

**TUNING THE CHEMICAL ENGINEERING CURRICULUM TO  
MEET NEW CHALLENGES AND THE DEMAND OF THE JOB  
MARKET  
AIChE 2006 FALL PROCEEDINGS**

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**ABSTRACT**

Chemical Engineering graduates are exposed to widely diversified employment opportunities in the job market as a result of changing industrial trends, continuously growing research fields and a globalized job market. A classical chemical engineering curriculum is not enough to equip chemical engineers with the knowledge and tools needed to face the challenges and demands of the new market. As a result many chemical engineering departments have decided to upgrade their curriculum by integrating new courses, labs or tools to meet the contemporary needs and challenges. In this paper the changes and improvements to the curriculum in the department of chemical engineering at Tuskegee University will be presented. These include the additions of environmental, biochemical and pre-med options. In addition more focus is made to equip the students with interdisciplinary team experience in the labs, polish oral and written communication skills during the senior design project weekly presentations incorporate chemical engineering software applications in most of the chemical engineering courses and elevate engineering ethics through an engineering ethics course that is mandatory for all students.

**Introduction**

For the last ten years the department of chemical engineering at Tuskegee University has been offering its students an environmental engineering option. Those students who wish to go for this option will receive a basic introduction to several major environmental concepts and issues through several courses that they can take in their junior and senior years. Although this was a great step in helping our students to acquire the basic knowledge and tools needed for them in their professional career but it was not enough and did not meet the needs of some other students nor the other industrial fields and research areas.

In the last couple of years the department has decided to diversify the options and tools to equip our students to meet the diversity in job opportunities, the continuous changes in the job market as well as to better meet engineering practice challenges after their graduation. Two more options have therefore been added to the chemical engineering curriculum. These are the Biochemical engineering option and Pre-med option which are currently available for our students to choose from.

On another front, our department has made several improvements and/or changes to the curriculum to prepare our graduates to be better chemical engineers to compete with their fellow chemical engineers from other schools and to meet the future needs of

the chemical engineering discipline. ASPEN plus package, which has been already available for our students, is now incorporated all our chemical engineering courses in which the software has applications. To improve the written and oral communication, our students, present a written design report on weekly basis and also make an oral presentation that is attended by all the faculty members in the department in their senior design course. Interdisciplinary experience is gained by our students through our unit operations lab I in which our students work with mechanical engineering students in their lab experiments, and design projects. All chemical engineering students are currently required to take an engineering ethics course that features a series of speakers who discuss different topics in engineering ethics and contemporary issues. In addition, students are exposed to many real cases from industry and government. Engineering ethics is also discussed in the chemical engineering plant design course in the senior year.

### **Environmental Engineering Option**

Environmental concerns today profoundly influence all aspects of modern engineering design and practice. Yet most colleges and universities have been slow at integrating environmental considerations into the fabric of their engineering curricula.<sup>(1)</sup> Students who decide to take the environmental engineering option have to take at least 4 environmental related courses from the list of technical electives courses in their junior and senior year. One of these courses is from the environmental science department “ENSC 504 Environmental Science II”. The second course is from the chemistry department, “CHEM 541 Instrumental & Environmental Analysis”. The other two courses are offered in the department of chemical engineering, CENG 450 “Environmental Engineering Fundamentals”, and CENG 460 “Industrial Pollution Prevention”

By the completion of these courses, the students will develop a basic understanding of several environmental concepts and issues that include but not limited to: biologically active substances and potential hazardous synthetic chemicals in the environments, strategies in minimization and management of these chemicals, history and legal framework of environmental engineering, chemistry and microbiology in environmental engineering, water pollution, organic pollution, eutrophication, acidification and heavy metal pollution, air pollution, water and wastewater treatment technologies, anaerobic digestion and sludge treatment, solid and hazardous waste treatment, agricultural pollution and control, industrial air pollution problems and abatement techniques, sulfur dioxide pollution from high temperature processes, treatment methods, air particulates generation and removal processes, treatment of radioactive waste from Uranium processing, advanced oxidation processes for organic removal, mining and processing industry; acid mine drainage from coal and hard rock mining and processing, Cyanide removal from wastewater and land reclamation.

Figure 1 shows the chemical engineering curriculum at Tuskegee University for the environmental engineering option with required courses for this option highlighted.

**Figure 1**  
**Chemical Engineering Curriculum-Environmental Engineering Option**

<b>Freshman Year</b>					
<b>1<sup>st</sup> Semester</b>			<b>2<sup>nd</sup> Semester</b>		
Course #	Course Title	Cr. hrs	Course #	Course Title	Cr. hrs
OREN 100	Orientation	1	OREN 101	Orientation	1
MATH 207	Calculus I	4	MATH 208	Calculus II	4
ENGL 101	English Composition	3	ENGL 102	English Composition	3
CHEM 231	Inorganic Chemistry I	4	CHEM 232	Inorganic Chemistry II	4
CHEM 233	Inorganic Chem. Lab. I	1	CHEM 234	Inorganic Chem. Lab. II	1
CSCI 205/229	Fortran/C++ Programming	3	PHYS 310	Gen. Physics I	3
CENG 110	Intro. Chem. Engineering	1	PHYS 313	Gen. Physics Lab. I	1
<b>Total for the semester</b>		<b>17</b>	<b>Total for the semester</b>		<b>17</b>
<b>Sophomore Year</b>					
<b>1<sup>st</sup> Semester</b>			<b>2<sup>nd</sup> Semester</b>		
Course #	Course Title	Cr. hrs	Course #	Course Title	Cr. hrs
MATH 209	Calculus III	4	CENG 250	Chem. Eng. Thermo. I	3
PHYS 311	Gen. Physics II	3	CENG 220	Fluid Mechanics	3
PHYS 314	Gen. Physics Lab. II	1	MATH 307	Differential Equations	3
CENG 210	Material & Energy Balances	4	MENG 237	Eng. Prob. & Stat	3
CHEM 307	Quant. Analysis	3	PHED	Physical Education	1
CHEM 308	Quant. Analysis lab.	2		Socio-Hum. Elective	3
PHED	Physical Education	1			
<b>Total for the semester</b>		<b>18</b>	<b>Total for the semester</b>		<b>16</b>
<b>Junior Year</b>					
<b>1<sup>st</sup> Semester</b>			<b>2<sup>nd</sup> Semester</b>		
Course #	Course Title	Cr. hrs	Course #	Course Title	Cr. hrs
CENG 310	Heat Transfer	3	CENG 380	Mass Transfer	3
CENG 350	Chem. Eng. Thermo. II	3	CENG 360	Chem. Reaction Eng.	3
CENG 320	Unit Operations Lab. I	1	ENSC 504	Environmental Science II	3
CHEM 320	Organic Chem. I	3	CHEM 541	Instr. & Environmental Analysis	3
CHEM 322	Organic Chem. Lab. I	2	CENG 390	Eng. Ethics & Society	3
	Socio-Hum. Elective	3		Socio-Hum. Elective	3
<b>Total for the semester</b>		<b>18</b>	<b>Total for the semester</b>		<b>18</b>
<b>Senior Year</b>					
<b>1<sup>st</sup> Semester</b>			<b>2<sup>nd</sup> Semester</b>		
Course #	Course Title	Cr. hrs	Course #	Course Title	Cr. hrs
CENG 430	Process Control & Instrumentation	3	CENG 440	Process Control Lab	1
CENG 470	Plant Design	4	EENG 380	Principals of Elec. Eng.	3
CENG 450	Environmental Engineering Fundamentals	3	EENG 380L	Elec. Eng. Lab	1
CENG 441	EIT Review	0	CENG 420	Unit Operations Lab. II	1
	Socio-Hum. Elective	3	CENG 490	Senior Design Project	3
			CENG 460	Industrial Pollution Prevention	3
				Socio-Hum. Elective	3
<b>Total for the semester</b>		<b>13</b>	<b>Total for the semester</b>		<b>15</b>
<b>Total Degree Hours = 132</b>					

Recently a new environmental engineering course, Environmental Restoration/Waste Managements, has been introduced in our department. These courses will provide an excellent environmental engineering background and knowledge for the environmental engineering option students. In this course, students will develop a fundamental understanding of pollution prevention methods, fundamentals of hazardous waste, treatment and disposal methods of hazardous waste, fate and transport of contaminants and toxicology. With all of these environmental engineering background courses, our graduates who had chosen the environmental option are able to accept environmental engineering related jobs in industry, research or government that will let them use their strong chemical engineering background and build on their environmental engineering knowledge and experience.

### **Pre-Med Option**

One of the attractive choices for graduating chemical engineers is going to medical schools. These medical schools require a certain courses to be taken by their candidates to be able to get in their programs. The minimum requirements for most of medical schools are<sup>(2)</sup> one year in biology, one year in physics, 2 years in chemistry (through Organic Chemistry) and one year of English. The basic chemical engineering curriculum already include one year of English, one year of physics and 1.5 years of chemistry. To meet the pre-med requirements our students have to take 1/2 year of organic chemistry and one year of biology. The suggested courses are BIOL 120 “Organismic Biology”, BIOL 121 “Organismic Biology Lab”, BIOL 230 “Cell and Genetic Biology”, BIOL 231 “Cell and Genetic Biology Lab”, BIOL 301 “General Microbiology”, CHEM 321 “Organic Chemistry II”, and CHEM 323 “Organic Chemistry Lab II”.

Students who successfully complete these courses would have completed the minimum course requirements for most medical schools, and they can proceed to apply for medical schools if they wish to, or get a bio related research or industry position.

### **Biochemical Engineering Option**

Advances in biotechnology have already significantly improved the quality of our lives, but even more dramatic breakthroughs are likely. Research in tissue engineering and regenerative medicine may lead to new technology that will allow our bodies to replace injured or diseased parts without invasive surgery, but rather by using the natural growth processes inherent in cells<sup>(3)</sup>. Biochemical engineering is the second new option that is available for our chemical engineering students. Students who wish to take this option have to take at least four bio related courses to fulfill the requirement for this option. The required courses that are listed under the technical electives are: BIOL 230 “Cell and Genetic Biology”, BIOL 301 “General Microbiology”, CHEM 561 “Biochemistry”, CHEM 562 “Biochemistry Lab” and CENG 400 “Introduction to Biochemical Engineering”.

After taking these courses, students will develop a fundamental understanding of the chemical basis of life, contemporary concepts of the morphology and physiology of cell membranes, cellular organelles and basic genetic principles. In the general microbiology course, emphasis is on bacteria, their growth and control, composition and

structure, nutrition and metabolism, classification, ecology, role in nature and significance to man. Chemistry and metabolism of major biological materials, and their roles in the biochemical process of living organisms are covered in the biochemistry course. The biochemical engineering course will introduce the students to the biochemical and microbiological applications to commercial and engineering processes, including fermentation, enzymology, ultra filtration, food and pharmaceutical processing and resulting waste treatment, enzyme kinetics, cell growth, energetic and mass transfer. This foundation in biochemistry and biochemical engineering will give our graduates the basic knowledge and tools to accept jobs in a wide variety of biochemical related field in research or industry.

Figures 2 and 3 show the chemical engineering curriculum for pre-med and biochemical engineering options with the required courses for each option highlighted.

### **Conclusion**

In conclusion, based on the feedback from our alumni, employers, faculty and students and responding to the continuous changes and demand of the job market our chemical engineering curriculum was tuned to better prepare our students to meet these challenges. Currently our students have the choice to go through an environmental engineering option track that will qualify them to accept environmental engineering related research or industry jobs. In addition our students can choose to take a biochemical engineering option track that will qualify them to accept bio related research or industry jobs. If they wish to go to a medical school, our students have the choice to take the pre-med option that will provide them with the minimum required coursework needed by most medical schools in the US.

Our chemical engineering curriculum also now requires the use of ASPEN for design projects in all courses whenever applicable. And finally our students gain a great experience in written and oral communication in their senior year during the two design courses in our curriculum, in which they have to submit a weekly written progress report. In addition to the weekly written report our senior design project students have to make a weekly oral presentation in the presence of the whole faculty members of the department, which really give them a great communication experience that is needed for their professional careers.

### **References**

- 1) Edwards S. Rubin and Cliff I. Davidson, 2001, "Introduction to Engineering & the Environment", McGraw Hill.
- 2) Association of American Medical Colleges, 2006-2007, "Medical School Admission Requirements"
- 3) National Academy of Engineering, 2004, "The engineer of 2020", the national academies press, Washington, DC.

**Figure 2**  
**Chemical Engineering Curriculum-Pre-Med Option**

<b>Freshman Year</b>					
<u>1<sup>st</sup> Semester</u>			<u>2<sup>nd</sup> Semester</u>		
OREN 100	Orientation	1	OREN 101	Orientation	1
MATH 207	Calculus I	4	MATH 208	Calculus II	4
ENGL 101	English Comp.	3	ENGL 102	English Comp.	3
CHEM 231	Inorganic Chem. I	4	CHEM 232	Inorganic Chem. II	4
CHEM 233	Inorganic Chem. Lab. I	1	CHEM 234	Inorganic Chem. Lab. II	1
CSCI 205/229	Fortran/C++ Prog.	3	PHYS 310	Gen. Physics I	3
CENG 110	Intro. Chem. Eng.	1	PHYS 313	Gen. Physics Lab. I	1
		<b>17</b>			<b>17</b>
<b>Sophomore Year</b>					
<u>1<sup>st</sup> Semester</u>			<u>2<sup>nd</sup> Semester</u>		
MATH 209	Calculus III	4	CENG 250	Chem. Eng. Theromo. I	3
PHYS 311	Gen. Physics II	3	CENG 220	Fluid Mechanics	3
PHYS 314	Gen. Physics Lab. II	1	MATH 307	Differential Equations	3
CENG 210	Matl. & Eneg. Balances	4	MENG 237	Eng. Prob. & Stat.	3
CHEM 307	Quant. Analysis	3	PHED	Physical Education	1
CHEM 308	Quant. Analysis lab.	2		Socio-Hum. Elective	3
PHED	Physical Education	1			
		<b>18</b>			<b>16</b>
<b>Junior Year</b>					
<u>1<sup>st</sup> Semester</u>			<u>2<sup>nd</sup> Semester</u>		
CENG 310	Heat Transfer	3	CENG 380	Mass Transfer	3
CENG 350	Chem. Eng. Thermo. II	3	CENG 360	Chem. Reaction Eng.	3
CENG 320	Unit Operations Lab. I	1	CENG 390	Eng. Ethics & society	3
CHEM 320	Organic Chem. I	3	BIOL 120	Organismic Biology	3
CHEM 322	Organic Chem. Lab. I	2	BIOL 121	Organismic Biology Lab	1
MATH 461	Engineering Math	3		Socio-Hum. Elective	3
	Socio-Hum. Elective	3			
		<b>18</b>			<b>16</b>
<b>Senior Year</b>					
<u>1<sup>st</sup> Semester</u>			<u>2<sup>nd</sup> Semester</u>		
CENG 430	Process Control & Instr.	3	CENG 440	Proc. Contr. & Instr. Lab	1
CENG 470	Chem. Eng. Plant Design	4	EENG 380	Principles of Elec. Eng.	3
CENG 441	EIT Review	0	EENG 380L	Elec. Eng. Lab	1
BIOL 230	Cell & Gen. Biology	3	CENG 420	Unit Operations Lab. II	1
BIOL 231	Cell & Gen. Biology Lab	1	CENG 490	Senior Design Project	3
	Socio-Hum Elective	6	CHEM 321	Organic Chemistry II	3
			CHEM 323	Organic Chemistry Lab II	2
		<b>17</b>			<b>14</b>
<b>Total Degree Hours = 133</b>					

**Figure 3**  
**Chemical Engineering Curriculum-Biochemical Engineering Option**

<b>Freshman Year</b>					
<u>1<sup>st</sup> Semester</u>			<u>2<sup>nd</sup> Semester</u>		
OREN 100	Orientation	1	OREN 101	Orientation	1
MATH 207	Calculus I	4	MATH 208	Calculus II	4
ENGL 101	English Comp.	3	ENGL 102	English Comp.	3
CHEM 231	Inorganic Chem. I	4	CHEM 232	Inorganic Chem. II	4
CHEM 233	Inorganic Chem. Lab. I	1	CHEM 234	Inorganic Chem. Lab. II	1
CSCI 205/229	Fortran/C++ Prog.	3	PHYS 310	Gen. Physics I	3
CENG 110	Intro. Chem. Eng.	1	PHYS 313	Gen. Physics Lab. I	1
		<b>17</b>			<b>17</b>
<b>Sophomore Year</b>					
<u>1<sup>st</sup> Semester</u>			<u>2<sup>nd</sup> Semester</u>		
MATH 209	Calculus III	4	CENG 250	Chem. Eng. Thermo. I	3
PHYS 311	Gen. Physics II	3	CENG 220	Fluid Mechanics	3
PHYS 314	Gen. Physics Lab. II	1	MATH 307	Differential Equations	3
CENG 210	Matl. & Eneg. Balances	4	MENG 237	Eng. Prob. & Stat.	3
CHEM 307	Quant. Analysis	3	PHED	Physical Education	1
CHEM 308	Quant. Analysis lab.	2		Socio-Hum. Elective	3
PHED	Physical Education	1			<b>16</b>
		<b>18</b>			
<b>Junior Year</b>					
<u>1<sup>st</sup> Semester</u>			<u>2<sup>nd</sup> Semester</u>		
CENG 310	Heat Transfer	3	CENG 380	Mass Transfer	3
CENG 350	Chem. Eng. Thermo. II	3	CENG 360	Chem. Reaction Eng.	3
CENG 320	Unit Operations Lab. I	1	CENG 390	Eng. Ethics & society	3
CHEM 320	Organic Chem. I	3	<b>BIOL 301</b>	<b>Gen. Microbiology</b>	<b>3</b>
CHEM 322	Organic Chem. Lab. I	2		Socio-Hum. Elective	6
<b>BIOL 230</b>	<b>Cell &amp; Gen. Biology</b>	<b>3</b>			<b>18</b>
Math 461	Engineering Math	3			
		<b>18</b>			
<b>Senior Year</b>					
<u>1<sup>st</sup> Semester</u>			<u>2<sup>nd</sup> Semester</u>		
CENG 430	Process Control & Instr.	3	CENG 440	Proc. Contr. & Instr. Lab	1
CENG 470	Chem. Eng. Plant Design	4	EENG 380	Principles of Elec. Eng.	3
CENG 441	EIT Review	0	EENG 380L	Elec. Eng. Lab	1
<b>CHEM 561</b>	<b>Biochemistry</b>	<b>3</b>	CENG 420	Unit Operations Lab. II	1
<b>CHEM 562</b>	<b>Biochemistry Lab</b>	<b>1</b>	CENG 490	Senior Design Project	3
	Socio-Hum Elective	3	<b>CENG 400</b>	<b>Intro. Biochem Eng.</b>	<b>3</b>
		<b>14</b>		Socio-Hum Elective	3
					<b>15</b>
<b>Total Degree Hours = 133</b>					