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Automation Engineering

Topics and Curriculum for a BS Degree

Setting the Standard for Automation™

Automation Engineering—Model Curriculum

Mission

Develop human resources who will use automation engineering to contribute to human welfare. In addition, the broader departmental mission includes the development of professional knowledge to improve the discipline and the infrastructure by which automation engineering contributes to human welfare.

Educational Objectives

Within the first few years after graduation, BS graduates will possess:

- **Competencies** – Adequate skills in tools and techniques that are fundamental to the job, many of which need to be learned after graduation.
- **Professionalism** – Partnership in the mission and human context of the enterprise, including ethics, effectiveness, initiative, creativity, critical thinking, and awareness of the broad context of the detailed work.
- **Balance** – A wise self-direction to life, community, and health. This includes a self-view that finds the right balance between personal choices and that energizes and enables self and others.

Program Outcomes

Upon graduation BS students 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
- An ability to function on teams with diverse members
- 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 and societal context
- A recognition of the importance of, a 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

Unique Essence

Automation engineering (AE)'s unique aspect is that it focuses on the specification of an algorithm and its implementation that makes a system evolve in a desired manner in time or stages. Dynamic modeling of continuous, batch, staged, discrete, robotic, machining, electronic, and stochastic processes; and nonlinear, constrained, or multivariable optimization over a time horizon would characterize requisite math and analysis skills. Knowledge of all dynamic systems (mechanical, electrical, and chemical) would characterize the required application scope.

Essential to designing the algorithm, AE students must be able to model dynamic and stochastic behavior of a variety of mechanical, electrical, and process units. In addition, AE students must be able to integrate unit models into a system dynamic model. AE students must understand all of the desired attributes for system behavior, many of which are conflicting and which are subject to various external situations, internal stages, and constraints. AE students must be able to define a control strategy that optimizes the variety of desired attributes over a future time horizon.

Essential to algorithm implementation, AE students must understand the devices, computers, and networks from all aspects—hardware, software, operating systems, networking, database management, and analog and digital communication protocol. Implementation includes the design of a control system that provides reliability, security, failure robustness, loss prevention, safety, operator-friendliness, self-diagnosis, and management support. AE students must be able to include the automation devices and algorithms in the dynamic system model and simulate the system behavior.

Essential to automation sensing, AE students must be able to calibrate measurement systems, construct algorithms for inferential assessments of quality, and construct perception algorithms such as vision and health monitoring.

AE students must be able to assess all aspects of the economic impact of automation and determine the balance of complexity and benefit. AE students must be able to manage an automation project in a manner that is consistent with objectives within a human enterprise. This would include compliance with codes and regulations, effective teamwork, planning, communications, creativity, credibility, and quality management.

While there is a control course in most of the Chemical Engineering (ChE), Electrical Engineering (EE), and Mechanical Engineering (ME) degree programs, these courses barely reveal the tip-of-the-iceberg in one discipline—control as a concept and its primitive strategies—and do not adequately prepare graduates for a career in automation. The AE program will cover breadth of applications (mechanical objects, electronic behaviors, and process units) and will provide discipline depth—including nonlinear, MIMO strategies for constrained processes and the implementation practice with hardware and software.

An AE degree program could evolve into separate tracks for **manufacturing automation** (robotics, motion control, CNC, PLC, CAD/CAE/CAM/CIM, freeform fabrication), **process automation** (DCS, analysis, model-predictive), **manufacturing information technology** (IT) (MES, business system integration), and perhaps **economic and natural processes** (traffic, scheduling, dam management, prime interest rate, etc.).

Sample Curriculum Courses and Topics

SCH = Semester Course Hours

General Education – 33-SCH

Composition I & II or Technical Writing or Speech – 6-SCH
Goal: effectiveness in communication

Humanities – 6-SCH
Goal: understanding of mankind, art, emotion, culture, values, critical thinking, and ethics in a qualitative manner

Social Sciences – 6-SCH
Goal: understanding of mankind and relationships to economics, law, geography, politics, self and others, etc. in a quantitative manner

History, Government, Law – 6-SCH
Goal: understanding of the reality of citizenship, mechanics, and heritage of self and others

Business, Legal, Global – 3-SCH
Goal: understanding of the environment for engineering practice

Professional Electives – 6-SCH
Goal: breadth of experience for utility in career or life

Fundamental Math and Science – 35-SCH

Calculus I, II, III – 10-SCH
- Multi-variable, complex

Ordinary Differential Equations – 3-SCH
- Linear, Laplace, continuous

Linear Algebra – 3-SCH
- Discrete, systems, Z-transform, backshift operators, ARMA

Chemistry I and II with labs or II and Organic with labs – 8-SCH

Physics I and II (calculus based) with labs – 8-SCH

Other Science Course – 3-SCH
- Biology, Astronomy, Solid State Physics, Materials Science, Modern Physics, Genetics, etc.

Applied Math and Science – 9-SCH

Probability and Statistics – 3-SCH
- Probability, distributions, confidence intervals, hypothesis, regression, propagation of uncertainty, SPC

Numerical Methods – 3-SCH
- Root finding, integration, solving ODEs, linear algebraic systems

Optimization – 3-SCH
- Multivariable, nonlinear, constrained

Engineering Sciences – 20-SCH

Computer Programming – 2-SCH

Statics – 3-SCH

Thermodynamics I – 3-SCH

Solid and Particle Dynamics – 3-SCH

Fluid Dynamics – 3-SCH
- Bernoulli's, flow measurement, pumps

Electrical Circuits – 3-SCH
- dc and ac L-R-C analysis

Process Material and Energy Balances – 3-SCH

Technology – 6-SCH

Computer Course – 2-SCH
- Hardware - solid state electronic devices, internal functions, A/D, and D/A
- Software - operating system, digital communication protocol, wireless
- Logic devices - PC, DCS, PLC
- Strong emphasis on digital communications concepts
- Digital communications applications to field communications and system
- System integration programming

Instrumentation Course – 2-SCH
- Sensor principles, transducers, signals, calibration, final elements, device dynamics

Devices Course (Lab II) – 2-SCH
- Pneumatics, hydraulics, transmitters, wireless, etc.

Control System Engineering – 29-SCH

Seminars – 4-SCH
- Freshman, Sophomore, Junior, and Senior years
- Retention, advising, skill make-up, software training, preparation for next stage of curriculum, human effectiveness training, preparation for recruiting and jobs, understanding of educational objectives

Basics Implementation (Lab I) – 2-SCH
- Calibration, instruments, actuators, robotic and process dynamics, HMI
- Infused with practical issues
- Lecture and lab
- Emphasis on people effectiveness, teams, oral and written reports

Modeling and Control I – 3-SCH
- SISO, linear, standard algorithms
- Mechanical, electrical, process
- Batch stages and continuous
- Laplace discrete and ARMA models
- Symbology and communication
- Stages of operation and transitions

Modeling and Control II – 3-SCH
- MIMO and nonlinear algorithms
- Overrides, real-time algorithms with interrupts and priorities
- Robots, electronic, and process
- Inferential models
- Fuzzy, neural net, first principles models

Modeling and Control III – 3-SCH
- Model predictive, optimal, coordinated, supervisory levels
- Quality management, SPC, 6-sigma
- Perception, vision, failure detection
- Validation

System Reliability/Security/Safety – 3-SCH
- Analysis of vulnerability and risk, prevention systems, fault tolerance, and codes and standards for systems and products

System Dynamics and Simulation – 3-SCH
- Complex systems with real-world behaviors: chemical, manufacturing, heat, aero, economic, drying, batch, robots, stochastic, etc.
- Phenomenological and empirical modeling

Knowledge Engineering – 3-SCH
- Health and condition monitoring, perception, learning systems, data mining, autonomy, database management

Capstone Implementation (Lab III) – 2-SCH
- Design, implementation, tuning, performance analysis of control systems
- Infused with practical issues
- Lecture and lab
- Emphasis on people effectiveness, teams, oral and written reports

Capstone Control System Design – 3-SCH
- Paper project
- Practical issues: simulation of strategy effectiveness, sizing devices, reliability, costs, operator training, etc.
- Emphasis on Project Management: people effectiveness, teams, oral and written reports, economic assessments, planning

Sample Course Schedule

SCH	Fall Year 1	SCH	Spring Year 1
4	Calculus I	3	Calculus II
4	Chemistry I	4	Chemistry II
2	Engineering Programming	3	Statistics
3	Thermodynamics	3	Fluid Dynamics
3	Composition I	3	Humanity/Social Science 1
1	Seminar		
17	**Total**	**16**	**Total**

SCH	Fall Year 2	SCH	Spring Year 2
3	Calculus III	3	Linear Algebra
3	ODEs	4	Physics II
4	Physics I	3	Probability and Statistics
2	Instrumentation	3	Process Material and Energy Balances
3	Solid Dynamics	3	Electrical Circuits
1	Seminar		
16	**Total**	**16**	**Total**

SCH	Fall Year 3	SCH	Spring Year 3
3	Numerical Methods	3	Optimization
3	Modeling and Control I	3	System Dynamics & Simulation
3	Science Elective	2	Automation Lab I (sensors, calibration)
3	Humanity/Social Science 2	3	Composition II/Tech writing/Speech
3	History/Political Science/Government	3	Science Elective
1	Seminar	3	Modeling and Control II
16	**Total**	**17**	**Total**

SCH	Fall Year 4	SCH	Spring Year 4
2	Automation Lab II (devices)	3	System Design Capstone (paper)
3	Professional Elective 1	2	Automation Lab III (system design)
3	Modeling and Control III	3	Knowledge Engineering
3	History/Political Science/Government	3	Humanity/Social Science 4
3	Humanity/Social Science 3	3	Business/Legal/Global
2	Computers	3	Professional Elective 2
1	Seminar		
17	**Total**	**17**	**Total**

Shaded Courses = automation engineering courses

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For more information contact ISA at **(919) 549-8411**
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