Market Analysis for Undergraduate Programs In Engineering

Prepared for Clarion University of Pennsylvania

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In the following report, Hanover Research assesses the market for bachelor's degree programs in engineering at Clarion University of Pennsylvania. The analysis contained in this report relies on degree completions data, national and state labor market projections, and profiles of similar programs in the area.

HANOVER RESEARCH

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Executive Summary and Key Findings

Introduction

In this report, Hanover Research analyzes the market for a bachelor's degree in various engineering fields for Clarion University of Pennsylvania. Hanover's analysis is based on degree completions data from the National Center for Education Statistics, labor market information from the Bureau of Labor Statistics and state governments, and secondary literature on current trends in engineering education. This report comprises the following sections:

- **Section I** provides an overview of student demand for bachelor's degrees in engineering fields. Hanover relies on national and regional degree completions data to assess the potential viability of an engineering degree program at Clarion University This section also discusses the program features most likely to attract male students, transfer students, online students, and military personnel/veterans.
- **Section II** analyzes the projected labor market for college graduates with engineering degrees drawing on data from the Bureau of Labor Statistics and the Pennsylvania Department of Labor and Industry.
- **Section III** provides detailed profiles of several potential competitor programs.

Key Findings

- **Based on demand, several engineering fields show strong potential for a Bachelor of Science degree program at Clarion University, including chemical engineering, biomedical engineering, and environmental engineering.** These fields exhibit high student demand nationally and regionally, and associated careers are expected to grow significantly over the coming decade as well.
- **When compared with other occupations, engineering fields are expected to see faster-than-average growth.** Nationally, occupations across all engineering fields are expected to grow 13.5 percent from 2012 to 2022, above the national job growth rate of 10.8 percent. In Pennsylvania, engineering jobs are expected to grow 13.3 percent from 2010 to 2020, well exceeding the state average of 6.4 percent.
- **Engineering degree programs disproportionately attract male students.** Approximately 81 percent of all engineering degrees from 2009 to 2013 were awarded to male students. The highest concentrations of male students are typically in computer-related engineering fields.
- **Significant challenges exist for creating online engineering programs, and there are currently few accredited, fully-online engineering degree programs.** While some engineering courses are suited to online formats, laboratory courses incorporating expensive equipment are difficult to adapt to an online setting.

- **Simplifying the process of awarding transfer credit and credit for military training can help attract transfer students and veteran students to engineering degree programs.** Transfer students often struggle with the complexity of transfer protocols, and veteran students are eager to receive academic credit for technical military training. In addition, providing opportunities for military personnel to complete advanced mathematics courses will ease veterans' transition into engineering bachelor's programs.
- **Engineering programs are typically expensive to launch and maintain.** In addition to expenses for faculty and ongoing operations, laboratories in particular are costly. However, industry support, donations, state funding, partnerships between higher education institutions, and proposed alternatives such as a "lab in a box" or using cloud computing to enhance laboratory experiences can help offset some costs. Additional research would be required to investigate start-up costs for specific undergraduate engineering programs.

SECTION I: STUDENT DEMAND INDICATORS

In this section, Hanover Research examines trends in undergraduate engineering degree completions to determine the level of interest that Clarion University of Pennsylvania might expect for its own engineering degree programs.

ENGINEERING DEGREE COMPLETION TRENDS

METHODOLOGY

To assess completions trends in engineering programs, Hanover analyzes the five most recent years of data available through the National Center for Education Statistics (NCES). The NCES uses a taxonomic system of numeric codes to classify higher education programs known as the Classification of Instructional Programs (CIP). All institutions of higher education are required to submit conferral data, sorted by award level and CIP code, to the NCES's Integrated Postsecondary Education Data System (IPEDS).

In considering program completion data obtained through IPEDS, it should be noted that institutions classify their programs independently, meaning that two programs that are identical in all respects could hypothetically be classified under different CIP codes, which can skew trends.

Hanover relies on three statistical metrics when considering year-to-year trends in completions data: Compound Annual Growth Rate (**CAGR**), Average Annual Change (**AAC**), and Standard Deviation (**STDEV**). CAGR is a theoretical indicator that demonstrates the percentage growth of the dataset from year to year, assuming a steady rate of growth between the first and final years. AAC is determined by calculating the average numerical year-to-year change, which helps to account for the volume of completions. STDEV measures the variance in yearly changes. To avoid misrepresenting market trends, Hanover has only calculated these figures for datasets that include at least five years of information.

In assembling this report, Hanover considered bachelor's degree completions in all engineering-related CIP classifications (the 14.XXXX family). However, in the following tables, Hanover lists only the top ten engineering classifications according to the conditions specified for each figure. Data are provided for these top fields at the national, regional, and state levels. In all tables detailing **top engineering majors by CAGR**, Hanover eliminated any CIP classifications that had:

- Nationally: Fewer than 50 conferrals in 2013,
- Regionally: Fewer than 20 conferrals in 2013, and
- Statewide: Fewer than 10 conferrals in 2013.

This was done to prevent very low-volume fields from taking undue precedence.

NATIONAL TRENDS

Overall, bachelor's degrees in engineering have shown moderate growth over the last several years, with a compound annual growth rate of 5.5 percent across all fields (see Figure 1.1).

Figure 1.1: National Engineering Bachelor's Degree Completions, All Fields

2009	2010	2011	2012	2013	TOTAL	CAGR	AAC	STDEV
70,832	74,490	78,151	83,353	87,903	**394,729**	*5.5%*	*4,267.8*	*650.5*

Source: IPEDS

The overall growth of engineering degree programs is reflected in the trends of particular subfields as well. In terms of raw completions, **traditional engineering fields, such as mechanical engineering, civil engineering, electrical engineering, and chemical engineering, remain the most popular majors** (Figure 1.2). However, several emerging fields, such as environmental engineering, polymer/plastics engineering, and petroleum engineering have shown especially strong growth over the last five years (Figure 1.3). Some caution is warranted, however, in assessing the opportunity that some of these fields provide for a new program, given the comparatively small number of completions in several of these high-growth fields. **Fields that consistently show both high numbers of completions and strong growth include chemical engineering, bioengineering/biomedical engineering, and environmental engineering.**

Figure 1.2: Top Engineering Bachelor's Degrees by 2013 Headcount, National

DEGREE PROGRAM	2009	2010	2011	2012	2013	CAGR	AAC	STDEV
14.1901 Mechanical Engineering	17,663	18,867	19,569	20,977	22,388	*6.1%*	*1,181.3*	*289.1*
14.0801 Civil Engineering, General	10,822	11,435	12,605	12,796	13,314	*5.3%*	*623.0*	*352.5*
14.1001 Electrical and Electronics Engineering	12,134	11,792	11,882	12,484	13,172	*2.1%*	*259.5*	*415.8*
14.0701 Chemical Engineering	5,176	5,822	6,391	7,149	7,572	*10.0%*	*599.0*	*121.8*
14.0501 Bioengineering and Biomedical Engineering	3,766	3,854	4,105	4,537	4,931	*7.0%*	*291.3*	*135.4*
14.0901 Computer Engineering, General	3,834	3,984	4,021	4,381	4,705	*5.3%*	*217.8*	*131.1*
14.3501 Industrial Engineering	3,012	3,183	3,221	3,571	3,747	*5.6%*	*183.8*	*110.8*
14.0201 Aerospace, Aeronautical and Astronautical/Space Engineering	3,077	3,247	3,388	3,614	3,571	*3.8%*	*123.5*	*100.9*
14.0101 Engineering, General	2,094	2,080	2,108	2,177	2,217	*1.4%*	*30.8*	*29.8*
14.1401 Environmental/Environmental Health Engineering	598	662	763	1,015	1,213	*19.3%*	*153.8*	*74.9*

Source: IPEDS

Figure 1.3: Top Engineering Bachelor's Degrees by CAGR, National

DEGREE PROGRAM	2009	2010	2011	2012	2013	CAGR	AAC	STDEV
14.1401 Environmental/Environmental Health Engineering	598	662	763	1,015	1,213	*19.3%*	*153.8*	*74.9*
14.3201 Polymer/Plastics Engineering	67	75	90	104	112	*13.7%*	*11.3*	*3.3*
14.2501 Petroleum Engineering	690	779	1,018	1,068	1,130	*13.1%*	*110.0*	*75.8*
14.1801 Materials Engineering	708	922	907	1,055	1,129	*12.4%*	*105.3*	*85.3*
14.2301 Nuclear Engineering	377	410	473	555	595	*12.1%*	*54.5*	*19.4*
14.0701 Chemical Engineering	5,176	5,822	6,391	7,149	7,572	*10.0%*	*599.0*	*121.8*
14.2101 Mining and Mineral Engineering	176	197	226	250	239	*7.9%*	*15.8*	*15.7*
14.0501 Bioengineering and Biomedical Engineering	3,766	3,854	4,105	4,537	4,931	*7.0%*	*291.3*	*135.4*
14.0903 Computer Software Engineering	463	571	630	594	595	*6.5%*	*33.0*	*55.0*
14.2201 Naval Architecture and Marine Engineering	325	341	365	386	412	*6.1%*	*21.8*	*3.8*

Source: IPEDS

REGIONAL TRENDS

For purposes of compiling completion statistics, NCES places Pennsylvania in the Mideast region, which also includes Delaware, Maryland, New Jersey, New York, and the District of Columbia. Within the Mideast region, engineering bachelor's degree conferrals have grown at a slightly slower rate than seen at the national level, with a compound annual growth rate across all engineering fields of 5.2 percent (Figure 1.4).

Figure 1.4: Engineering Bachelor's Degree Completions, Mideast Region

2009	2010	2011	2012	2013	TOTAL	CAGR	AAC	STDEV
12,296	12,920	13,322	14,317	15,085	**67,940**	*5.2%*	*697.3*	*215.8*

Source: IPEDS

As at the national level, established fields, such as mechanical, electrical, civil, and chemical engineering, have the greatest number of completions (Figure 1.5 on the following page). Growth rates of individual fields in the Mideast are also commensurate with national data, with petroleum engineering, environmental engineering, naval engineering, and nuclear engineering among the fastest-growing degree programs (Figure 1.6 on the following page).

Figure 1.5: Top Engineering Bachelor's Degrees by 2013 Headcount, Regional

Degree Program	2009	2010	2011	2012	2013	CAGR	AAC	STDEV
14.1901 Mechanical Engineering	3,046	3,213	3,296	3,558	3,927	*6.6%*	*220*	*107*
14.1001 Electrical and Electronics Engineering	2,041	2,092	2,159	2,230	2,240	*2.4%*	*50*	*24*
14.0801 Civil Engineering, General	1,581	1,732	1,860	1,831	1,923	*5.0%*	*86*	*69*
14.0701 Chemical Engineering	1,122	1,237	1,307	1,392	1,491	*7.4%*	*92*	*17*
14.0501 Bioengineering and Biomedical Engineering	864	881	906	1,031	1,062	*5.3%*	*50*	*44*
14.0901 Computer Engineering, General	630	612	602	670	693	*2.4%*	*16*	*34*
14.3501 Industrial Engineering	424	470	420	513	539	*6.2%*	*29*	*52*
14.0201 Aerospace, Aeronautical and Astronautical/Space Engineering	394	414	435	456	454	*3.6%*	*15*	*10*
14.0101 Engineering, General	270	297	301	361	331	*5.2%*	*15*	*33*
14.1401 Environmental/Environmental Health Engineering	161	168	203	243	327	*19.4%*	*42*	*28*

Source: IPEDS

Figure 1.6: Top Engineering Bachelor's Degrees by CAGR, Regional

Degree Program	2009	2010	2012	2012	2013	CAGR	AAC	STDEV
14.2501 Petroleum Engineering	15	21	32	37	70	*47.0%*	*14*	*11*
14.1401 Environmental/Environmental Health Engineering	161	168	203	243	327	*19.4%*	*42*	*28*
14.2301 Nuclear Engineering	73	96	107	125	129	*15.3%*	*14*	*7*
14.0601 Ceramic Sciences and Engineering	27	34	23	32	47	*14.9%*	*5*	*10*
14.9999 Engineering, Other	74	81	77	106	124	*13.8%*	*13*	*12*
14.2201 Naval Architecture and Marine Engineering	124	128	149	172	175	*9.0%*	*13*	*9*
14.0701 Chemical Engineering	1,122	1,237	1,307	1,392	1,491	*7.4%*	*92*	*17*
14.0301 Agricultural Engineering	164	152	173	217	213	*6.8%*	*12*	*22*
14.1901 Mechanical Engineering	3046	3213	3296	3558	3927	*6.6%*	*220*	*107*
14.3501 Industrial Engineering	424	470	420	513	539	*6.2%*	*29*	*52*

Source: IPEDS

Of the engineering CIP classifications that are among the highest growth fields in the Mideast region, two in particular are unlikely to reflect any important trends. The first, "14.9999 Engineering, Other," is a catch-all category for degree programs that do not fit clearly into one of the other CIP classifications. Therefore its place among the fastest-growing fields likely does not represent an increase in popularity of any particular degree program.

The second, "14.0601 Ceramic Sciences and Engineering," exhibited a 14.9 percent compound annual growth rate during the years studied. While the field meets this report's criterion for inclusion (with at least 20 graduates in 2013), the small overall size of the field makes the compound annual growth rate sensitive to small fluctuations, even in a single program in a single year. Ceramic engineering's high growth rate is primarily due to a jump from 32 to 47 graduates over 2012–2013; over that same year, the number of ceramic engineering graduates at Alfred University in New York grew from eight to 17.[1] Given these considerations, there do not appear to be any significant region-specific trends (i.e., trends distinct from those seen at the national level) in the demand for engineering degree programs.

PENNSYLVANIA COMPLETIONS

Growth for engineering degrees in Pennsylvania slightly lags growth seen at the national level, with a compound annual growth rate of 4.5 percent (Figure 1.7).

Figure 1.7: Pennsylvania Engineering Bachelor's Degree Completions

2009	2010	2011	2012	2013	TOTAL	CAGR	AAC	STDEV
4,369	4,578	4,594	4,880	5,203	**23,624**	*4.5%*	*208.5*	*118.5*

Source: IPEDS

Again, traditional fields have the greatest number of degree completions during the time period examined. Among the top 10 fields by number of completions, the fastest growing fields are environmental, general, and mechanical engineering (Figure 1.8). These three fields also appear in Figure 1.9, which details the fastest-growing fields in Pennsylvania. The particular fields with the highest growth rates are petroleum, mining/mineral, and nuclear engineering, though again these fields confer a relatively small proportion of degrees overall.

[1] "Enrollment and Graduation Data." Inamori School of Engineering, Alfred University. http://engineering.alfred.edu/undergrad/docs/abet-census-data.pdf

Figure 1.8: Top Engineering Bachelor's Degree in Pennsylvania by 2013 Headcount

Degree Program	2009	2010	2011	2012	2013	CAGR	AAC	STDEV
Mechanical Engineering	1,039	1,067	1,083	1,154	1,340	*6.6%*	*75.3*	*67.1*
Electrical and Electronics Engineering	675	738	755	804	752	*2.7%*	*19.3*	*44.4*
Civil Engineering, General	644	663	691	635	655	*0.4%*	*2.8*	*34.1*
Chemical Engineering	444	481	466	532	515	*3.8%*	*17.8*	*35.3*
Bioengineering and Biomedical Engineering	313	319	295	330	351	*2.9%*	*9.5*	*21.9*
Industrial Engineering	209	239	206	241	259	*5.5%*	*12.5*	*27.0*
Computer Engineering, General	234	218	182	190	203	*-3.5%*	*-7.8*	*19.7*
Engineering, General	118	126	132	147	170	*9.6%*	*13.0*	*6.7*
Architectural Engineering	150	157	157	144	152	*0.3%*	*0.5*	*8.4*
Environmental/Environmental Health Engineering	54	46	53	65	89	*13.3%*	*8.8*	*11.5*

Source: IPEDS

Figure 1.9: Top Engineering Bachelor's Degree in Pennsylvania by CAGR

Degree Program	2009	2010	2011	2012	2013	CAGR	AAC	STDEV
Petroleum Engineering	15	21	32	37	70	*47.0%*	*13.8*	*11.3*
Engineering, Other	25	33	36	62	79	*33.3%*	*13.5*	*8.8*
Mining and Mineral Engineering	5	6	9	13	13	*27.0%*	*2.0*	*1.6*
Nuclear Engineering	35	50	62	83	84	*24.5%*	*12.3*	*7.3*
Agricultural Engineering	20	25	34	45	43	*21.1%*	*5.8*	*5.0*
Computer Software Engineering	29	31	23	36	60	*19.9%*	*7.8*	*12.0*
Environmental/Environmental Health Engineering	54	46	53	65	89	*13.3%*	*8.8*	*11.5*
Engineering Science	26	29	26	45	40	*11.4%*	*3.5*	*9.4*
Engineering, General	118	126	132	147	170	*9.6%*	*13.0*	*6.7*
Mechanical Engineering	1,039	1,067	1,083	1,154	1,340	*6.6%*	*75.3*	*67.1*

Source: IPEDS

Demand by Student Type

Because Clarion University has expressed interest in the engineering program features likely to be attractive to several particular student demographics, this subsection includes information on the needs and interests of male students, transfer students, online students, and veterans/military personnel in engineering bachelor's degree programs. Where quantitative data are not available, we rely on secondary research on best practices for attracting and supporting these students in engineering programs.

MEN

Engineering programs nationwide tend to be male-dominated,[2] with 80.6 percent of all engineering degrees from 2009 to 2013 awarded to men, according to IPEDS data. The highest concentrations of male graduates occur in computer-related fields, as shown in Figure 1.10. There is little research on engineering program features that attract men because most attention has been directed toward increasing the proportion of women in such programs.[3]

Figure 1.10: Engineering Majors with Highest Concentration of Men in 2013, National

DEGREE PROGRAM	TOTAL GRADUATES	MALE GRADUATES	% MEN
Computer Software Engineering	595	545	91.6%
Construction Engineering	413	378	91.5%
Electrical, Electronics and Communications Engineering, Other	65	59	90.8%
Computer Engineering, General	4,705	4,239	90.1%
Engineering Mechanics	94	83	88.3%
Electrical and Electronics Engineering	13,172	11,611	88.1%
Mechanical Engineering	22,388	19,685	87.9%
Naval Architecture and Marine Engineering	412	362	87.9%
Mining and Mineral Engineering	239	209	87.4%
Petroleum Engineering	1,130	975	86.3%

Source: IPEDS

TRANSFER STUDENTS

According to a 2014 literature review by Andrea Ogilvie, a doctoral researcher at Virginia Tech University, research on the needs and experiences of transfer students in engineering programs can be divided into two areas: research on students transferring from four-year institutions and research on students transferring from community colleges.[4] Ogilvie notes that there is a substantial body of literature on community college (or "vertical") transfers but very little work on transfers between four-year colleges ("lateral" transfers).[5]

The existing literature on the experiences of community college transfers to engineering bachelor's degree programs suggests several lessons for institutions wishing to provide a supportive environment for such students. In 2011, a team of researchers at Iowa State University studied the experiences of 157 community college students who had transferred

[2] "Science and Engineering Indicators 2012: Chapter 2, Higher Education in Science and Engineering." National Science Foundation. http://www.nsf.gov/statistics/seind12/c2/c2s2.htm

[3] See, for example: St. Rose, A. "STEM Major Choice and the Gender Pay Gap." Association of American Colleges and Universities. http://www.aacu.org/ocww/volume39_1/feature.cfm?section=1

[4] Ogilvie, A. "A Review of the Literature on Transfer Student Pathways to Engineering Degrees." *121st ASEE Annual Conference & Exposition,* June, 2014. http://www.asee.org/public/conferences/32/papers/9849/view

[5] Ibid., pp. 2-3.

to the engineering program at a Midwestern university.[6] The students reported generally positive experiences, and the researchers conclude that "overall, transfer students in Engineering majors are adjusting well to the university environment."[7] However, the researchers did find that 38 percent of transfer students felt that university students attached a stigma to beginning at a community college, and a similar number (33 percent) felt that their abilities were underestimated because of their transfer status.[8] Therefore, institutions should seek to ensure that transfer students are afforded the same respect and recognition as other students.

When asked what advice they would give to other students transferring to an engineering program from a community college, the students in the Iowa State study emphasized the importance of talking with an academic advisor, getting involved on campus, and making sure that community college credits will transfer to the university.[9] This suggests that **community college transfer students will find the transition to a university engineering program easiest if they have ready access to academic advisors, clear guidelines about transfer credits, and ample opportunity to become involved on campus.**

Again, there is little research on students making "lateral" transfers between four-year institutions. One notable trend in the field of engineering, however, is the prevalence of dual-degree (or "3-2") collaborative programs. In these programs, students spend three years completing general education requirements and "pre-engineering" courses in science and math at one institution. Then, they transfer to a second institution to complete two years of engineering-focused courses.[10] Students in such programs typically receive two degrees—for example, one in math or physics from the "sending" institution and one in engineering from the "receiving" institution. It is common for both sending and receiving institutions to establish "3-2" articulation agreements with multiple partner institutions. Pennsylvania State University, for example, receives students from 16 other institutions (15 in Pennsylvania),[11] while the State University of New York at Fredonia sends students to 14 other institutions.[12]

Because research on lateral transfers is scarce, there is little information available on the particular degree types or program features likely to be of particular interest to transfer students. As with "vertical" transfers from community colleges, however, researchers have observed that complicated or confusing credit transfer procedures—even when a formal

[6] Laanan, F.S., D.L. Jackson, and D.T. Rover. "Engineering Transfer Students: Characteristics, Experiences, and Student Outcomes." American Society for Engineering Education. http://www.asee.org/public/conferences/1/papers/1250/download

[7] Ibid., p. 13.

[8] Ibid., p. 8

[9] Ibid., p. 12.

[10] Shealy, E., et al. "A Descriptive Study of Engineering Transfer Students at Four Institutions: Comparing Lateral and Vertical Transfer Pathways." *120th ASEE Annual Conference & Exposition*, 2013. p. 4.

[11] "Dual Degree Institutions" Pennsylvania State University. http://www.engr.psu.edu/FutureStudents/Undergraduate/Transfer/DualDegree/Institutions.aspx

[12] "Cooperative Engineering." SUNY Fredonia. http://www.fredonia.edu/department/physics/engineer.asp

articulation agreement exists, as in “3-2” programs—are a significant challenge for students making lateral transfers.[13] Again, providing clear information on credit transfer procedures and supporting students through the process will likely make engineering degree programs more attractive to lateral transfer students.

Online Students

Despite the general growth of online degree programs, there are relatively few fully-online engineering programs. According to ABET, an accrediting body for degree programs in engineering and technology, there are only seven institutions in the United States with fully-online, ABET-accredited bachelor’s degree programs in one or more engineering fields.[14] A total of 32 online bachelor’s degree programs in engineering have been reported by 23 institutions to the NCES, indicating that—even putting accreditation standards aside—few institutions have found it feasible to offer fully-online engineering bachelor’s degrees.

One likely reason for the relative scarcity of online engineering programs is that many engineering courses include lab components, which typically require expensive equipment and close supervision from skilled educators.[15] Some institutions have begun to experiment with offering lab-based courses online by, for example, having students purchase inexpensive equipment in order to complete lab exercises at home. Educators have reported significant drawbacks to the course formats that have been attempted thus far, however.[16]

One program model with potential for addressing this challenge involves a partnership between two institutions, one providing online instruction in advanced engineering topics and the other providing laboratory facilities and hands-on learning activities for students. This model is used in the partnership between Frostburg State University and the University of Maryland, which is profiled in Section III of this report.[17] Such a delivery option also indicates that one institution could itself offer both online and in-person instruction in an engineering bachelor’s program, thus reducing the time students must be on-campus (if this is a desired goal).

Veterans and Military Service Personnel

The National Science Foundation (NSF) has argued that the large population of post-9/11 veterans represents a promising resource for fulfilling the national workforce shortages in STEM fields. According to NSF, “[p]ost-9/11 veterans offer the nation’s engineering and

[13] Shealy et al., Op. cit., p. 4.
[14] “Online Programs.” ABET. http://www.abet.org/online-programs/
[15] Pintong, K. and D. Summerville. “Transitioning a Lab-Based Course to an On-Line Format.” *American Society for Engineering Education Annual Conference*, June, 2011. http://www.asee.org/public/conferences/1/papers/532/view
[16] Ibid.
[17] Undergraduate Engineering Programs.” Frostburg State University. http://www.frostburg.edu/dept/engn/

science employers a diverse and pre-qualified pool of future talent."[18] In addition to the match between veterans' skills and training and national workforce needs, a 2008 update to the GI Bill provides additional educational benefits for veterans, resulting in further opportunities for veterans to earn college degrees.[19]

However, both veterans and active-duty military personnel face unique challenges in adapting to higher education environments, and they can experience particular difficulties in pursuing engineering degrees. In addition to the various challenges that confront veterans entering all areas of higher education, **two issues in particular create barriers for veterans and military personnel seeking to earn engineering degrees: lack of academic credit for technical skills acquired during military service and lack of advanced mathematics training while on active duty.** These two challenges were highlighted in a 2011 study by a team of researchers at Pennsylvania State University's Center for the Study of Higher Education.[20] Interviews with veteran students in engineering programs revealed that they were highly frustrated by their institutions' unwillingness to award credit for military training, and degree program administrators often noted veterans' lack of math prerequisites.

Resources exist for aiding institutions in addressing these challenges, and several institutions have taken steps both to ease veterans' transition to engineering programs and to reduce their time to degree. Regarding credit for military training, the American Council on Education (ACE) evaluates military training and experience for academic credit and makes credit recommendations that institutions can use to guide the process of mapping military training to academic engineering curricula.[21]

Regarding math prerequisites, the Penn State researchers suggest that institutions can provide opportunities for active duty personnel to take advanced math courses so that they are prepared to begin progress toward an engineering degree immediately upon leaving active duty. In addition to offering on-site math courses, institutions can offer online courses that are easier for active duty servicemembers to access or partner with community colleges to offer prerequisite mathematics courses for active or retired servicemembers who will be entering an engineering bachelor's program.[22]

[18] "Veterans Education for Engineering and Science." National Science Foundation, 2009. p. 6. http://www.nsf.gov/eng/eec/VeteranEducation.pdf

[19] "Attracting Student Veterans to Science and Engineering Degree Fields." Florida Senate Committee on Military Affairs, Space, and Domestic Security, September, 2011. p. 4. http://www.flsenate.gov/PublishedContent/Session/2012/InterimReports/2012-133ms.pdf

[20] Heller, D. et al. "Veterans' Education in Science and Engineering: Evaluation Design." Pennsylvania State University Center for the Study of Higher Education Working Paper, July, 2011. https://www.ed.psu.edu/cshe/working-papers/wp-10

[21] Witcham, M. "Academic Recognition of Military Experience in STEM Education." American Council on Education, June, 2013. p. 1. http://www.acenet.edu/news-room/Documents/Academic-Recognition-of-Military-Experience-in-STEM-Education.pdf

[22] Heller et al., Op. cit., p. 50.

In addition to addressing these two specific challenges, institutions can offer more general support to veterans as well. The NSF has outlined a series of recommendations for helping veterans to attain engineering degrees,[23] and in 2009, it awarded grants to 16 colleges and universities to develop programs to aid veterans in pursuing engineering degrees.[24] The NSF's recommendations for programs to provide an enriching and supportive environment for veteran engineering students include: [25]

- Programs should run for the full academic year, allowing veterans to complete their degrees needing only four years of financial support.
- Institutions should develop agreements with public- and private-sector organizations to provide paid internships and research opportunities specifically for veterans.
- Institutions should establish support structures for the particular needs of veterans, including financial aid information, disability services, student veterans' organizations, and family support services.
- Faculty members who will be involved in educating veterans should receive special training in recognizing and responding to veterans' unique needs.

A 2011 report by the Florida Senate made similar recommendations to those of the NSF and also recommended that higher education institutions establish a dedicated staff position "responsible for STEM outreach services targeting veterans."[26]

With support from NSF grants, a number of institutions have already launched special programs designed to attract and retain veterans in engineering programs.[27] As shown in the brief profiles presented below, these programs implement several of the recommendations discussed above:

- **University of San Diego (USD)** hosts a program that "seeks to improve veterans' ability to join the engineering workforce by creating customized engineering education opportunities for our returning veterans."[28] USD modified its recruitment, admissions, and advising procedures to better serve veterans, publicized campus support services for veterans, developed online resources to prepare incoming veteran students for the mathematics requirements of engineering courses, and established an advisory board of employers committed to hiring veterans.
- **Kansas State University (KSU)** offers an accelerated electrical engineering bachelor's degree for veterans. KSU developed procedures for evaluating military training experiences to award academic credit for veterans' pre-acquired skills and offers

[23] Ibid.
[24] Heller et al., Op. cit., p. 5.
[25] "Veterans' Education for Engineering and Science," pp. 13-14.
[26] "Attracting Student Veterans to Science and Engineering Degree Fields," Op. cit.
[27] Lord, S. et al. "Special Session – Attracting and Supporting Veterans in Engineering Programs." *ASEE/IEEE Frontiers in Education Conference*, October, 2011. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6142857
[28] Ibid., p. 2.

accelerated courses specifically for veterans. KSU also works to provide veterans with information and support in finding internships and employment.

- **Mississippi State University (MSU)** leads a consortium of institutions working to help veterans transition to STEM careers. Key components of the program are faculty mentors and a "buddy" system for veteran students, veteran-only STEM classes, and a "transition class" for veterans covering study skills and university structure.
- **San Diego State University (SDSU)** collaborates with local community colleges and industry partners to support veterans before, during, and after they earn their engineering bachelor's degrees. Math courses at community colleges prepare veterans for college-level engineering coursework, while industry partners provide internships to veteran students as they complete their degrees.[29]

[29] Ibid., pp. 2-3.

SECTION II: LABOR MARKET TRENDS

EMPLOYMENT PROJECTIONS METHODOLOGY

The Bureau of Labor Statistics (BLS) and state departments of labor data follow a similar classification process to that of NCES and its CIP codes. For labor projections, the Standard Occupational Classification (SOC) code system is used to index occupations. When constructing labor market assessments, Hanover Research uses the CIP-SOC Crosswalk, provided by the NCES,[30] to identify SOCs related to the academic fields of interest. Using this method, Hanover identified 26 occupational classifications for graduates with a bachelor's degree in engineering, shown in Figure 2.1 (related occupational classifications most often requiring more than a bachelor's degree, such as postsecondary teaching, were excluded).

Figure 2.1: Engineering Occupations by SOC Code

SOC	OCCUPATION
11-3051	Industrial Production Managers
11-9041	Architectural and Engineering Managers
11-9121	Natural Sciences Managers
13-1051	Cost Estimators
15-1132	Software Developers, Applications
15-1133	Software Developers, Systems Software
15-1143	Computer Network Architects
15-2031	Operations Research Analysts
17-2011	Aerospace Engineers
17-2021	Agricultural Engineers
17-2031	Biomedical Engineers
17-2041	Chemical Engineers
17-2051	Civil Engineers
17-2061	Computer Hardware Engineers
17-2071	Electrical Engineers
17-2072	Electronics Engineers, Except Computer
17-2081	Environmental Engineers
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors
17-2112	Industrial Engineers
17-2121	Marine Engineers and Naval Architects
17-2131	Materials Engineers
17-2141	Mechanical Engineers
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers
17-2161	Nuclear Engineers
17-2171	Petroleum Engineers
17-2199	Engineers, All Other

Source: Bureau of Labor Statistics

[30] "Resources: 2000-2010 CIP Conversion." National Center for Education Statistics. http://nces.ed.gov/ipeds/cipcode/resources.aspx?y=55

NATIONAL LABOR PROJECTIONS

Occupational projections on a national level demonstrate how the field is growing on a broad scale. Figure 2.2, on the following page, displays BLS projections for employment related to engineering from 2012 to 2022. Eleven of the 26 occupations exhibit expected growth greater than the national average of 10.8 percent. **Occupations with particularly high projected growth include "Operations Research Analysts," "Biomedical Engineers," "Cost Estimators," and "Petroleum Engineers."**

PENNSYLVANIA EMPLOYMENT PROJECTIONS

To provide a more geographically-specific picture of projected employment for graduates from an engineering program at Clarion University, Hanover Research analyzed 2010-20 employment projections from the Pennsylvania Department of Labor and Industry. Note that because the years included in the statewide projections differ from those of the national BLS data, the two datasets are not directly comparable. As shown in Figure 2.3, two occupational areas are expected to see extremely rapid growth in the coming decade: petroleum engineering and biomedical engineering. Developers of systems software and cost estimators are also projected to see high levels of occupational growth.

Figure 2.2: National Employment Projections, Engineering-Linked Occupations, 2012-2022

Occupation Title	2012 (000s)	2022 (000s)	Change (000s)	Change (%)	Avg. Annual Openings (000s)
Industrial Production Managers	172.7	168.6	-4.1	-2.4%	31.4
Architectural and Engineering Managers	193.8	206.9	13.1	6.7%	60.6
Natural Sciences Managers	51.6	54.5	2.9	5.7%	13.7
Cost Estimators	202.2	255.2	53.0	26.2%	118.0
Software Developers, Applications	613.0	752.9	139.9	22.8%	218.5
Software Developers, Systems Software	405.0	487.8	82.8	20.4%	134.7
Computer Network Architects	143.4	164.3	20.9	14.6%	43.5
Operations Research Analysts	73.2	92.7	19.5	26.7%	36.0
Aerospace Engineers	83.0	89.1	6.1	7.3%	25.4
Agricultural Engineers	2.6	2.7	0.1	4.8%	0.8
Biomedical Engineers	19.4	24.6	5.2	26.6%	10.1
Chemical Engineers	33.3	34.8	1.5	4.5%	9.2
Civil Engineers	272.9	326.6	53.7	19.7%	120.1
Computer Hardware Engineers	83.3	89.4	6.2	7.4%	24.1
Electrical Engineers	166.1	174.0	7.9	4.7%	44.1
Electronics Engineers, Except Computer	140.0	144.8	4.8	3.4%	35.3
Environmental Engineers	53.2	61.4	8.1	15.3%	21.1
Health and Safety Engineers, Except Mining Safety Engineers	24.1	26.7	2.6	11.0%	9.7
Industrial Engineers	223.3	233.4	10.1	4.5%	75.4
Marine Engineers and Naval Architects	7.3	8.1	0.8	10.3%	2.6
Materials Engineers	23.2	23.4	0.2	0.9%	7.5
Mechanical Engineers	258.1	269.7	11.6	4.5%	99.7
Mining and Geological Engineers, incl. Mining Safety Engineers	7.9	8.9	1.0	12.0%	3.0
Nuclear Engineers	20.4	22.3	1.9	9.3%	7.1
Petroleum Engineers	38.5	48.4	9.8	25.5%	19.6
Engineers, All Other	133.0	138.1	5.1	3.8%	29.5
Total, All Related Occupations	**3,444.5**	**3,909.3**	**464.7**	**13.5%**	**1,200.7**
Total, All Occupations	***145,355.8***	***160,983.7***	***15,628.0***	***10.8%***	***50,557.3***

Source: Bureau of Labor Statistics[31]

[31] "Employment by Detailed Occupation." BLS. http://www.bls.gov/emp/ep_table_102.htm

Figure 2.3: Pennsylvania Employment Projections

Occupation Title	2010	2020	Change	Change (%)	Avg. Annual Openings
Industrial Production Managers	6,700	7,290	590	8.8%	217
Engineering Managers	6,000	6,340	340	5.7%	151
Natural Sciences Managers	1,880	2,020	140	7.4%	128
Cost Estimators	9,450	11,490	2,040	21.6%	386
Software Developers, Applications	14,760	16,570	1,810	12.3%	334
Software Developers, Systems Software	13,050	16,740	3,690	28.3%	505
Operations Research Analysts	1,960	2,090	130	6.6%	77
Aerospace Engineers	1,250	1,380	130	10.4%	41
Agricultural Engineers	40	40	0	0.0%	1
Biomedical Engineers	960	1,560	600	62.5%	81
Chemical Engineers	1,290	1,420	130	10.1%	54
Civil Engineers	12,830	14,450	1,620	12.6%	423
Computer Hardware Engineers	2,000	2,190	190	9.5%	66
Electrical Engineers	4,760	5,200	440	9.2%	159
Electronics Engineers, Except Computer	4,290	4,360	70	1.6%	111
Environmental Engineers	2,530	2,840	310	12.3%	87
Health & Safety Engineers, Except Mining Safety Engineers/Inspectors	1,280	1,430	150	11.7%	43
Industrial Engineers	10,930	12,140	1,210	11.1%	359
Marine Engineers & Naval Architects	50	40	-10	-20.0%	1
Materials Engineers	1,440	1,620	180	12.5%	57
Mechanical Engineers	10,790	11,840	1,050	9.7%	452
Mining & Geological Engineers, Incl. Mining Safety Engineers	620	710	90	14.5%	23
Nuclear Engineers	1,690	1,670	-20	-1.2%	37
Petroleum Engineers	240	420	180	75.0%	23
Engineers, All Other	3,020	3,040	20	0.7%	68
Total, All Related Occupations	**113,810**	**128,890**	**15,080**	**13.3%**	**3,884**
Total, All Occupations	***5,983,460***	***6,363,730***	***380,270***	***6.4%***	***185,472***

Source: Pennsylvania Department of Labor and Industry[32]

[32] "Long-Term Occupational Employment Projections." Pennsylvania Department of Labor & Industry. http://www.portal.state.pa.us/portal/server.pt?open=514&objID=814813&mode=2

SECTION III: COMPETITOR PROFILES

In this section, Hanover presents high-level information about student outcomes and the costs of establishing a new engineering program. Most of this section focuses on profiles of engineering programs at several possible competitors for a potential engineering bachelor's degree program at Clarion University. These profiles feature programs that exhibit one or more of the following characteristics:

- Offered at institutions that are geographically close to Clarion University
- Offered at institutions of similar size to Clarion University
- Focused on high-growth degree and employment fields

STUDENT OUTCOMES

All of the programs profiled share general, overall goals for student outcomes. As part of the accreditation process for engineering bachelor's programs, ABET requires institutions to "define and refine objectives and outcomes" for graduates.[33] ABET provides a standard list of objectives, and most engineering programs use this list as the basis for their program goals.[34] A version of the following student objectives may be found on the websites of each of the programs profiled in this section, but standard goals are presented below:[35]

- An ability to apply knowledge of mathematics, science, and engineering
- An ability to communicate effectively
- An ability to design and conduct experiments, as well as to analyze and interpret data
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- An ability to function in multidisciplinary teams
- An ability to identify, formulate, and solve engineering problems
- An understanding of professional and ethical responsibility
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- A recognition of the need for and an ability to engage in life-long learning
- A knowledge of contemporary issues
- An ability to use the techniques, skills and modern engineering tools necessary for engineering practice

[33] "Assessment Planning." ABET. http://www.abet.org/assessment-planning/

[34] Felder, R. and R. Brent. "Designing and Teaching Courses to Satisfy the ABET Engineering Criteria. *Journal of Engineering Education,* 92:1, 2003. http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/ABET_Paper_(JEE).pdf

[35] Taken verbatim – with some modifications to improve readability – from: Ibid., p. 2.

ENGINEERING PROGRAM START-UP COSTS

Engineering programs are expensive to launch and maintain. In addition to faculty and other new program expenditures, laboratories play an important role in engineering education. However, there are some associated challenges with establishing, staffing, and running an engineering lab:[36]

> Through systematically designed experiments, students can gain hands-on experience, enhance classroom learning, and cultivate career interests. However, traditional laboratory conduction is often restricted by various reasons such as facility cost, conflicted schedule, and limited space.

One source indicates that an engineering lab with 10 workbenches costs between $50,000 and $100,000, and beyond initial costs, labs must update equipment as new technical advances are made and older equipment becomes obsolete.[37]

Start-up costs are significant. In 2013, Western Carolina University received more than $1.4 million from the state to expand its undergraduate engineering program. About $700,000 of the money was allotted for start-up costs and laboratory equipment, and the university would receive another approximately $720,000 in "recurring funds to cover faculty positions and ongoing operations."[38]

Some academics and others in the field have proposed solutions that allow students to access lab time despite the expense and scheduling conflicts that engineering departments often face. For example, potential solutions such as enhancing engineering laboratory experiences through cloud computing[39] or "labs in a box"[40] have been proposed.

Although additional research is required to provide a more in-depth examination of start-up and maintenance costs for specific types of engineering programs, Figure 3.1 presents the renovation costs for updating engineering laboratories at Texas Tech University's Edward E. Whitacre Jr. College of Engineering. The total initiative cost $6.5 million, and the source includes the price of each piece of requested equipment or updates as part of the renovation. The $6.5 million includes updates to 20 labs, including new and updated equipment, but excludes start-up costs and expenses to maintain and run these laboratories.[41]

[36] "Li, L., Y. Zhang, and L. Huang. "AC 2012-2974: Engineering Laboratory Enhancement Through Cloud Computing." *American Society for Engineering Education*. 2012.

[37] Restauri, D. "What's the Next Big Thing for Engineering Students? A Lab That Fits in a Backpack." *Forbes*. September 26, 2014. http://www.forbes.com/sites/deniserestauri/2013/09/26/whats-the-next-big-thing-for-engineering-students-a-lab-that-fits-in-a-backpack/

[38] "Budget Includes Funding for Expansion of Engineering Program to Biltmore Park." Western Carolina University. August 5, 2013. http://news-prod.wcu.edu/2013/08/state-budget-includes-funding-for-engineering-program-at-biltmore-park/

[39] Li, Zhang, and Huang, Op. cit.

[40] Restauri, Op. cit.

[41] "Undergraduate Laboratory Renovation Initiative." Texas Tech University. http://www.depts.ttu.edu/coe/dean/development/documents/Lab-Renovations.pdf

Figure 3.1: Estimated Engineering Lab Renovation Costs, Texas Tech University

LABORATORY	ESTIMATED RENOVATION COST
Chemical Engineering	**$605,000**
Undergraduate Teaching Labs	$605,000
Civil and Environmental Engineering	**$1,962,600**
Environmental Engineering Teaching Laboratory	$321,500
Geotechnical Engineering Laboratory	$210,000
Structures Laboratory	$668,300
Mechanics of Fluids Laboratory	$447,800
Construction Materials and Mechanics of Solids	$315,000
Electrical and Computer Engineering	**$1,162,919**
ECE Undergraduate Laboratory	$58,500
Telecommunications and RF Laboratory	$251,319
Robotics, Controls & Mechatronics Laboratory	$359,000
Undergraduate Fabrication Facility	$130,000
Undergraduate Measurements Facility	$283,200
ELVIS II Labs	--
Bioinstrumentation Lab	$60,000
MEMS Labs	$20,900
Optics & Photonics Lab	--
Power Systems & Alternative Energy Lab	--
Audiovisual, Studio & Collaborative Classrooms	--
Construction Engineering and Engineering Technology	**$140,000**
Computer Labs	$140,000
Industrial Engineering	**$1,572,500**
Advanced Manufacturing Laboratory	$1,445,000
Ergonomics Laboratory	$127,500
Mechanical Engineering	**$1,434,895**
Mechanics and Materials Laboratory	$295,000
Dynamic Systems & Control Laboratory	$69,611
Machine Shop Laboratory	$900,745
Thermal Fluid Systems Laboratory	$169,539

Source: Texas Tech University[42]

[42] Ibid.

THE COLLEGE OF NEW JERSEY

The College of New Jersey (TCNJ) is a public, four-year college located in Ewing, New Jersey, that currently enrolls approximately 6,135 full-time students.[43] TCNJ was among the peer institutions identified in Clarion University's 2010 self-study design proposal submitted to the Middle States Commission on Higher Education.[44]

TCNJ's School of Engineering offers bachelor's degrees in five engineering fields:

- Biomedical Engineering,
- Civil Engineering,
- Computer Engineering,
- Electrical Engineering, and
- Mechanical Engineering.[45]

In addition to these core engineering degrees, the School of Engineering offers bachelor's programs in engineering science management and STEM/technology education, which combine training in the fundamentals of engineering and technology with coursework in business and education, respectively.[46] Figure 3.1 presents enrollment and completions data for the core engineering degrees at TCNJ in 2012-2013.

Figure 3.1: Recent Graduation and Enrollment Data, School of Engineering, TCNJ

PROGRAM	2012-2013 GRADUATES	FALL 2013 ENROLLMENT
Biomedical Engineering	30	113
Civil Engineering	35	111
Computer Engineering	6	55
Electrical Engineering	5	68
Mechanical Engineering	36	121

Source: School of Engineering, The College of New Jersey[47]

Each of these programs requires students to complete a total of 39 course units, where one course unit is equivalent to four semester hours.[48] Students across TCNJ's engineering degree programs take a similar set of courses during the first year (Figure 3.2), with the

[43] "At a Glance." The College of New Jersey. http://tcnj.pages.tcnj.edu/about/at-a-glance/
[44] "Self-Study Design." Clarion University. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCcQFjAB&url=http%3A%2F%2Fclarion.edu%2F247524.doc&ei=z_v8U9jANdW0yAT65YIo&usg=AFQjCNHbrqbitSc0XmJCUKDiUAbePmW3qA&bvm=bv.73612305,d.aWw
[45] "Departments and Academic Programs." School of Engineering, The College of New Jersey. http://engineering.pages.tcnj.edu/departments-programs/
[46] Ibid.
[47] "Graduation and Enrollment Data." School of Engineering, The College of New Jersey. http://engineering.pages.tcnj.edu/about-the-school/graduation-and-enrollment-data/
[48] "School of Engineering Advising Guide." School of Engineering, The College of New Jersey. p. 7. http://engineering.pages.tcnj.edu/files/2010/02/2012-2013-School-of-Engineering-Advising-Guide.pdf

curriculum for each degree diverging thereafter. In addition to core classes in physical sciences and calculus, first-year engineering students at TCNJ take two non-credit courses (graded on a pass/fail basis) designed to introduce them to the curriculum and the engineering profession.[49]

Figure 3.2: First-Year Courses for Engineering Students, TCNJ

Fall	Spring
General Physics I	General Physics II
Calculus A	Calculus B
Engineering Seminar I	Engineering Seminar II
General Chemistry I	Academic Writing
Introduction to Engineering	Creative Design (General Chemistry II for Bioengineering program)
Fundamentals of Engineering Design *or* Computer Science I	Computer Science I *or* Fundamentals of Engineering Design

Source: School of Engineering, The College of New Jersey

Biomedical Engineering Curriculum

Biomedical engineering is one of the fields that shows high numbers of completions and strong growth nationally. The required course distributions for the biomedical engineering degree at TCNJ are shown in Figure 3.3, while a detailed curriculum (beyond the first year) is presented in Figure 3.4.

Figure 3.3: Course Distribution Requirements, Biomedical Engineering Degree, TCNJ

Course Distribution	Course Units
Mathematics	5
Natural Science (Physics/Chemistry)	5
Life Sciences	2
Computer Science	1
Biomedical Engineering	20
Social Science/Humanities	6

Source: School of Engineering, The College of New Jersey[50]

The curriculum shown in Figure 3.4 is for the "mechanical" track within the biomedical engineering degree. TCNJ also offers an "electrical" track that substitutes certain courses, such as those in microprocessors and digital signal processing for those in statics and fluid mechanics.[51]

[49] Kim, S. "Dr. Kim's First-Year Students." http://www.drseungkim.com/first_year.html
[50] "Biomedical Engineering Curriculum." School of Engineering, The College of New Jersey. http://biomedicalengineering.pages.tcnj.edu/academic-programs/curriculum/
[51] "Bachelor of Science in Biomedical Engineering (BSBME) Electrical Option." School of Engineering, College of New Jersey. http://electrical-computerengineering.pages.tcnj.edu/academic-programs/curriculum/electrical-engineering-curriculum/

Figure 3.4: Biomedical Engineering Curriculum, TCNJ

Fall	Spring
Sophomore Year	
Themes in Biology	Fundamentals of Biomedical Engineering
Circuit Analysis	Creative Design
Circuit Analysis Lab (0.5)	Microeconomics
Advanced Engineering Math I	Mechanical Engineering Laboratory I (0.5)
Statics	Multivariable Calculus
--	Strength of Materials
Junior Year	
Engineering Seminar III (0)	Engineering Seminar IV (0)
Organic Chemistry I	Advanced Engineering Math II
Physiological Systems	Electronics
Physiological Systems Lab (0.5)	Electrical Engineering Lab I (0.5)
Biology of the Eukaryotic Cell	Biomechanics
Society, Ethics, & Technology	Physiological Systems II
Thermodynamics I	--
Senior Year	
Senior Professional Seminar (0)	Fundamentals of Engineering Review (0)
Mechanical Design I	Engineering Economy
Fluid Mechanics	Bioinstrumentation
Introduction to Biomaterials	Senior Project II
Senior Project I (0)	Liberal Learning Elective
Liberal Learning Elective	Biomedical Engineering Elective
Biomedical Engineering Elective	--

Source: School of Engineering, College of New Jersey[52]

Faculty and Institutional Resources

Each engineering department at TCNJ has a complement of full-time faculty and operates a number of laboratory facilities. All laboratories are used in the undergraduate curriculum, with many also supporting faculty research. Figure 3.5 shows the number of faculty appointments and the facilities operated by each department.[53]

[52] "Bachelor of Science in Biomedical Engineering (BSBME) Mechanical Option." School of Engineering, College of New Jersey. http://biomedicalengineering.pages.tcnj.edu/academic-programs/curriculum/bachelor-of-science-in-biomedical-engineering-bsbme/

[53] "Biomedical Engineering Faculty." School of Engineering, The College of New Jersey. http://biomedicalengineering.pages.tcnj.edu/our-people/faculty/

Figure 3.5: Faculty Appointments and Lab Facilities, School of Engineering, TCNJ

Department	Faculty Appointments	Facilities
Biomedical Engineering	Four full-time faculty; Two affiliated appointments in mechanical engineering	▪ Biomechanical Laboratory ▪ Bioinstrumentation Laboratory ▪ Physiological Systems Laboratory
Electrical and Computer Engineering	Five full-time faculty; Two visiting faculty	▪ Circuits and Electronics Lab ▪ Computer Architecture and VLSI (Very-Large-Scale Integration) Lab ▪ Controls Lab ▪ Digital Signals Processing Lab ▪ Image Processing Lab Embedded Systems Lab ▪ Microprocessor Lab ▪ RF/Communications Lab ▪ Robotics Lab
Civil Engineering	Five full-time faculty; Three adjunct faculty	▪ Surveying/Transportation Laboratory ▪ Hydrology/Water Resources Laboratory ▪ Mechanics of Materials Laboratory ▪ Soil Mechanics Laboratory ▪ Civil Engineering Materials Laboratory
Mechanical Engineering	Eight full-time faculty; Three adjunct faculty	▪ Mechanics of Materials Lab ▪ Thermo-fluids Lab ▪ Biomechanics Lab ▪ Vibrations Lab ▪ Robotics Lab ▪ Manufacturing Processes Lab

Source: School of Engineering, The College of New Jersey[54]

Gannon University

Gannon University is a private, four-year, Catholic university located in Erie, Pennsylvania. As of Fall 2013, Gannon enrolled 3,111 undergraduates.[55]

Gannon's College of Engineering and Business offers bachelor's degrees in:

- Biomedical Engineering
- Electrical and Computer Engineering
- Environmental Engineering
- Mechanical Engineering
- Software Engineering[56]

[54] Root page: "Departments and Academic Programs," Op. cit.
[55] "About Gannon." Gannon University. http://www.gannon.edu/About-Gannon/

Mechanical engineering is the most popular concentration for engineering students at Gannon, though the environmental engineering program has gained popularity in recent years, as shown in Figure 3.6.

Figure 3.6 Engineering Degree Completion Data, Gannon University

Degree	2010-11		2011-12		2012-13		2013-14	
	Enrollment	Graduates	Enrollment	Graduates	Enrollment	Graduates	Enrollment	Graduates
Biomedical Engineering	12	0	8	0	13	1	-	-
Electrical and Computer Engineering	35	8	30	10	33	7	-	-
Environmental Engineering	14	0	16	2	20	6	32	-
Mechanical Engineering	83	12	79	17	88	17	-	-
Software Engineering	18	9	12	2	15	1	14	-

Source: Gannon University[57]
"-" indicates no data available.

Environmental Engineering Degree

Given the rapid growth of degree completions in environmental engineering and the expected strength of the job market for environmental engineers, this profile includes a full description of the stated program goals and curriculum of the environmental engineering bachelor's program at Gannon University.

In addition to the ABET standard objectives for engineering programs, the environmental engineering department defines a series of further education outcomes for students. According to these objectives, graduates of the program will:

- Have engineering knowledge and skills that allow them to effectively begin a career as environmental engineers in consulting, industry, or government;
- Have an understanding of the scientific basis of engineering design and be prepared for graduate study in environmental engineering or a related field;
- Have a broad but individualized general education that fosters leadership, teamwork, ethics, and an understanding of the impact of their profession in a global and societal context; and
- Value professional development as evidenced by pursuit of graduate education, professional licensure, and/or membership in professional organizations.[58]

[56] "Engineering and Business." Gannon University. http://www.gannon.edu/Academic-Offerings/Engineering-and-Business/
[57] See the Accreditation and Licensure pages for respective degree programs listed in ibid.
[58] "Undergraduate Catalog 2014-2015." Gannon University. pp. 146. http://issuu.com/gannonuniversity/docs/undergraduatecatalog2014/147?e=3615257/8289333

Figure 3.7 displays the full curriculum for the environmental engineering major. All courses are three credits unless otherwise noted.

Figure 3.7: Environmental Engineering Curriculum, Gannon University

MATH & BASIC SCIENCES: 37 CREDITS	
Calculus I	Mol/Cellular Biology
Calculus II	Intro to Microbiology
Calculus III	Intro to Microbiology Lab (1 cr.)
Differential Equations	General Chemistry I
Probability and Statistics	General Chemistry I Lab (1 cr.)
General Physics III	General Chemistry II
General Physics IV	General Chemistry II Lab (1 cr.)
Physics Lab (1 cr.)	--
GENERAL ENGINEERING: 13 CREDITS	
First-Year Seminar	Digital Computer Usage
Statics	Digital Computer Usage Lab (1 cr.)
Dynamics	Engineering Thermodynamics
ENVIRONMENTAL ENGINEERING SCIENCES: 45 CREDITS	
Physical Geology	Industrial Health I
Physical Geology Lab (1 cr.)	Environmental Law & Regulations
Environmental Hydrology	Water/Wastewater Engineering
Environmental Hydrology Lab (1 cr.)	Water/Wastewater Lab (1 cr.)
Water Quality	Soil & Groundwater Pollution
Water Quality Lab (1 cr.)	Fluid Mechanics and Water Systems Design
Environmental Toxicology	Fluid Mechanics & Water System Design Lab (1 cr.)
Environmental Health Lab (1 cr.)	Senior Design I
Environmental Engineering	Senior Design II

Source: Gannon University[59]

FROSTBURG STATE UNIVERSITY

Located in Frostburg, MD, Frostburg State University (FSU) is a public, four-year university with an enrollment of 4,704 undergraduates.[60] FSU offers a Bachelor of Science degree in engineering, with concentrations in electrical engineering and materials engineering. In addition, FSU participates in a unique collaborative program with the University of Maryland, College Park, (UMD) that allows students to obtain a mechanical engineering degree from UMD while spending four years on the FSU campus.[61] In this profile, Hanover Research summarizes the key features of the electrical and materials engineering curriculum and describes FSU's partnership arrangement with the University of Maryland.

[59] Ibid., pp. 147-148.
[60] "Undergraduate Admissions." Frostburg State University. http://www.frostburg.edu/ungrad/admiss/
[61] Undergraduate Engineering Programs." Frostburg State University. http://www.frostburg.edu/dept/engn/

MECHANICAL ENGINEERING PARTNERSHIP WITH UMD

Students in FSU's collaborative mechanical engineering program begin with two years of general education and engineering science courses at FSU, during which time they are designated as "pre-engineering" majors. Students may then apply for admission to UMD's School of Engineering. If accepted, they will be designated as engineering majors at UMD for their final two years of study. During these final two years, students remain on the FSU campus and complete laboratory and project courses taught by FSU faculty but complete online, upper-level engineering courses taught by faculty at UMD. At the end of four years of study, students receive a Bachelor of Science degree in mechanical engineering from UMD. Students must satisfy all UMD general education requirements, and, during the time they are designated as UMD students, pay UMD's tuition rates and must apply for scholarships and financial aid from UMD, rather than FSU.[62]

While FSU students may also participate in a more traditional, institutional-transfer "3-2" program with UMD to earn degrees in other engineering disciplines over five years, the mechanical engineering program is unique in allowing students to earn an engineering bachelor's degree in four years while remaining on a single campus.

ELECTRICAL AND MATERIALS ENGINEERING CONCENTRATIONS

Figure 3.8 shows the enrollment and completions data for FSU's complete engineering programs. Mechanical engineering graduates are excluded because these data are mixed into UMD's general completions data, and FSU offers no indication of the size of that program. Figures 3.9 and 3.10 detail the credit hour requirements and specific courses required for FSU's engineering programs. The core requirements in Figure 3.10 are substantially identical to those of UMD's for the mechanical engineering program, though some courses are titled or placed differently.[63]

Figure 3.8: Recent Enrollment and Graduation Data, Frostburg State University

CONCENTRATION	FALL 2013 ENROLLMENT	2012-2013 DEGREES AWARDED
Electrical	23	10
Materials	162	5

Source: Frostburg State University[64]

[62] "2013-2015 Undergraduate Catalog: Mechanical Engineering Collaborative Program." Frostburg State University. http://www.frostburg.edu/fsu/assets/File/dept/pdf/mengi.pdfhttp://www.frostburg.edu/fsu/assets/File/dept/pdf/mengi.pdf

[63] "2013-2015 Undergraduate Catalog: Mechanical Engineering." Frostburg State University. http://www.frostburg.edu/fsu/assets/File/dept/pdf/mengi.pdf

[64] There is no explanation regarding why so many are enrolled in Materials Engineering with so few graduates; this could be a typographical error in source. "Enrollment and Graduation Data." Department of Engineering, Frostburg State University. http://www.frostburg.edu/fsu/assets/File/dept/engn/Engineering_Majors_and_Degrees_Awarded-Fall_2013_Enrollment-Concentrations.pdf

Figure 3.9: Engineering Degree Course Distribution Requirements

CONCENTRATIONS	HOURS IN ENGINEERING	HOURS IN OTHER DISCIPLINES	TOTAL HOURS
Electrical	42-44	47	89-91
Materials	47	40	87
Mechanical (collaborative program)	66	40	106

Source: Frostburg State University[65]

Figure 3.10: Engineering Curriculum

CORE COURSES – ALL MAJORS (56 HOURS)	
Introduction to Engineering Design	Programming Concepts for Engineers
Calculus I	Calculus II
Calculus III	Differential Equations
General Chemistry	Principles of Physics I – Mechanics
Principles of Physics II – E&M	Principles of Physics III – Acoustics & Optics
Principles of Physics IV – Thermo. And Mod. Physics	Electronics and Instrumentation I
Electronics & Instrumentation II	Seminar
Capstone Design Project	Fundamentals of Energy Engineering
ELECTRICAL ENGINEERING (33-35 HOURS)	
Electricity and Magnetism	Basic Circuit Theory
Fund. Digital and Electrical Circuits Lab	Digital Logic Design
Analog and Digital Electronics	Electronic Circuits Lab
Computer Organization	Mechatronic and Robotic Design
Topics in Signal Processing	Power Electronics
Two electives from 300- or 400-level science/engineering courses	
MATERIALS ENGINEERING (31 HOURS)	
Statics	Mechanics of Materials
Dynamics	Thermodynamics
Fluid Mechanics	Transfer Processes
Engineering Materials and Manufacturing	Fundamentals of Materials Engineering
Two electives from 300- or 400-level science/engineering courses	

Source: Frostburg State University[66]

[65] "2013-2015 Undergraduate Catalog: Engineering Major." Frostburg State University. http://www.frostburg.edu/fsu/assets/File/dept/pdf/engi.pdf
[66] Ibid.

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