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## **AC 2012-5298: FIVE-YEAR B.S./M.S. IN ENGINEERING: THE TIME HAS COME**

### **Dr. Michael G. Jenkins P.E., California State University, Fresno**

Michael G. Jenkins is a professor in mechanical engineering and Former Dean of Engineering at California State University, Fresno. He is an advocate of the active learning and teaching philosophy per ABET EC2000. Jenkins is a registered professional engineer in Washington and is actively involved through leadership roles in national/international committees such as ASTM, ASME and ISO. He is also an experienced ABET Program Evaluator (PEV) for general engineering and mechanical engineering. Jenkins received his B.S.M.E. from Marquette University, his M.S.M.E. from Purdue University, and his Ph.D. from the University of Washington. He worked at PACCAR Technical Center as an R&D engineer and at Oak Ridge National Laboratory as a development staff member. He was also faculty and associate chair at University of Washington, Seattle, and professor and chair at University of Detroit Mercy before starting his position as faculty and dean at CSU, Fresno. His research and teaching interests include characterization of advanced materials (e.g., ceramics), experimental mechanics, data base development, cumulative damage mechanics, and probabilistic design and reliability.

### **Dr. Walter V. Loscutt, California State University, Fresno**

Walter V. Loscutt is a professor and Former Chair of Mechanical Engineering as well as Former Associate Dean of Engineering at California State University, Fresno. Loscutt received his B.S.M.E., M.S.A.E., and Ph.D. from the University of California, Berkeley. He worked at Flow Industries, Inc., as Executive Vice President & COO of Flow Research, Inc.; Vice President & General Manager of Flow-Dril Corporation; Manager of Research & Technology Division, at Pacific Northwest National Laboratory through Battelle Memorial Institute; Associate; and Project Manager; Program Manager, Section Manager and Rocketdyne: Research Engineer. He was also Assistant Professor at University of California, Davis, and Adjunct Associate Professor at Washington State University before starting his position as faculty at CSU, Fresno. His research and teaching interests include advanced materials, alternate energy, systems analysis, and project management.

### **Dr. Thomas Nguyen**

# **Five-Year BS/MS in Engineering – The Time Has Come**

**Michael G. Jenkins<sup>1</sup>, PhD, PE; Walter V. Loscutoff<sup>1</sup>, PhD; Thomas L. Nguyen<sup>2</sup>, PhD**

**<sup>1</sup>California State University, Fresno, CA; <sup>2</sup>Levitas Consultants, Merced, CA**

## Abstract

The time has come to implement five-year BS/MS programs as the norm for the first professional degrees of entry-level engineers. The impetus for this change stem from the following: i) calls from such professional organizations as NCEES to change licensure requirements to include both a mandatory baccalaureate degree and up to thirty semester credits of post-baccalaureate education and ii) pressure to reduce minimum semester credit requirements for baccalaureate degrees to 120. Five-year BS/MS degrees in engineering disciplines provide the opportunities to satisfy the demands for 120-semester credit BS degrees while meeting the needs of the profession (and licensure) with 30 semester-credit MS degrees. While 120-credit BS degree programs provide engineering fundamentals, the 30-credit MS degree programs provide discipline-specific focus. So called “accelerated” (a.k.a., 5-year masters, 4+1, etc.) masters programs allow seniors to take graduate-level courses that apply toward their Master’s degree while still classified as undergraduates. Economies of scale provide opportunities for concurrent offerings of upper division technical elective and graduate courses to fulfill the needs of both groups for students. The needs of the profession demand graduate degrees of engineering practitioners at some point in their careers and five-year BS/MS programs address this need at the entry level.

## Introduction

Engineering is defined as the profession “that applies knowledge of the mathematical and natural sciences gained by study, experience, and practice to develop ways to economically utilize the materials and forces of nature for the benefit of humankind.”<sup>1</sup>

The National Society of Professional Engineers (NSPE) asserts that engineering educational programs must prepare graduates for the practice of engineering at a professional level.<sup>1</sup> Programs should include certain elements that distinguish the engineering function, namely, the analysis, design, and synthesis of engineering systems. Basic and advanced programs of study should be designed to provide engineering graduates with competent technical and managerial skills as well as broad, cultural education in the humanities and social sciences. This approach enables engineers to provide the technical and managerial leadership in industry, government, and society needed to fulfill the engineering profession’s public purpose.

However, pressures from multiple sources are pointing to the need to change the way higher education approaches engineering degrees. For example:

- Stagnant numbers of new degreed engineers annually despite increasing demand (e.g., about 75,000-80,000 BS degrees per year in the United States since 2000)<sup>2</sup>
- Mandates for greater degree efficiency (e.g., minimum 120 semester-credit graduation requirements) in public institutions such as those in California<sup>3</sup>
- Increased costs of four-year undergraduate engineering programs at single institutions make attractive cost-effective options that involve two-year, lower-division pre-engineering programs at one institution combined with a two-year upper division engineering program and/or graduate program at another institution.

If engineering programs are reduced to a minimum of 120 semester credits for graduation, the quality of the degree in preparing new graduates for immediate practice in the profession is questionable. Some institutions offering engineering degrees have addressed this concern by offering “blended programs” that blur the transition from the baccalaureate and masters programs enabling the new engineering graduate to obtain two degrees in nearly the same time as that for an undergraduate degree. Such blended programs are the exceptions rather than the norm.

## Background

Over the past decade, National Council of Examiners for Engineering and Surveying (NCEES) has focused on how it can increase the minimum foundational engineering education required to become a professional engineer. NCEES believes that by expanding the educational requirement, professional engineers will be better prepared to meet the demands they will face in professional practice and that the public will benefit from the higher standards for licensure.

One of the outcomes to this effort is NCEES’s modification of Section 230.15 of the *Model Rules* (effective in January 01, 2020) such that:

“The following individuals shall be admitted to an 8-hour written examination in the principles and practice of engineering and, upon passing such examination and providing proof of graduation shall be licensed as a professional engineer, if otherwise qualified:

(1) An engineer intern who satisfies one of the following education and experience requirements:

(a) Following the bachelor’s degree, an acceptable amount of coursework resulting in a master’s degree in engineering from an institution that offers EAC/ABET accredited programs, or the equivalent, and with a specific record of 3 years or more of progressive experience on engineering projects of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(b) Following a master’s degree in engineering from an EAC/M-ABET-accredited program, a specific record of three (3) years or more of progressive experience on engineering projects of a grade and a character which indicate to the board that the applicant may be competent to practice engineering

(c) Following the bachelor's degree, an acceptable amount of coursework from approved course providers and a specific record of four (4) years or more of progressive experience on engineering projects of a grade and a character which indicate to the board that the applicant may be competent to practice engineering.....”

The term “acceptable amount of coursework” is interpreted to mean the following:

1. A minimum of an additional 30 credits of coursework, none of which were used to fulfill the bachelor's degree requirement.
2. All 30 additional credits shall be equivalent in intellectual rigor and learning assessments to upper-level undergraduate and/or graduate courses offered at institutions that have a program accredited by EAC/ABET.
3. Of the minimum required 30 additional credits, a minimum of 15 credits must be in engineering.
4. The term “credit” is defined as a semester hour, or its equivalent, from an approved course provider.

This requirement became known as the B+30 requirement (Bachelors plus 30 semester credits of additional coursework) where the extra 30 semester credits is equivalent to a Masters degree in many engineering programs.

Interestingly, in defiance of current trends in higher education regarding reduction of the minimum number of credits required to obtain the baccalaureate, NCEES is also considering the following wording:

“Following a bachelor's degree from an EAC/ABET-accredited program that has a minimum of 150 credit hours, of which at least 115 are in math, science, and engineering combined and at least 75 of the 115 are in engineering, a specific record of 4 years or more of progressive experience on engineering projects of a grade and a character which indicate to the board that the applicant may be competent to practice engineering.”

Prior to the NCEES actions, the American Society of Civil Engineers (ASCE) was the first professional society to formally address post baccalaureate course requirement for professional licensure. ASCE has developed [Policy Statement 465](#), which incorporates the concept of using the Master's or equivalent (MOE) as a prerequisite for the practice of civil engineering, and as the proposed requirements to sit for the professional engineering (PE) examination. Policy Statement 465 was motivated by the fact that the required number of credits to obtain a BS degree has declined significantly in the past few decades.

NCEES and ASCE support concerns for additional education for engineers. The National Academy of Engineering (NAE) in its study “Educating the Engineer of 2020” contains a statement “It is evident that the exploding body of science and engineering knowledge cannot be accommodated within the context of the traditional four-year baccalaureate degree.”

## Five-Year BS/MS in Engineering

In the past, there were two primary methods in the United States by which Masters in engineering were obtained: 1) As a separate Masters degree pursued after full completion of the Bachelors degree and 2) As a “consolation” degree after student pursues but fails to obtain a Doctoral degree. Timing for the two separate degrees could be anywhere from four to five years for the Bachelors degree to one and a half to two years for the Masters degree.

Also, in the past, the Bachelors degree (BS) in engineering has often been seen as the “entry-level” degree for start of practice in the profession. Masters degrees (MS) were often pursued by those interested in specialization, either personally or at the behest of the employer. However, currently, it is generally accepted that the Masters degree is fast becoming the “entry-level” degree for the profession. This general acceptance is both anecdotally-based (e.g., industry support of an employee obtaining a Masters degrees) and pronouncement-based (NAE in “Educating the Engineer of 2020” and NCEES in “B+30”).

Accepting the Masters as the entry-level degree, an expeditious method for students to obtain a Masters degree is as a “blended” program in which the curriculum for the Bachelors degree transitions smoothly into the curriculum of the Masters degree. A precedent of this type of “blended” program is the German “Diplom-Ingenieur” (Dipl-Ing) which is often interpreted as a degree intermediate between the traditional Masters and the Doctorate. The advantage of “blended” BS/MS programs is that students receive a much more comprehensive engineering education that results in not one but two degrees. The disadvantage is the students must take more credits of coursework often extending their educational experience to five years or more.

Many variations of “blended programs” (sometimes called Accelerated Masters, 4+1 Blended BS/MS, 5-year Masters, etc.) include the following examples. Note that this listing is not exhaustive but is a limited selection of representative examples. In addition, these examples are often taken verbatim from websites, catalogs or flyers and therefore, the authors of this article have made no editing or interpretation of their content or format.

## 4+1 Blended BS/MS Program at California Polytechnic State University, San Luis Obispo (CalPoly)<sup>9</sup>

Blended BS+MS engineering degree programs are offered by the following departments:

Aerospace Engineering  
Biomedical and General Engineering  
Civil and Environmental Engineering  
Computer Science  
Electrical Engineering  
Industrial and Manufacturing Engineering  
Materials Engineering  
Mechanical Engineering

Each of these blended programs provides an accelerated path to the simultaneous conferral of both BS and MS degrees in the particular discipline.

The blended program provides motivated students with an accelerated route to the MS in Engineering, simultaneously conferring both bachelor's and master's degrees. Students in the blended program are provided with a seamless process whereby they can progress from undergraduate to graduate status. The blended program may allow students to earn graduate credit for several senior electives, effectively decreasing the summed unit requirements for both degrees.

### **Eligibility for Blended BS/MS (4+1)**

Students may be eligible to pursue the blended program toward the MS Engineering. Students with earned undergraduate degrees in any engineering major are eligible for admission. A *minimum* grade point average of 3.0 in the last 90-quarter units (60 semester units) is required for admission.

## Accelerated Master's Degree Program at Carnegie Mellon University<sup>10</sup>

### Accelerated Master's Degree Program

An accelerated program is available to Carnegie Mellon undergraduate students who also wish to complete a coursework Master's degree in mechanical engineering. Exceptional students can apply for admission to the program at the end of the first semester of the Senior year and must meet the requirements for admission to the department's graduate program. Financial aid in the form of Teaching or Research Assistantships is not offered to students in the Accelerated Graduate Program.

In this program, students must complete at least 24 units of graduate coursework by the end of the Senior year. A QPA of 3.0 or better must be attained in those courses, and they cannot be used to satisfy the requirements of the baccalaureate degree. During the summer immediately after the Senior year, students complete up to 24 units of 24-793 Supervised Reading and 24-794 Master of Science Project. During the following Fall semester, students then complete all remaining coursework. A total of 96 units are required for completion of the coursework Master's degree. For information on our Accelerated Master's Program, download a copy of the degree outline. In addition to the general graduate application requirements, interested students are required to complete the Accelerated Graduate Program Form.

## The Integrated BS/MS Program at California State University, Los Angeles<sup>11</sup>

The Integrated BS/MS program provides an accelerated route for academically excellent upper-division students in the BS degree program to complete the MS degree program while simultaneously completing the BS requirements. The main objectives of the program are:

- To provide an accelerated route to a graduate degree, with simultaneous awarding of both bachelor's and master's degrees.

### Program Features

- Simplified application process
- BS and MS coursework can be taken concurrently
- Eight (8) common 400 level elective units between BS and MS programs
- Access to graduate student facilities
- TA appointments (if available)
- The scheduling flexibility provided by the program enables students to complete the BS and MS degrees efficiently.
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### Admission to the Integrated BS/MS Program

The eligibility requirements for application to the Blended BS/MS program are:

- Students must have a minimum GPA of 3.0 in the last 90-quarter units.
- Students must have completed the foundation required courses: CE/ME 303, CE/ME 312, CE/ME 313, CE/ME 320, CE 360, CE 361, CE 364, CE 366, CE 368, CE 370, CE 384, and CE 386) in the BS with a minimum GPA of 3.0.
- Students must have completed the Graduation Writing Assessment Requirement (GWAR)

Students are selected by a faculty committee based on prior academic performance and other measures of professional promise.

### Degree Requirements

1. Students must successfully complete all requirements for the BS (193 units) and the MS (45 units) degrees with an overlap of eight units in electives.
2. Students must maintain a minimum 2.0 GPA for courses counting towards the bachelor's degree and a minimum 3.0 GPA for courses counting towards the master's degree.
3. The degrees are awarded when requirements for both the bachelor's and the master's degrees are met by the student and recorded by the Registrar's Office. Both degrees are awarded in the same quarter.
4. If students select the thesis option, they must be enrolled during the term that they submit their approved graduate thesis/project to the Library.
5. The student applies to graduate in the integrated program (BS & MS) by submitting two GRADUATION APPLICATIONS. These applications should be submitted at least two quarters prior to graduation.
6. If a student fails to complete the requirements for the master's degree, the student may petition to withdraw from the Integrated Program, and the bachelor's degree will be granted when all the requirements for that degree are met.

## +1 Accelerated Master's Degree Program at Southern Methodist University (SMU)<sup>12</sup>

An Engineering Master's Degree helps you in the job market – more money, more responsibility, more contacts, and more options for your future. Take the time now to become a leader in engineering.

Earn both a bachelor's and master's degree in less time than completing the degrees separately. Start exploring this option in the spring of your sophomore year and apply to the program early in your junior year. Begin taking graduate-level coursework that will be applied to both the bachelor's and master's degrees (up to 9 hours). Network with your graduate-level classmates who have years of experience to share with you.

### **Work and Study, Options for Master's Classes**

Undergraduates with co-ops and job offers can work and study at the same time. Your graduate coursework can be completed through **evening classes on campus and/or distance education**. Lyle Engineering offers convenient and flexible options to working professionals who are continuing their education, in Dallas and across the nation.

### **4+1 Leadership and Service Scholarship Information**

The Lyle School of Engineering offers 4+1 Accelerated Master's Degree Program scholarships worth up to 75% of fifth-year tuition. Depending on your GPA and volunteer and leadership contributions to the Lyle School, up to 75% of the tuition of your 7 graduate level 4+1 courses could be covered.

- 3.750-3.899 SMU GPA could earn a scholarship of 50% tuition
- 3.900-4.000 SMU GPA could earn a scholarship of 75% tuition

### **How to Apply**

**Please note:** Students are not eligible for the scholarship once the bachelors degree has been conferred. You must be enrolled as a “full-time” graduate student as defined by the University. The scholarship is awarded based on the student's cumulative SMU undergraduate GPA at the time of graduation AND contributions to the Lyle School of Engineering via volunteer work and leadership activities. The scholarship only covers the 7 additional graduate courses required for the first masters degree received.

8 hours per semester of documented volunteer and leadership work per semester is the minimum requirement in addition to the GPA requirement. Seniors should have completed 48 hours of volunteer/leadership activity by the time of graduation with the undergraduate degree. Students currently in the SMU Lyle undergraduate program need to inquire about their specific volunteer commitments.



## Accelerated BS/MS Program in Engineering at University of Nevada, Reno (UNR)<sup>13</sup>

### Program Availability within the College of Engineering

- a) *Civil and Environmental Engineering, Computer Science and Engineering, and Electrical and Biomedical Engineering* -As shown with both thesis and non-thesis options available for MS portion.
- b) *Chemical and Metallurgical Engineering* – As shown except only the thesis option will be available.

### Admission Requirements

Students apply for the Accelerated Program after completing at least 75 credits towards their BS degree with a 3.2 GPA (all UNR courses complete on the Engineering Degree Checklist are included in the GPA calculation). This will typically occur during the spring of their junior year. Students must have completed their Basic Science courses and at least 30 credits of Engineering Science or Design courses (see Engineering Degree Checklist for each program). At least 24 credits of the Engineering Science or Design classes must have been earned at UNR at time of application. As part of the admission process, a student must select a faculty advisor for their graduate degree.

### Program Requirements

Students that are admitted into the program will be allowed to take up to 6-credits of technical electives for their BS degree as 600-level graduate courses. The 600-level courses selected for this purpose must be approved by the student's BS program department and graduate advisor, and permission granted by the Graduate School. 700-level courses cannot be taken as long as you are considered an undergraduate student. The student must receive a B (3.0) or better in the course for it to be considered for the program. The graduate academic advisor must be in the area of specialization that the student has selected for their graduate degree. Upon completion of all BS requirements, a student will receive her/his BS degree. A student must complete the BS degree at UNR to be part of the Accelerated BS/MS Program.

During their senior year, student will apply for admission into the Graduate School. The student must be admitted by the MS degree granting department and the Graduate School. Requirements can include but are not limited to a GPA and/or GRE minimum. If a student is not admitted by the MS degree granting department or the Graduate School, the 600 level courses completed will apply as technical electives within the BS degree program. Only 9 credits of graduate work can be completed before entering into the Graduate School. The GRE should be taken before or during the 1st semester of the student's senior year. The Accelerated BS/MS Program Application must be done before completing the BS degree. Students will complete all MS degree requirements and may apply the 6 credits of 600-level courses towards both the BS and MS degree requirements. For the MS degree, the student must meet the Graduate School requirement of an average of a 3.0 GPA in courses applied to the MS degree. Courses and/or thesis requirements will be established by the department graduate advisor.

### Continuation in the Program

Continuation in the program requires that students maintain a grade point average of 3.2 or higher in their UNR degree required courses. If a student's GPA drops below 3.2, the student will be placed on academic probation within the program for one semester. If the student raises their GPA to 3.2 or higher, he or she will be removed from probation and returned to good status to the program. If after one semester the student is not able to raise their GPA sufficiently, she/he will be removed from the Accelerated Program. At which point she/he may pursue a BS and MS degrees through normal requirements.

## Accelerated Bachelor/Master Degree Programs at Temple University<sup>14</sup>

The College of Engineering is pleased to announce the following new Accelerated Bachelors/Masters Degree (ABMD) programs:

Bachelor of Science in Civil Engineering & Master of Science in Civil Engineering  
Bachelor of Science in Civil Engineering & Master of Science in Environmental Engineering  
Bachelor of Science in Engineering Technology in Construction Management Technology & Master of Science in Civil Engineering  
Bachelor of Science in Electrical Engineering & Master of Science in Electrical Engineering  
Bachelor of Science in Electrical Engineering (Computer Engineering concentration) & Master of Science in Electrical Engineering  
Bachelor of Science in Mechanical Engineering (Bioengineering concentration) & Master of Science in Bioengineering  
Bachelor of Science in Mechanical Engineering & Master of Science in Mechanical Engineering

These 4+1 accelerated programs are designed to provide high achieving undergraduate students an opportunity to earn a bachelor's degree and a master's degree within five years. In this program, students take three graduate-level courses in place of technical electives during the Junior and Senior years. Students then take one graduate-level course in the summer after completing the undergraduate degree. In the following fall and spring semesters, students complete an additional 18 semester hours of graduate-level coursework to complete the master's degree.

### Admission Requirements

Students must meet the following criteria in order to be eligible for admission into one of the ABMD programs:

- Cumulative GPA of at least 3.25 by the end of the 5th semester
- Completion of required coursework
- Transfer Students with at least a 3.25 cumulative transfer GPA will be eligible to apply for the 4+1 accelerated programs in the College of Engineering. The program coordinator will conditionally accept transfer students into the 4+1 program if the students can complete their undergraduate degree in three, contiguous full-time semesters beginning with the spring semester of their junior year and if they can complete 45 credits at Temple prior to taking the third graduate course in the spring semester of their senior year.

Students will take one graduate course in the spring of their junior year, one in the fall of the senior year, and if they have completed 45 credits with a 3.0 cumulative GPA at the end of the fall semester of their senior year, one in the spring of their senior year.

Students must be able to complete their graduate degree in one year directly following the completion of their undergraduate degree.

If for whatever reason, students do not complete the undergraduate degree in three contiguous semesters or do not complete 45 credits with a 3.0 cumulative GPA at Temple prior to their spring semester of their senior year, they can still apply to the Graduate School through the normal application for a Masters in the College of Engineering. (Graduate courses taken as an undergraduate will be usable towards their graduate program." *The GRE is not required.*

### Program Requirements

Once admitted into the ABMD program, students need to register for the three required graduate-level courses in place of three undergraduate technical electives. Students must obtain at least a grade of "B" in these graduate-level courses.

After matriculating formally into the graduate program (summer after completing undergraduate requirements), students must take an additional 21 semester hours of graduate-level coursework and complete either a research (thesis or project) or non-research (coursework only) option. Students pursuing the thesis option must complete a total of 24 semester hours of coursework and 6 semester hours of thesis. Students completing the project option must complete 27 semester hours of coursework and 3 semester hours of thesis. Students must maintain a cumulative and semester GPA of at least a 3.0 to remain in the program and to graduate with a master's degree.

### **Accelerated Bachelor/Master Degree Programs at Bucknell University<sup>15</sup>**

Bucknell University's graduate program leads to the degrees of Master of Science in chemical, civil, electrical, or mechanical engineering. Each graduate program is individually tailored to meet the needs, preparation, and goals of the student.

Undergraduate students who have completed three years in the chemical, civil, electrical, or mechanical engineering program at Bucknell, earned a cumulative grade point average of at least 3.0, and who show aptitude for graduate study, may apply for admission to the integrated 3-2 program. This program permits selected students to complete all requirements for both a Bachelor of Science degree and a Master of Science degree in five years. Those students who are selected receive a full tuition scholarship for the fifth year.

Traditional master's degree programs are offered in addition to the special 3-2 program. Assistantships are available. Information can be obtained from the dean of engineering or the dean of graduate studies.

In addition to formal master's degree programs, any undergraduate student who has arranged to complete all undergraduate degree requirements may, with prior approval, take up to two courses for graduate credit. An application for graduate credit by undergraduate students may be obtained from the Office of Graduate Studies or the Office of the Registrar.

### **5-Year Bachelor/Master Program at University of Detroit Mercy<sup>16</sup>**

Students who are completing their Bachelor degree at UDM may apply for the 5-year Bachelor/Master's program in their senior year if they have a GPA of at least 3.25, are in good standing with UDM, and are within two to three terms of graduating. If accepted into the 5-year Bachelor/Master's program, students can receive up to nine transfer credits to their Master's program from appropriate courses in their Bachelor program.

The 5-year Bachelor/Master Degree track allows students to accumulate course credits that will count toward their graduate degree while still an undergraduate. This track provides two distinct advantages: 1) reduces the total time for achieving the Bachelor and Master degrees and 2) provides some financial aid advantages by maintaining a student's undergraduate status while completing the graduate work.

A total of 30 credits is necessary for the Master Degree with the thesis option (six credits for thesis) of which nine credits can be transferred from the Bachelor program. A total of 33 credits is necessary for the Master Degree with the nonthesis, project option (three credits for project) of which nine credits can be transferred from the Bachelor program.

It is interesting to note the wide variations of the requirements of various MS/BS programs. A summary of the results show the following:

Most programs require admission in the late junior/early senior year after an application process and a minimum GPA of 3.0 or greater in the BS.

Most programs require maintaining a GPA of 3.0 or greater in the MS.

Most programs award the BS and MS degrees simultaneously upon completion of MS requirements.

Some programs require or allow taking graduate courses in the senior year of the BS.

Some programs allow “double-dipping” of up to 9 credits for the BS and MS degrees.

## Conclusions

Five-year BS/MS degrees in engineering disciplines provide the opportunities to satisfy the demands for 120-semester credit BS degrees while meeting the needs of the profession (and licensure) with 30 semester-credit MS degrees. So called “blended degrees” (a.k.a., 5-year Masters, 4+1 MS/BS, etc.) lead to the following conclusions:

- While 120-credit BS degree programs provide engineering fundamentals, the 30-credit MS degree programs provide discipline-specific focus.
- These “accelerated” masters programs allow seniors to take graduate-level courses that apply toward their Master’s degree while still classified as undergraduates.
- Economies of scale provide opportunities for concurrent offerings of upper division technical elective and graduate courses to fulfill the needs of both groups for students.
- The needs of the profession demand graduate degrees of engineering practitioners at some point in their careers and five-year BS/MS programs address this need at the entry level.

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## Biographical

Michael G. Jenkins is a Professor in Mechanical Engineering and Former Dean of Engineering at California State University, Fresno. He is an advocate of the active learning and teaching philosophy per ABET EC2000. Prof. Jenkins is a registered professional engineer in Washington and is actively involved through leadership roles in national/international committees such as ASTM, ASME and ISO. He is also an experienced ABET program evaluator (PEV) for general engineering and mechanical engineering. Prof. Jenkins received his BSME from Marquette University, his MSME from Purdue University, and his PhD from the University of Washington. He worked at PACCAR Technical Center as an R&D engineer and at Oak Ridge National Laboratory as a development staff member. He was also faculty and associate chair at University of Washington, Seattle, and professor and chair at University of Detroit Mercy before starting his position as faculty and dean at CSU, Fresno. His research and teaching interests include characterization of advanced materials (e.g., ceramics), experimental mechanics, data base development, cumulative damage mechanics, and probabilistic design and reliability.

Walter V. Loscutoff is a Professor and Former Chair of Mechanical Engineering as well as Former Associate Dean of Engineering at California State University, Fresno. Prof. Loscutoff received his BSME, MSAE and PhD from the University of California, Berkley. He worked at Flow Industries, Inc. as Executive Vice President & COO of Flow Research, Inc.; Vice President & General Manager of FlowDril Corporation; Manager of Research & Technology Division, at Pacific Northwest National Laboratory through Battelle Memorial Institute; Associate; Project Manager; Program Manager, Section Manager and Rocketdyne: Research Engineer. He was also assistant professor at University of California, Davis and adjunct associate professor at Washington State University before starting his position as faculty at CSU, Fresno. His research and teaching interests include advanced materials, alternate energy, systems analysis, and project management.

Thomas L. Nguyen is a senior consultant at Levitas Consultants. Dr. Nguyen received his BSME from California State Polytechnic University, his MSME from University of California, Davis and his PhD from Purdue University. He has over ten years of industry experience in design, analysis, product development and testing with companies that include Aerojet Techsystems Company, TRW Electronic Systems Group, Bendix Oceanics Division, Keebler Company, and MHCI. In addition, his academic experience includes such universities as University of California, Merced, University of Portland, Bucknell University, California State University, LA, and California State University, Fresno. His research and teaching interests include design, manufacturing, CAD/CAM, vibrations, measurement and control systems, mechatronics, and materials engineering.