Biometric Systems

Nature of Program

Biometric systems are composed of complex hardware and software designed to measure a signature of the human body, compare the signature to a database, and render a decision for a given application based on the identification achieved from this matching process. Uses of biometric systems for positive personal identification are experiencing rapid growth in such areas as law enforcement, access control, banking, and a wide range of business and administrative systems. In an even broader application context, biometric systems are having a revolutionary impact on health care and the enhancement of the human computer interface, including in vivo identification of specific human conditions via implantable devices and the automated administration of life-saving medical therapies. The continued rapid advance of integrated sensor, signal/image processing, computer, and mass storage technology promises to extend these applications further into our daily lives with even the most inanimate objects able to identify, interact with, and assist their users.

Biometric systems for personal identification are based upon fundamental biometric features that are typically unique and time invariant, such as features derived from fingerprints, faces, irises, retinas, and voices. Biometrics for biomedical, human computer interface, and other applications may include these but will necessarily extend to a wide range of physiological signals which possess identifiable patterns that may change in time, albeit predictably. The spectrum of usable biometrics is defined by human physiology, the bioengineering implied by their measurement, and the application. As biometric system capabilities and applications evolve, biometrics will extend to any known measurement of the human body.

Biometric identification is a highly interdisciplinary field mixing traditional engineering with the forensic sciences. As a result, the engineering design and development of biometric systems requires knowledge of the biometric as well as the engineering disciplines. Designers work with the physics of the sensor to obtain measurements of the biometric defined by human physiology. Signal and image processing techniques are applied to the sensor signal to extract features usable for identification. Databases combined with artificial intelligence enable rapid storage, retrieval, and pattern matching while decision theory supports the mechanisms whereby systems can provide the needed identification results. Underlying the entire system is a foundation of statistics and mathematics that provides the language for implementing and evaluating biometric technology and systems.

Program Educational Objectives

The Program Educational Objectives (PEO) of the Biometric Systems (BS) program at West Virginia University is to produce graduates who will apply their knowledge and skills to achieve success in their careers in industry, research, government service or graduate study. It is expected that in the first five years after graduation our graduates will achieve success and proficiency in their profession, be recognized as leaders, and contribute to the well-being of society.

Student Outcomes

Upon graduation, all Bachelor of Science students in Biometric Systems will have:

- An ability to apply knowledge of mathematics, science, and engineering
- An ability to design and conduct experiments, as well as to analyze and interpret data
- 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
- An ability to function on multidisciplinary teams
- An ability to identify, formulate, and solve engineering problems
- An understanding of professional and ethical responsibility
- An ability to communicate effectively
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- A recognition of the need for, and an ability to engage in life-long learning
- A knowledge of contemporary issues
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Areas of Emphasis

Presently, four specialization paths have been identified for the biometric systems curriculum. Each emphasis area enables students to develop an in-depth technical background in an area of their own choosing which is central to biometric system development. Currently designated areas of emphasis are sensors and circuits, signal processing, statistics, and software systems. Each emphasis area is fulfilled by the successful completion of three courses. Students may obtain at most one emphasis area designation from this four-course set in their degree curriculum. Each emphasis area curriculum is defined by three courses chosen from a set of classes prescribed for that area. At least one of these three courses is a required course. Successful completion of an emphasis area's requirements is designated on the student's transcript.

Click here to view the Suggested Plan of Study (p. 3)

Curriculum in Biometric Systems

GENERAL EDUCATION FOUNDATIONS

Please use this link to view a list of courses that meet each GEF requirement. (http://registrar.wvu.edu/gef)

NOTE: Some major requirements will fulfill specific GEF requirements. Please see the curriculum requirements listed below for details on which GEFs you will need to select.

General Education Foundations		
F1 - Composition & Rhetoric		3-6
ENGL 101 & ENGL 102	Introduction to Composition and Rhetoric and Composition, Rhetoric, and Research	
or ENGL 103	Accelerated Academic Writing	
F2A/F2B - Science & Technology		4-6
F3 - Math & Quantitative Skills		3-4
F4 - Society & Connections		3
F5 - Human Inquiry & the Past		3
F6 - The Arts & Creativity		3
F7 - Global Studies & Diversity		3
F8 - Focus (may be satisfied by completion of a minor, double major, or dual degree)		9
Total Hours		31-37

Please note that not all of the GEF courses are offered at all campuses. Students should consult with their advisor or academic department regarding the GEF course offerings available at their campus.

Curriculum Requirements

To receive a bachelor of science in biometric systems, a student must meet the University's undergraduate degree requirements, take all the courses indicated below, and attain a grade point average of 2.0 or better for all Lane Department of Computer Science and Electrical Engineering courses. If a Lane Department of Computer Science and Electrical Engineering course is repeated, only the last grade received is used to compute the major grade point average, and the course credit hours are counted only once. This requirement assures that the student has demonstrated overall competence in the major.

Freshman Engineering Requirements		
ENGR 101	Engineering Problem Solving 1	2
Engineering Problem Solving:		3
CHE 102	Introduction to Chemical Engineering	
ENGR 102	Engineering Problem-Solving 2	
ENGR 103	Introduction to Nanotechnology Design	
MAE 102	Introduction to Mechanical and Aerospace Engineering Design	
ENGR 199	Orientation to Engineering	1
Non-Biometric Systems Core		
BIOL 115	Principles of Biology (GEF 8)	4
BIOL 324	Molecular Genetics	3
CHEM 115	Fundamentals of Chemistry (GEF 2B)	4
ECON 201	Principles of Microeconomics (GEF 4)	3
ECON 202	Principles of Macroeconomics	3
Calculus I (GEF 3):		4
MATH 155	Calculus 1 (Minimum grade of C- is required)	
MATH 153 & MATH 154	Calculus 1a with Precalculus and Calculus 1b with Precalculus (Minimum grade of C- is required)	
MATH 156	Calculus 2 (GEF 8 - Minimum grade of C- is required)	4
MATH 251	Multivariable Calculus (Minimum grade of C- is required)	4
MATH 261	Elementary Differential Equations	4
MATH 375	Applied Modern Algebra	3
PHYS 111	General Physics	4

PHYS 112	General Physics	4
STAT 215	Introduction to Probability and Statistics	3
STAT 316	Forensic Statistics	3
Biometric Core (Minimum 2.0 GPA is required in all of the following courses.)		
BIOM 426	Biometric Systems	3
BIOM 480	Senior Design Seminar (Fulfills Writing and Communications Skills Requirement)	2
BIOM 481	Senior Design Project	3
CPE 271	Introduction to Digital Logic Design	3
CPE 272	Digital Logic Laboratory	1
CPE 310	Microprocessor Systems	3
CPE 311	Microprocessor Laboratory	1
CS 110	Introduction to Computer Science	4
CS 111	Introduction to Data Structures	4
CS 350	Computer System Concepts	3
CS 465	Introduction to Cybersecurity	3
EE 221	Introduction to Electrical Engineering	3
EE 222	Introduction to Electrical Engineering Laboratory	1
EE 223	Electrical Circuits	3
EE 224	Electrical Circuits Laboratory	1
EE 327	Signals and Systems 1	3
EE 425	Bioengineering	3
EE 465	Introduction to Digital Image Processing	3
Area of Emphasis		9
Free Elective		3
Technical Elective (300 level or higher course in Biometric Systems, Computer Engineering, Computer Science, or Electrical Engineering)		3
GEF Electives 1, 5, 6, 7		15
Total Hours		133

Suggested Plan of Study

It is important for students to take courses in the order specified as much as possible; all prerequisites and concurrent requirements must be observed. A typical B.S.B.S. degree program, which completes degree requirements in four years, is as follows.

First Year

Fall	Hours	Spring	Hours
BIOL 115 (GEF 8)*	4	CHEM 115 (GEF 2)	4
ENGL 101 (GEF 1)	3	CS 110	4
ENGR 101	2	ENGR 102	3
ENGR 199	1	MATH 156 (GEF 8)	4
MATH 155 (GEF 3)	4	PHYS 111 (GEF 8)	4
GEF 5	3		
	17		19

Second Year

Fall	Hours	Spring	Hours
CS 111	4	CPE 271	3
EE 221	3	CPE 272	1
EE 222	1	EE 223	3
MATH 251	4	EE 224	1
PHYS 112	4	ENGL 102 (GEF 1)	3
		MATH 261	4
		STAT 215	3
	16		18

Third Year			
Fall	**Hours**	**Spring**	**Hours**
BIOM 426*	3	BIOL 324*	3
CPE 310	3	EE 465*	3
CPE 311	1	MATH 375	3
CS 350	3	GEF 6	3
EE 327*	3	Area of Emphasis Course 1	3
STAT 316*	3	Area of Emphasis Course 2	3
	16		18
Fourth Year			
Fall	**Hours**	**Spring**	**Hours**
BIOM 480	2	BIOM 481	3
CS 465*	3	ECON 202	3
ECON 201 (GEF 4)	3	Area of Emphasis Course 3	3
EE 425*	3	GEF 7	3
Free Elecitve	3	Technical Elective	3
	14		15

Total credit hours: 133

* Offered once per year in the semester shown.

Areas of Emphasis

MICROSENSORS AND CIRCUITS AREA OF EMPHASIS REQUIREMENTS

EE 251 & EE 252	Digital Electronics and Digital Electronics Laboratory	4
Choose two of the following:		6
PHYS 314	Introductory Modern Physics	
PHYS 321	Optics	
EE 355 & EE 356	Analog Electronics and Analog Electronics Laboratory	
EE 450	Device Design and Integration	
EE 455	Introduction to Microfabrication	
Total Hours		10

SIGNAL PROCESSING AREA OF EMPHASIS REQUIREMENTS

EE 251 & EE 252	Digital Electronics and Digital Electronics Laboratory	4
EE 329 & EE 328	Signals and Systems 2 and Signals and Systems Laboratory	4
Choose one of the following:		3
CS 453	Data and Computer Communications	
EE 463	Digital Signal Processing Fundamentals	
EE 565	Advanced Image Processing	
Total Hours		11

STATISTICS AREA OF EMPHASIS REQUIREMENTS

Choose either the Applied or Theory Option		9
Applied Option		
STAT 312	Intermediate Statistical Methods	
Choose two of the following:		
STAT 313	Introductory Design and Analysis	
STAT 331	Sampling Methods	

STAT 421	Statistical Analysis System (SAS)	
Theory Option		
STAT 312	Intermediate Statistical Methods	
STAT 461	Theory of Probability	
STAT 462	Theory of Statistics	
Total Hours		9

SOFTWARE SYSTEMS AREA OF EMPHASIS REQUIREMENTS

CS 230	Introduction to Software Engineering	3-4
or CPE 484	Real-Time Systems Development	
Choose two of the following:		6
CPE 442	Introduction to Digital Computer Architecture	
or CS 455	Computer Architecture	
CS 430	Advanced Software Engineering	
CS 450	Operating Systems Structure	
CS 453	Data and Computer Communications	
CS 472	Artificial Intelligence	
Total Hours		9-10

Major Learning Goals

BIOMETRIC SYSTEMS

Program Educational Objectives

The Program Educational Objectives (PEO) of the Biometric Systems (BS) program at West Virginia University is to produce graduates who will apply their knowledge and skills to achieve success in their careers in industry, research, government service or graduate study. It is expected that in the first five years after graduation our graduates will achieve success and proficiency in their profession, be recognized as leaders, and contribute to the well-being of society.

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- An ability to function on multidisciplinary teams
- An ability to identify, formulate, and solve engineering problems
- An understanding of professional and ethical responsibility
- An ability to communicate effectively
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- A recognition of the need for, and an ability to engage in life-long learning
- A knowledge of contemporary issues
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

BIOMETRIC SYSTEMS COURSES

BIOM 426. Biometric Systems. 3 Hours.
PR: STAT 215 and MATH 261 and CS 111. This course presents an introduction to the principles of operation, design, testing, and implementation of biometric systems, and the legal, social, and ethical concerns associated with their use. (Cross-listed with EE 426.).

BIOM 480. Senior Design Seminar. 2 Hours.
PR: ENGL 102 and consent. Penultimate semester. Group senior design projects with individual design assignments appropriate to student's discipline. Complete system-level designs of the subsequent semester's project presented in written proposals and oral presentations. (Equivalent to CPE 480, CS 480 and EE 480.) (2 hr. lec., 1 hr. conf.).

BIOM 481. Senior Design Project. 3 Hours.
PR: BIOM 480. Continuation of BIOM 480. Detailed design and implementation of the system including choice of components, algorithm development, interfacing, troubleshooting, working in groups, and project management. Also covers professional topics including ethics, liability, safety, socio-legal issues, risks, and employment agreements. (1 hr. lec., 1 hr. conf., 2 hr. lab.).

COMPUTER ENGINEERING COURSES

CPE 271. Introduction to Digital Logic Design. 3 Hours.
PR: MATH 156 or consent. Introduction to the design of digital systems. Topics include number systems, coding, Boolean and switching algebra, minimization of logic, analysis and design of combinational and sequential logic circuits.

CPE 272. Digital Logic Laboratory. 1 Hour.
CoReq: CPE 271. Experiments with digital electronic circuits including number systems, design and application of modern digital circuitry for both combinational and sequential logic circuits. (3 hr. lab.).

CPE 293. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

CPE 310. Microprocessor Systems. 3 Hours.
PR: CPE 271 and CPE 272 and PR or CONC: CPE 311. Theory and design of microprocessors: organization and architecture of modern processors; integration of microprocessors with RAM, ROM, and I/O devices; machine language, assembly language and software development. (3 hr. lec.).

CPE 311. Microprocessor Laboratory. 1 Hour.
CoReq: CPE 310. Machine language, assembly language and hardware and software interfacing. (This includes editing, linking, and debugging.) Memory, I/O and basic techniques of microprocessor interfacing. (3 hr. lab.).

CPE 312. Microcomputer Structures and Interfacing. 3 Hours.
PR: CPE 310 and CPE 311 and EE 251 and EE 252 and CoReg: CPE 313 and CS 350. Design of computer systems with emphasis on interface hardware including communications, high power interface devices, line driver/receiver circuits, A/D and D/A devices, and utilization of software techniques for programmed, interrupt, and direct memory access. (3 hr. lec.).

CPE 313. Microcomputer Structures and Interfacing Laboratory. 1 Hour.
PR: CPE 310 and CPE 311 and CoReq: CPE 312. A microprocessor based single-board computer is designed and built. A semester project is required using standard I/O techniques. (3 hr. lab.).

CPE 435. Computer Incident Response. 3 Hours.
PR: CPE 310 and CPE 311 and (CS 350 or CS 355) or consent. Introduction to computer incident response, forensics, and computer security. Legal basis, proper procedures, and multiple operating systems application.

CPE 442. Introduction to Digital Computer Architecture. 3 Hours.
PR: (MATH 375 or MATH 378) and (CPE 310 or CPE 320). Control, data, and demand-driven computer architecture; parallel processing, pipelining, and vector processing; structures and algorithms for array processors, systolic architectures, design of architectures. (3 hr. lec.).

CPE 462. Wireless Networking. 3 Hours.
PR: EE 327 and (STAT 215 or MATH 448). Design and analysis of modern wireless data networks. Digital modulation techniques, wireless channel models, design of cellular networks, spread spectrum, carrier sense multiple access, ad-hoc networks routing, error control coding, automatic request strategies.

CPE 480. Senior Design Seminar. 2 Hours.
PR: ENGL 102 and consent. Penultimate semester group senior design projects with individual design assignments appropriate to student's discipline. Complete system-level designs of the subsequent semester's project presented in written proposals and oral presentations. (Equivalent to BIOM 480, CS 480, and EE 480). (2 hr. lec., 1 hr. conf.).

CPE 481. Senior Design Project. 3 Hours.
PR: CPE 480. Continuation of CPE 480. Detailed design and implementation of the system including choice of components, algorithm development, interfacing troubleshooting, working in groups, and project management. Also covers professional topics, including ethics, liability, safety, socio-legal issues, risks and employment agreements. (1 hr. lec., 1 hr. conf., 2 hr. lab.).

CPE 484. Real-Time Systems Development. 3 Hours.
PR: CS 350 or working knowledge of C programming language and UNIX. Characteristics of real-time systems, system and software development standards, structured and object oriented development methods for real-time systems, using a computer aided software engineering (CASE) tool in the development of a large engineering project. Emphasis is on real-time systems requirements analysis and design. This is a project based course. (3 hr. lec.).

CPE 490. Teaching Practicum. 1-3 Hours.
PR: Consent. Teaching practice as a tutor or assistant.

CPE 491. Professional Field Experience. 1-18 Hours.
PR: Consent. (May be repeated up to a maximum of 18 hours.) Prearranged experiential learning program, to be planned, supervised, and evaluated for credit by faculty and field supervisors. Involves temporary placement with public or private enterprise for professional competence development.

CPE 493. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

CPE 494. Seminar. 1-3 Hours.
PR: Consent. Presentation and discussion of topics of mutual concern to students and faculty.

CPE 495. Independent Study. 1-6 Hours.
Faculty supervised study of topics not available through regular course offerings.

CPE 496. Senior Thesis. 1-3 Hours.
PR: Consent.

CPE 498. Honors. 1-3 Hours.
PR: Students in Honors Program and consent by the honors director. Independent reading, study or research.

COMPUTER SCIENCE COURSES

CS 101. Intro to Computer Applications. 4 Hours.
Introduction to spreadsheets and databases for problem-solving in disciplines such as math, science, engineering, business, social sciences, behavioral sciences, and environment: using computer applications to create technical reports and presentations.

CS 110. Introduction to Computer Science. 4 Hours.
PR: (MATH 126 and MATH 128) or MATH 129 or MSAT score of 600 math ACT score of 26. Programming and design; simple data types, variables, and expressions; program modularization through procedures, functions, and classes; repetition, selection through control structures; structured data types including arrays and records; application. (3 hr. lec., 1 hr. lab.).

CS 111. Introduction to Data Structures. 4 Hours.
PR: CS 110 with a minimum grade of C-. Software development with abstract data types; elementary data structures including lists, stacks, queues and binary trees. Object-oriented design and development, dynamic allocation, recursion, design methodology. (3 hr. lec., 2 hr. lab.).

CS 210. File and Data Structures. 4 Hours.
PR: CS 111 with a minimum grade of C- or consent for non-majors. Complex internal data structures including hashing, record collision and overflow techniques. Extension of internal data structures to external storage; indexed structures, external sorting and merging, direct access methods.

CS 220. Discrete Mathematics. 3 Hours.
PR: (CS 110 with a minimum grade of C- or CS 122) and (MATH 154 or MATH 155). Mathematical concepts used in computer science such as sets, relations, functions, counting principles, graphs, trees, and automata; introduction to basic graph algorithms and applications. (3 hr. lec.).

CS 221. Analysis of Algorithms. 3 Hours.
PR: WVU sections require CS 111 with a grade of C- or better and CS 220 with a grade of C- or better and MATH 156, WVUIT sections require CS 201 and CS 220 and MATH 156. Introduction to algorithm design and analysis. Growth rate of functions and asymptotic notation. Divide-and-conquer algorithms and recurrences; searching and sorting; graph algorithms including graph searching, minimum spanning trees, and shortest paths.

CS 230. Introduction to Software Engineering. 4 Hours.
PR: CS 111 with a minimum grade of C-. Techniques and methodologies of software engineering; specification, modeling,requirement analysis and definition, design, quality assurance, testing, reuse, development tools and environments.

CS 293. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

CS 310. Principles of Programming Languages. 3 Hours.
PR: CS 111 with a minimum grade of C- or CS 201. Theoretical and practical aspects of languages including internal representations, run-time environments, run-time storage management; historical, current, special purpose and experimental languages; finite-state automata, regular expressions and context-free grammars, language translation, semantics and paradigms. (3 hr. lec.).

CS 350. Computer System Concepts. 3 Hours.
PR: CS 111 with a minimum grade of C-. System software organization; operating system concepts including processes, threads, memory management, and the user interface; elementary network concepts. (Equivalent to CS 355).

CS 410. Compiler Construction. 3 Hours.
PR: WVU sections require CS 310 with a C- or better or consent for non-majors, WVUIT sections require CS 310 or consent for non-majors. Theory and practice of the construction of programming language translators; scanning and parsing techniques, semantic processing, runtime storage organization, and code generation; design and implementation of interpreter or compiler by students. (3 hr. lec.).

CS 420. Design of Algorithms. 3 Hours.
PR: CS 221 with a C- or better and completed Pre-CS or consent for non-majors. Algorithm design paradigms: divide-and-conquer, dynamic programming, greedy. Advanced data structures: balanced search trees, mergeable heaps, union-find. Introduction to computational complexity. Selected topics such as backtracking, branch-and-bound, amortized analysis, approximation algorithms.

CS 422. Automata Theory. 3 Hours.
PR: WVU sections require CS 220 with a minimum of C- or better or consent for non-majors, WVUIT sections require CS 220 or consent for non-majors. Introduction to formal languages, grammars, and automata; regular expressions and finite automata, context- free and context-sensitive languages; push down and linear- bounded automata; turning machines and recursively enumerable languages.

CS 426. Discrete Mathematics 2. 3 Hours.
PR: CS 221 with a C- or better or consent for non-majors. Applications of discrete mathematics to computer science. Selected topics from algorithmic graph theory, combinatorics, and order theory.

CS 430. Advanced Software Engineering. 3 Hours.
PR: CS 230 with a C- or better or CS 222 or consent for non-majors. Engineering process, project economics, project organizational and management issues, configuration management. (3 hr. lec.).

CS 440. Database Design and Theory. 3 Hours.
PR: CS 230 with minimum grade of C- or consent for non-majors. Database terminology, SQL, stored procedures, the relational and object-relational data model, triggers, and entity-relationship model.

CS 450. Operating Systems Structure. 3 Hours.
PR: CS 350 with a C- or better or CS 355. Support of computer components; device management and interrupts, process scheduling, file management, complete OS structure, OS development and debugging, configuration management, and performance testing. (3 hr. lec.).

CS 453. Data and Computer Communications. 3 Hours.
PR: (CS 350 with a C- or better or CS 355) or consent for non-majors. or consent for non-majors. An in-depth study of the Internet, networking fundamentals, protocols, algorithms, and principles of distributed computing, introduction to network security and management.

CS 455. Computer Architecture. 3 Hours.
PR: CPE 271. Computer structure; emphasis on implications for software design; evolution of computers; elementary digital logic; CPU structures; memory and I/O structures; pipelining and memory management; introduction to parallel and high-level architectures. (3 hr. lec.).

CS 465. Introduction to Cybersecurity. 3 Hours.
PR: CS 350 with a C- or better or CS 321 or consent. Covers the fundamentals of cybersecurity, including encryption, malicious code, authentication and access control, database security, operating system security, and network security. Provides students with a comprehensive overview of the cybersecurity threats, technologies for information assurance, and engineering approaches to build and maintain secure computer systems and networks.

CS 470. Introduction to Computer Graphics. 3 Hours.
PR: CS 201 or CS 210 with a minimum grade of C- or consent for non-majors. Overview of 3D graphics hardware and gaming consoles; focus on developing 3D graphics software; fundamental algorithms for real-time 3D graphics with focus on game engine component development; introduction to three-dimensional game engine development.

CS 472. Artificial Intelligence. 3 Hours.
PR: CS 222 or CS 230 with a minimum grade of C- or consent for non-majors. Survey of AI techniques, heuristic search, game playing, and knowledge representation schemes: logic, semantic net, frames, rule-based; natural language processing, advanced AI techniques/systems: planning, blackboard architecture, neural net model; AI implementation. (3 hr. lec.).

CS 473. Data Mining. 3 Hours.
PR: (CS 230 with a C- or better or CS 222) and (CS 350 with a C- or better or CS 355). Presents the theory practice of industrial data mining. Combining pragmatics with theory, students will learn to select appropriate data mining methods for industrial applications.

CS 475. Game Development. 3 Hours.
PR: CS 222 or (CS 220 and CS 310 with a minimum grade of C- in each). Design and implementation of games using innovative technology in human-computer interfaces. Principles of game design, physiology and psychology of each of the five senses, and technologies for delivering sensory stimuli.

CS 480. Senior Design. 2 Hours.
PR: ENGL 102 and consent. Penultimate semester. Group senior design projects with individual design assignments appropriate to student's discipline. Complete system-level designs of the subsequent semester's project presented in written proposals and oral presentations. (Equivalent to BIOM 480, CPE 480, and EE 480.) (2 hr. lec., 1 hr. conf.).

CS 481. Senior Project. 3 Hours.
PR: CS 480. Continuation of CS 480. Detailed design and implementation of the system including choice of components, algorithm development, interfacing, troubleshooting, working in groups, and project management. Also covers professional topics, including ethics, liability, safety, socio-legal issues, risks and employment agreements. (1 hr. lec., 1 hr. conf., 2 hr. lab.).

CS 490. Teaching Practicum. 1-3 Hours.
PR: Consent. Teaching practice as a tutor or assistant.

CS 491. Professional Field Experience. 1-18 Hours.
PR: Consent. (May be repeated up to a maximum of 18 hours.) Prearranged experiential learning program, to be planned, supervised, and evaluated for credit by faculty and field supervisors. Involves temporary placement with public or private enterprise for professional competence development.

CS 492. Directed Study. 1-3 Hours.
Directed study, reading, and/or research.

CS 493. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

CS 494. Seminar. 1-3 Hours.
PR: Consent. Presentation and discussion of topics of mutual concern to students and faculty.

CS 495. Independent Study. 1-6 Hours.
Faculty supervised study of topics not available through regular course offerings.

CS 496. Senior Thesis. 1-3 Hours.
PR: Consent.

CS 497. Research. 1-6 Hours.
Independent research projects.

ELECTRICAL ENGINEERING COURSES

EE 221. Introduction to Electrical Engineering. 3 Hours.
PR: WVU and PSC sections require PHYS 111 and MATH 156, WVUIT sections require MATH 156. Electrical engineering units, circuit elements, circuit laws, measurement principles, mesh and node equations, network theorems, operational amplifier circuits, energy storage elements, sinusoids and phasors, sinusoidal steady state analysis, average and RMS values, complex power. Pre-requisite(s) and/or co-requisite(s) may differ on regional campuses.

EE 222. Introduction to Electrical Engineering Laboratory. 1 Hour.
CoReq: EE 221. Design and experimental exercises basic electrical circuits. Use of the digital computer to solve circuit problems. (3 hr. lab.).

EE 223. Electrical Circuits. 3 Hours.
PR: WVU and PSC sections require EE 221 and EE 222 and PHYS 112 and MATH 251 all with a grade of C- or better, WVUIT sections require EE 221 and EE 222 and MATH 251 all with a grade of C- or better. Time response of RC and RL circuits, unit step response, second order circuits, poly-phase systems, mutual inductance, complex frequency, network frequency response, two-port networks and transformers. Fourier methods and Laplace Transforms.

EE 224. Electrical Circuits Laboratory. 1 Hour.
CoReq: EE 223. Design and experimental exercises in circuits. Transient circuits, steady state AC circuits, frequency response of networks. Use of digital computer to solve circuit problems. (3 hr. lab.).

EE 251. Digital Electronics. 3 Hours.
PR: EE 221 and CPE 271 and PHYS 112. Diode and bipolar and field-effect transistor device operation and switching models. Use of bipolar and field-effect transistors and diodes in switching and logic circuits. Switching circuits and logic gates including logic levels, circuit configuration, and interfacing. (3 hr. lec.).

EE 252. Digital Electronics Laboratory. 1 Hour.
CoReq: EE 251. Design, fabrication, and measurement of digital electronic circuits. Modeling and use of discrete devices, logic gates, display devices in switching circuits and timer circuits, Interfacing with integrated logic gates. (3 hr. lab.).

EE 293. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

EE 327. Signals and Systems 1. 3 Hours.
PR: MATH 261 and EE 223. Introduction to linear system models and solutions in the time and frequency domains. Balanced emphasis is placed on both continuous and discrete time and frequency methods. (3 hr. lec.).

EE 328. Signals and Systems Laboratory. 1 Hour.
PR: EE 327 and CoReq: EE 329. Laboratory experiments in measurement and analysis of systems and signals. (3 hr. lab.).

EE 329. Signals and Systems 2. 3 Hours.
PR: EE 327 and (STAT 215 or MATH 448). Analysis of continuous and discrete time systems. Block diagrams, stability, feedback control. Statistical description of nondeterministic signals, correlation functions, and spectral density, concepts applied to communication and feedback systems. (3 hr. lec.).

EE 335. Electromechanical Energy Conversion and Systems. 3 Hours.
PR: WVU sections require EE 223 and EE 224 and PHYS 112, WVUIT sections require EE 223 and EE 224 and a co-requisite of EE 345. Electric energy sources, fundamentals of electromechanical energy conversion, transformers and rotating machinery.

EE 336. Electromechanical Energy Conversion and Systems Lab. 1 Hour.
Transformers, DC motors and generator performance and characteristics, synchronous machine performance and characteristics.

EE 345. Engineering Electromagnetics. 3 Hours.
PR: WVU sections require MATH 261 and PHYS 112, WVUIT sections require MATH 261 and PHYS 112 and EE 223. Continued use of vector calculus, electrostatics, magnetoststics, Maxwell's Equations, and boundary conditions. Introduction to electromagnetic waves, transmission lines, and radiation from antennas.

EE 355. Analog Electronics. 3 Hours.
PR: EE 223 and EE 251. Electronic devices in analog circuits. Small-signal and graphical analysis of BJT and FET circuits; frequency response, feedback, and stability. Linear and nonlinear operational amplifier circuits. Power amplifiers and power control by electronic devices. (3 hr. lec.).

EE 356. Analog Electronics Laboratory. 1 Hour.
CoReq: EE 355. Design, fabrication, and measurement of analog electronic circuits. Use of discrete devices, integrated circuits, operational amplifiers, and power electronic devices. Study of biasing and stability, frequency response, filters, analog computation circuits, and power control circuits. (3 hr. lab.).

EE 411. Fundamentals of Control Systems. 3 Hours.
PR: EE 327. Introduction to classical and modern control; signal flow graphs; state-cariable characterization; time-domain, root locus, and frequency techniques; stability criteria. (3 hr. lec.).

EE 413. Introduction to Digital Control. 3 Hours.
PR: EE 327. Sampling of continuous-time signals and transform analysis. Stat-variable analysis for linear discrete-time systems and design of digital controller. (3 hr. lec.).

EE 425. Bioengineering. 3 Hours.
Introduction to human anatomy and physiology using an engineering systems approach. Gives the engineering student a basic understanding of the human system so that the student may include it as an integral part of the design. Co-listed with MAE 473. (3 hr. lec.).

EE 426. Biometric Systems. 3 Hours.
PR: STAT 215 and MATH 261 and CS 111. It is also suggested (not required) that EE 327 and CS 350 also be taken prior to enrolling in this course. This course presents an introduction to the principles of operation, design, testing, and implementation of biometric systems, and the legal, social and ethical concerns associated with their use.

EE 431. Electrical Power Distribution Systems. 3 Hours.
PR: EE 335 and EE 336 or consent. General considerations; load characteristics; subtransmission and distribution substations; primary and secondary distribution, secondary network systems; distribution transformers; voltage regulation and application of capacitors; voltage fluctuations; protective device coordination. (3 hr. lec.).

EE 435. Introduction to Power Electronics. 3 Hours.
PR: EE 335 and EE 355 and EE 356 or consent. Application of power semiconductor components and devices to power system problems; power control; conditioning processing, and switching. Course supplemented by laboratory problems. (3 hr. lec.).

EE 436. Power Systems Analysis. 3 Hours.
PR: EE 335 and EE 336. Power system network modeling, network calculations by matrices, node equations, node elimination, bus admittance, impedance matrices, and fault calculations. Transmission line inductance, capacitance, network models, and power circle diagrams. Symmetrical and unsymmetrical faults. Load flow and economic dispatch.

EE 437. Fiber Optics Communications. 3 Hours.
PR: EE 329 and EE 345. Fundamentals of optics and light wave propagation, guided wave propagation and optical wave guides, light sources and light detectors, couplers, connections, and fiber networks, modulation noise and detection in communication systems. (3 hr. lec.).

EE 445. Introduction to Antennas. 3 Hours.
PR: EE 345 or equivalent. Development of Maxwell's equations and general electromagnetic theory underpinning broadcast communication systems, wave propagation, antennas and antenna arrays.

EE 450. Device Design and Integration. 3 Hours.
PR: EE 345 and EE 355. Fundamentals of semiconductor materials, p-n junctions, metal-semiconductor junctions, JFET's, MESFET's, MOSFET's, physical device design, device simulation, gate level CMOS design and layout. (3 hr. lec.).

EE 455. Introduction to Microfabrication. 3 Hours.
PR: EE 355 or consent. Introduction to the physical processes underlying current and emerging microfabrication technology and their selective use in the technology computer aided design (TCAD) and fabrication of electrical, optical, and micromechanical devices and systems.

EE 457. Fundamentals of Photonics. 3 Hours.
PR:EE 345 or equivalent. Basic physics and optical engineering concepts necessary to understand the design and operation of photonic -based systems, including communications, nanophotonics, sensing and display technologies. Scaling, integration, and packaging of optical approaches and their compatibility with micro/nanosystems.

EE 461. Introduction to Communications Systems. 3 Hours.
PR: EE 329. Application of random processes and spectral analysis to the design and analysis of communication systems. Analysis and comparison of standard modulation techniques relative to bandwidth, noise, threshold, and hardware constraints.

EE 463. Digital Signal Processing Fundamentals. 3 Hours.
PR: MATH 251 and EE 327. Theories, techniques, and procedure used in analysis, design, and implementation of digital and sampled data filters. Algorithms and computer programming for software realization. Digital and sampled data realizations, switched capacitor and charge-coupled device IC's. (3 hr. lec.).

EE 465. Introduction to Digital Image Processing. 3 Hours.
PR: EE 251 and EE 327. Introduction to the vision process fundamental mathematical characterization of digitized images, two-dimensional transform methods used in image processing, histogram analysis and manipulation, image and filtering techniques, image segmentation, and morphology. (3 hr. lec.).

EE 467. Digital Speech Processing. 3 Hours.
PR: EE 327 and EE 329. Covers fundamentals in digital speech processing including production, speech analysis, speech coding, speech enhancement, speech recognition and speaker recognition. Emphasize hand-on experience of processing speech signals using MATLAB.

EE 480. Senior Design Seminar. 0-3 Hours.
PR: ENGL 102 or consent. Penultimate semester. Group senior design projects with individual design assignments appropriate to student's discipline. Complete system-level designs of the subsequent semester's project presented in written proposals and oral presentations. (Equivalent to BIOM 480, CPE 480, CS 480) (2 hr. lec., 1 hr. conf.) Note: WVU Tech course is 3 credit hours.

EE 481. Senior Design Project. 3 Hours.
PR: EE 480; Continuation of EE 480. Detailed design and implementation of the system including choice of components, algorithm development, interfacing, trouble shooting, working in groups, and project management. Also covers professional topics, including ethics, liability, safety, socio-legal issues, risks and employment agreements. (1 hr. lec., 1 hr. conf., 2 hr. lab.).

EE 490. Teaching Practicum. 1-3 Hours.
PR: Consent. Teaching practice as a tutor or assistant.

EE 491. Professional Field Experience. 1-18 Hours.
PR: Consent. (May be repeated up to a maximum of 18 hours.) Prearranged experiential learning program, to be planned, supervised, and evaluated for credit by faculty and field supervisors. Involves temporary placement with public or private enterprise for professional competence development.

EE 492. . 1-6 Hours.
Directed study, reading, and/or research.

EE 493. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

EE 494. Seminar. 1-3 Hours.
PR: Consent. Presentation and discussion of topics of mutual concern to students and faculty.

EE 495. Independent Study. 1-6 Hours.
Faculty supervised study of topics not available through regular course offerings.

EE 496. Senior Thesis. 1-3 Hours.
PR: Consent.

EE 497. Research. 1-6 Hours.
Independent research projects.

EE 498. Honors. 1-3 Hours.
PR: Students in Honors Program and consent by the honors director. Independent reading, study or research.