

# **AC 2007-2773: IDENTIFYING THE CONTENT OF A GENERAL ENGINEERING PROGRAM USING BENCHMARKING AND THE FUNDAMENTALS OF ENGINEERING EXAMINATION**

## **Stephanie Sullivan, East Carolina University**

Stephanie Sullivan is a Visiting Instructor in the Department of Engineering at East Carolina University. Sullivan has fourteen years of industrial experience in project engineering, quality operations, and operations planning roles. She received her B.S. in Mechanical Engineering from the University of Notre Dame and her M.S. in Chemical Engineering from North Carolina State University. Sullivan has earned the American Production & Inventory Control Society (APICS) Certification in Production and Inventory Management (CPIM) and is currently a doctoral student in the Department of Chemical & Biomolecular Engineering at North Carolina State University.

## **Rick Williams, East Carolina University**

Rick Williams is an Assistant Professor of Engineering at East Carolina University. Prior to joining ECU, he was a faculty member and Associate Research Professor at Auburn University. Williams has sixteen years of industrial experience in design and project engineering functions. He received BS and MS degrees from Georgia Tech, and his PhD degree from Auburn University. Williams is a registered Professional Engineer in Virginia.

## **William Howard, East Carolina University**

William E.(Ed) Howard is an Assistant Professor of Engineering at East Carolina University. Prior to joining ECU, he was a faculty member and program coordinator at Milwaukee School of Engineering. Howard has fourteen years of industrial experience in design and project engineering functions. He received BS and MS degrees from Virginia Tech, and his PhD from Marquette University. Howard is a registered Professional Engineer in Wisconsin.

## **Jason Yao, East Carolina University**

Jianchu (Jason) Yao received a B.S. and M.S. degrees in electrical engineering from Shaanxi university of Science and Technology, China, in 1992 and 1995, respectively, and the Ph.D. degree in electrical engineering from Kansas State University in 2005. Dr. Yao joined East Carolina University as an Assistant Professor in August, 2005. Prior to this appointment, he served as a Research Engineer in China from 1995 to 2001. His research interests include wearable medical devices, telehealthcare, bioinstrumentation, control systems, and biosignal processing. His educational research interests are laboratory/project-driven learning and integration of research into undergraduate education. Dr. Yao is a member of the American Society of Engineering Education.

## **Paul Kauffmann, East Carolina University**

Paul J. Kauffmann is Professor and Chair in the Department of Engineering at East Carolina University. His industry career included positions as Plant Manager and Engineering Director. Dr. Kauffmann received a BS degree in Electrical Engineering and MENG in Mechanical Engineering from Virginia Tech. He received his Ph.D. in Industrial Engineering from Penn State and is a registered Professional Engineer.

# Identifying the content of an Engineering program using benchmarking and the Fundamentals of Engineering examination

## Abstract

Several studies related to the future of engineering and engineering practice have highlighted the importance of broad engineering skills such as those targeted by General Engineering programs. However, identification of the curricular content for general engineering is still evolving. In the Fall of 2004, a new Engineering program was initiated in a large state university which aims to support a diverse group of constituencies ranging from traditional design, engineering and production companies, biopharmaceutical and bioprocess manufacturing, and biomedical interests (complementing the university's medical school). This paper describes the process pursued to identify the core courses of this multidisciplinary program, receiving recommendations and ultimate consensus from the advisory board, industry representatives, and the new department's academic and industrial experienced faculty. A critical tool to build this consensus was the mapping of the core curriculum to the Fundamentals of Engineering (FE) examination to ensure that students will be prepared to succeed in that recognized engineering benchmark.

## Introduction

In the engineering profession and education over the past fifty years, a lot has changed, and a lot has stayed the same, depending upon the viewpoint and application of the term. Definitions for the terms "engineer" and "engineering" can be found in Table 1 for both the year 1956 and 2006. The 2006 definition of "engineer" includes the first 1956 definition of "a designer and constructor of engines." Of most interest may be the expansion from the 1956 "applied science" to the 2006 "application of science and mathematics" as well as references to biological (genetic engineering) and computational (software engineering) components. As "scientific and engineering knowledge...doubles every 10 years"<sup>1</sup>, what is included in the definitive sphere of engineering thus continues to expand.

The concept of engineering and approaches to its teaching is in 2006 the subject of many publications such as the *Journal of Engineering Education*, the *International Journal of Engineering Education*, and the *Engineering Management Journal*. Recent National Academy of Engineering publications titled *The Engineer of 2020* and *Educating the Engineer of 2020* discuss the future of engineering and the direction engineering education should proceed. *The Engineer of 2020* "designs devices, components, subsystems and systems and, to create a successful design, in the sense that it leads directly or indirectly to an improvement in our quality of life, must work within the constraints provided by technical, economic, business, political, social and ethical issues."<sup>2</sup> Elements of this definition of *The Engineer of 2020* are found in the dictionary definitions given in Table 1 such that both science and math are applied to an end result "useful to people" and "supplying human needs".

The ultimate goal of an engineering curriculum is to produce engineers that can contribute to the profession and society in agreement with such past and present definitions and the vision of *The*

*Engineer of 2020.* Professionals who graduate with engineering degrees of any discipline may directly use their undergraduate technical knowledge as well as use, in more general terms, their engineering problem solving approaches in many fields. Today’s engineers work in traditional as well as non-traditional fields perceived completely different from any design theory studied in the classroom. Many industries, from mainstream business and consulting to design and manufacturing, desire to hire engineers for their learned way of thinking and ability to apply available resources to improve quality of product, service and thus human life. A well-rounded engineer, with effective technical knowledge and analytical skills as well as effective soft skills – writing, presentation and interpersonal skills – is a gem to employers of 2006 and to the vision for 2020.

*Table 1. Definition of engineer and engineering in 1956 and 2006.*

	1956 <sup>3</sup>	2006 <sup>4</sup>
engineer (n).	<ol style="list-style-type: none"> <li>1. a designer or constructor of engines.</li> <li>2. <i>mil. naval.</i> one of a corps of men who perform engineering work, as in building forts, bridges, etc.</li> <li>3. one versed in or who follows as a calling any branch of engineering.</li> <li>4. one who operates an engine</li> <li>5. <i>colloq</i> one who skillfully manages or carries through some enterprise.</li> </ol>	<ol style="list-style-type: none"> <li>1. a member of a military group devoted to engineering work</li> <li>2. <i>obsolete</i> : a crafty schemer : PLOTTER</li> <li>3. a : a designer or builder of engines b : a person who is trained in or follows as a profession a branch of engineering c : a person who carries through an enterprise by skillful or artful contrivance</li> <li>4. a person who runs or supervises an engine or an apparatus</li> </ol>
engineer (v).	<ol style="list-style-type: none"> <li>1. to lay out, construct or manage as an engineer</li> <li>2. to guide the course of; to manage as, to engineer a bill through Congress</li> </ol>	<ol style="list-style-type: none"> <li>1. to lay out, construct, or manage as an engineer &lt;engineer a bridge&gt;</li> <li>2. a : to contrive or plan out usually with more or less subtle skill and craft &lt;engineer a business deal&gt; b : to guide the course of &lt;engineer a rally&gt;</li> <li>3. to modify or produce by genetic engineering &lt;corn engineered to resist crop pests&gt;</li> </ol>
engineering	<ol style="list-style-type: none"> <li>1. originally, the art of managing engines.</li> <li>2. applied science concerned with utilizing inorganic products of earth, properties of matter, sources of power in nature, and physical forces for supplying human needs in the form of structures, machines, manufactured products, precision instruments, industrial organizations, the means of lighting, heating, refrigeration, communication, transportation, sanitation, and public safety and other productive work.</li> <li>3. maneuvering; contriving.</li> </ol>	<ol style="list-style-type: none"> <li>1. the activities or function of an engineer</li> <li>2. a : the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people b : the design and manufacture of complex products &lt;software engineering&gt;</li> <li>3. calculated manipulation or direction (as of behavior) &lt;social engineering&gt;</li> </ol>

Each university that offers an engineering program, college and/or department may express its own mission and/or definition of engineering. Unique to many schools are ABET-accredited Engineering and General Engineering programs that are by definition non-specific. In other words, the multidisciplinary nature of these programs provides a student with a more broad education than do civil, mechanical, chemical, industrial, electrical or other specific engineering disciplines. Such programs in the United States currently number approximately 34.<sup>5</sup> Such a

general engineering program aims to meet the needs of industry searching for those well-rounded engineering gems – diamonds in the rough to polish and train to lead their companies.

In 2004, a new general engineering program was initiated at East Carolina University (ECU) in Greenville, North Carolina, part of the University of North Carolina system, in order to create such gems. ECU Engineering multidisciplinary faculty have implemented this by working together to achieve consensus on a common core of engineering curricula which maps to the Fundamentals of Engineering (FE) Exam, the first step towards professional engineering certification. Along the way in addition to the general engineering core curriculum, the students do have an opportunity to select one of four concentrations or areas of interest specific to them, topped off with two semesters of senior capstone design in which they will work with each other as cross-functional teams to solve pertinent engineering problems.

Throughout this program starting in the freshman year, students develop presentation and technical writing skills as well as teamwork skills. Students studying engineering at East Carolina University will not just be technically proficient, but also excel in “identifying customer needs, developing a comprehensive business case for technology, analyzing problems from a systems perspective, and solving the customer’s core problem rather than just superficial parts of it.”<sup>6</sup> The National Academy of Engineering reports that engineering education must include “buyer-centric business strategy that combines mass customerization with customized marketing”<sup>1</sup> that is key to the global economy. The success of engineers produced in the United States will depend on what “additional value” they can bring over cheaper engineering labor worldwide; engineers must be able to work in teams that possess<sup>1</sup>

- excellence in communication with both technical and public audiences
- ability to communicate using technology and
- understanding of complexity associated with global market and social context

The expected result is a well-rounded engineer with those industry-valued attributes – technical as well as communication skills and the proven ability to work in teams.

### **New Program Development**

Initial program development was highlighted in 2004 conference proceedings by Kauffmann et al.<sup>7</sup> Figure 1 shows the conceptual architecture presented at the time, with Integrated Collaborative Engineering Environment (ICEE) courses being designated as the core curricula, followed by concentration courses. Nucleated in the ECU College of Technology and Computer Science, this new engineering program will graduate its first class of engineers in 2008 with a Bachelor of Science in Engineering degree with a concentration in Systems Engineering, with a second class concentrating in Systems Engineering finishing in 2009. The third class, which entered as freshmen in 2006, will have three concentration options, followed by the addition of a fourth option for 2011 graduates. This timeline is outlined in Figure 2.

The four concentrations of the BSE curricula - Systems Engineering (SYSE), Engineering Management (ENMA), Bioprocess Engineering (BIOE), and Biomedical Engineering (BME) – encompass what *The Engineer of 2020* lists as six “breakthrough technologies”<sup>2</sup> that are at the

forefront of engineering activities in research and industry. They are Biotechnology (BIOE/BME), Nanotechnology (SYSE/BIOE/BME), Materials Science & Photonics (SYSE/BIOE/BME), Information & Communications Technology (SYSE/ENMA), Information Explosion (SYSE/ENMA), and Logistics (SYSE/ENMA). ECU Engineers are expected to be able to support these technologies into the future.

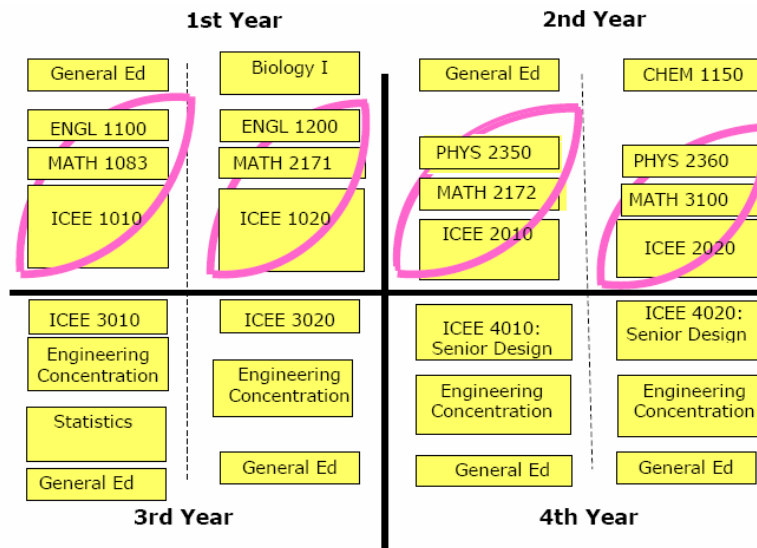


Figure 1. Conceptual architecture of BS in Engineering curricula.<sup>7</sup>

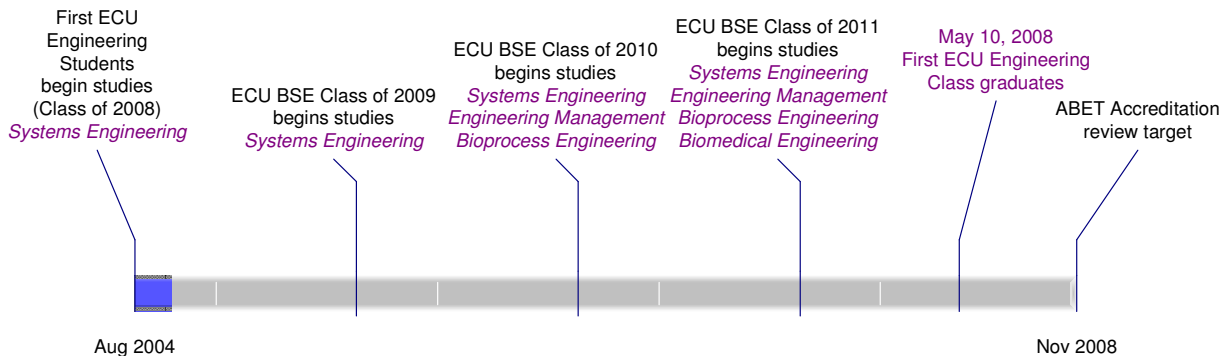


Figure 2. Concentration timeline and corresponding graduating classes.

Since the beginning of the Engineering program offerings, the curriculum has changed as faculty learned best approaches to courses. Figures 3(a) and (b) present the Systems Engineering curriculum from the initial requirements for the Class of 2008 (start Fall 2004) to those required for the Class of 2011. Table 2 outlines the changes that have evolved since the beginning of the program. One primary change from the initial program plan to that for students entering in Fall 2007 will be the subsequent split of the freshman and sophomore six credit hour courses in

Integrated Collaborative Engineering. In theory, students in these classes were to jump right in and get a feel for engineering igniting the “fire in the belly” in order to better retain students<sup>8</sup>. However, the courses were found to be structurally difficult to administer and inherently unfair to students who discover that engineering is not for them. The high number of credit hours means that most students cannot drop the course without falling below full-time status, and a poor grade in this course has a major impact on the student’s grade average. Students will still get an introduction to engineering, as shown in Figure 3b and Table 2, but topic areas are limited to those thought to better target retention and enable better timing of subject matter presentation. These changes also allow a more focused introductory year to the curricula and better math preparation for some topic areas previously included in the freshman year.

Additional curriculum analysis that follows here supports these conclusions as well. For example, the topic of Engineering Entrepreneurship, or also known as Engineering Economics in other traditional programs, will be removed from the freshman year second semester six (6) credit hour course ICEE 1020 and replaced in a stand alone course later in the program. So, as the new program progresses, faculty are continuously evaluating the successes and less desirable attributes and making continuous improvements as determined, by both faculty consensus and from advisement of industry and ABET experts internally and externally, to be best for the program.

Additional Department of Engineering activities to further enhance the curriculum have included the formation of an Industry Advisory Board as required by ABET. This board consists primarily of representatives from industry located in the state of North Carolina, as the creation of the Engineering program at ECU was intended for the economic development of the region.<sup>7</sup> To this board in the Fall of 2006, curriculum assessment data contained in the next section was presented that showed benchmark evaluation of the ECU Engineering curriculum to the FE examination. The new ECU Engineering program is offering curriculum in line with topic areas covered by the FE examination as shown by this data.

In addition to other vital activities from the new Department formation, the Fall of 2006 began the development and submission for approval of a Biomedical Engineering concentration. The ECU Brody School of Medicine is growing both in size and success, with US News & World Report rankings in the top ten of all medical schools in the areas of primary care, family medicine and rural medicine<sup>9</sup>. Also, as an example of growth, Brody just added a third surgical robot to its resource team in December 2006<sup>10</sup>. The development of Biomedical Engineering faculty support towards both resulting research collaborations with the medical school as well as resulting undergraduate BSE concentration curricula to produce graduates to support this growing area on the ECU campus is not only natural, but necessary. Similar programs have been developed at Trinity College and LeTourneau University<sup>11</sup>, for example.

New program development efforts initiated with the arrival of new students starting in the Fall of 2004, ongoing curriculum development, and new diverse faculty additions have given this new general engineering program a good start. ECU expects to have an ABET accreditation review in Fall of 2008.

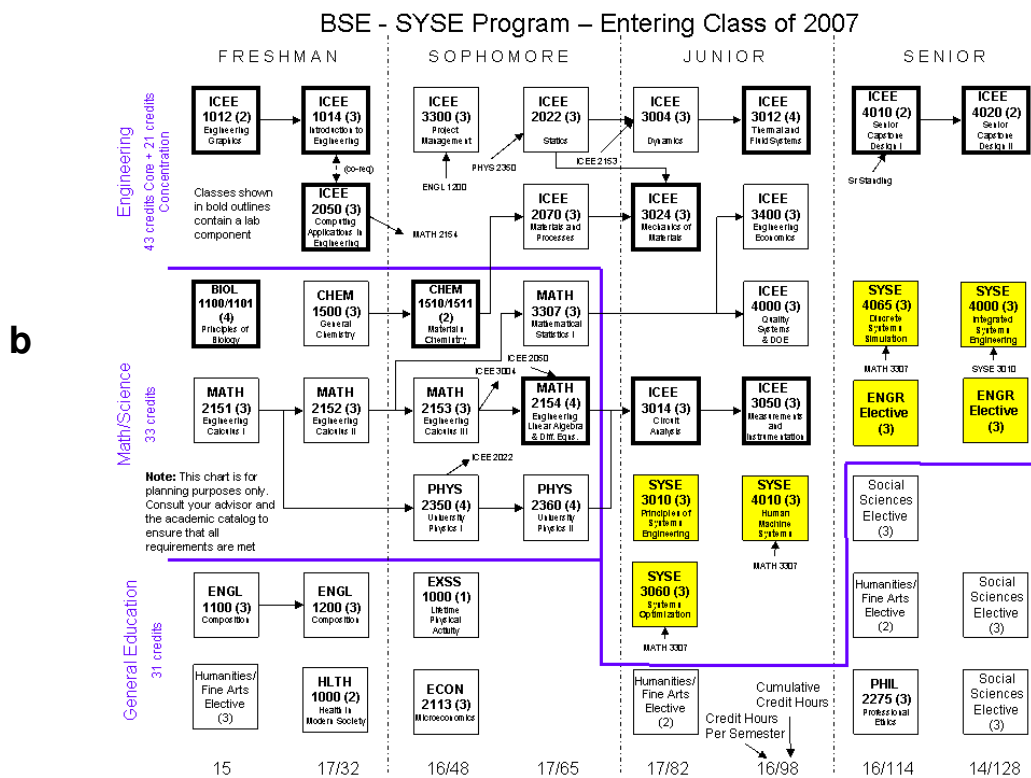
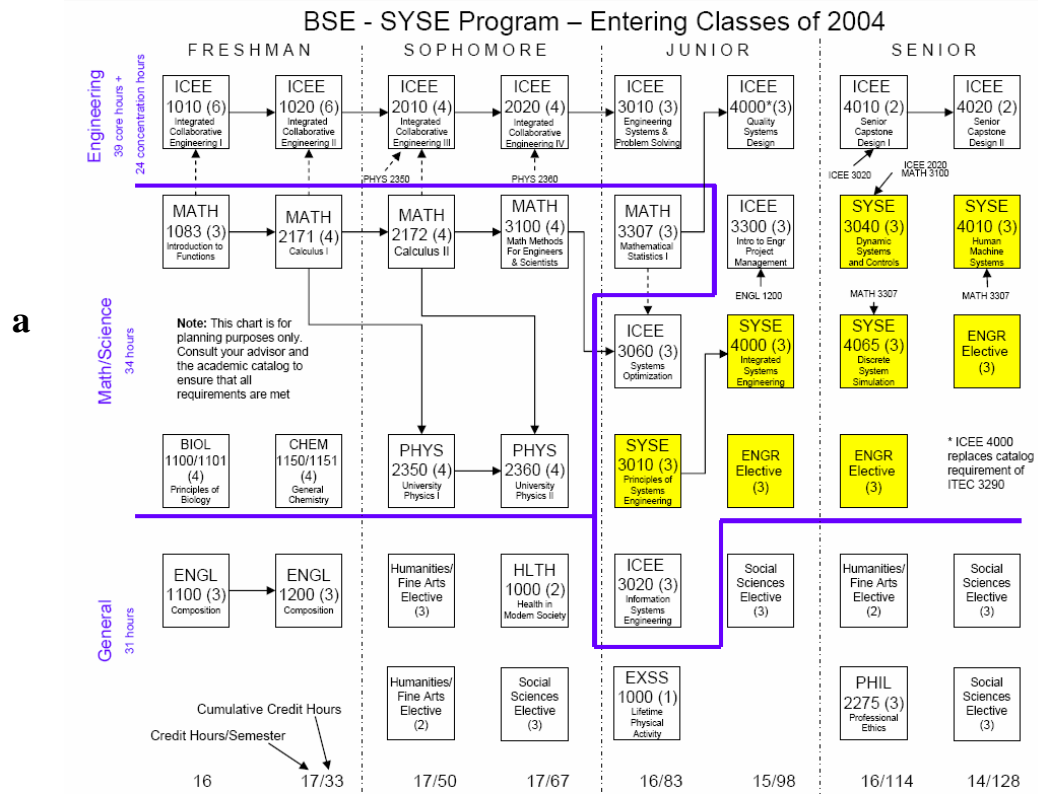
Table 2. Engineering Core (a) and Math/Science Curriculum (b) for ECU Engineering classes entering in years 2004 and 2007.

(a) Engineering Core Curriculum		Class Entering Fall 2004		Class Entering Fall 2007	
		Hours	Hours	Hours	Hours
Freshman	ICEE 1010 Integrated Collaborative Engineering I		6	ICEE 1012 Introduction to Engineering	3
	ICEE 1020 Integrated Collaborative Engineering II		6	ICEE 1014 Engineering Graphics	2
Sophomore	ICEE 2010 Integrated Collaborative Engineering III		4	ICEE 2050 Computing Applications in Eng	3
	ICEE 2020 Integrated Collaborative Engineering IV		4	ICEE 3300 Project Management	3
Junior	ICEE 3010 Engineering Systems & Problem Solving		3	ICEE 2022 Statics	3
	ICEE 3060 Systems Optimization		3	ICEE 2070 Materials and Processes	3
	ICEE 3020 Information Systems Engineering		3	ICEE 3004 Dynamics	3
	ICEE 4000 Quality Systems Design		3	ICEE 3014 Circuit Analysis	3
	ICEE 3300 Introduction to Engr Project Mgmt		3	ICEE 3024 Mechanics of Materials	3
			3	ICEE 4000 Quality Systems Design	3
Senior	ICEE 4010 Senior Capstone Design I		2	ICEE 3050 Measurements & Instrumentation	3
	ICEE 4020 Senior Capstone Design II		2	ICEE 3012 Thermal and Fluid Systems	4
			39	ICEE 3400 Engineering Economics	3
				ICEE 4010 Senior Capstone Design I	2
				ICEE 4020 Senior Capstone Design II	2
Total					43

(b) Math/Science Curriculum		2004/2005		2007	
		Hours	Hours	Hours	Hours
Freshman	MATH 1083 Introduction to Functions		3	BIOL 1100/1101 Principles of Biology	4
	MATH 2171 Calculus I		4	MATH 2171 Calculus I	4
Sophomore	BIOL 1100/1101 Principles of Biology		4	ICEE 2030 Engineering Analysis I	3
	CHEM 1150/1151 General Chemistry		4	CHEM 1500 General Chemistry	3
	MATH 2172 Calculus II		4	ICEE 2040 Engineering Analysis II	3
	MATH 3100 Math Methods for Engineers		4	ICEE 2080 Engineering Analysis III	3
	PHYS 2350 University Physics I		4	PHYS 2350 University Physics I	4
	PHYS 2360 University Physics II		4	PHYS 2360 University Physics II	4
Junior	MATH 3307 Mathematical Statistics I		3	CHEM 1510/1511 Materials Chemistry	2
				ICEE 2060 Engineering Statistics	3
Total			34		33

Figure 3. Bachelor of Science in Engineering Course curricula with Systems Engineering concentration. (a) First Class of 2008 (entering 2004); (b) Class of 2011 (entering 2007).





## Mapping curriculum to the Fundamentals of Engineering Exam

The Fall of 2006 was also pivotal as the Department of Engineering was officially established with its own Chair and the continued hiring of new faculty. A total of twelve full-time faculty members are now members of the Department, with diverse backgrounds in Systems, Mechanical, Electrical, Materials, Biomedical, and Chemical Engineering, and many with industry and military experience. This well-rounded faculty provides a sound foundation upon which to build a general engineering program with the necessary multidisciplinary knowledge.

One primary charter of the new faculty was to establish both a core and the concentration committees so that faculty could begin to focus on further curriculum development and improvement, and to confirm the curricular coverage by mapping it to the Fundamental of Engineering examination topics. An initial study was completed by the faculty Curriculum Core Committee to determine the gaps that exist between the topical coverage of the Fundamentals of Engineering (FE) General Engineering exam and the current ECU engineering curriculum. The approach utilized was to compare the FE topical areas specified within the NCEES Fundamentals of Engineering General Engineering Sample Questions & Solutions book to the individual course syllabi for the courses in the initial ECU Engineering curriculum (classes entering 2004/2005). Table 3 lists the thirteen FE topical areas, the percentage of each topical area on the FE exam, and the course(s) that support the FE material.

*Table 3: FE Topical Area Mapping*

FE Topical Area	Percentage of FE Exam	Supporting Course(s)
Mathematics	12.5	MATH 2171, MATH 2172, ICTN 4501/4505, ICEE 1020
Engineering Probability and Statistics	8	MATH 3307
Chemistry	4.5	CHEM 1150/1151
Computers	3.5	ICEE 1010
Ethics and Business Practices	3.5	PHIL 2275, ICEE 1010
Engineering Economics	9	ICEE 1020
Engineering Mechanics (Statics/Dynamics)	5	ICEE 1020, ICEE 2010
Strength of Materials	10	ICEE 1020
Material Properties	9	ICEE 1020
Fluid Mechanics	11	ICEE 3010
Electricity and Magnetism	10.5	ICEE 2020, PHYS 2360
Thermodynamics and Heat Transfer	11	ICEE 3010
Biology	2.5	BIOL 1100/1101

Figure 4 shows the relative importance of each FE topical area. The percentage represents the cumulative percentage of the FE exam that is covered in each academic year based upon the mapping and percentages shown in Table 3.

The key objective of this initial study was to determine gaps between the FE topical areas and the engineering curriculum. This was accomplished by comparing the topics within each FE topical area to the course objectives from the course syllabi. Two determinations were made:

1. How adequately is the FE material covered in accordance with the objectives listed in the syllabi and;
2. How well do the FE topics map to the course objectives?

Number 1 above was given a rating of green, yellow, red, or blue corresponding to the following:

Green: Topic adequately covered according to course objective(s),  
 Yellow: Topic marginally covered according to course objective(s),  
 Red: Topic inadequately covered according to course objective(s),  
 Blue: Topic highly specific and not recommended for coverage.

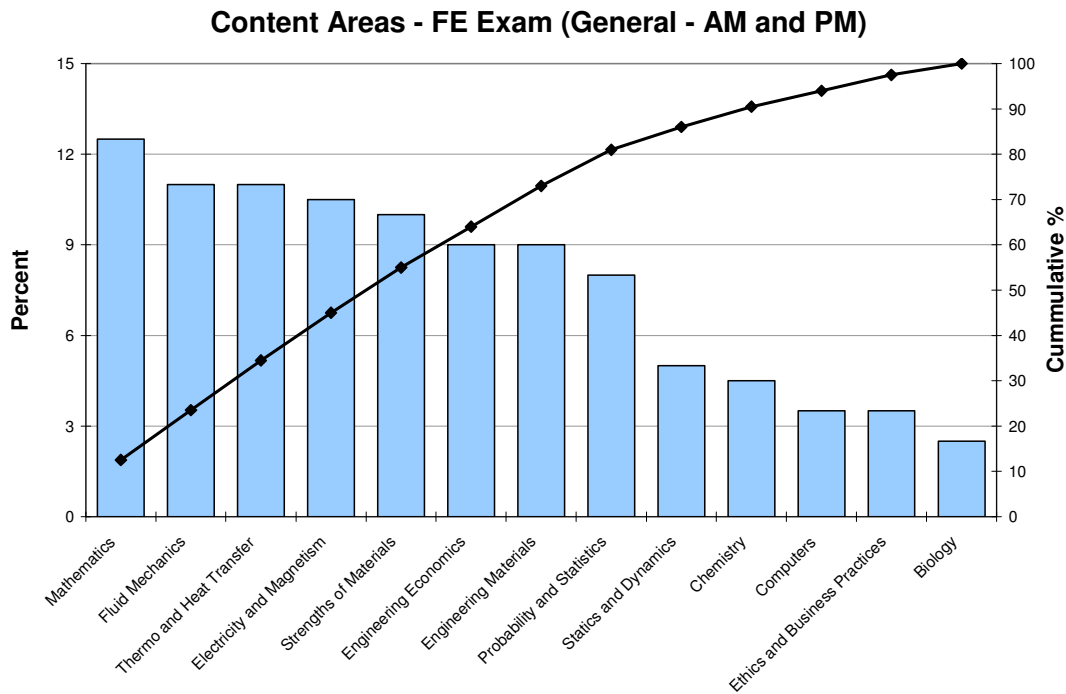


Figure 4: FE Topical Area Coverage by Engineering Program Year

Each FE topic within an FE topical area was given the same weighting. For example, in the fluids FE topical area there are eleven topics and it was assumed that each topic has the same probability of appearing on a given exam. Next, a coverage factor was given to each FE topic as follows: Green, 1.0; Yellow, 0.75; Red, 0.25; and Blue, 0.25. (Since the exam is multiple choice, students have a 25% chance of guessing a correct answer.) The coverage factors were summed and divided by the number of FE topics to represent a quantifiable un-weighted coverage (not accounting for the percentage of the FE topical area on the exam) of the FE topical area, as shown in the following equation:

$$Coverage = \frac{\sum 1.0G + 0.75Y + 0.25R + 0.25B}{\sum Topics}$$

Table 4 summarizes the unweighted coverage for the thirteen topical areas with any unweighted coverage of less than 80% highlighted in red. Using this method it can be concluded that the engineering program is adequately covering 66% of the FE material. However, this method does not account for the weighting of the FE topical areas on the exam.

*Table 4: Unweighted FE Coverage*

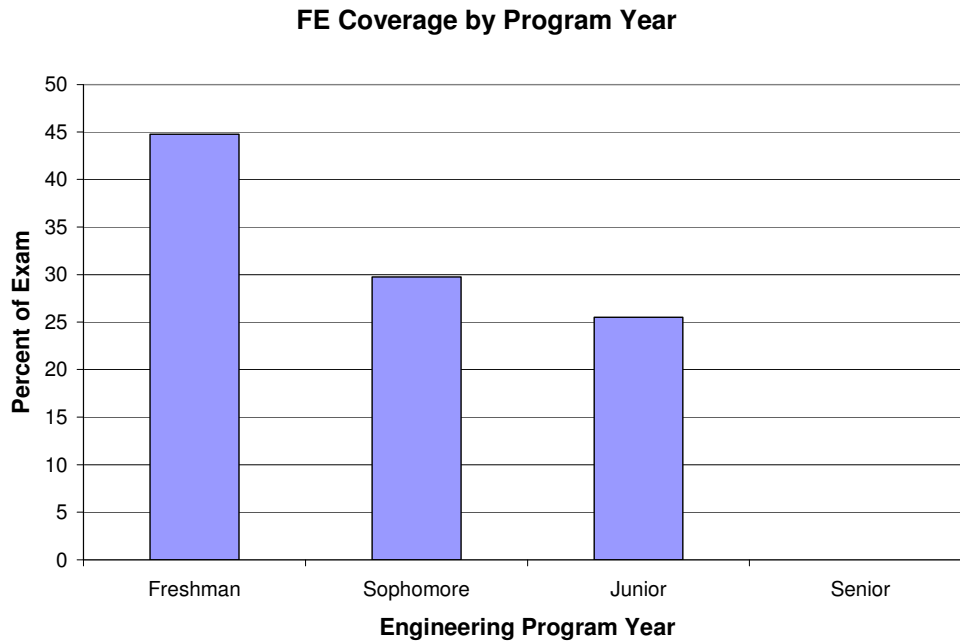
Topical Area	Number of Topics	Number of Green	Number of Yellow	Number of Red	Number of Blue	Un-Weighted Coverage %
Mathematics	9	6	1	2	0	81
Engineering Probability and Statistics	9	3	3	3	0	67
Chemistry	8	6	2	0	0	94
Computers	3	1	0	2	0	50
Ethics and Business Practices	5	1	4	0	0	80
Engineering Economics	7	3	3	1	0	79
Engineering Mechanics (Statics & Dynam	12	7	1	4	0	73
Strengths of Materials	10	5	2	3	0	73
Engineering Materials and Properties	4	0	0	0	0	0
Fluid Mechanics	11	1	2	8	0	41
Electricity and Magnetism	14	12	2	0	0	96
Thermo and Heat Transfer	15	0	5	8	2	42
Biology	4	1	0	3	0	44
<b>Program Total</b>	<b>111</b>	<b>46</b>	<b>25</b>	<b>34</b>	<b>2</b>	<b>66</b>

To account for the FE topical area weighting, the unweighted coverage per Table 4 was multiplied by the percentage of the FE exam per Table 3 to provide a weighted coverage. This weighted coverage represents the exam score we would expect a student of our program to achieve. Table 5 summarizes the weighted coverage and also shows the lost coverage percentage or the areas that the most opportunity for gains exists. Any lost coverage greater than 1.5% is highlighted in red.

*Table 5: Weighted FE Coverage*

Topical Area	Exam %	Unweighted Coverage %	Weighted Coverage %	Lost Coverage %
Mathematics	12.5	81	10.1	2.4
Engineering Probability and Statistics	8.0	67	5.3	2.7
Chemistry	4.5	94	4.2	0.3
Computers	3.5	50	1.8	1.8
Ethics and Business Practices	3.5	80	2.8	0.7
Engineering Economics	9.0	79	7.1	1.9
Engineering Mechanics (Statics and Dynam	5.0	73	3.6	1.4
Strengths of Materials	10.0	73	7.3	2.8
Engineering Materials and Properties	9.0	0	0.0	9.0
Fluid Mechanics	11.0	41	4.5	6.5
Electricity and Magnetism	10.5	96	10.1	0.4
Thermo and Heat Transfer	11.0	42	4.6	6.4
Biology	2.5	44	1.1	1.4
<b>Program Total</b>	<b>100</b>	<b>63</b>	<b>62</b>	<b>38</b>

The location of topical coverage within the curriculum (freshman, sophomore, junior, or senior year) was also studied. Results are shown in Figure 5.



*Figure 5: FE Topical Area Coverage by Engineering Program Year*

Faculty made three general observations from this analysis about the existing program as follows:

- 1) As shown in Figure 5, there is a heavy emphasis of FE material in the freshman year. This raises concerns as there is very little follow-on coverage of the material in the upper-level courses. In addition, freshmen are not prepared for the depth and breadth of engineering material that would be required to adequately prepare them for the FE exam.
- 2) As shown in Table 5, the weighted coverage is not sufficient to ensure a high passing rate on the exam. It is our belief that the engineering program should achieve a weighted coverage of at least 80%, or in general we should not allow greater than 1.5% lost coverage in any one of the thirteen topical areas. Applying this criterion, 8 of the 13 topical areas are inadequately covered in the engineering curriculum.
- 3) The inadequate coverage stems from two sources. First, the material is just not being covered. This is the case for the Engineering Material and Properties FE topical area. Second, the course syllabus gives little indication that the material is being adequately covered. This is the case for the Thermodynamics and Heat transfer FE topical area, for example.

The recommendations resulting from this analysis are two fold. First, there is too much material covered early in the curriculum. The curriculum should be reviewed and changes considered that will distribute the material into the sophomore and junior years when the students are better

prepared to handle the material. Second, the gaps greater than 1.5% should be closed. This should be done by making changes to the course syllabi to ensure that the course objectives more directly map to the FE topics. Both detailed specific FE topical area recommendations as well as individual FE topical area gap analyses were provided to the department faculty by the Curriculum Core committee to provide further substantiation to build faculty support of these findings. It is important to note that for the initial classes of engineering students that are affected by the observations, the engineering electives in the initial curriculum map will be designed to provide greater coverage of required material. Thus, all ECU Engineering graduates will ultimately have full engineering coverage deemed necessary for success in their careers, but some graduates will have received this knowledge in a different order in some topic areas.

In parallel to the initial study described above, each of the four concentration committees (Systems Engineering, Engineering Management, Bioprocess Engineering and Biomedical Engineering) also executed FE mapping exercises to determine which afternoon examination would be best suited for students in each concentration. Table 6 summarizes the results of this mapping, which was based on the key points of the subject matter covered in courses offered. As shown in Table 6, the two concentrations with a biological component best mapped to the General afternoon examination due to its biology content and lack of logistics or systems engineering content found in the Systems and Engineering Management concentrations.

*Table 6. Results of FE examination mapping to curriculum; identifying best match of afternoon exam to BSE concentration area.*

Concentration	Afternoon FE exam ideal mapping based on planned curricula	First expected BSE graduates with these concentrations
Systems	Industrial	2008
Engineering Management	Industrial	2009
Bioprocess Engineering	General	2009
Biomedical Engineering	General	2011

It is important to note that although the FE examination is considered an important tool for curriculum assessment and continuous improvement of the ECU general engineering program, the program is not devised to teach to the FE exam. Rather, the FE exam and its characteristics are considered in both evaluation of students' preparation for it as well as in evaluating success of the curriculum. As LeFevre et al. note, the FE exam should not be used to develop curricula, but to test the competency of the students<sup>12</sup>. For example, examinations in ECU Engineering core curricula have included questions targeting the FE exam and students were only permitted those resources to take the exam that would be permitted for use during the FE exam. Results on such targeted questions can help faculty better understand how and what they are teaching compares to what is expected by the accepted Professional Engineering certification so that students are best prepared to function and contribute in the real world once they depart from their ECU Engineering education.

LeFevre et al. supports this process to use the FE exam as an assessment tool by (a) using it to “determine what subjects to teach and to what depth and breadth to teach them,” (b) setting “specific goals for student performance and then use the relevant portions of the FE exam to assess the students’ knowledge in specific areas” as ECU Engineering is doing in its subject

matter areas such as kinematics and thermal/fluid systems.<sup>12</sup> Also, all ECU Engineering students, as opposed to only selected students as LeFevre et al. discourage, will be required to take a practice FE exam as well to help assess their competency as well as to help them prepare for the actual exam. All Engineering students are required to take the FE exam as a graduation requirement, but are not required to pass it. Following implementation of targeted FE exam questions in the course examination process, faculty meet regularly to review data on student outcomes of these targeted questions. Analyses of these results are underway to provide data that supports the curriculum development so that faculty consensus can be achieved by understanding this supporting data. Due to the diverse nature of the ECU Engineering faculty, sound data is deemed critical to bring together faculty to continue work towards the common goal of an ideal core curriculum.

Successful student outcomes will also be measured by performance in summer internships as well as in senior capstone design projects which are targeted for local industry support. Several relationships are forming with the regional industry by a faculty Industry Outreach committee so that students have hands-on experiences vital to their preparation for their final entry into real world engineering practice. Feedback from these industry partners on the success and improvement opportunities of these students will also help guide curricular improvements. Correlating success rates of the students in both pre-graduation work experiences as well as the capstone design courses with their results on the practice FE exam may also be an effective tool to gain faculty consensus on the success of the curriculum.

Curricula evolution as shown in Figure 3 and Table 2 indicates subtle changes each year for the Systems Engineering concentration. The following efforts to involve faculty both internal and external to the department are also in progress to further improve curricula development as well as student recruitment and retention:

1. Integrated engineering courses split from freshman year 6 credit hour courses to more more courses with fewer number of hours, but retaining the introductory engineering content throughout the freshman year.
2. Development of a new set of chemistry courses designed with the ECU Department of Chemistry tailored to the engineering curriculum and its needs.
3. Teamwork established with the Mathematics Department to improve preparation for engineering courses dependent on these principles for success and retention, while working towards implementation of engineering based examples using these mathematical principles. The Mathematics Department has agreed to develop new course for engineering students and to participate in the Engineering program's assessment activities.
4. Teaming with the ECU Department of Biology for the development of key Bioprocess Engineering curricula.
5. Teaming with the ECU Brody School of Medicine for development of the Biomedical Engineering concentration curricula to meet their needs for future engineering support both at the research level as well as at the practicum level in supporting day-to-day hospital operation support.
6. Teaming with ECU Campus Housing to set up a novel collaborative learning environment where students live and learn together. Students entering pre- and post-

- learning community and their retention and resulting successes in courses as well as on the FE exam may also provide data for curriculum and learning community improvement opportunities for future assessment. The ECU Engineering Learning Community will be initiated with the class entering in Fall 2007. This supports the NAE report recommendations that “engineering schools must teach engineering students how to learn” by providing “interdisciplinary learning in the undergraduate environment.”<sup>1</sup>
7. Focused advising for tailored support of each student in the program has been implemented with a core advisor for the first two years of the engineering curricula.
  8. Formation of a K-12 Outreach Committee in addition to the Industry Outreach Committee for both pre- and post-engineering education communication in order to grow the future student base as well as growing the future alumni success. In other words, assessing where students come from and where they go – charting their education and career path will provide a continuous data stream in order to best improve and grow the ECU Engineering program. These committees are working to put these data collection processes in place. Also, a recently awarded \$1.2 million NSF ITEST grant to East Carolina University will allow ECU Engineering to contribute to a NAE recommended “national effort to improve math, science and engineering education at the K-12 level.”<sup>1</sup>

In addition to contributions of an integrated learning community for engineering students as well as support of this national K-12 education initiative, ECU Engineering faculty committees will continue to develop the new curriculum offerings, including lab experiences for concentrations with a biological component as well as relevant technical electives, in addition to practicing continuous improvement of established and core courses. These faculty committees will also partner with the industry advisory board members beginning in Spring 2007 for further collaborative efforts in curriculum adjustment to meet the needs of the North Carolina regional stage and beyond. Thus, processes of coming to faculty consensus on both means of assessing student progress utilizing the FE examination tool as well as the collection of other supporting data have provided positive progress towards the ultimate goal of recruiting, retaining, and graduating students that will successfully both pass the FE examination and develop the strong reputation of the new ECU Engineering program graduates.

## **Conclusion**

East Carolina University’s new Department of Engineering ushers in the National Academy of Engineering’s plan for Engineering education<sup>1</sup> by producing engineers that will have experienced multidisciplinary education including core engineering design and theoretical background as well as hands on technical experiences, coupled with writing, presentation and team skill development efforts. Teamwork yielded from faculty efforts for consensus on curriculum both intra-and inter-department, serves to foster the success of the new department and its curricular development and ultimate improvements. These efforts and resulting achievements also demonstrate those team skills toward the common goal – teaching; while serving as an example for student teams that must collaborate towards one common goal – learning. The Department of Engineering is on track to graduate its first class of BSE students in 2008, while later that same year, being evaluated for its ABET accreditation. With the consensus

of faculty and an industry advisory board, and utilizing future outcomes data such as FE exam results for the entire ECU Engineering student body, industry internship and project feedback, and ultimately ECU Engineering graduate job placements and successes, ECU Engineering will continue to evolve its program as the needs for engineers change toward the vision for 2020 and beyond.

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