (1). Operation, testing, and applications of energy conversion machines including AC and DC motors and generators. Experiments on magnetic circuits and transformers. Prerequisite: EEL 4410. Corequisite: EEL 4213.

EEL 4214 Power Systems II (3). Transmission line models, the bus admittance matrix, load flow studies and solution techniques, economic dispatch with and without losses, and computer applications related to power system operations. Prerequisite: EEL 4213.

EEL 4215 Power Systems III (3). Short circuit calculations, symmetrical and unsymmetrical fault analysis, transient stability and dynamic studies as well as power system control. Computer applications. Prerequisite: EEL 4213.

EEL 4241 Power Electronics (3). Power semiconductor devices, power supplies, DC choppers, AC voltage controller, power inverter, AC and DC drives. Prerequisites: EEE 3303C or permission of the instructor.

EEL 4410 Introduction to Fields and Waves (3). Electric and magnetic fields. The relation between field and circuit theory: waves and wave polarization, reflection, refraction, and diffraction. Electromagnetic effects in high-speed digital systems. Prerequisites: MAC 2313 or MAC 2283 and EEL 3110C.

EEL 4413 Wave-Propagation for Wireless Communication (3). Basics of wireless propagation of radio wave for communication, imaging, and circuit design. Introduce Maxwell's equation and types of waves, link budget, antennas, transmission lines, and waveguides. Prerequisite: MAP 2302

EEL 4421 Introduction to RF Circuit Design (3). Basic EM theory, transmission lines, guided EM propagation, microwave circuits, impedance matching, passive components, and filters. Full-wave simulation software will be used. Prerequisites: EEL 3135 and EEL 3110C.

EEL 4461C Antennas (3). Introduction to linear antennas, linear arrays and aperture antennas. Far-field pattern calculation and measurement techniques. Prerequisites: EEL 3514 or permission of the instructor.

EEL 4495 Introduction to Applied Electromagnetics for Safety Analysis (3). Course applies EM theory and problem solving for Safety Analysis. Topics include safety schemes, lightning hazards, electrostatic discharge, and electromagnetic radiation. Prerequisites: PHY 2049, MAC 2283, and MAP 2302.

EEL 4515 Advanced Communication Systems (3). A course on wireless communications, digital communication, fading channels, channel capacity, multiple antennas, and multiuser communication. Prerequisite: EEL 3135 or permission of the instructor

EEL 4583 Basics of RF Systems (3). The course introduces the basic concepts of radio frequency propagation and wireless receiver design. Topics include radiofrequency basics, noise fundamentals, linearity, cascade designs. Prerequisite: EEL 3514 or permission of the instructor.

EEL 4595C Introduction to Wireless Digital Communications with USRP Applications (4). The course covers the fundamentals of wireless digital communications from a DSP perspective. A lab component using USRP boards complements the course through hands-on experimentation with the concepts learned in the class. Prerequisites: EEL 3514, EEE 4510.

EEL 4611 Control Systems II (3). Design by Root-Locus, Bode plot, and Guillin-Truxal approach; characteristics of some typical industrial controllers and sensors. Computer simulation and other modern topics are included. Prerequisites: EEL 3657 or permission of the instructor.

EEL 4611L Systems Laboratory (1). Laboratory experiments in various systems. Includes position and velocity control systems, zeroth-order, first order, and second-order systems. Communication Systems. Corequisite: EEL 3657.

EEL 4658 Industrial Control Systems (3). To learn the characteristics and the selection of hardware used in industrial control systems design. Various measurement devices, transducers, and actuators used in control systems will be studied. Prerequisite: EEL 3657.

EEL 4664 Sensors, Perception, and Robotic Manipulation (3). This course will explore the state-of-the-art technology supporting autonomous robots for service domain with high robustness to environmental change and optional wear, and minimal reliance on application. Prerequisite: EEL 3657 or EEL 3664

EEL 4689 Hardware and Embedded Systems Security (3). This course covers hardware and embedded systems security: secure design, threat analysis, encryption, attacks, hardware Trojans, physical attacks, counterfeiting, side-channel attacks, and more. Prerequisite: (EEL 3712 or CDA 3102) and (EEL 2880 or COP 2210 or COP 2250).

EEL 4709C Computer Design (3). Computer architecture, arithmetic units, RAM, DRAM, ROM, disk, CPU, memory systems, data, input/output devices. Distributed and centralized control. Prerequisites: EEL 3712, EEL 3712L, and ESI 3215.

EEL 4730 Programming Embedded Systems (3). Embedded Systems implementation using programming of synchronous state machines to capture the behavior of time-oriented systems for running on microcontrollers. Prerequisite: EEL 2880.

EEL 4734 Embedded Operating Systems (3). This is an intermediate course to the use of Embedded Operating Systems (OS) as a developing environment. Course also includes OS concepts and unique embedded application development. Prerequisite: EEL 2880.

EEL 4740 Embedded Computing Systems (3). Principles of embedded computing systems: architecture, hardware/software components, interfacing, hardware/software co-design, and communication issues. Prerequisite: EEL 4709C.

EEL 4740L Embedded Computing Systems Laboratory (1). Hands-on experience on Hardware/Software co-design of embedded computing systems: architecture, hardware/software components, interfacing, and communication issues. Prerequisite: EEL 4709C. Corequisite: EEL 4740.

EEL 4746 Microcomputers I (3). RAM, ROM, and CPU architecture. Instruction set. Timing sequences. Subroutines. Interrupts. Peripherals. Applications. System design. Prerequisites: EEL 4709C or permission of the instructor. Corequisite: EEL 4746L.

EEL 4746L Microcomputers I Laboratory (1). Hands-on design experience with microcomputer systems and applications including buses, interfaces, and in-circuit emulation. Prerequisite: EEL 4709C. Corequisite: EEL 4746.

EEL 4747 Reduced Instruction Set Computing Processors (3). Design of interfacing schemes of RISC processors, and state-of-the-art hardware and software features of advanced RISC processor families. Prerequisite: EEL 4709C. Corequisite: EEL 4747L.

EEL 4747L Microcomputers II (RISC) Lab (1). Hands-on design experience with microprocessor systems and applications using Electronic Design Automation tools. Prerequisite: EEL 4709C. Corequisite: EEL 4747.

EEL 4793 Special Topics in Computer Engineering (1-3). Special topics in computer engineering are not covered in other courses. Prerequisite: Permission of the instructor.

EEL 4802 Introduction to Digital Forensics Engineering (3). The fundamentals of computer and network forensics and media exploitation techniques and introduces students to computer forensic software and hardware tools. Prerequisites: EEL 2880 or equivalent or CNT 4403 or permission of the instructor.

EEL 4804 Introduction Malware Reverse Engineering (3). This course familiarizes the student with the practice of performing reverse engineering on suspicious files and firmware present on various devices (computer to DVD player) and understand its impact. Prerequisites: EEL 2880 or equivalent or CNT 4403 or permission of the instructor.

EEL 4806 Ethical Hacking and Countermeasures (3). This course will give individuals exposure to the latest hacking tools and techniques to understand the anatomy of computer attacks and teach them the countermeasures to protect their valuable data.

EEL 4808L Ethical Hacking and Countermeasures Lab (1) This class is designed to provide a student hands-on activities on security scenarios applying different hacking techniques on various information systems. Prerequisite: EEL 4806

EEL 4831 Embedded GUI Programming (3). Graphical user interface (GUI) for the embedded system including elements and style, events, component and object-oriented user interface models, and graphical application programming issues. Prerequisites: EEL 4730 and EEL 4740.

EEL 4905 Individual Problems in Electrical Engineering (1-3). Selected problems or projects in the student's major field of electrical engineering. It can be extended to a maximum of six hours. Student works independently with minor advisement from the designated faculty member. Prerequisites: Senior level and permission of the instructor.

EEL 4920 Senior Design I: Ethics, Communications, and Constraints – GL (2). Professional ethics, oral communications, project feasibility study, proposal writing, system design methodology, human factors, intellectual property, liability, and schedules. Prerequisites: ECE Department Core and Program Core.

EEL 4921C Senior Design II: Project Implementation – GL (2). Design of a complete EE or CpE system including the use of design methodology, formulation, specifications, alternative solutions, feasibility, economic, reliability, safety ethics, and social impact. Prerequisite: EEL 4920.

EEL 4930 Special Topics in Electrical Engineering (1-3). Special topics in electrical engineering not covered in other courses. Prerequisite: Permission of the instructor.

EEL 4933 Engineering Entrepreneurship (3). Lectures, case studies, and seminars. Active student participation. Course material is augmented through seminars given by engineers, business people, and specialists, based on their own experiences.

EEL 4949 Co-Op Work Experience (1-3). Practical Co-op engineering work under approved industrial supervision.

EGN 2271 Introduction to Circuits and Electronic Hardware (3). Introduction to resistive circuits, laws governing circuits, electronic switches, logic gates, electronic memories, standard input, and output ports.

TCN 2720 Introduction to Internet of Things (3). Introduces the fundamental concepts of IoT and motivates the study of IoT. Focuses on the Devices, Data Collection, Networking, Cloud Computing, Risks, and Opportunities in IoT context.

TCN 4081 Telecommunication Network Security (3). Introduction and overview of security issues for engineering applications. Topics include design, implementation, and management of security in networks. Prerequisites: TCN 4211 or permission of the instructor.

TCN 4211 Telecommunication Networks (3). Underlying engineering principles of computer and digital networks. Topics include physical, link, and network layers; telecommunication, and switching technologies. Prerequisites: EEL 2880 or COP 2210 or permission of the instructor.

TCN 4212 Telecommunication Network Analysis and Design (3). The principle and practice of telecommunication and computer networks with emphasis on telecommunication network protocols, datagram services, routing, and QoS. Prerequisites: TCN 4211 or permission of the instructor.

TCN 4431 Principles of Network Management and Control Standards (3). Problems, principles and technologies in network management. General challenges in the management of modern data and telecommunication networks. Prerequisites: TCN 4211 or permission of the instructor.

TCN 4940 Senior Project (3). Beginning of the Major Design Experiment of Professional ethics, oral communications, project feasibility study, report writing, system design methodology, human factors, and intellectual property. Prerequisite: Senior Standing