Electrical Engineering Undergraduate Handbook

Department of Electrical Engineering and Computer Science

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CHAIR'S WELCOME NOTE

Welcome to the Department of Electrical Engineering and Computer Science (EECS) at Howard University. The department offers accredited undergraduate electrical engineering, computer engineering, and computer science programs.

The EECS at Howard University is a dynamic unit of the College of Engineering and Architecture (CEA). Over the years the EECS has established a reputation for excellence in teaching, research and service to the Howard local, national, and international communities. For many years the department has been one of the large producers of African-American and minorities engineers at the bachelor, master's and Ph.D. level. The department has some of the most highly regarded Centers and laboratories where exciting research in innovative technology continues to attract the local and international students from all over the world. Also our graduates are sought after by industry and government agencies. Many of our graduates have been accepted in top graduate programs in the nation. A large number of our graduates have moved to leadership positions and academy all over the world.

The department continues to attract and hire outstanding faculty members. We put a special emphasis in our undergraduate programs: We are continually improving our labs, curriculum and advising programs; we are establishing new mentoring and research programs for undergraduates; and we are working on developing better relationship with local and national industry.

This handbook for undergraduate electrical engineering ((EE) program contains a listing of courses designed for a four-year curriculum and a few other resources that you should find very useful. This Handbook does not provide a complete guide to information you need for your day-to-day stay here at Howard. You should consult other university and college publications such as ***the H-Book and the Howard University Undergraduate Bulletin*** and you should visit the web site www.howard.edu for detailed information. You will be assisted by a program faculty advisor for your course registration. Therefore, you are encouraged to visit the faculty advisor as often as possible, at least thrice per semester for academic matters relating to your courses and career objectives.

You should feel free to visit the EECS Office in Room 1016, L.K. Downing Building and the CEA Office of Student Services in Room 1114, L.K. Downing Building and acquaint yourself with other academic and non-academic resources that are available in the College and the University.

The EECS faculty and staff are committed to continuous improvements of our program. We encourage your comments on all aspects of our program. We are particularly interested in comments regarding program educational objectives, student outcomes and the curriculum.

Again, we welcome you to the EE program of the EECS and we wish success.

Ahmed Rubaai, D.Eng.
Chair

I. ELECTRICAL ENGINEERING PROGRAM

A. INTRODUCTION

Electrical Engineering continues to be an attractive and lucrative profession of this century and beyond. It has rich tradition in design, development, testing and commercialization of cellular and information highway technology, command, control and delivery of power system/energy using intelligent systems for terrestrial and non-terrestrial applications, development of high speed machines, digital network using microprocessor and super computers, creation of smart materials such as super conductors, bio-materials, very large scale integrated circuits for consumer and industrial electronic applications.

Graduates with a bachelor's degree in electrical engineering find employment in the aerospace, communications, computer, power distribution, consumer electronics, biomedical engineering and military industries. Many graduates pursue post baccalaureate studies for advanced degrees in electrical engineering or related fields, and many apply their technical expertise to engineering professions as well as to business, law or medicine.

The EE program is fully accredited by ABET. Courses are taught to meet the requirements of ABET for the program. The curriculum for the program is design-based and fully integrated with basic science and math, liberal arts and humanities, and electrial engineering core courses. Depth in EE program is covered in the upper level courses and EE electives courses. Foundation courses are covered at sophomore and junior levels.

B. MISSION AND EDUCATIONAL OBJECTIVES

EECS Mission

The mission of the EECS is consistent with the CEA and the University in that it strives to become a world leader in engineering research and education while dedicated to promotion of excellence among students, faculty and staff. The mission of the EECS is to:

1. Provide its students with the engineering knowledge and education experiences required for them to compete and succeed as engineers at the highest levels of engineering practice.
2. Engage in research that benefits Howard University and its local community, the United States and the global community.
3. Advance, in concert with the CEA, Howard University's goal of becoming a Historically Black University that is among the best of all its peer institutions.

EE Program Objectives

Objective 1: Howard University Electrical Engineering (**EE**) graduates will achieve successful careers in **EE** or other fields that require technical and/or professional skills and knowledge

Objective 2: Howard University EE graduates will pursue continuous professional development, including advanced study and/or research in technical or professional fields

Objective 3: Howard University EE graduates will demonstrate active engagement and leadership within professional/community activities, with a special emphasis on African-American and other underrepresented communities

EE Program Educational Objectives

EE Program Student Outcomes

Our EE program demonstrates that our EE graduates have:

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
(l) an understanding of issues related to minorities and gender diversity, society and culture, and an historical awareness of Africa and its Diaspora.

The first eleven program outcomes, (a) to (k), are consistent to the "Criteria for accrediting engineering programs 2012-2013" Reference Manual. Outcome (l) acknowledges one of Howard University's unique characteristics as a Historically Black College/University.

C. ADMISSION, ACADEMIC AND DEGREE REQUIREMENT

Admission Requirements

The Electrical Engineering program, within the Department of Electrical Engineering and Computer Science (EECS), conforms to the same policy for admission as the entire College of Engineering and Architecture (CEA). Information for potential applicants is maintained in the Undergraduate Bulletin on the University Website. Each applicant to the Electrical Engineering program is evaluated on an individual basis. The admission policy is as follows:

Prospective students submit an application, an official transcript of the secondary school record and character recommendations from the school principal or counselor. An applicant must be a graduate of a secondary school or have equivalent credentials.

Minimum requirements for admission to the CEA are:
(1) a combined SAT score of 1080 or a composite score of 23 on the ACT;
(2) graduation from a secondary school with a grade point average (GPA) of 2.5 or higher out of 4.0 or equivalent, (3) rank in upper half of graduating class, and (4) completion of at least 15 units of high school coursework, including a minimum of three units of English, one unit of social science, two units of science, and three-and-one-half units of mathematics, including two units of algebra, one unit of geometry and one unit of trigonometry. A unit represents one year of study in any subject in a secondary school. Applicants must furnish the results of the Scholastic Aptitude Test (SAT I and SAT II in Mathematics). Admission is based on an evaluation of the academic record, test scores and letters of recommendation.

Transfer students must have completed at least 12 credit hours of coursework including mathematics and science. International applicants must submit a transcript of all work taken at other institutions (secondary and collegiate) and must pass the Test of English as a Foreign Language (TOEFL) with a cumulative score of 550 or better.

The CEA Office of Student Services conducts an orientation program for new students who arrive in the fall semester. During orientation, students are introduced to the departmental Chair, and are briefed on the registration process to be conducted by each program, including Electrical Engineering. At the scheduled days for course registration new students meet with the program advisor for course selection.

Transfer Students and Transfer Credits

While admission of transfer students is handled by the Office of Students Services, approval of transfer credits is handled by the department chair in consultation with the program academic advisors. Transfer credit is awarded after review of official transcripts from the student's previous accredited institutions by the program academic advisor.

Courses for which credit is given must be equivalent to Howard University courses in content and credit hours. Only courses in which a grade of "C" or better was obtained are transferable. The student must provide official course descriptions and a current University Catalog. To enforce the policy for acceptance of transfer credit, only designated program academic advisors can recommend courses for transfer credit to the department chair. Details of the transfer credit policy of the program are as follows (as listed in the Electrical Engineering and Computer Science Undergraduate Program Handbook):

1. Transfer Credit Review Process
    a. Official transcripts, along with a copy of the course catalog showing descriptions of the courses in the transcripts, from the institutions attended by a student must be submitted to the Department for evaluation.
    b. If any document mentioned above is not in English, a notarized translation of the document in English must be accompanied by the original non-English document. An official translation by WES into equivalent US system showing grades and credit hours is acceptable.
    c. Advanced level (A level) courses with grades of “C” or higher will be processed accordingly (for example A-level physics a two-year course is equivalent to Phys 013- 3cr, lecture, and PHYS-023-1cr lab.).
    d. The transcripts and the catalog are reviewed by an appointed faculty member of the Department.
    e. After the approval from the chair of the Department, the list of the approved courses for transfer are sent through the Office of Student Services to the Registrar's Office for posting on the student’s transcript.
2. Limitations in Transfer Credit
    a. Only the courses that correspond in credit hours and content to the courses offered at the Department can be transferred.
    b. Only the courses listed in the curriculum (curricula) of the program can be transferred.
    c. One credit hour in a quarter system is converted to 2/3 credit hour of Howard University semester standard.
    d. The maximum number of credit hours transferable is 92 hours.
    e. A course cannot be transferred if the corresponding Howard course requires pre-requisites that are not listed in the submitted transcripts with satisfactory grades. (Example, Network Analysis I cannot be transferred without Physics II taken with C or above, which is a pre-requisite for Fundamentals of Circuit Theory. Calculus III cannot be transferred without its pre-requisite Calculus II.)

f. A laboratory course alone cannot be transferred without the accompanying lecture course taken with a satisfactory grade. (Example: Fundamentals of Electronics Lab cannot be transferred without Fundamentals of Electronics lecture course.)
g. Transfer credits shall be granted only for the courses completed within six calendar years before the student's first enrollment at Howard University. However, students can petition the Department chair, during the first semester at the University, to ask for examination for possible transfer of those courses taken more than six years before.

3. Course Transfer Limitation of Howard University Students
   a. After the first enrollment at Howard University, the core courses of the program cannot be taken at other institutions including consortium universities, unless the core courses are not offered in the program for one academic year.
   b. Students, however, have their rights to bring their individual and specific cases, before taking core courses at other institution, to the department chair and the appointed faculty member for lifting the limitation.

Academic Requirement

DEAN'S HONOR ROLL: Students with a grade point average of at least 3.0 based on a minimum load of 14 credits for the semester will have their names placed on the Dean's Honor Roll.

CLASS ATTENDANCE: Faculty members are responsible for reporting to the assistant dean of the CEA the names of students, whose repeated absences or tardiness are in their opinion, impairing the students work. In such cases, the assistant dean will take appropriate action, which may include withdrawing the student from the course.

PROBATION STATUS: A first-time student whose cumulative grade point average is less than 1.8 at the end of the first semester in residence or less than 2.00 at the end of any subsequent semester, will be placed on academic probation. Regulations governing students on probation are as follows:

- Full-time students on probation normally are expected to carry no more than 14 credits. These may be reduced or increased only with the permission of the department chair.
- Students on academic probation are required to report to the chairman or a designated faculty member for counseling and assistance on academic status, participation in University activities and other related matters.
- Probationary status will be removed when the student has achieved a cumulative average of at least 2.0.
- After three successive semesters of probation, a student automatically incurs academic suspension.
- A suspended student may request reinstatement by writing a petition to the chair for
- consideration.

Degree Requirement

In order for students to receive the Degree of Bachelor of Science in Electrical Engineering, they must satisfy all entrance requirements; satisfactorily complete the course requirements of the program; have a cumulative Grade Point Average (GPA) of at least 2.0, and at least a 2.0 GPA in the Electrical Engineering Major. The latter GPA is computed based on all courses offered by the Department taken by the student. Each student must also achieve a grade of C or higher in at least five-sixths of the total credit

hours earned, i.e. for 120 total credit hours, the student may not have more 20 credits of Ds (1/6 of the total number of credit); they must be in residence at the University for the last 30 credits in the curriculum. Students enrolled in the Electrical Engineering Program must follow the published curriculum. The Department must approve any deviation from the published curriculum, and it must be consistent with current curriculum criteria set by ABET. In summary, to receive a Bachelor of Science degree in Electrical Engineering, students must:

- Obtain a cumulative GPA of at least 2.0.
- Obtain a major GPA of at least 2.0.
- Obtain a grade of C or higher in at least 5/6 (no more than 1/6 D's) of the credits presented for graduation.
- Complete the last 30 hours at Howard University.
- Follow the sequences of courses recommended by the program curriculum.
- Apply for graduation and submit a senior coursework checklist to the Department at least one semester before the expected graduation date.

The procedure of verifying the requirement and receiving the degree is as follows:

a. The Senior check sheet must be verified by the program faculty advisor and chair.
b. The Chair presents a list of prospective candidates.
c. The department faculty approves each prospective candidate.
d. The CEA faculty approves each prospective candidate.
e. After certification of financial clearances by the appropriate offices in the university, the final list of prospective candidates for graduation is compiled, and the CEA Dean these candidates to receive the degrees at the University Convocation.

II. Bachelor of Science in Electrical Engineering (EE) Program

A. CURRICULUM FOR EE PROGRAM

The Electrical Engineering curriculum contains a broad core of topics, which underlie the practice of engineering and provide a balanced curriculum through integration of studies in mathematics and basic science, engineering science and engineering design, and general studies that meet or exceed expectations of the ABET criterion 5 including the requirement that the curriculum culminate in a major design experience. A total of 120 semester credit hours are required and distributed as follows:

Undergraduate EE Curriculum (Distribution of Hours)

Concentration	**Number of Credit Hours**
Math, sciences and Liberal Arts and Software Systems Fundamental Core Courses	**44**
Electrical Engineering Core	**41**
Electrical Engineering Electives	**18**
Engineering Science Elective Courses	**3**
Social Science and Humanities	**9**
African American Studies	**3**
Physical Education	**2**
Total	**120**

B. CURRICULUM DETAILS FOR EE PROGRAM

1. Math, Science, and Liberal Arts Core Courses (Total 44 credit hours)

CHEM-003	General Chemistry Lecture	4
CHEM-005	Chemistry Lab.	1
ECON-001	Principles of Economics	3
ENGW -104 (002) – Writing Literacy & Discourse		3
ENGW -105 (003) Reflective Writing Portfolio		3
MATH-156	Calculus I	4
MATH-157	Calculus II	4
MATH-158	Calculus III	4
PHYS-013	Physics for Science & Engineers I	3
PHYS-014	Physics for Science & Engineers II	3
PHYS-023	Physics for Science & Engineers I-Lab.	1
PHYS-024	Physics for Science & Engineers II - Lab.	1
CSCI -135 Computer Science I		4
EECE -156 Math I Lab		1
EECE -157 Math II Lab		1
EECE -158 Math III Lab		1
EECE – 160 Engineering Mathematics		3

2. Electrical Engineering Core Courses (Total 41 credit hours)

EGPP-101 Intro to Engineering	2
EECE-102 Introduction to Electrical and Computer Engineering	1
EECE – 203 Fund Circuit Theory	4
EECE - 209 Fund Circuit Theory (Lab)	1
EECE–212 Fund Digital Systems	4
EECE– 218 Fund Digital Systems Lab	1
EECE-305 Fund Electromagnetics	3
EECE-306 Fund Electromagnetics (Lab)	1
EECE-309 Fund Electronics and SS	3
EECE-312 Fund Electronics and SS (Lab)	1
EECE-331 Probability & Random Var	3
EECE-318 Fund Energy Systems	3
EECE-324 Fund Energy Systems (Lab)	1
EECE-333 Fund Signals & Systems	3
EECE 320 Research in Undergrad Exp	1
EECE – 260 Engineering Programming and Appl	3
EECE 401 Senior Design I	3
EECE 404 Senior Design II	3

3. Electrcal Engineering Elective Courses (and Concentration): Note - Minimum 6 credit hours are to be taken from a concentation area)

Digital Systems and Microcomputer Area

EECE-406	Advanced Digital Systems Design	3
EECE-416	Microcomputer Design	3
EECE-417	Computer Systems Architecture	3
EECE-446	ASICS Design	3

Signals and Communication Area

EECE-454	Communication Electronics	3
EECE-460	Wireless Communication	3
EECE-487	Telecommunications	3
EECE-495	Real-Time Signal Processing	3

Energy and Power Control Systems Area

EECE-418	Power Electronics	3
EECE-419	Motor Dynamics and Drives	3
EECE-421	Power Systems Analysis/Design	3
EECE-422	Power Communication and Control	3
EECE -408	Linear Control Theory	3

Physical Electronics and Material Sciences Area

EECE-420	Intro to VLSI Design	3
EECE-465	Physical Electronics	3
EECE-471	Design of Integrated Circuits	3
EECE-463	Digital Electronics	3

Electromagnetics and Microwave Area

EECE-443	Intro to Microwaves	3
EECE-444	Antenna Theory and Practices	3
EECE-466	Advanced Electromagnetic Theory	3

4. Engineering Science Elective Courses (3 credit hours Required)

CIEG 202	Statics	3
MECH 304	Thermodynamics	3
PHYS 015	Modern Physics	3
BIOL	Biology	3
CHEM	Chemistry	3

5. Social Science Elective Course (3 hours required)

Social Science Electives (3 hours)

AFRO-005	Introduction to Afro-American Studies I	3
ANTH-110	Introduction to Anthropology I	3
CLAS-104	Greek Civilization	3
CLAS-105	Roman Civilization	3
ECON-001	Principles of Economics I (required)	3
GERM-145	German Culture	3
HIST-001	Introduction to the Study of Civilization I	3
HIST-005	Introduction to Black Diaspora I	3
HIST-009	U.S. History to 1877	3
HIST-010	U.S. History since 1877	3
HIST-040	Introduction to the History of Latin America to the Mid-19th Century	3
HIST-041	Introduction to the History of Latin America since the Mid-19th Century	3
HIST-050	Introduction to European History	3
HIST-101	World Geography	3
HIST-102	Economic Geography	3
POLS-001	Introduction to Political Science	3
RUSS-145	Russian Culture I	3
SOCI-001	Introduction to Sociology	3
SOCI-160	The Sociology of African Americans	3

6. Humanities Elective Courses (3 hours from the list)

Literature Group

CLAS-101	Greek Literature in English	3
CLAS-102	Roman Literature in English	3
CLAS-108	Greek Drama in English	3
CLAS-109	Classical Mythology	3
CLAS-113	Women in the Ancient World	3
FREN-100	Francophone Literature in English	3
RUSS-100	Great Short Stories	3
SPAN-100	Hispanic Literature in English	3
CLAS-014	Introduction to Humanities	3
CLAS-114	Lyric Poetry in Classical Antiquity	3
ENGL-009	Tech Writing – Pre-professional	3
ENGL-168	Modern Caribbean Literature	3
GERM-101	Literature of Love	3
HUMA-107	Women In Literature	3

Non-literature Group

GERM-100	Individual and Society	3
GERM-109	Northern Myths and Legends	3
GERM-111	Classic Films in English	3
RUSS-109	Slavic Mythology	3
ARTH-161	Art Appreciation	3
CLAS-103	Classical Art and Archaeology	3
CLAS-111	Satire and Comedy in the Ancient World	3
MUSC-100	Introduction to Music	3
MUTP-100	Blacks in the Arts	3
THSV-010	Introduction to Theatre	3

7. African American Studies Elective Courses (3 hours required)

AFRO-005	Introduction to Afro-American Studies I	3
AFST-101	African World: Intro to Contemporary Africa	3
ARTH-193	Black Body Dress & Culture	3
ENGL-054	Afro-American Literature to 1940	3
FASH-102	African-American Dress	3
HIST-005	Introduction to Black Diaspora I	3
MUTP-100	Blacks in the Arts	3
POLS-006	Pan Africanism	3

8. Physical Education (2 credit hours Required)

HHPL-xxx	PE/ROTC	1
HHPL-xxx	PE/ROTC	1

C. ELECTRICAL ENGINEERING 4-Year Degree Plan with Pre/Co-Requisites

Freshmen Semester 1

Course	Prerequisite	Co-requisite
EGPP-101 Intro to Engineering		
CHEM-003 Chemistry		CHEM-005
CHEM-005 Chemistry Lab.		
MATH-156 Calculus I		
EECE -156 Math I Lab		MATH - 156

ENGW -104 (002) – Writing Literacy & Discourse

Freshman Semester 2

Course	Prerequisite	Co-requisite
MATH-157 Calculus II	MATH-156	PHYS 013
EECE -157 Math II Lab		MATH - 157
PHYS-013 Physics for Science & Engineering	MATH -156	PHYS-023
PHYS-023 Physics for Science & Engineering Lab.		PHYS-013
EECE-102 Intro. Electrical & Comp Engineering	EGPP-101	
ENGW -105 (003) Reflective Writing Portfolio	ENGW -104	
Social Science Elective		

Sophomore Semester 1

Course	Prerequisite	Co-requisite
CSCI -135 Computer Science I		
MATH-158 Calculus III	MATH-157	
EECE -158 Math III Lab		MATH - 158
PHYS-014 Physics for Science & Engineering	PHYS-013, MATH-157	PHYS-024
PHYS-024 Physics for Science & Engineering Lab.		
HHPL – xxx /ROTC		

Sophomore Semester 2

Course	Prerequisite	Co-requisite
EECE – 160 Engineering Mathematics	MATH – 158	
EECE – 260 Engineering Programming and Appl	CSCI - 135	
EECE – 203 Fund Circuit Theory	PHYS - 014	EECE - 209
EECE - 209 Fund Circuit Theory (Lab)		
EECE–212 Fund Digital Systems		EECE 218
EECE–218 Fund Digital Systems Lab		

Junior Semester 1

Course	Prerequisite	Co-requisite
HHPL – xxx /ROTC		
EECE-305 Fund Electromagnetics	MATH-158	EECE -306
EECE-306 Fund Electromagnetics (Lab)	MATH-158	EECE -306
EECE-309 Fund Electronics and SS	EECE-203	EECE-312
EECE-312 Fund Electronics and SS (Lab)	EECE-209	
EECE-331 Probability & Random Var	MATH – 157	
Humanities		

JuniorSemester 2

Course	Prerequisite	Co-requisite
EECE 320 Research in Undergrad Exp	Junior Standing	
EECE-318 Fund Energy Systems	EECE-203	EECE-326
EECE-324 Fund Energy Systems (Lab)		
EECE-333 Fund Signals & Systems		
Engineering Science Electives		
African American Studies		

Senior Semester 1

Course	Prerequisite	Co-requisite
EECE-401 Senior Design I		
EECE-4xx EECE-Elective		
EECE-4xx EECE-Elective		
EECE-4xx EECE-Elective		

Free Electives

Senior Semester 2

Course	Prerequisite	Co-requisite
EECE-404 Senior Design II	EECE-401	
EECE-4xx EECE-Elective		
EECE-4xx EECE-Elective		
EECE-4xx EECE-Elective		
ECON – 001 Principles of Economics		

III. EE COURSE DESCRIPTIONS

The following course description will also appear on the department web site and the course catalogue.

EGPP-101 Introduction to Engineering 2 Credits
Provides information on engineering education, the engineering profession, and basic concepts and tools. Introduces the engineering design process and provides opportunity for students to complete engineering design projects. Course Offering: FALL.

EECE-102 Introduction to Electrical & Computer Engineering 1 Credit
Continuation of EGPP-101 as related to the electrical engineering profession. Organized in five (5) Blocks: Descriptive, Environment, Technical, Practical (Hands on), and Projects, students are introduced to various engineering issues related to the profession of electrical engineering. Historical perspectives and Electrical Engineering Education / Profession and Design are reviewed. Ethics, social / environmental / cultural / religion issues facing electrical engineers in a global work environment are discussed. An overview of electrical engineering discipline and five major classifications of electrical systems in communication, computer, control, power, and signal processing is presented. Technical aspects and safety considerations of a typical electrical engineering laboratory are introduced. A capstone term project requires assembling an electrical system (e.g., a robot kit) and its study and presentation from a system point of view. Prereq.: EGPP-101. Course Offering: SPRING.

EECE-156 Math I Laboratory 1 Credit
The purpose of this course is to develop students' problem solving skills, and improve their understanding of the calculus techniques and concepts they learn in Math 156 (Calculus I). Topics include: Algebra Review, Limits, Continuity, Derivative: definition, rules: sum, quotient, product, power, chain, Implicit Differentiation, Applications of the Derivative: related rates, max/min problems, L'Hospital's Rule, Anti-derivative, Integration. Course Offering: FALL

EECE-157 Math II Laboratory 1 Credit
The purpose of this course is to further develop students' problem solving skills, improve their understanding of the calculus techniques and concepts they learn in Math 157 (Calculus II), and help them see how calculus can be used to solve engineering problems. Topics include: integration techniques, applications of integration, polar functions and parametric functions, sequences and series. Course Offering: FALL, SPRING

EECE-158 Math III Laboratory 1 Credit
The purpose of this course is to further develop students' problem solving skills, improve their understanding of the calculus techniques and concepts they learn in Math 158 (Calculus III), and help them see how calculus can be used to solve engineering problems. Topics include: Vectors and scalars, Dot and Cross Product, Vector Differentiation, Gradient, Divergence, and Curl, Vector Integration, Divergence Theorem, and Stokes' Theorem. Course Offering: FALL.

EECE-160 Engineering Mathematics 3 Credits
Course introduction; history and importance of engineering Mathematics, trigonometry in engineering,

2-D vectors in engineering, complex numbers in engineering, 3-D vectors in engineering, systems of equations in engineering, application of derivatives in engineering, application of integrals in engineering, solving differential equation, applications of differential equations in engineering,
Laplace transforms and applications, Interdisciplinary Applications. Course Offering: SPRING

EECE-203 Fundamental Circuit Theory 4 Credits
Understanding of basic circuit theory, circuit theorems, dc, ac circuits, magnetic circuits, transients, Laplace and Fourier transforms, Fourier series, electric devices, 2-port network, basic filters and op-amps.. Prereqs.: PHYS-014, PHYS-024. Coreq.: EECE-209 Course Offering: SPRING.

EECE-209 Fundamental Circuit Theory Laboratory 1 Credit
Understanding of hands-on labs associated basic circuit theory, circuit theorems, dc, ac circuits, operational amplifiers (op-amps), electric devices network, basic filters and op-amps. Coreq.: EECE-203. Course Offering: SPRING.

EECE-212 Fundamental Digital Systems 4 Credits
Introduction to hardware building blocks used in digital computers and systems. Introduces number systems (including binary, octal and hexadecimal), Boolean algebra, two-level/multilevel logic minimization/simplification using K-Maps and Quine-McCluskey Methods, combinational logic circuit design and implementation with available SSI, MSI, and programmable logic devices (PAL, PLA, multiplexers, encoders, ROMS). Practical considerations such as Hazard and glitches are treated. Basics of sequential logic design including latches, flip-flops, registers, counters, finite state machines design, minimization, and implementation are presented. Prereq: Sophomore standing. Course Offering: SPRING.

EECE-218 Fundamental Digital Systems Laboratory 1 Credit
Laboratory experiments and (mini) projects in design and implementation of simplex to moderately complex combinational and sequential logic circuits provide a practical understanding of concepts covered in EECE-212. Project(s) introduce students to design with programmable logic devices and logic design/simulation software such as Electronics Workbench. Coreq: EECE-212. Course Offering: SPRING.

EECE-260 Engineering Programming and Application 3 Credits
Course Offering: Spring

EECE-305 Fundamental Electromagnetics 3 Credits
Electric fields, flux and potential; Coulomb's Poisson's and Gauss's laws; permitivity and conductivity, magnetostatics, magnetic materials, magnetic materials and forces, Biot-Savart law and time varying fields, Maxwell's equations in integral and differential forms, time-domain analysis of waves. Application of electromagnetic theory to Transmission lines. Prereqs. MATH-158 and PHYS-014. Course Offering: FALL.

EECE-306 Fundamental Electromagnetics Laboratory 1 Credits

Coreq.: EECE-305. Course Offering: FALL.

EECE-309 Fundamental Electronics and Solid States 3 Credits
Understanding of basic semiconductors devices, characteristics, switching and basic amplifiers, operational amplifiers, frequency response, filters, wave generation, introduction to power electronics, team work. Prereq.: EECE-203, Coreq: EECE-312. Course Offering: FALL.

EECE-312 Fundamenatal Electronics and Solid States Laboratory 1 Credit
Understanding of basic semiconductors devices, characteristics, switching and basic amplifiers, operational amplifiers, frequency response, filters, wave generation, introduction to power electronics, team work. Coreq: EECE-309. Course Offering: FALL.

EECE-320 Research in Undergraduate Experience 1 Credit

EECE-325 Fundamentals of Energy Systems 3 Credits
This course focuses on the fundamentals of energy systems centered around electric power generation. Starting with the traditional system of large, central power stations connected to their customers by hundreds or thousands of miles of transmission lines, this course covers distributed, renewable, cleaner, smaller generation systems located closer to their loads. In that regard, while other generation sources such as Biomass and Fuel Cells are covered, wind power generation systems and photovoltaic (PV) power generation systems are highlighted in the course. Prereq.: EECE-203, Coreq: EECE-326. Course Offering: FALL.

EECE-326 Fundamentals of Energy Systems Laboratory 1 Credits
This course focuses on the laboratory experiments of fundamentals of energy systems dealing with poly-phase power measurements, synchronous machines, transmission line, renewable electricity systems of induction motor/generator. Also emphasized is renewable energy system modeling tools and system development using the modeling tools.Coreq.: EECE-325. Course Offering: FALL.

EECE-331 Probability & Random Variables 3 Credits
Applications of signals and systems control, to communications and signal processing, (digital filter, narrow-band signals, modulation/demodulation, multiplexing: control systems, feedback and stability), computer exercises. Applied probability and statistics, sample spaces and events, measure theory, experiments, trials, distributions (such as Poisson, Bionomial, and normal), random variables (continuous and discrete), law of large numbers, Chebyshev's inequality, estimation, reliability and quality. Designing with tolerance, applications of probability and statistics in engineering design. Prereq.: MATH-159. Course Offering: FALL.

EECE-333 Fundamental Signals and Systems 3 Credits
Design-based course, introduces comprehensive treatment of basic signal theory in time and frequency domains. Discrete and continuous time cases are treated simultaneously, covers concepts of signals and systems, convolution of difference and differential systems, block diagrams, state-space realizations and solution, matrix theory, Fourier series, transform techniques (Fourier, FFT, Z and Laplace), frequency response and stability. Exercises include traditional homework problems, computer applications such as MATLAB, C and SIGSYS and hardware design (laboratory generation of various signals and application to systems response) and design projects (Demonstration is required). Prereqs: EECE-331. Course Offering: SPRING.

EECE-350 Operating Systems for Engineers 3 Credits
Fuses the history and evolution of operating systems, concepts of process management, memory addressing and allocation, files and protection, deadlocks and distributed systems. Prereq.: CSCI-135 or SYCS-135. Course Offering: SPRING.

EECE-401 Senior Design I 3 Credits
Fundamentals of design principles, and engineering applications, design methodologies with emphasis on synthesis and evaluation, design process, reliability, the impact of engineering economy, report writing, ethics and alternative solutions will be discussed. Prereqs.: ADV. MATH., EECE-307., EECE-211., and EECE-332. Course Offering: FALL and SPRING. NOTE: At the conclusion of this course, students must identify a topic and an advisor for their Thesis Design Project. The project must be approved by the advisor; this is a prerequisite for EECE-404.

EECE-404 Senior Design II 3 Credits
To enhance knowledge of engineering design principles to solve real world problems, project planning, analysis, simulation and presentation, economic impact, ethics synthesis. Design areas are selected from solid state electronics, digital systems, communications (signal processing), power/energy systems and controls, power electronics, antennas and microwave and others. Oral presentation (with poster session) as well as written report required. Prereq.: EECE-401. Course Offering: FALL and SPRING. NOTE: The entire semester will be devoted to the design and implementation of the Senior Thesis Project selected by students and approved by his/her advisor at the conclusion of EECE-401. It is the prerequisite of this course that students identify a topic and an advisor for their Senior Thesis Design Project at the conclusion of EECE-401.

EECE-406 Advanced Digital Systems Design 3 Credits
Consists of design, analysis, optimization, and implementation of complex sequential digital systems and finite state machines (FSM). Hardware description languages (HDL), VHDL and/or Verilog, are introduced and will be used to design and implement digital systems. The structure of a computer and its organization will be reviewed. Finite state machine of a Simple CPU will be developed and various implementation alternatives (FSM, time state, jump counters, and microprogramming) of its controller will be studied. Prereq.: EECE-211. Coreq.: EECE-412. Course Offering: FALL.

EECE-408 Linear Control Systems 3 Credits
Analysis of time and frequency response of closed loop systems, block diagrams, signal flow graphs, Mason gain, Routh-Hurwitz and Nyquist criteria for stability, root-locus method and system specifications, compensators, state variable methods, introduction to digital control. Prereq.: EECE-332. Course Offering: FALL.

EECE-412 Advanced Digital Systems Design Laboratory 2 Credits
Laboratory projects will use a PC based Computer Aided Design Tool environment that supports hardware description languages (HDL) such as VHDL and Verilog for design, simulation, and synthesis of logic systems. Early lab exercises (mini projects) will use SSI/MSI chips; then HDL-based design tools and associated methodologies will be introduced to design, simulate, and synthesize complex digital systems for implementation with Programmable Logic Devices and Field Programmable Gate Arrays (FPGA). Teams of two or three students will specify and undertake design projects. Coreq.: EECE-406. Course Offering: FALL.

EECE-416 Microprocessors and Microcomputers 3 Credits
Examines microprocessors, support architectures, and hardware/software. Microprocessors' software model and programming, assembly language programming, microprocessor applications, microprocessor-based systems, and microcomputers. Projects will be used to introduce microprocessor applications. Prereq.: EECE-211. Course Offering: FALL.

EECE-418 Power Electronics 3 Credits
Characteristics of power electronics devices, converters, ac-dc, dc-dc, ac-ac, dc-ac, power supplies, cycloconverters, design projects, computer simulations. Prereqs.: EECE-332, and EECE-307. Course Offering: SPRING.

EECE-419 Motor Dynamics and Drives 3 Credits
D.C. and A.C. drives, electric motors, microcomputer control, protective relaying, projects, computer simulations. Prereqs.: EECE-318, and EECE-418. Course Offering: FALL

EECE-420 Introduction to VLSI Design 3 Credits
CMOS technology and theory; CMOS circuit and digital logic design; layout rules and techniques; circuit characterization and performance estimation; CMOS subsystem design; VLSI systems design methods; VLSI CAD tools; laboratory experience in custom VLSI chip design on workstations using concepts in cell

hierarchy; final project involving specification, design and evaluation of a VLSI chip or VLSI CAD program. Written report and oral presentation of the final project are required. Prereqs.: EECE-211, and EECE-308. Course Offering: FALL

EECE-421 Power Systems Analysis 3 Credits
Covers one-line diagram per unit quantity, power generation and synchronous machines, transmission line theory, analysis of interconnected systems using load flow studies and computation techniques. Economic operation of power system. Design Projects. Prereq.: EECE-318. Course Offering: FALL.

EECE-422 Power Communications & Control 3 Credits
Continuation of EECE-421. Introduction to Telecommunication, Fundamentals of Communications, Data Representation and Communication, Power System and Fault Analysis, Protection and Controls, Power System Stability, Communication Protocol Concepts and Security and Standards. Prereq.: EECE-421. Course Offering: SPRING.

EECE-443 Introduction to Microwaves 3 Credits
Electromagnetic wave propagation, microwave transmission systems, tube and solid-state microwave devices, and waveguides. Time-domain reflections, matching, Smith chart, S-parameters analysis, active and passive microwave components. Microwave measurement techniques. Prereq.: EECE-304. Course Offering: SPRING.

EECE-444 Antenna Theory and Practice 3 Credits
Antenna parameters; polarization of electromagnetic waves; basic antenna types; antenna arrays; broadband antenna design. Electrically small wire type apertures antenna design, measurements and simulation using Matlab or Mathcad. Prereq.: EECE-304. Course Offering: SPRING

EECE-453 Communications Theory 3 Credits
Includes probability theory, hypothesis testing, channel capacity, coding, detection and system performance analysis. Prereq.: EECE-331 or EECE-332. Course Offering: FALL.

EECE-454 Communication Electronics 3 Credits
Spectrum and noise measurements. Analog and digital communication techniques. Design of AM and ASK detectors, FM and FSK modulators and phase lock loops. Prereq.: EECE-308. Course Offering: SPRING.

EECE-456 Embedded Systems Design Lab 3 Credits
Project based course for design and system integration of embedded systems using microprocessor boards and I/O devices. Prereq: EECE-416. Course Offering: SPRING.

EECE-459 Communications Theory Lab 1 Credit
Design of modulation and demodulation circuits, filters. Coreq: EECE-453. Course Offering: FALL.

EECE-460 Wireless Communication 3 Credits
The physical layer of wireless communication systems. Implementation of speech coding, error control, modulation/demodulation and filtering schemes for wireless links using digital signal processors for baseband functions. Prereqs.: EECE-453. Course Offering: SPRING

EECE-461 Solid State Electronics I 3 Credits
Semiconductor properties, valence bands, energy bands, equilibrium distribution of electrons and non-equilibrium transport of charges, Breakdown mechanisms; essential features of small ac characteristics, switching and transient behavior of p-n junctions. Prereq.: EECE-307. Course Offering: SPRING

EECE-462 Solid State Electronics II 3 Credits
Semiconductor electronic properties and applications to electronic devices; Tunnel and Zener diodes, point contact transistors, FETs, MOSFETS, BJTS, multi junction devices, and small, medium and large scale integrated circuits. Prereq.: EECE-461. Course Offering: FALL

EECE-463 Digital Electronics 3 Credits
Bipolar and MOS field effect transistor characterization; characteristics and applications of TTL integrated circuits, design of memories, digital processors, special computer architecture, interfaces and A/D and D/A converters. Prereqs.: EECE-307. Course Offering: SPRING

EECE-465 Physical Electronics 3 Credits
Analysis of semiconductor device characteristics, junction breakdown, base-width modulation and capacitive effects. Model derivations from physical considerations. Prereqs.: PHYS-015 and EECE-307. Course Offering: SPRING

EECE-466 Advanced Electromagnetic Theory 3 Credits
Propagation of electromagnetic waves in general waveguides, losses in waveguides, fields and matter interaction, electromagnetic theory and special relativity, ionospheric propagation. Prereq. ELEG-304. Course Offering: SPRING

EECE-471 Design of Integrated Circuits 3 Credits
Microelectronics and circuit design. In depth coverage of Silicon integrated device characteristics and fabrication. Prereq.: EECE-308. Course Offering: FALL.

EECE-477 Design of Integrated Circuits Lab 3 Credits
In depth theoretical and experimental microelectronics through hands-on circuit design and testing. Detailed coverage of Silicon integrated device characteristics and fabrication. Prereq.: EECE-471. Course Offering: SPRING.

EECE-479 Cybersecurity for Net CPS/IoT 3 Credits
This course is designed to introduce emerging topics related to cybersecurity challenges and practical cyber-defense/countermeasures in networked Cyber-Physical Systems (CPS) and Internet-of-Things (IoT). The course will cover fundamental concepts, technologies, theoretical understanding and practical basis for cybersecurity of networked CPS/IoT. Graduate students will complete an independent research project which involves a written and oral presentation not required at the undergraduate level. Course Offering: FALL.

EECE-487 Telecommunications 3 Credits
Consists of telecommunications systems design for point-to-point and mass data distribution, modulation techniques, propagation modes and control methods. Prereq.: EECE-453. Course Offering: SPRING

EECE-495 Signal Processing 3 Credits
Sampling as a modulation process; aliasing; the sampling theorem; the Z-transform and discrete-time system analysis; direct and computer-aided design of recursive and non recursive digital filters; the Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT); digital filtering using the FFT;
analog-to-digital and digital-to-analog conversion; effects of quantization and finite-word-length arithmetic, and design and implementation of these algorithms on Motorola family of Digital Signal Processor chips and/or other similar DSP chips. Prereq.: EECE-333. Course Offering: FALL

EECE-498 Independent Project 3 Credits
Study performed by individual student under faculty supervision. Prereq.: Departmental approval. Course Offering: FALL /SPRING.

EECE-496 Integrated Circuits Tech Lab 3 Credits

EECE-499 Special Topics in Electrical Engineering **3 Credits**
Special courses not offered on a regular basis. Prereq.: Departmental approval. Course Offering: FALL/SPRING.

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V. CODE PF ETHICS OF ENGINEERS

The Fundamental Principles

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

- using their knowledge and skills for the enhancement of human welfare;
- being honest and impartial, and serving with fidelity the public, their employers and clients;
- striving to increase the competence and prestige of the engineering profession; and
- supporting the professional technical societies of their disciplines.

The Fundamental Canons

1. Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.
2. Engineers shall perform services only in the areas of their competence.
3. Engineers shall issue public statements only in an objective and truthful manner.
4. Engineers shall act in professional manners for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.
5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
6. Engineers shall act in such manner as to uphold and enhance the honor, integrity and dignity of the profession.
7. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those engineers under their supervision.

VI. POLICY ON EQUAL OPPORTUNITY

The mission of Howard University includes the provision of quality education for any student, but with emphasis upon the provision of educational opportunities for those students who may not otherwise have an opportunity to acquire an education of the type provided at Howard. In fulfilling its mission, the university does not discriminate on the basis of race, color, national and ethnic origin, sex, marital status, religion, or handicap in the administration of its educational policies, admissions policies, scholarship and loan programs, and other University administered programs and employment.

Howard University is committed to equal opportunity in all aspects of its relations with faculty, students, and staff members without regard to race, color, national and ethnic origin, sex, marital status, religion, age or handicap. The requirement not to discriminate in education programs and activities extends to employment therein and admission thereto.

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