

AC 2010-216: DEVELOPMENT OF NANOTECHNOLOGY AND POWER SYSTEMS OPTIONS FOR AN ON-LINE BSEET DEGREE

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Development of Nanotechnology and Power Systems Concentrations for an On-line BSEET Degree

Abstract

According to a report titled “Workforce Planning for Public Power Utilities: Ensuring Resources to Meet Projected Needs”, published by the American Public Power Association (APPA) in 2005, the electric utility industry is faced with an aging workforce and the potential retirements of a large percentage of its employee base. A large number of electric utilities believe that as a result of the anticipated retirements over the next five years, the loss of critical knowledge will be their biggest problem. This problem is augmented by the fact that the newest engineers and technologists often do not have an academic background that emphasized electrical power systems and they may find themselves thrust into situations for which they are unprepared.

Nanotechnology has been identified as an important new growth area for industry, government, and the education community, embraced by both the public and private sectors. Yet, an abiding impediment to its progress is the dearth of trained practitioners. Engineering teams composed of engineers, technologists, and technicians, typically support experimentation, fabrication, and testing in the nanotechnology arena. There are recognized shortages of these skill levels, and the problem threatens to become more acute as time goes on.

Excelsior College, a well known distance learning higher education institution, has recently started developing nanotechnology and power systems concentrations in its on-line Bachelor of Science in Electrical Engineering Technology Program (BSEET). In addition to the electronics concentration which already exists in the BSEET Program, students will have the option of a 15 credit-hour concentration in nanotechnology or power systems. All the courses in either concentration will be taught on-line. In each of these concentrations, students will be required to complete five on-line 3 credit-hour upper division courses. Two of them will include on-line laboratories.

The Excelsior College’s nanotechnology and power systems concentrations will address the technical workforce shortage in the disciplinary areas of nanotechnology and electrical power systems by providing education and training at the undergraduate level to the technicians and the technologists. The program will be geared to adult learners, and features distance delivery of courses including laboratories, as well as opportunities for assessment of the current level of students’ proficiency for course credit.

This manuscript focuses on a description of the development of nanotechnology and power systems concentrations within the on-line BSEET Program offered by Excelsior College. The manuscript describes several issues to be dealt with during the development of completely on-line nanotechnology and power systems concentrations. One of the important issues is the development of on-line laboratories in different topical areas of nanotechnology and power systems. The manuscript provides information regarding the on-line curriculum development strategy used by Excelsior College to address the above mentioned issues. In addition, the manuscript describes the innovative on-line/web-based course development model used by

Excelsior College. This course model combines virtual reality, graphics, text, and sound. The model features multidisciplinary perspective and it is designed specifically to meet the learning needs of working adults.

Introduction

Nanotechnology is the creation of functional materials, devices, and systems through control of matter on the nanometer length scale and the exploitation of novel properties and phenomena developed at that scale. Nanotechnology holds singular promise to revolutionize science, engineering, and technology. It already has significant impact in countless industries including communications, medicine, environmental cleanup, agriculture, and more. Innovative materials, components, and systems based on nanotechnologies are recognized as promising growth innovators for the years to come. It is expected that eventually nanotechnologies will merge into a nanotechnology cluster offering a complete range of functionalities in formation, energy, construction, environmental, and biomedical domains [1].

Nanotechnology as a unified discipline has started receiving much attention after the establishment of the National Nanotechnology Initiative (NNI) in early 2000. This major initiative resulted in significant funding for research in nanoscience and technology in the USA through a number of government agencies led by the National Science Foundation (NSF). The NSF has also helped establishing nanoscience and engineering research centers at several universities across the USA [2]. The university-based research is now generating significant intellectual property (IP) which is the basis for new startup ventures. In addition, many well established large, medium, and small companies are actively engaged in nanotechnology research and development.

The numerous developments in the emerging field of nanotechnology and the potential for more in the future underscore a need for educating the future technical workforce in nanoscience and technology. It is necessary that science and technology graduates develop a good understanding of this rapidly developing technology. They should be able to integrate the key concepts of nanotechnology into their knowledge bases. Academic programs in nanotechnology should be interdisciplinary in nature and need to include several academic disciplines such as materials science, chemistry, biology, physics, and electronics.

Realizing the need for providing nanotechnology education and training at the undergraduate level to technicians and engineering technologists, Excelsior College has recently started developing a Nanotechnology Concentration within its on-line Bachelor of Science in Electrical Engineering Technology Program (BSEET). Students will have the option of a 15 credit-hour concentration in either electronics, power systems, or nanotechnology. In the nanotechnology concentration, students will be required to complete five on-line 3 credit-hour upper division courses. Two of them will include on-line labs.

Excelsior College's BSEET Nanotechnology Concentration will address the shortage of skilled workers in the emerging field of nanotechnology by providing education and training at the undergraduate level to technicians and engineering technologist members of the nanotech skills spectrum. This concentration will be geared to the training needs of adult learners and it will feature distance delivery of courses including laboratories.

There are similarly pressing reasons for establishing a power systems option. Just as oil is refined into gasoline, energy sources such as natural gas must undergo a conversion process to make electrical power. Improvements to electrical energy systems will drive the next revolution in generating, transmitting, and using electrical power, thus raising standards of living and better serving the environment. Electrical power makes the modern world run. Yet it is faced with new and unprecedented challenges.

Electrical power engineering technology deals with electrical power systems, electrical machines, power system protection, power electronics, power quality issues, alternate/renewable energy, and electrical system design. As in all modern enterprises, digital computers are used to control and coordinate electrical generation, transmission, and distribution, as well as motors and other electrical loads. Of particular importance is power electronics which is used to process electrical power into more usable forms for lighter, smaller, and more efficient power systems.

Electrical utility planning, design, and operation departments require a staff of engineers with a wide range of power systems skills to deal with systems that continue to grow in size and complexity. This engineering workforce need stems from the deployment of new and advanced technologies, changing customer expectations, and the addition of new services being offered by electric utilities.

Besides the electric utility industry, the manufacturers of electrical systems and machines need electrical power engineers/technologists who are able to design the electrical machines, power electronic devices, and electrical protection systems required to power homes, businesses, and industries.

The Structure of the Options

With the advancement of the Internet, on-line instruction is becoming popular in engineering education [3]. Traditional and non-traditional colleges and universities are now using a variety of instruction tools to deliver on-line instruction to their students. WebCT is an on-line tool that facilitates the development of web-based educational environments. In the case of Excelsior College, delivery of instruction is achieved primarily through the use of WebCT distance learning tool. The key features of WebCT are listed in [4] and [5].

The curriculum for Bachelor of Science in Electrical Engineering Technology (with concentrations in electronics, power systems, and nanotechnology) being developed by Excelsior

College is presented in Figure 1. This undergraduate degree program requires 124 semester hours of credit including 60 credit hours in Arts and Sciences.

The key advantage of offering on-line nanotechnology and power systems courses will be a virtual classroom that is available anywhere: at school, at work, at home, or even on a trip. In addition to the geographic and temporal independence, the on-line nanotechnology courses being developed by Excelsior College will be of significant help in enhancing the communication skills of students. The students taking these courses will be able to communicate both synchronously and asynchronously using web-based electronic mail, chat rooms, and electronic whiteboards.

As mentioned before, the planned Nanotechnology Concentration comprises five on-line upper level undergraduate courses which include:

- Introduction to Nanotechnology
- Basic Nanofabrication Process
- Nanotechnology Process Equipment
- Introduction to Nanofabrication Manufacturing Technology
- Micro-electro-mechanical systems (MEMS)

The five courses of the Power Systems Concentration are as follows:

- Programmable Logic Controllers
- Instrumentation and Data Acquisition
- Electrical Machines
- Generation and Transmission of Electric Power
- Power Electronics

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING TECHNOLOGY

Total Degree Credits Required: 124

ARTS AND SCIENCES COMPONENT

ELECTRONICS ENGINEERING TECHNOLOGY COMPONENT

Credit Hours

Communications (must include 3-credit Written English Requirement)	9
Ethics	3
Social Sciences/History	6
Humanities and Social Sciences/History Electives	6
Mathematics and Natural Sciences	
• Mathematics (at least 12 credits at the Level of College Algebra And above to include Calculus I and II and Differential Equations)	24
• Natural Sciences (must include Physics I And Physics II at least One physics lab)	
Arts and Sciences Electives	12
Total Arts and Sciences Component	60
Free Elective Component	6
Information Literacy	1
Technology Electives	12
TOTAL DEGREE CREDITS	124

Core Requirements

- DC Circuits (LL)
- AC Circuits (LL)
- Electronics I (LL)
- Electronics II (LL)
- Digital Electronics (LL)
- Microprocessors I (LL)
- Computer Programming (LL/UL)
- Project Management (UL)
- Integrated Technology Assessment (UL)
- 3 Labs from the following DC Circuits, AC Circuits; Electronics I; Electronics II; Digital Electronics; Microprocessors I (all LL)

Total Common Core Component 30

Concentrations

(must choose five courses from the concentration; at least two of the courses must include labs; three out of five Courses must be upper level)

Electronics Concentration

- Electronic Communication
- Advanced Digital Electronics
- Data Communications
- Control Systems
- Microprocessors II

Power Systems Concentration

- Programmable Logic Controllers
- Generation and Transmission of Electric Power*
- Power Electronics*
- Electrical Machines/Energy Conversion*
- Instrumentation and Data Acquisition

Nanotechnology Concentration

- Introduction to Nanotechnology
- Basic Nanofabrication Process
- Nanotechnology Process Equipment
- Introduction to Nanofabrication Manufacturing Technology*
- Micro-electro-mechanical Systems (MEMS)*

Total Concentration Component 15

*= course not developed
 EC offers this as LL = Lower Level
 EC offers this as UL = Upper Level

Figure 1: Bachelor of Science in Electrical Engineering Technology Program with the Electronics, Power Systems, and Nanotechnology Concentrations

Implementation

At Excelsior College, the on-line instruction in nanotechnology is being phased in gradually. At present, two on-line nanotechnology courses have been developed. The first one, titled “Introduction to Nanotechnology” was developed during Spring 2008. This on-line course was offered to the Excelsior College Engineering Technology students during Fall 2008 semester. The second on-line course titled “Basic Nanofabrication Processes” was developed during summer 2009 and will be offered during Spring 2010. Three additional on-line nanotechnology courses will be developed and offered during the 2010 and 2011.

The first on-line nanotechnology core course which was developed at Excelsior College is titled “Introduction to Nanotechnology”. It is a 3 credit-hour on-line course that does not have a lab component. The course is offered at the junior level of a 4-year undergraduate degree. The topical coverage for this course consists of:

- Manipulation of Materials at Nanoscale
- Carbon Nanotubes
- Semiconductor Quantum Dots
- Nanoparticles
- Nanoshells
- Nanobiology Applications
- Nanosensors Applications
- Nanomedicines
- Molecular Nanomachines

Since this is an on-line course, all the students are required to have access to the following computing resources:

- A reasonably up-to-date personal computer that runs Windows 98 or later.
- Availability to MS-Office, especially Word
- Capability to open and display PDF files
- A working and reliable internet connection with a current Web Browser.

The second on-line nanotechnology course developed at Excelsior College is titled “Introduction to Nanofabrication Processes” (ELEC 310). This 4 credit-hour course provides an introduction and basic understanding of the fundamental principles of nanofabrication processes used in industrial and research applications of nanotechnology. This course describes the industrial scaling of nanofabrication techniques and showcases examples of specific industrial applications in electronics, photonics, chemistry, biology, medicine, defense, and energy.

The course descriptions for the other three courses included in the on-line Nanotechnology Concentration within the BSEET Degree Program are as follows:

Nanotechnology Process Equipment:

This course is intended to provide a description and understanding of the equipment used in nanofabrication processes at the manufacturing level as well as at the research and development stages. Nanotechnology, 300-mm wafer processing, “Green” processes and devices, new fabrication advances, as well as non-vacuum processing tools will be discussed. Examples of equipment used in applications for micro/nanoelectronics and photovoltaics processing will be presented.

Introduction to Nanofabrication Manufacturing Technology:

This course provides an introduction to the fundamentals of Nanofabrication Manufacturing Technology (NMT). Students will learn the basic concepts of NMT and then study its applications.

Micro-electro-mechanical Systems:

This course focuses on MEMS and NEMS. Topical coverage includes MEMS and NEMS architecture, synthesis, modeling, and control.

The Nanotechnology Concentration within the Excelsior College’s BSEET Degree Program will be gradually phased in. At present, the two nanotechnology courses which have already been developed do not have an on-line lab component. However, courses titled “Introduction to Nanofabrication Manufacturing Technology” and “MEMS” will include on-line lab components. The lab experiences in these two courses will be provided through use of on-line simulation techniques.

The Power Systems Concentration is outlined in Figure 1. This concentration will provide students with a high quality applications-oriented undergraduate education covering the topical areas of power electronics, rotating machinery, programmable logic controllers, and power generation, transmission, and distribution. The Power Systems Concentration is following a similar development trajectory for implementation, with the gradual introduction of optional courses augmenting the same core curriculum as the Electrical Engineering Technology Program. This concentration also benefits from courses and other resources from the college’s Nuclear Engineering Technology program, which currently has over 600 enrolled students.

The course descriptions for the five Power Systems Concentration courses are as follows:

Virtual Instrumentation and Data Acquisition:

This course provides an introduction to virtual instrumentation and data acquisition. Topics covered include virtual instruments, sub virtual instruments, structures, and data acquisition.

Electrical Machines and Energy Conversion:

Topics covered include energy storage and conversion, force and emf production, electromagnetic induction, transformers, and generators. Performance characteristics of DC, induction, and synchronous machines will be studied. Stepper motor and brushless DC machines will also be covered in this course.

Programmable Logic Controllers:

Introduces students to programmable logic controllers (PLCs) and their applications. Topics include PLC programming, troubleshooting, networking, and industrial applications.

Generation and Transmission of Electric Power:

This course focuses on electric power generation and transmission systems. Topics covered include power flow, economic scheduling of electric power generation, transmission operations, and power systems faults.

Power Electronics:

This course covers principles of operation of power semiconductor devices such as Thyristors and IGBTs. Also covers fundamentals of power converter circuits including DC/DC converters, phase controlled AC/DC rectifiers, and DC/AC inverters.

As with all engineering technology curricula, the laboratory experiences are extremely important. Most of the fundamental lab techniques are introduced as a part of the core curriculum. The Excelsior College policy on laboratory instruction is the same for all three concentrations, Electronics, Nanotechnology, and Power Systems. It holds that on-line laboratories using such courseware as MultiSIM, NI Circuit Design Suite-Package, LABVIEW, MATLAB, LogixPro, and Xilinx can be used in courses taken at Excelsior or transferred in from elsewhere, provided that two traditional hands-on Laboratory courses are a part of the student's background. This two-non-virtual-lab rule is waived only if the student can demonstrate that he or she has sufficient hands-on experience, typically through employment.

One of the key issues during the development of these on-line web based concentrations is the use of an appropriate software tool for the development and delivery of on-line instruction. This issue is addressed through the use of WebCT which facilitates the creation of a web-based educational environment. Another key issue is the assessment of the quality of course content. This issue is addressed through the use of an appropriate course evaluation instrument. Course attributes such as the clarity of course overview/introduction and learning outcomes, quality of course resources and materials, the availability of adequate technology for the delivery of instruction, the infrastructure for learner support, the potential of the course for facilitating learner engagement in class activities, and the accessibility features of the course are scored to assess the quality of a course.

Conclusion

Two of the most compelling specialties in technology education in recent times are nanotechnology and power systems. The promise of nanotechnology is that new materials and devices with previously unanticipated beneficial properties can be applied for the common good. The older specialty of power systems has recently taken on new importance with the growing awareness of the need for conservation and a greener environment.

Excelsior College has positioned itself to leverage several existing advantages in these specialties. The college is located in the Hudson Valley of New York, home to General Electric, IBM, the State University at Albany and soon, a new plant of the AMD Corporation, all players in the nascent nanotech revolution. As for Power, the institution has a thriving Nuclear Engineering Technology program with particularly close ties to the nuclear industry, which is of course an important component of utility power generation. And finally, Excelsior has a long tradition of fashioning programs that are particularly relevant to the adult learner, including those who desire to transition to new and important fields of endeavor. Taken together, these advantages are propelling the college to make nanotechnology and power well-established offerings for engineering technologists.

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