2019

First-Year Curricula Review: College of Engineering

College of Engineering

Office of the Executive Vice President for Academic Affairs & Provost

First Year Student Success
College of Engineering

April 12, 2019

Dean's Summary

Of the five academic colleges, the College of Engineering (COE) has the highest first year total retention rate (i.e., retained in University). The COE average for the Fall'07 through Fall'16 entering class is 84%, while it ranged from 75% to 80% for the other colleges. The comparison over time is illustrated in Figure 1.

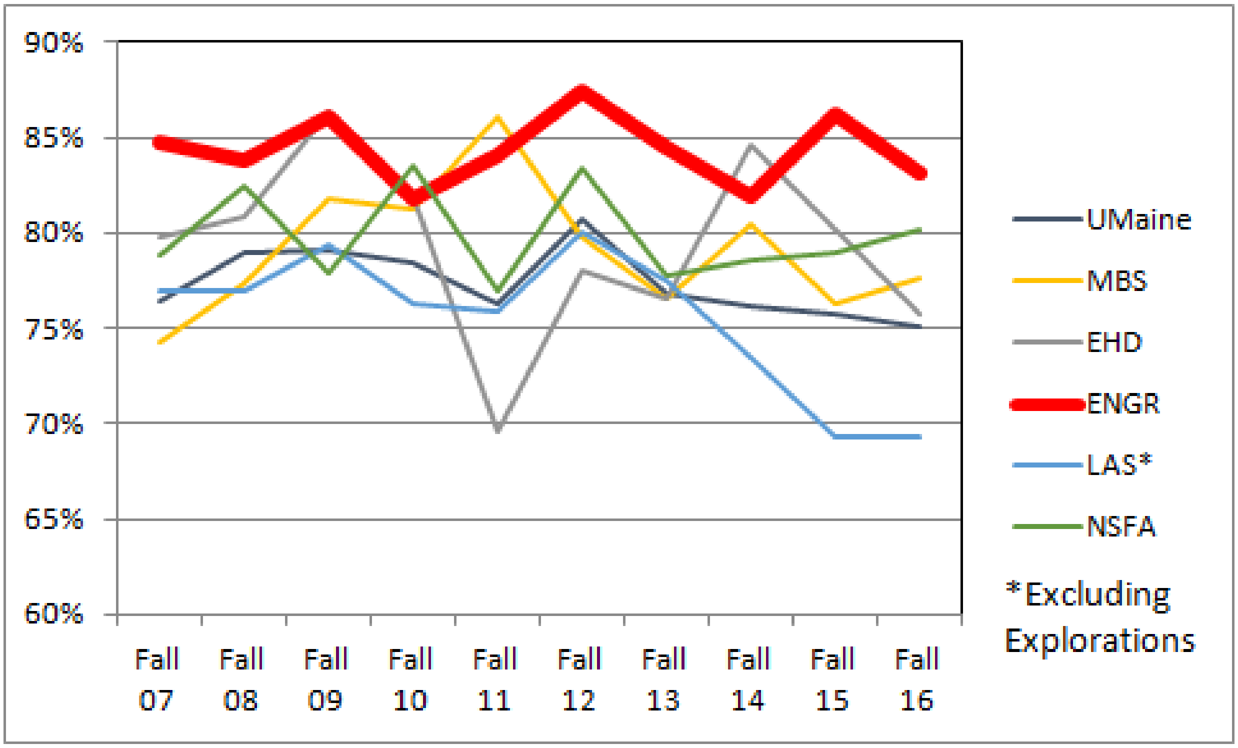

Figure 1. Total retention rate for UMaine and five academic colleges.

Likewise, the COE has the highest retention rate in the same college. The COE average for the Fall'07 through Fall'16 entering class is 76%, while it ranged from 64% to 71% for the other colleges. The comparison over time is illustrated in Figure 2. A related statistic is the percent of students who transfer from their original college to another college. On average, 8% of the students who start in COE transfer to MBS, EHD, LAS or NSFA in their first year. This is the lowest percentage of any of the five academic colleges. Taken as a whole, this data dispels the notion that engineering is so hard that students tend to drop out or switch out of engineering. In fact the reverse is true, **first year students generally like and succeed in engineering**.

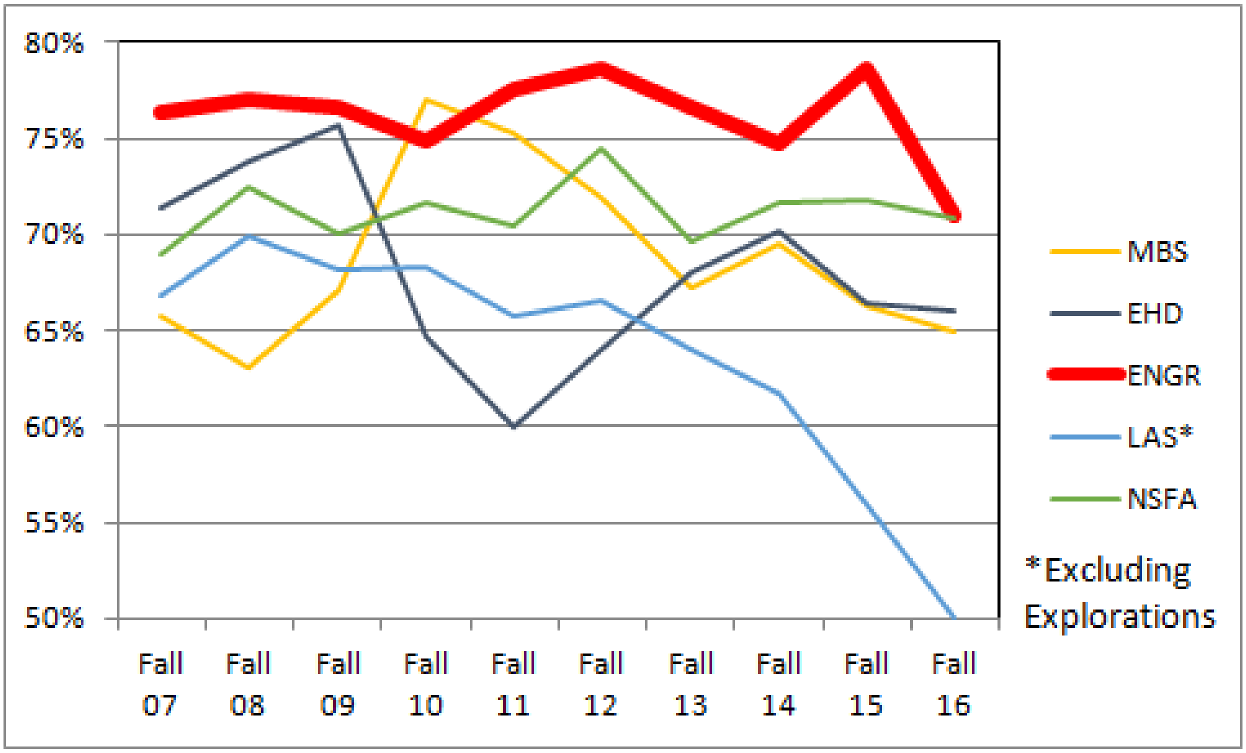

Figure 2. Retention in same college.

The high first year retention rate is due in part to the COE having slightly higher admissions standards compared to the other colleges. However, the high rate is also a result of how each degree program in the COE structures its first-year curriculum. Specifically, every first year student takes at least one engineering course in their first semester. This immediately gets students into engineering, which is the reason that they are attending college, rather than just taking math and science courses so that some day they can study engineering. Moreover, students immediately experience the fun of being an engineer and begin to build a sense of community with their engineering classmates and faculty. Here are some examples from first year courses. Civil engineering students learn how to proportion concrete mixes, then make actual concrete samples, and finally load the samples to failure (i.e., breaking them!). Electrical and computer engineers build, program, and then launch scientific instruments as part of a high altitude ballooning project. Biomedical engineering students designed and fabricated a low-cost, portable, single-use device to transport a cow ovum from the field to the lab. Mechanical engineering technology students develop CAD drawings for a steam engine in the first semester and in the second semester they build it. Other programs take field trips. Chemical engineering students take trips to the DuPont carageenan plant in Rockland, SAPPI paper mill in Hinckley, Bangor Water District treatment plant in Otis, and Bangor waste water treatment plant in Bangor.

The average first year retention rate for students in each unit of the COE for the Fall'07 through Fall'16 entering class is shown in Table 1. The retention in the same unit ranges from 60% to 75%. Not counting EPS the range is 66% to 75%, with the lowest being mechanical engineering. The unit retention of EPS is slightly lower because some students make a minor adjustment to major in physics or one of the engineering degree programs. The pattern of retention in the same unit over time is shown in Figure 3. Data for EPS is not shown because the small number of students in the program leads to wide variability from year to year that is outside of the range of the other engineering and engineering technology degrees. As seen in Figure 3 for a given unit there is variability from year to year with no evident pattern. For this reason, it is felt that long term averages in Table 1 are more representative. The relatively lower percentage for students retained in SET in Fall'16 is due to a higher than normal number of students who switched from SET to one of the seven engineering majors. This is not expected to be a long term pattern.

Table 1. Average first year retention rate by unit for Fall'07through Fall'16 entering class.

Unit	Retained in Unit	Retained in COE	Retained in Different College	Total retention rate
CBE	75%	4%	9%	88%
CIE	75%	4%	10%	89%
ECE	70%	6%	7%	83%
MEE	66%	9%	8%	83%
SET	71%	4%	4%	79%
EPS	60%	7%	14%	81%

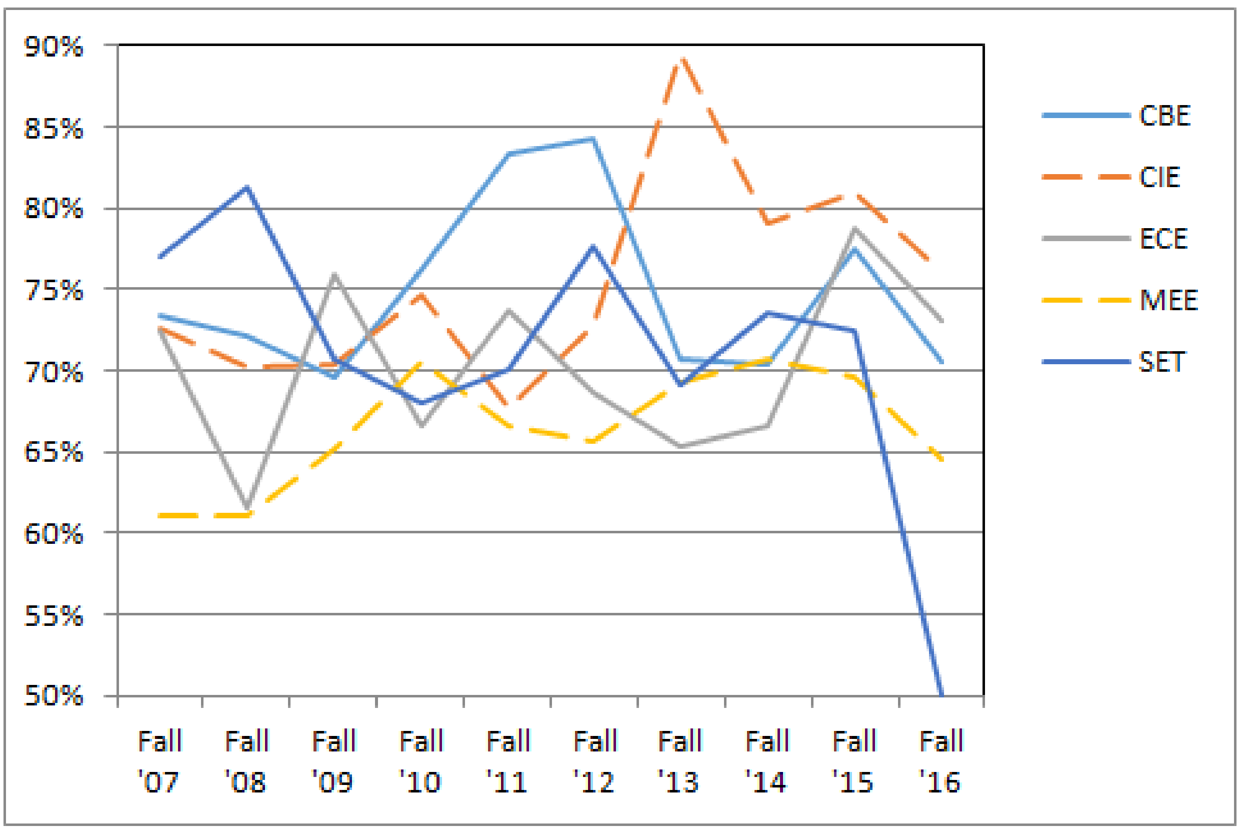

Figure 3. Retention in same unit for Fall'07 through Fall'16 incoming class.

The Undecided Engineering Program (UND) deserves separate treatment because this is only for first year students. On average 53% of UND students have changed into an engineering major by the end of their first year and another 10% have changed into a major outside of COE. At the start of the second year, there are still 19% retained within UND, but these students soon change to a degree granting major. The average total first year retention rate for this program is 82% which is comparable to the COE as a whole (84%).

Even with the overall high first year retention rate, there is room for improvement. In 2016, the COE hired its first professional academic advisor, Niya Bond. Ms. Bond's primary responsibilities include advising first-year students in the Undecided Engineering Program and mentoring students who are on academic probation. Another year of data is needed to evaluate the effect of Ms. Bond's work on retention rates.

Engineering students typically take two mathematics courses and two to five science courses in the first year. Thus, quality instruction in these courses contributes to retention in the COE.

At the unit level, MEE has made substantial changes to its first year curriculum. In the last few years, they have added two MEE course to their first year curriculum, resulting in four MEE courses total. They have added more hands-on activates in one of the existing courses. First year retention rates will be monitored to determine the effect of increased engagement in their major. Additional changes are being considered that would lower the total number of credits taken in the first year.

Minor changes have been made to the remaining programs. However, moving forward the primary focus will be to continue to effectively implement the first-year courses and programs that are already in place.

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Chemical and Biomedical Engineering

Executive Summary

The state of first-year retention for the Chemical and Biomedical Engineering for students still enrolled at UMaine after 1 year is excellent at 88%. Two introductiony courses (2 credit hours each) in our CHE (CHE111 & 112) and BME (BEN111& 112) programs successfully engage our first-year students with our department office staff, faculty and student chapters. Assignment of UG mentors during the spring semester first-year courses (CHE112 & BEN112) is helpful. Students know that they will have the faculty advisor for all four years, or until they graduate, is a source of comfort. Students also know that they have 24-hour access to the Jenness Hall make the Jenness Hall their second home.

Key Findings

1. Review of retention data for students still enrolled at UMaine after 1 year shows that the CBE department does consistently better than the College of Engineering, and much better than UMaine, with fall'14 being an outlier. Average retention for the six year period (Fall'11 to Fall'16) shows that the CBE retention is 88%, compared to COE at 85% (i.e. close) and UMaine at 77% (i.e. 11 points better).

	Fall 11	**Fall 12**	**Fall 13**	**Fall 14**	**Fall 15**	**Fall 16**	**Average Fall11-16**	***StdDev Fall11-16***
UMAINE	76%	81%	77%	76%	76%	75%	**77%**	***2.0%***
ENGR COLLEGE	84%	87%	84%	82%	86%	83%	**85%**	***2.0%***
CBE DEPT	93%	89%	90%	78%	88%	87%	**88%**	***5.1%***

2. Retention rates for students still enrolled in the same college or same unit after 1 year are very close for CBE and COE data at 76% +/- 1%.

Key components of a plan to improve student success and timeline for it

No changes in the first-year curricula or student-faculty interaction, for CHE and BME programs, are planned. Keeping up the good work is the plan.

Biomedical Engineering

What is the required first-year curriculum

Fall Semester

Course ID	Course Name	Credit Hours
BEN 111	Introduction to Biomedical Engineering I	2
CHY 121	Introduction to Chemistry	3
CHY 123	Introduction to Chemistry Laboratory	1
MAT 126	Calculus I	4
PHY 121	Physics for Engineers and Physical Scientists I	4
ENG 101	English Composition	3
	Semester Credits	17

Spring Semester

Course ID	Course Name	Credit Hours
BEN 112	Introduction to Biomedical Engineering II	2
CHY 122	The Molecular Basis of Chemical Change	3
CHY 124	The Molecular Basis of Chemical Change Laboratory	1
MAT 127	Calculus II	4
PHY 122	Physics for Engineers and Physical Scientists II	4
BMB	Introduction to Molecular and Cell Biology	3
	Semester Credits	17

2. What is the recommended first-year curriculum?

Not applicable. The courses required for the first year are given above. The only elective is one HVSC.

3. Why is this the required/recommended FY curriculum?

- Courses identified in #1 are needed to satisfy pre-requisites for other courses to follow in Years 2 to 4, except for ENG101 which itself a GenEd requirement.
- Helps students make timely progress towards their degree requirements.

4. What are risks associated with this curriculum?

Some students encounter difficulties in CHY, PHY or MAT course sequences, but they can try to catch during the summer between the 1st and 2nd years.

5. In light of risk assessment, what are the alternative first-year curriculum?
N/A

6. What practices, resources and/or tactics are in place to mitigate risks?
N/A

7. What additional steps can be taken to mitigate risk?
No change is needed in the 1st year curriculum. UG mentors assisting the second semester 1st year students in BEN112 is helpful. No additional steps are contemplated.

Chemical Engineering

1. What is the required first-year curriculum

Fall Semester

Course ID	Course Name	Credit Hours
CHE 111	Introduction to Chemical Engineering	2
CHY 121	Introduction to Chemistry	3
CHY 123	Introduction to Chemistry Laboratory	1
MAT 126	Calculus I	4
PHY 121	Physics for Engineers and Physical Scientists I	4
HVSC	Elective	3
	Semester Credits	17

Spring Semester

Course ID	Course Name	Credit Hours
CHE 112	Introduction to Chemical Engineering	2
CHY 122	The Molecular Basis of Chemical Change	3
CHY 124	The Molecular Basis of Chemical Change Laboratory	1
MAT 127	Calculus II	4
PHY 122	Physics for Engineers and Physical Scientists II	4
ENG 101	College Composition	3
	Semester Credits	17

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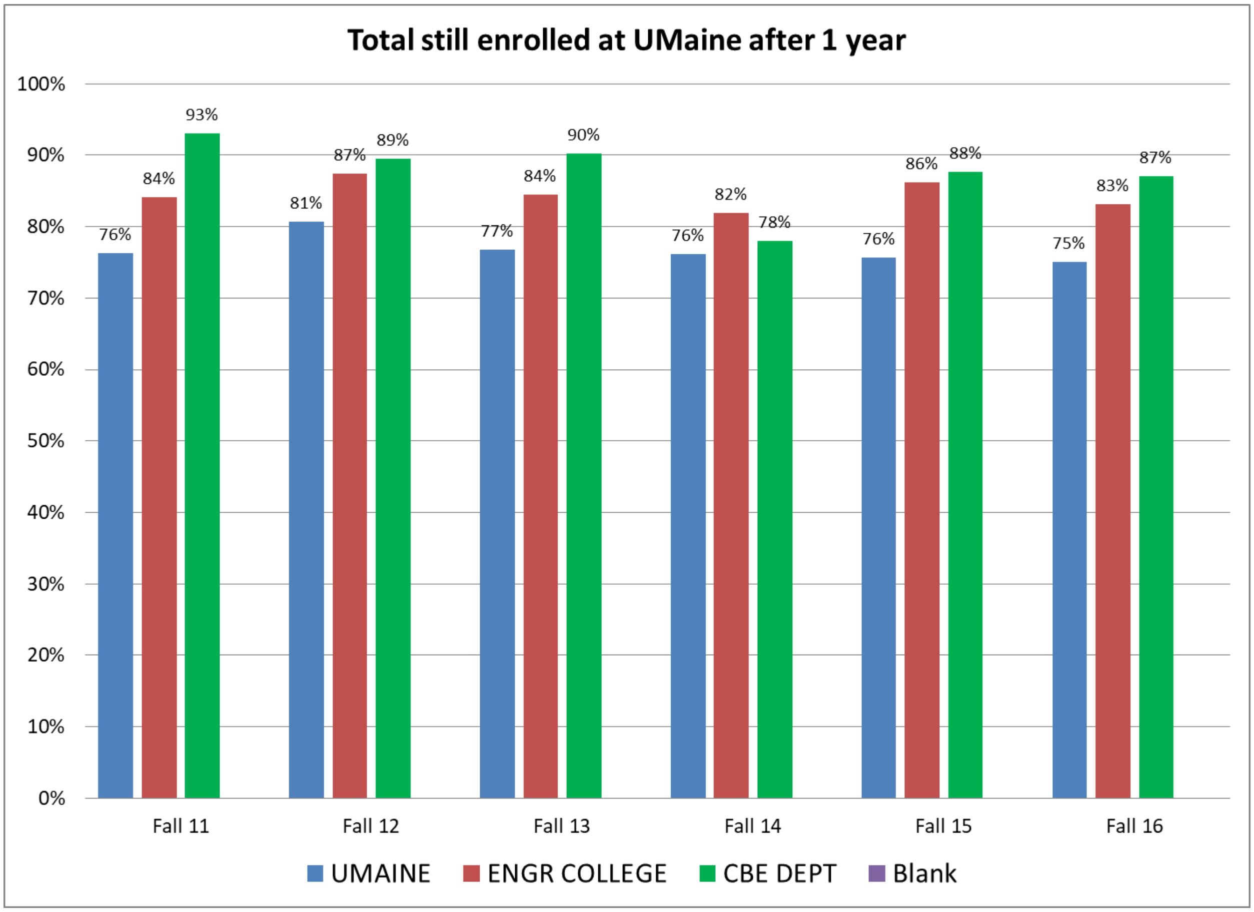
5. In light of risk assessment, what are the alternative first-year curriculum?
6. What practices, resources and/or tactics are in place to mitigate risks?
7. What additional steps can be taken to mitigate risk?

No change is needed in the 1^{st} year curriculum. UG mentors assisting the second semester 1^{st} year students in CHE112 are helpful. No additional steps are contemplated.

Supplementary Materials

Total still enrolled at UMaine after 1st year for the CBE department ranges from 87% to 93%, compared to the corresponding data (75% to 81%) for the UMaine campus.



A detailed look at the data (Fall'11 to Fall'16) for individual programs within CBE (CHE & BME) by gender indicates that the BME Male sub-population consistently lags behind, but the cohort sizes being very small (average 18) these differences not statistically significant. The trend, however needs to be investigated further to understand the significance and the root causes behind this trend. The retention numbers for all four sub-populations are comparable to the UMaine campus-wide data within the statistical uncertainty.

Table 1: First-year retention data by Program and Gender within the CBE Department

	Average Fall 11-16 Cohort Size	Average Fall 11-16			Average Fall 11-15		
		Still enrolled after 1 year at UMaine	Still enrolled after 1 year at same college	Still enrolled after 1 year **in the same unit**	Still enrolled after 2 years at Umaine	Still enrolled after 2 years at same college	Still enrolled after 2 years **in the same unit**
UMAINE	2000	77%	77%	**77%**	67%	67%	**67%**
COE	392	85%	76%	**76%**	78%	67%	**67%**
CBE DEPT	83	88%	78%	**76%**	79%	68%	**64%**
BME PROG	35	83%	72%	**70%**	75%	60%	**57%**
CHE PROG	48	91%	83%	**81%**	82%	73%	**69%**
BME Male	18	79%	65%	**63%**	70%	56%	**51%**
CHE Male	34	91%	84%	**82%**	81%	75%	**70%**
BME Female	16	89%	79%	**78%**	82%	65%	**64%**
CHE Female	14	92%	79%	**76%**	84%	69%	**66%**

Civil and Environmental Engineering

Executive Summary

Civil and environmental engineering (CIE) has high first year retention rates. Over the period including Fall'07 through Fall'16 the average retention rate in the unit is 75% (tied for highest in the COE) and the total retention rate is 89% (highest in the COE). Decades ago, CIE moved PHY 121/122 from the first to the second year. This allows students to master calculus prior to taking calculus based physics. This has a positive effect on retention that is still evident today. It is worth noting that CIE also has the highest second year retention rate in the COE, so postponing PHY 121/122 does not simply delay poor performance, rather it improves performance. CIE has two in-major courses in both the fall and spring semesters of the first year. When combined with events like the First-Year Student Banquet, this builds a strong sense of camaraderie within CIE. As such, the plan moving forward is to continue to effectively implement the measures that are already in place.

1. What is the required first-year curriculum

Fall Semester

Course ID	**Course Name**	**Credit Hours**
CIE 100	Intro to Civil & Environmental Engineering	1
CIE 110	Materials	3
CIE 111	Material Laboratory	1
CHY 131	Chemistry for Engineering	3
CHY 133	Chemistry Laboratory	1
ENG 101	College Composition	3
MAT 126	Calculus I	4
	Semester Credits	16

Spring Semester

Course ID	**Course Name**	**Credit Hours**
CIE 101	Civil Engineering Graphics	3
CIE 115	Computers in Civil Engineering	3
MAT 127	Calculus II	4
MEE	Strength of Materials	3
N/A	HVSC WSCPA	3
	Semester Credits	17

2. What is the recommended first-year curriculum?

Not applicable. The courses required for the first year are given above. The only elective is one HVSC.

3. Why is this the required/recommended FY curriculum?

In addition to a first-semester, 1-cr introductory CIE course, the first-year CIE curriculum incorporates a mix of three CIE courses, four math and science courses, an HVSC elective and ENG 101. All courses provide important content and their timely completion is essential for on-time graduation. The inclusion of three CIE courses in the first year is purposeful, as they provide our students with a tractable engineering experience and meaningful engagement with the major starting with their first semester. In addition to being essential components of an engineering curriculum, MAT 126, MAT 127, PHY121 and CHY 131/133 are also required for program accreditation.

4. What are risks associated with this curriculum?

The 10 credits of engineering courses and 12 credits of math and science are challenging, and some of these courses have high DFW rates. However, this is inevitable, and indeed is the case throughout any rigorous, accredited engineering program.

5. In light of risk assessment, what are the alternative first-year curriculum?

While some time-consuming CIE courses could be deferred until later (CIE 110/111 and CIE 115, for example), this would result in additional risks as these first-year CIE courses would have to be replaced with general education electives. Specifically, students would be exposed to less engineering in their first year and therefore identify less strongly with their major, and the course workload would go up to unreasonably high levels in subsequent years.

6. What practices, resources and/or tactics are in place to mitigate risks?

We are already mitigating risks by incorporating tractable, in-major courses throughout the first year. We also strive to staff these courses with well-respected and effective instructors. Other actions, such as providing a meaningful experience in our 1-cr introductory CIE 100 course by engaging students in a poster presentation on a Civil Engineering topic and hosting a first-year student banquet, are also in place.

7. What additional steps can be taken to mitigate risk.

There are no clear steps available to mitigate risk.

Electrical and Computer Engineering

Executive Summary

Much of the data and discussion presented in this report are derived from the ECE continuous improvement process which requires regular review of all ECE courses and curricula. The ECE introductory courses are each reviewed on a three year rotation, and once every three years a more extensive “curriculum review” takes place. In addition, all graduating seniors are interviewed and specifically asked to reflect upon their first-year experience. This academic year (2018/19) happens to be a “curriculum-review” year in which coordination between courses (including courses taught by other departments), and broader curriculum goals are receiving closer examination.

No fundamental curriculum changes are recommended in this report. The ECE first-year course sequence receives regular review and continues to receive positive comments in the graduating senior exit interviews. All ECE students participate in 1-credit first-year orientation course, as well as a 3-credit laboratory based project course in their first semester. The four-year ECE curricula are fairly rigid and have limited flexibility in the first year. Students receive extensive exposure to potential careers and research opportunities within the department. Advisors have been made aware of possible adjustments to the first year curriculum so that students know of options to lighten their schedule as needed. Electrical students who are able to take courses in the summer may choose to take Chemistry or Physics in a summer term, and all students are made aware of the possibility of completing Human Values and Social Context electives in the summer or winter terms. However, delaying difficult courses to later years is not appropriate for Electrical or Computer Engineering students: All students must complete at least two semesters of Calculus, one semester of Physics, and the introductory ECE courses to satisfy the prerequisites for 2nd year core courses.

The following observations relate to broader University initiatives/goals that could make a significant impact on the retention of students entering the ECE majors:

- Having adequate support services for accessibility, mental health services, physical health (Rec Center & Maine Bound are excellent positive examples), tutoring, and clean, well kept facilities for both academics and residents is very important.
- Build schedule of class bases on next semester's wish lists and historic enrollments so that every student has a seat in the classes they need. Provide adequate funding to have enough instructors for course workloads.
- Some students seem somewhat unprepared for calculus. The efficacy of the math placement exam is questioned. The use of this online non-proctored exam with multiple attempts allowed seems dubious. The cost to students who begin in the wrong math course is often substantial, as failure to obtain a C or better may result in delayed graduation. A better, more accurate placement procedure would be welcomed.

The final observation is that not all students have the ability to cope with college life. This includes emotional issues, roommate problems, alcoholism, employment with excessive hours, drug problems, how well one was prepared from high school, transition from high school to college, dealing with low academic performance, and quality of work expectations. Are adequate support services in place for these students? How are these students identified and directed towards proper services? The university should have a proactive mindset rather than a passive one, where students are expected to get themselves to these resources.

Required Curriculum

The first-year required courses for both electrical engineering (EE) and computer engineering (CE) students are:

Table 1: Required First Year Courses in Electrical and Computer Engineering

In discipline, both Electrical and Computer Engineering		
Fall	ECE 100	Electrical and Computer Engineering Seminar
	ECE 101	Introduction to Electrical and Computer Engineering
Spring	ECE 177	Introduction to Programming for Engineers
General Education Courses, both Electrical and Computer Engineering		
Fall	CMJ 103	Fundamentals of Public Communication
Spring	ENG 101	College Composition
Other Required Courses for Electrical and Computer Engineering		
Fall	MAT 126	Calculus I
	PHY 121 (CE) - or - CHY 131 (EE) CHY 133 (EE)	Physics for Engineers and Scientists I - or - Chemistry for Civil, Electrical and Mechanical Engineers Chemistry for Civil, Electrical and Mechanical Engineers Laboratory
Spring	MAT 127	Calculus II
	PHY 122 (CE) - or - PHY 121 (CE)	Physics for Engineers and Scientists II - or - Physics for Engineers and Scientists I

Students that have equivalent credit for any of the courses listed above (some do) will take another course in its place with the help of the Dean's office (first semester) and the academic advisor (second semester). Some students in Honors replace ENG 101 with Honors or HV&SC courses. A couple other students may enter the program as sophomores their first year and take second year courses. Table 2 summarized replacement courses.

Table 2: Replacement Courses for Transfer Credit

Transferred Course	**Replacement**
CHY 131 & CHY 133	HV&SC, ECE 210, ECE 214, ECE 271
CMJ 103	HV&SC, Honors, ECE 198, Ethics
ECE 101 & ECE 100	ECE 210 (Required)
ECE 177	ECE 210 (Required), ECE 198 (Technical Elective), or ECE 214 (Required)
ENG 101	HV&SC, Honors, ECE 198, Ethics
MAT 126	MAT 127 (Required)
MAT 127	MAT 228 (Required)
MAT 228	MAT 259 (Required)
PHY 121	PHY 122 (Required)
PHY 122	Probably entering as a sophomore (rare)

Recommended Curriculum

The recommended curriculum is the same as the required curriculum. Sample curriculums for both majors and including honors options are published on the department’s web server at https://ece.umaine.edu/undergraduate/

Justification for the First Year Curriculum

Much of the first year curriculum lays the foundation for subsequent courses. Electrical and computer engineering's foundation is in physics and calculus, thus requiring Physics I &II and Calc I & II. Good oral and written communication skills are essential in engineering, thus requiring ENG 101 and CMJ 103. ENG 101 is also a University requirement. Chemistry is a prerequisite for several upper level elective courses (ECE 457 and ECE 462) for electrical engineering majors. Although one could argue that requiring chemistry for all electrical engineering students seems excessive, this course helps to satisfy the 30-credit math/science requirement specified by the accreditation board (ABET). The final three courses, ECE 100, ECE 101, and ECE 177 are discipline specific. ECE 100 introduces students to campus life, the transition from high school to college, and then discusses the expectations and obligations of being an engineer. ECE 101 contains technical content to lay the fundamentals of electrical and computer engineering, including exercising, reinforcing, and in some cases learn skills (typically mathematics) and behaviors (go to class, work the homework, ...) expected to be present for high school. ECE 177 teaches fundamentals of programming.

ABET requires every engineering discipline to write an extensive report every six years for the purpose of re-accreditation. The department went through the process last semester (Fall 2018). Extensive assessment and evaluation is done every three years on the entire curriculum, potentially resulting in curriculum modification, as part of a continuous improvement process as required by ABET and accreditation. The results show that the curriculum meets expected outcomes.

The ABET continuous improvement process includes writing measurable performance indicators for each course. A select set of key performance indicators is then used to assess and evaluate a small number of broader student outcomes as required by ABET. The terminology appears to differ between this UMaine request and ABET. The performance indicators and student outcomes appear at the end of this document.

The program is successful in achieving both student outcomes and performance indicators. An extensive report with supporting evidence for the previous statement is available upon request.

Curriculum Risks

ABET and university requirements, and preparation for higher level courses leave little room for adjusting the first-year curriculum to reduce risk. To remain on track for completion of the program in four years, students must complete two semesters of Calculus, at least one semester of Physics, and introductory ECE courses in the first year. Chemistry is a high DFW course which is normally taken in the first year that could be delayed to another semester (and is typically delayed for Honors students). The first-year workload is the standard 15 credit hours per semester.

Alternative first year curricula

Students who have the option of taking courses in the Summer may choose to lighten their first-year curriculum by delaying Chemistry to a summer term. Delaying Chemistry to a different academic year is generally not advised, as most later semesters in the curriculum are already full.

Risk reduction techniques

First year students are advised on possible curriculum modifications to "lighten the load" by incorporating summer/winter terms or planning for additional semesters before graduation. An effort is made to engage the students more directly in the program through an extensive first-year project course. Students are exposed to career options through a mix is presentations and participation in the Engineering Job Fair. Through ECE 100, students are made aware of tutoring opportunities, career center support, and other campus support programs. One of the first year instructor's purposes is to make sure students are in the right major. Students who are considering a change of major are assisted with courses, as best as possible, to find the right major and discuss options with other department chairs. (It is unfortunate that helping students realistically explore alternative majors is generally detrimental to the department and to the college. The current funding models at the University do not encourage this type of exploration — departments that pursue goals of retaining students *within the major or college* may be doing so at the detriment of the students.)

Additional steps that could reduce risk

Some general comments about how the university could do better follow.

- Having adequate support services for accessibility, mental health services, physical health (Rec Center & MaineBound are excellent positive examples), tutoring, and clean, well kept facilities for both academics and residents is very important.
- Build schedule of classes bases on next semester's wish list and historic enrollments so that every student has a seat in the classes they need. Provide adequate funding to have enough instructors for course workloads.
- Some students seem somewhat unprepared for calculus. The efficacy of the math placement exam is questioned. The use of this online non-proctored exam with multiple attempts allowed seems dubious. The cost to students who begin in the wrong math course is often substantial, as failure to obtain a C or better may result in delayed graduation. A better, more accurate placement procedure would be welcomed.

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Student Outcomes

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

3. An ability to communicate effectively with a range of audiences

4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Key Performance Indicators for ECE 100

- Write a summary reflecting on a presentation about ethics.
- Write summaries of various topics related to engineering as presented by guest speakers
- Write a summary reflecting on a presentation about working as an engineer.
- Write a summary reflecting on a presentation from the tutor program about studying.
- Work several exercises on study habits during class as presented by the tutor program.

Key Performance Indicators for ECE 101

- Convert to and from scientific notation and SI prefixes.
- Calculate a resistor's value from the resistor color code or list the color code for a given resistor value.
- Calculate the equivalent resistance for combinations of series and parallel resistors. Calculate all currents and voltages in a circuit of series and parallel resistors.
- Calculate the current through a LED.
- Calculate the duration a battery will last.
- Solve for the capacitor voltage in a RC circuit.
- Sketch an exponential function.
- Calculate the period, duty cycle, frequency, positive and negative pulse widths, and amplitude of periodic signals.
- Identify 555 timer parts and explain the operation of each and how they fit into the whole.
- Describe how the robot is moved using stepper motors, MOSFETs, and diodes.

- Convert between decimal, binary, and hexadecimal.
- Add in binary.
- Characterize an IR emitter and detector pair by empirical measurement and interpret the resulting plot by relating specific parts of the graph to physical behavior.
- Calculate the value for a LED current limiting resistor.
- Determine the component values to give a specific frequency and duty cycle for a stable 555 timer.
- Work productively and collaboratively in a group to construct and debug circuitry.
- Debug circuits using a multimeter and make signal measurements with an oscilloscope.
- Plot functions and collected data in MATLAB using m-files and data files.
- Modify an existing C program.
- Demonstrate prototyping skills and techniques by soldering a small electronic device
- Identify and draw schematic symbols.
- Select an appropriate mode and range for making a multimeter measurement
- List the steps to solder a surface mount component
- Use appropriate terminology for electric circuits: series, parallel, current through, voltage across

Key Performance Indicators for ECE 177

- List in ascending order by size the fundamental data types in C.
- Locate and correct syntax errors
- Locate and correct logical errors
- Demonstrate the conversion between decimal, binary and hexadecimal.
- Demonstrate basic mathematical operations in binary.
- Identify errors due to overflow and carry.
- Describe built-in operators in C
- Apply precedence to evaluate expressions
- Select appropriate control structures for a specific application.
- Demonstrate index-based array creation, initialization and use
- Demonstrate pointer-based array creation, initialization and use
- Demonstrate the ability to create structures and access structure elements.
- Evaluate operations and correctness of code.
- Write a function that performs a specific task with given constraints.
- Write code to interact with LEDs and play sound of different frequencies on a speaker
- Write a function to scan a keypad and decode a key press.
- Use a compiler to compile C code.
- Use an in-circuit programmer to program embedded processors.
- Use a debugger to debug C code.

Engineering Physics

Executive Summary

Overview

The Department of Physics and Astronomy at the University of Maine offers three undergraduate degrees: a B.S. and B.A. in Physics and a B.S. in Engineering Physics (ABET accredited since 1949). The B.S. in Physics and Engineering Physics (EPS) are rigorous four-year programs that prepare students for advanced physics and engineering studies in graduate school, as well as for careers in industry and government laboratories. The B.A. in Physics provides the necessary background to ensure student preparation for advanced studies in Physics, but the added flexibility in the curriculum is ideal for double majors (in the arts/humanities, education, or the life sciences). The physics degree programs at UMaine are delivered almost entirely by the traditional modes of weekday daytime lecture/laboratory courses, with the long-standing exception of weekday evening offerings of a lecture section and several recitation and laboratory sections of our calculus-based PHY 121/122 sequence, *Physics for Engineers and Physical Scientists.* On the other hand, many of the required General Education and a few of the Engineering elective courses that the EPS student might choose to take have a variety of less traditional delivery modes, e.g., evenings, weekends, off-campus, distance education, web-based, etc. Both the B.S. and B.A. in Physics require 120 credits to graduate, while the B.S. in Engineering Physics requires 122 credits. All three programs require 18 credit hours in Human Values / Social Contexts & Ethics courses, with students taking courses from each of the general education focus areas. The EPS students must also take at least 24 credit hours of specific Engineering courses, while the B.A. Physics students must take at least 72 credit hours outside their major. To succeed in a four-year program, courses in the first year cover a great deal of material in many different areas, with students having to take a rigorous program of mathematics, science, and computer science courses in addition to their physics courses.

Facilitating student success via academic advising

The Department possesses a strong academic advising process that begins in the first year. All students take PHY 100, a seminar course, in the fall of the first year which introduces the students to the Department and things to expect as a physics major. The Department Chair typically teaches this course and serves as all first-year students' initial advisor. During PHY 100, each student is assigned to a formal advisor (one for the BS and BA cohort, and one for the EPS cohort) who will work with that student for the rest of his/her undergraduate career. This advisor provides advising that is as consistent and well-suited to student needs as possible. The Physics Department advisors usually meet with each of their advisees for about one hour once each semester to review the student's progress and determine which classes to register for in the next semester and eventually to discuss the full degree plan. The familiarity between advisor/advisee inherently elicits some level of flexibility into the curriculum, as the faculty advisor is aware of advisee academic issues and can work with the advisee to plan the student's long-term schedule to ensure timely graduation.

Key Findings

In analyzing all three of our major programs, we have identified one common concern: in the first-year, the majority of our majors are taking multiple courses that suffer from extremely high DFW rates (>40%). For instance, both CHY 121 and two of the COS courses have a ~50% DFW rate, while MAT 127 is at 42% (it should be noted that MAT 126 is only slightly lower, at 38%). Students taking these courses alongside the difficult introductory physics sequence (although we point to our low DFW rates in PHY 121/122) could potentially set students up for first-year struggles. This can either put the students' four-year graduation time frame immediately in peril, or worse, discourage students from continuing their studies.

Coupled to this fact, we have found that success in our introductory physics course (PHY 121) is critical to ensure success in our more advanced courses. For instance, we have found that over 50% of the students who receive a grade below C- in PHY 121 receive a D,F, or W in PHY 122, while ~25% of the students who receive a grade below C in MAT 126 receive a DFW in PHY 122. Simply put, students who do not receive at least a C- in these prerequisite courses have a low probability for success in PHY 122. In addition, the mathematics and computer science courses must be taken by our students during the first-year to ensure a high probability of a four-year graduation.

Lastly, for the last six years we have been using the ETS© Major Field Test (MFT) as an independent metric to evaluate student learning outcomes in our program. Our goals were to find ways to track/assess student learning without relying on the "letter grade" that the student obtained in the class. The emphasis of the MFT is on the students' firm grasp of fundamental principles and their ability to apply an understanding of them in the solution of problems. While we will not detail the exact outcomes of the MFT in this report (as it is focused on the entire program, and not just the first-year), we have used the results from this exam towards understanding the strengths and weaknesses of our students and where we can possibly look for improvements in our methods of instruction. We have found that weaknesses in certain subject areas by our students could be possibly improved through emphasizing critical thinking skills at an earlier stage of their career. This has led us to re-think and re-organize our first-year introductory physics sequence.

Continuing Improvement for first-year student success

We have two plans towards continually improving the first-year success rate for our majors.

1) We will begin to recommend that CHY 121/123 be taken in the student's second-year, thereby improving the first-year success rate by dropping a historically high DFW course from their list of recommended courses. Not only will this change benefit students in terms of moving a high-DFW-rate course from the first-year curriculum to the second year when students will be better equipped to handle the course, but anecdotal evidence has suggested that taking CHY 121 at the same time as PHY 236 (Introductory Quantum Physics) should prove to be useful, as there is some overlap in content between these two courses. This again helps students to continually grow as physicists and allows them to see the connections between similar sciences, such as physics and chemistry.

2) As alluded to above, we have been making several modifications to the PHY 121/122 sequence in order to strengthen its effectiveness, which in turn makes the learning experience much more fruitful. The PHY 121/122 laboratories have been (and continue to be) revised and now include a focus on understanding error and error propagation, a necessity for any physical scientist or engineer. Most recently, one weekly 50-minute recitation slot was converted into a 50 minutes of lecture for both content coverage and pedagogical reasons. While initially seeming pedagogically counterintuitive, the lectures in PHY 121/122 have become much more interactive in the past few years, based on input from physics education research; adding lecture time will enable instructors to integrate even more active learning activities and problem-solving activities into the lectures. These modifications will help improve student learning as well as course sequencing issues across all components.

We envision these plans to be implemented immediately, with the Fall, 2019 first-year cohorts being formally advised under these new suggestions.

Detailed Report

1. What is the required first-year curriculum?

We will note, first, that the Department of Physics and Astronomy does not explicitly require certain courses during the first year, except for PHY 100 (*Introduction to Physics and Astronomy*). Advisors work with students and suggest a certain curriculum for each to provide the best plan for that student to graduate within four years. Students who deviate from the suggested curriculum (or fail a course) have a higher probability of not graduating within four years, so the "recommendation" is a strong one.

With that said, for both the B.S. in Physics and EPS, students are expected to take the following physics courses: the PHY 121/122 sequence, *Physics for Engineers and Physical Scientists*, and the aforementioned PHY 100, a seminar course. Both majors are expected to take the MAT 126/127 sequence (Calculus I/II), as these courses serve as prerequisites for a majority of our upper division physics courses. Example first-year curricula for the B.S. degrees in Physics and EPS are shown below.

First year curriculum for a B.S. in Physics

FALL SEMESTER			SPRING SEMESTER		
Course		Credits	Course		Credits
PHY 121	Physics for Engineers & Physical Scientists I	4	PHY 122	Physics for Engineers & Physical Scientists II	4
ENG 101	College Composition	3	COS 220	Intro. to Computer Sci. [2]	3
MAT 126	Calculus I	4	MAT 127	Calculus II	4
PHY 100	Intro to Physics & Astronomy	1		HV/SC & E Elective II[1]	3
	HV/SC & E Elective I[1]	3			
	Total Credits	**15**		**Total Credits**	**14**

First year curriculum for a B.S. in Engineering

FALL SEMESTER			SPRING SEMESTER		
Course		Credits	Course		Credits
PHY 100	Intro to Physics & Astronomy	1	PHY 122	Physics for Engineers & Physical Scientists II	4
PHY 121	Physics for Engineers & Physical Scientists I	4	ENG 101	College Composition	3
CHY 121	Introduction to Chemistry	3	COS 220	Computer Programming Elective [1]	3
CHY 123	Introduction to Chemistry Lab.	1	MAT 127	Calculus II	4
MAT 126	Calculus I	4		Engineering Sequence I [2]	3
	HV/SC & E Elective I [3]	3			
	Total Credits	**16**		**Total Credits**	**17**

For the B.A. in Physics, students have much more flexibility and are not necessarily expected to take any physics or mathematics courses in the first year, except for PHY 100. Students can take the introductory physics and calculus sequence in the first-year, or wait until their second year and still successfully graduate in four years. Two example curricula for the B.A. Physics degree is shown below: in one example, students take the physics/mathematics sequence their first year and in the other example, they wait until their second year.

For all three majors, we have no specific requirements for taking general education courses during the first year; we do, however, recommend students taking at least two general education courses and ENG 101 during their first year. This timing makes sense for our students, as the majority of first-year students will not possess the necessary prerequisites to take any other higher level PHY or MAT courses.

One possible first-year curriculum for a B.A. in Physics. Note that physics courses are taken in the first year.

Sample #1 PHYSICS CURRICULUM

FIRST YEAR

FALL SEMESTER			SPRING SEMESTER		
Course		Credits	Course		Credits
PHY 121	Physics for Engineers & Physical Scientists I		PHY 122	Physics for Engineers & Physical Scientists II	
	OR	4		**OR**	4
PHY 111	General Physics I		PHY 112	General Physics II	
ENG 101	College Composition	3	MAT 127	Calculus II	4
MAT 126	Calculus I	4		HV/SC & E Elective II[1]	3
PHY 100	Intro to Physics & Astronomy	1		**Elective**	**3**
	HV/SC & E Elective I[1]	3			
	Total Credits	**15**		**Total Credits**	**14**

One possible first-year (and second-year) curriculum for a B.A. in Physics. Note that physics courses are taken in the second year. *This curriculum is designed for students who desire a degree in physics but who wish greater breadth in background in other areas of science, e.g., biological, chemical, earth, or environmental sciences. (Or students who switch into the major after their first year.)*

Sample #2 PHYSICS CURRICULUM

FIRST YEAR

FALL SEMESTER Course		Credits	SPRING SEMESTER Course		Credits
ENG 101	College Composition	3		HV/SC & E Elective II[1]	3
PHY 100	Intro to Physics & Astronomy	1		**Electives**	**12**
	HV/SC & E Elective I[1]	3			
	Electives	9			
	Total Credits	**16**		**Total Credits**	**15**

SECOND YEAR

FALL SEMESTER Course		Credits	SPRING SEMESTER Course		Credits
PHY 121	Physics for Engineers & Physical Scientists I		PHY 200	Career Prep in Phys & EP I	1
	OR	4	PHY 122	Physics for Engineers & Physical Scientists II	
PHY 111	General Physics I			**OR**	4
MAT 126	Calculus I	4	PHY 112	General Physics II	
CHY 121	Intro. to Chemistry	3	MAT 127	Calculus II	4
CHY 123	Intro. to Chemistry Lab.	1		HV/SC & E Elective IV[1]	3
	HV/SC & E Elective III[1]	3		Elective	3
	Total Credits	**15**		**Total Credits**	**15**

2. What is the recommended first-year curriculum?

For the B.S. in Physics and EPS, we recommend that students take COS 220 (Computer programming). For B.S. EPS majors, we also recommend CHY 121/123 (Introductory Chemistry I). As stated above, we recommend students take at least two general education courses and ENG 101 during their first year.

3. Why is this the required/recommended first-year curriculum?

The first-year curriculum is designed to maximize the probability for student success in the major and to foster the idea of "thinking like a physicist" early in the student's academic career. This occurs through high achievement in our introductory courses, which both lays the groundwork for our program educational objectives and facilitates success in our future courses.

Although the specific educational objectives differ for our three majors, they are all similar in form. Our degree programs will provide students with:

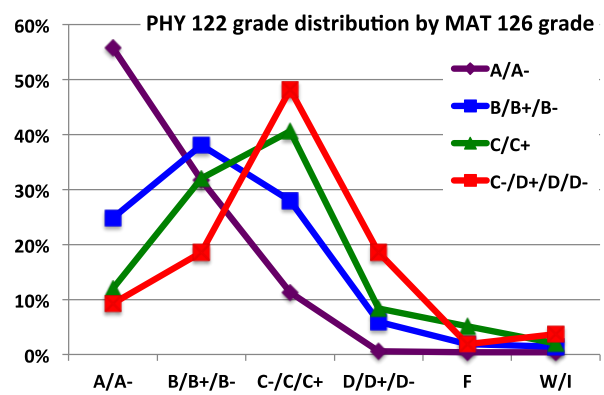
1. Strong knowledge of the fundamental principles of engineering and physics, together with an appropriate mathematical background for these subjects.
2. Problem solving experience in engineering and physics, in both the classroom and the laboratory learning environment.
3. An understanding of the role of the engineer/scientist in today's society.
4. Practice in oral and written communication.
5. Experience using computers to assist problem solving, data acquisition and analysis.

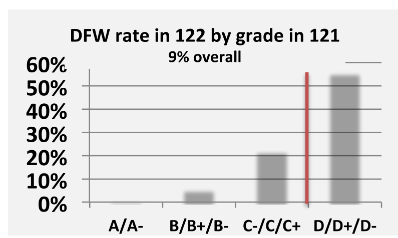
Graduates of our programs will have:

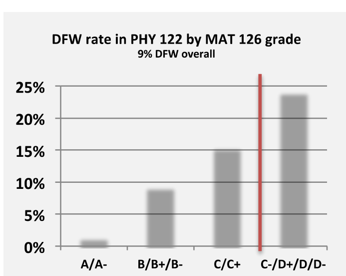
1. An ability to apply knowledge of mathematics, science, and engineering.
2. An ability to conduct experiments as well as to analyze and interpret data.

3. An ability to identify, formulate and solve physics and engineering problems.
4. An understanding of modern professional and ethical responsibilities.
5. An ability to communicate effectively, both orally and in writing.
6. A general educational experience sufficient to support an understanding of the impact of scientific/engineering solutions in a global/societal context.
7. A recognition of the need for, and an ability to engage in, lifelong learning.
8. A knowledge of contemporary issues.
9. An ability to use the techniques, skills and modern tools necessary for physics and engineering practice.

To achieve these goals, we have found that success in our introductory physics course (PHY 121) is critical to ensure success in our more advanced courses. (See the data below.) For instance, we have found that *over 50%* of the students who receive a grade below C- in PHY 121 receive a D,F, or W in PHY 122, while ~25% of the students who receive a grade below C in MAT 126 receive a DFW in PHY 122. Simply put, students who do not receive at least a C- in these prerequisite courses have a low probability for success in PHY 122. In addition, the mathematics and computer science courses must be taken by our students during the first-year to ensure a high probability of a four-year graduation. This is part of the Departmental justification for our recommended first-year curriculum.







5 yrs: 13-14 – 17-18
MAT 126: N=1616
PHY 121: N=2183!

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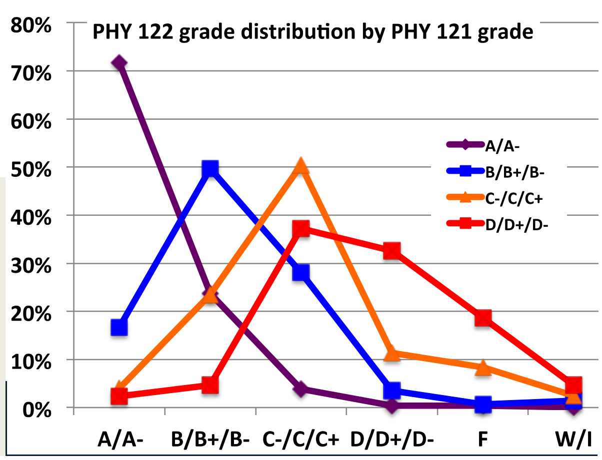
- !If!a!student!repeated!PHY!122,! the!grade!represents!the!first! 7me!the!student!took!the! course.!



4. What are the risks associated with this curriculum?

The largest risks in the first-year curriculum arise from the high DFW rates for many of the non-PHY courses that our majors must take (see table below for Fall 2017 DFW rates). For instance, both CHY 121 and two of the COS courses have ~50% DFW rate, while MAT 126 and 127 are at ~40%. Students taking these courses alongside the difficult introductory physics sequence (although we point to our relatively low DFW rates in PHY 121/122) could potentially set students up for first-year struggles. This can either put the students' four-year graduation time frame immediately in peril, or worse, discourage students from continuing their studies.

DFW(L) rates, Fall 2017 Undergraduate Courses

Course	% D,F,W, L	% D's	% F's	% W's	% L's
CHY 121	53%	11%	21%	20%	2%
CHY 123	28%	1%	12%	15%	0%
CHY 131	11%	7%	1%	3%	0%
CHY 133	9%	2%	5%	2%	0%
COS 125	50%	5%	12%	32%	1%
COS 220	47%	20%	11%	14%	2%
ENG 101	16%	4%	4%	6%	2%
MAT 126	38%	16%	14%	7%	1%
MAT 127	42%	24%	8%	6%	4%
PHY 121	19%	10%	6%	3%	0%
PHY 122	10%	4%	3%	3%	1%

For the last six years we have been using the ETS© Major Field Test (MFT) as an independent metric to evaluate student learning outcomes in our program. Our goals were to find ways to track/assess student learning without relying on the "letter grade" that the student obtained in the class. Our major undertaking towards assessing student learning outcomes is the implementation of the MFT. The MFT for Physics consists of 70 multiple-choice questions, some of which are grouped in sets and based on materials such as diagrams, graphs, experimental data, and descriptions of physical situations. The emphasis of the test is on the firm grasp of fundamental principles and the ability to apply an understanding of the principles in the solution of problems. Most of the test questions can be answered on the basis of a mastery of the first three years of undergraduate physics.

The output of the MFT allows institutions to evaluate their program's performance on the MFT relative to the larger group of test takers at other institutions. For the MFT, the comparative data are based on the scores of all senior-level students who took the most recent form of a test and who are from institutions where at least five students were tested. The data is comparative rather than normative, since the sample of institutions and students does not represent all possible types of institutions and departmental curricula. Thus, affordances of this exam as an assessment of student learning are the abilities to objectively measure individual student performance in the program, to historically compare student performance in the program, and to compare our program to national averages.

While we will not detail the exact outcomes of this exam in this report (as it is focused on the entire program, and not just the first year), we have used the results from this exam in understanding the strengths and weaknesses of our students and possible avenues for improvement in our methods of instruction.

5. In light of risk assessment, what are alternative first-year curriculums?

For the B.S. EPS majors, we can move CHY 121/123 to the second year, thereby moving a high-DFW-rate course to a time when the students are more a bit more mature and not first entering college. This will also remove 1 credit in the first semester of the first year (from 16 to 15 credits), easing the burden on students at this time. The additional credit in the sophomore fall (from 16 to 17) should be better handled by those students. The B.S. Physics students already have CHY 121/123 recommended in their second year.

We had discussed requiring CHY 131 instead of CHY 121 for our majors. This course has much lower DFW rates (11% versus 53% for CHY 121). However, the topics listed in the course catalog are not appropriate for physics students, so it was decided this was not a viable alternative course for our majors.

We also need to determine which computer science course is most appropriate for our majors, which is difficult given that COS is changing its courses at the moment, in part as a result of our discussions with the COS department (we had COS faculty visit our department to discuss). It may be possible to identify other COS courses with lower DFW rates, that also benefit our majors and prepare them for advanced courses in computational physics and engineering. This issue continues to be addressed.

Lastly, we have been making several modifications to the PHY 121/122 sequence in order to strengthen its effectiveness which, in turn, makes the student learning experience much more fruitful. The PHY 121/122 laboratories have been (and continue to be) revised and now include a focus on understanding error and error propagation, a necessity for any physical scientist or engineer. Most recently, one weekly 50-minute recitation slot was converted into a 50 minutes of lecture for both content coverage and pedagogical reasons. While initially seeming pedagogically counterintuitive, the lectures in PHY 121/122 have become much more interactive in the past few years, based on input from physics education research; adding lecture time will enable instructors to integrate even more active learning activities and problem-solving activities into the lectures. These modifications will help improve student learning as well as course sequencing issues across all components.

6. What practices, resources, and/or tactics are in place to mitigate risk?

The Department's main efforts towards ensuring student success and mitigating risk is via student academic advising for both the B.S. and B.A. degree programs. A team of ten faculty from the Department serves as academic advisors (Astumian, Batuski, Clark, S. Hess, Lad, McClymer, Meulenberg, Stetzer, Thompson, Wittmann), with one advisor assigned to a cohort of either BS/BA or EPS majors. Typically, our majors start off with PHY 100 in the fall of the first year. This course, which is typically taught by the Department Chair, provides the structure of weekly class meetings with a faculty member who introduces the students to the Department, and serves as their initial advisor. The design of this class allows for reasonably complete formal advising of all our first-year students. During this first semester, each student is assigned to a formal advisor who will work with that student for the rest of his/her undergraduate career. This advisor provides advising that is as consistent and well-suited to student needs as possible.

The Physics Department advisors usually meet with each of their advisees for about one hour once each semester to review the student's progress and determine which classes to register for in the next semester and eventually to discuss the full degree plan. For new transfer students there may be additional meetings in their first semester to ensure that items, such as transfer credits, have been completed. The frequent contact between advisor/advisee can allow for the faculty advisor to know the advisee on a personal level to ensure more effective communication thus providing a superior advising experience for the student. This is evident via the Departmental exit interview where the Chair asks each undergraduate major to complete an advising evaluation survey form, which asks questions to determine the student's level of satisfaction with their advisor's availability, quality of advice, and concern for them. Most respondents indicate that they would recommend or strongly recommend their advisor to a friend. The familiarity between advisor/advisee inherently enables some level of flexibility in the curriculum, as the faculty advisor is aware of advisee academic issues and can work with the advisee to plan the student's long-term schedule to ensure timely graduation.

7. What additional steps can be taken to mitigate risk?

As already discussed above, moving the CHY requirement for EPS majors from the first year to the second year may be an avenue to foster first-year success. Moving the COS requirement out of the first-year year does not seem feasible, as the computer science requirement is needed as a prerequisite for future courses in the second year. As discussed above, however, the choice of a different computer science course could be appropriate. In addition, for some of our EPS majors, courses offered by the Mechanical Engineering or Electrical and Computer Engineering Departments could replace the COS course. Lastly, the recent hire of a computational physicist in our Department (Dr. Liping Yu) has given us the opportunity to develop and offer a Computational Physics course in our Department that may be able to serve as a computer programming course for our majors as well. The course development process is still in the initial stages.

Mechanical Engineering

Executive Summary

The MEE curriculum structure develops problem-solving skills starting with the first semester in the program. In the first year, engineering courses (MEE 101, MEE 120, MEE 125 and MEE 150) give students basic preparation in mechanical engineering simultaneously with fundamental math and science.

The curriculum is credit-heavy in the first year (17 credits in each semester). The MEE faculty is currently discussing numerous potential revisions to the four-year curriculum. One proposal that will be considered is to introduce additional content (and a design project) and one additional credit to MEE 120 (increase from 2 to 3 credits). This (in concert with other curriculum changes) would potentially allow the removal of the 3-credit HVSC elective from Fall semester of first year, which would reduce that semester to 15 credits total. This reduction may help students who are overwhelmed with the total workload in their first semester of college.

If a student does not pass a required course, s/he must retake it, and if necessary, postpone taking any courses for which that course is a prerequisite. For example, if a student does not pass Calculus I in the Fall, s/he cannot take MAT 127, PHY 122, or MEE 150 in the Spring; this can make graduation in four years quite difficult. The student's academic advisor will suggest the best course of action, which may involve swapping courses from one semester to another, taking one or more courses in the winter or summer sessions, and/or making a 4.5- or 5-year plan for graduation (depending on each student's unique situation).

Recently (in Fall 2017), MEE 101 "Introduction to Mechanical Engineering" was redesigned, with the primary goal to get first-year students engaged and excited about mechanical engineering, while also providing an overview of the field and a sampling of MEE topics. In MEE 101, we currently devote a portion of the first class period to introducing the students to the department (faculty, staff, curriculum, minors, study abroad option, etc.). We are considering incorporating additional content related to first-year student success (starting in Fall 2019): for example, how to use MaineStreet (Student Center, Degree Progress Report, Wish List, Schedule of Classes, etc.), academic support services (UMaine tutor program, Writing Center, Math Lab), study skills and time management.

Initial data indicate that the MEE 101 redesign (implemented in Fall 2017) may be having a significant positive impact on first-year in-major retention rate. The cohort that entered in Fall 2017 shows the highest first-year in-major retention rate (76%) going as far back as 2007 and possibly earlier. This represents an increase of 11% from the previous year (65%) and is 5% higher than the previous highest (71% for cohorts entering in Fall 2010 and Fall 2014) going back to 2007 and possibly earlier.

The MEE department has recently developed a brand new "in-house" programming course, MEE 125 "Computational Tools for Mechanical Engineers", which is being offered for the first time this semester (Spring 2019). MEE 125 introduces students to programming in MATLAB, and also introduces them to MathCad and expands their skills in Excel. This course replaces the previous requirement of COS 220 (or ECE 177). For several years, MEE students had very high rates of failure or withdrawal in COS 220. The primary benefit is that MATLAB is a more useful programming language for mechanical engineers (compared to C++/C as used in COS 220 and ECE 177), and MATLAB is used in subsequent MEE courses in the curriculum. Furthermore, the examples/problems/projects given in MEE 125 are from mechanical engineering, and are therefore more relevant and generally more interesting to the students.

Detailed Report (responses to the seven guiding questions)

1. What is the required first-year curriculum?

Required first-year curriculum in Mechanical Engineering

Fall Semester

Course ID	**Course Name**	**Credit Hours**
ENG 101	College Composition	3
MAT 126	Calculus I	4
MEE 101	Introduction to Mechanical Engineering	1
MEE 120	Engineering Graphics and CAD	2
PHY 121	Physics for Engineers and Scientists I	4
HVSC	Elective	3
	Semester Credits	17

Spring Semester

Course ID	**Course Name**	**Credit Hours**
MAT 127	Calculus II;	4
MEE 125	Computational Tools for Mechanical Engineering	3
MEE 150	Statistics	3
PHY 122	Physics for Engineers and Scientists II	4
HVSC	Elective	3
	Semester Credits	17

2. What is the recommended first-year curriculum?

The recommended first-year curriculum is the same as the required one as listed in Table 1.

3. Why is this the required/recommended first-year curriculum?

The curriculum structure develops problem-solving skills starting with the first semester in the program. In the first year, engineering courses (MEE 101, MEE 120, MEE 125 and MEE 150) give students basic preparation in mechanical engineering simultaneously with fundamental math and science. MEE 101 introduces students to the field of mechanical engineering. MEE 120 enables students to develop skills in engineering graphics and computer-aided design using the 3D solid modeling package SolidWorks. MEE 125 familiarizes students with various computational tools used by mechanical engineers for calculations, problem solving, and presentation of results. MEE 150 develops students' ability to analyze and solve engineering problems through the study of force systems and equilibrium.

In Calculus I and II (MAT 126 and 127), students learn essential mathematical skills for engineering. For instance, skills learned in the Calculus I are needed for MEE 150 "Statics" in the Spring semester; hence, MAT 126 is a prerequisite for MEE 150. Skills learned in MEE 150 are needed for MEE 251 "Strength of Materials", which is taken in the Fall of second year. The physics courses (PHY 121 and 122) provide critical, foundational knowledge and skills for mechanical engineering majors. PHY 122 is a prerequisite for ECE 209 (Fundamentals of Electrical Circuits), which is taken in Spring of second year. College Composition (ENG 101) teaches writing skills that are critical for mechanical engineering majors.

a. What are the expected student-learning outcomes?

- MEE 101 "Introduction to Mechanical Engineering":
    - Have a better understanding of Mechanical Engineering discipline.
    - Perform simple engineering analyses and physical experiments.
    - Use Excel or Mathematica to produce graphs and charts describing various measurement or calculation results
    - Produce informative presentation materials using PowerPoint
    - Write short engineering reports using Word
    - Have an understanding of engineering ethics
    - Work in a team with multiple students

- MEE 120 "Engineering Graphics and Computer Aided Design":
    - Communicate mechanical designs via freeform, orthographic and axonometric hand sketching
    - Read and interpret mechanical drawings of parts and assemblies
    - Demonstrate familiarity with the fundamental concepts of fits, tolerances, and GD&T
    - Apply a Parametric Solid Modeling CAD package to:
        - Construct robust sketches that reflect the appropriate design intent
        - Construct mechanical parts using extrude, revolve, and sweep and blend techniques
        - Modify parts using fillets, chamfers, holes, patterns, mirror, copy, family tables
        - Construct assemblies of parts
        - Optional: create animations of assemblies
        - Produce engineering drawings of mechanical parts in accordance to a specified drafting standard

- MEE 125 “Computational Tools for Mechanical Engineers:
    - Create a worksheet using a graphical math tool to solve an engineering problem
    - Use spreadsheets to organize data and calculate results
    - Create and format graphs within a spreadsheet
    - Use a high-level computational platform’s native commands and functions to:
        - Enhance the workspace
        - Simplify engineering calculations
        - Create and manipulate plots
    - Write a script in a high-level computational platform using logical operations
    - Write functions/subroutines
    - Debug script files

- MEE 150 “Statics”:
    - Use both SI and US Customary units and use significant figures correctly
    - Use vectors in the solution of problems
    - Analyze the equilibrium of a particle, including the use of Free Body Diagrams
    - Determine moments, couples, and reduce simple distributed loads
    - Analyze the equilibrium of a rigid body, including the use of Free Body Diagrams
    - Analyze structures, including trusses, frames and machines including the use of Free Body Diagrams
    - Determine the internal loads for a structural member
    - Analyze the equilibrium of objects subjected to friction forces
    - Determine the centroid of an area and the center of gravity of an object
    - Determine the moments of inertia of an area and apply the parallel axis theorem

- *How successful is this curriculum at producing expected outcomes?*
    - We currently do not have assessment data available to answer this question (In accordance with ABET accreditation requirements, we currently perform program assessment only in upper-level classes).

4. What are the risks associated with this curriculum?

- High credit loads in both Fall and Spring (17 credits each)
- If a student does not pass MAT 126 (Calculus I) in the Fall, s/he cannot take MAT 127, PHY 122, or MEE 150 in the Spring, which makes graduation in four years quite difficult.
- Lack of student engagement during the first year in the MEE program (see Question #6)
- Requiring both MAT 126 and PHY 121 to be taken together in the first semester

5. In light of risk assessment, what are the alternative first-year curricula?

Based on the prerequisites associated with various courses in the first- and second-year curricula in MEE, students can pursue the following alternative:

- Replace PHY 121 in semester 1 with an HVSC elective from semester 3
- Replace PHY 122 in semester 2 with PHY 121
- Take PHY 122 in semester 3 in place of an HVSC elective

While the above alternative path will reduce the degree of difficulty in the first year, it will make the third semester more technically challenging.

6. What practices, resources, and or/tactics are in place to mitigate risks?

- MEE 101 redesign:

    Recently (in Fall 2017), MEE 101 "Introduction to Mechanical Engineering" was redesigned, with the primary goal to get first-year students <u>engaged and excited about mechanical engineering</u>, while also providing an overview of the field and a sampling of MEE topics (e.g. solid mechanics, fluid mechanics, heat transfer and thermodynamics, materials, and machine design). An additional goal of the course is to introduce students to basic software tools used by engineers. By limiting the "lecture" to the first 20-30 minutes of each class, we are able to incorporate some in-class activities involving teamwork (e.g. materials selection for certain applications), small-group discussion (e.g. ethics case studies), hands-on experiments, and the use of software tools.

    The first class period is devoted to introducing the students to the department (faculty, staff, curriculum, minors, study abroad option, etc.). Early in the semester, one class period is devoted to introducing Excel and Mathematica with students following along on their own laptops as the instructor demonstrates basic operations. Several assignments involve the use of each of these tools, as well as producing a PowerPoint presentation and engineering reports using Word.

    The course includes two hands-on activities in the classroom, including: (1) "Paper helicopter" experiment, in which students design, construct, and test simple paper helicopters of various geometries, as part of a lesson on experimental design; and (2) a cantilever beam deflection experiment, using beams of various materials and dimensions. Weekly assignments, corresponding to that week's topic, are designed to pique student's interest in the various MEE areas and to build their software skills.

    An entire class period (and assignment) is devoted to engineering ethics, as part of the department's effort to increase the students' exposure to ethics. The students tour engineering research facilities such as ASCC and AMC. In addition, portions of class periods are devoted to: engineering student organizations (featuring presentations by ASME, AIAA, SAE, Black Bear Robotics, 3-D Printing Club, and Engineers Without Borders representatives); research seminar by an ME faculty member; presentation on internships/coops and job fairs by Niya Bond (COE Academic Advising and Internship Coordinator); and library resources.

Initial data indicate that the MEE 101 redesign (implemented in Fall 2017) may be having a significant positive impact on first-year in-major retention rate. The cohort that entered in Fall 2017 shows the highest first-year in-major retention rate (76%) going as far back as 2007 and possibly earlier. This represents an increase of 11% from the previous year (65%) and is 5% higher than the previous highest (71% for cohorts entering in Fall 2010 and Fall 2014) going back to 2007 and possibly earlier. The total still enrolled at UMaine (89%) is also the highest going back to 2007 and possibly earlier.

- Development and implementation of MEE 125 to replace COS 220/ECE 177:

  We have recently developed a brand new "in-house" programming course, MEE 125 "Computational Tools for Mechanical Engineers", which is being offered for the first time this semester (Spring 2019). This course replaces the previous requirement of COS 220 (or ECE 177). For several years, MEE students had very high rates of failure or withdrawal in COS 220. MEE 125 covers Excel (3 weeks), MathCad (1 week), and MATLAB (10 weeks). The primary benefit is that MATLAB is a more useful programming language for mechanical engineers (compared to C++/C as used in COS 220 and ECE 177), and MATLAB is used in subsequent MEE courses in the curriculum. Excel and MathCad are also highly useful for mechanical engineering. Furthermore, the examples/problems/projects given in MEE 125 are from mechanical engineering, and are therefore more relevant and generally more interesting to the students.

- If a student does not pass a required course, s/he must retake it, and if necessary, postpone taking any courses for which that course is a prerequisite. Their academic advisor will advise them on the best course of action, which may involve swapping courses from one semester to another, and/or taking one or more courses in the winter or summer sessions.

- The largest potential "roadblock" for first-year MEE majors is Calculus I (MAT 126), which is a prerequisite for three courses in the following semester. If a student does not pass Calculus I in the Fall, they cannot take MAT 127, PHY 122, or MEE 150 in the Spring; this can make graduation in four years quite difficult. Their academic advisor will advise them on the best course of action, which may involve taking one or more courses in the winter or summer sessions, or making a 4.5- or 5-year plan for graduation (depending on each student's individual situation).

7. What additional steps can be taken to mitigate risk?

As described above, the MEE program is credit-heavy in the first year (17 credits in each semester). The MEE faculty is currently discussing numerous potential revisions to the four-year curriculum. One proposal that will be considered is to introduce additional content (and a design project) and one additional credit to MEE 120 (increase from 2 to 3 credits). This (in concert with other curriculum changes) would potentially allow the removal of the 3-credit HVSC elective from Fall semester of the first year, which would reduce that semester to 15 credits total.

This reduction may help students who are overwhelmed with the total workload in their first semester of college.

As described above, in MEE 101, we currently devote a portion of the first class period to introducing the students to the department (faculty, staff, curriculum, minors, study abroad option, etc.). We are considering incorporating additional content related to first-year student success (starting in Fall 2019): for example, how to use MaineStreet (Student Center, Degree Progress Report, Wish List, Schedule of Classes, etc.), academic support services (UMaine tutor program, Writing Center, Math Lab), study skills and time management.

School of Engineering Technology

Executive Summary

The School of Engineering Technology offers four undergraduate programs (Construction Engineering Technology, Electrical Engineering Technology, Mechanical Engineering Technology, and Surveying Engineering Technology) along with a Professional Science Masters degree in Surveying Engineering Technology. During the first year, each of the programs requires two science courses (PHY107 and PHY108), two math courses (MAT122 and TME152/MAT126), one English course (ENG 101), one public speaking course (CMJ 103), and at least one technical course in the major each semester. In addition, each course requires a single course in the first semester to introduce students to the major. In our efforts to improve retention in majors, we have focused on providing additional structural supports such as tutoring and mentoring in the math and science courses while improving the content in the introductory course to increase the connection of students to the program and campus. Those efforts will be discussed below.

As each curriculum leads to increasingly technical topics, the first year courses are necessary to provide the prerequisite knowledge necessary to succeed in the upper-level courses. Thus, the required curriculum is identical to the recommended curriculum. Students have the option of waiting to take ENG 101 or CMJ 103, but we believe that the knowledge gained in those courses during the first year will enhance their success in future courses although they are not necessarily prerequisites. We have found the curriculum is successful in preparing students for success in the second year courses. The primary risk associated with our curriculum is the math requirements in the first year. Students struggle the most with their math courses more than any other courses with MAT 122, MAT 126 and TME 152 having a significant amount of D, F, and W grades. If a student does not earn a grade of C in their math course, they are required to repeat the course before continuing on, thus delaying their graduation by at least one semester. To reduce the risk of this occurrence, our school offers in-major tutoring for our students in these classes to assist them. In discussions with members of the math department, they have identified that they struggle to fill the necessary teaching slots for these courses with adjuncts each semester. Faculty members have suggested considering alternate approaches to teaching first year math courses with full time lecturers or professors of practice dedicated to the effort might enhance student performance.

Detailed Steps

As mentioned in the executive summary, our programs are examining some of the activities taken within the introduction to the major courses and attempting to identify those steps that seem to be viewed most positively by students. During the fall semester, the following steps were taken by programs within the School of Engineering Technology:

Surveying Engineering Technology

- **Mentorship:** Each first year student was assigned an upper-level student as a mentor.
- **Inspiration:** Practicing surveyors provided guest lectures about the profession to show students the benefits of the career path.
- **Direct Support:** For online students, the Division of Lifelong Learning keeps a very detailed track of student performance and offers assistance when it appears an issue exists.

Electrical Engineering Technology

First year students were surveyed and many reported that they sometimes felt like a small fish in a big pond not knowing where things are located. So, in EET 100, activities are arranged to build connections. For example,

- **Campus Familiarity:** The instructor created a GPS scavenger hunt assignment where teams of two students use GPS to locate all support services such as financial aid, career center, tutor center, business office, career center, etc.
- **Teamwork:** The instructor assigns team projects throughout the semester to engage students with each other.
- **Tutoring:** The department hires upper level students to run small group tutoring in key subjects.
- **Engagement:** The department hires some first year students to work on department projects so they get to work with faculty and staff.

Construction Engineering Technology

Several actions were taken to help build community/positive culture and thus retention within the program.

- The primary focus of CET 100 has been shifted to building relationships and helping students feel at ease with interacting with faculty. For example, the university ropes course is used early in the semester for team-building exercises. Students reported that they enjoyed it and really appreciate the experience. Also, 2-4 field trips throughout the semester are scheduled. This allows students to learn about their major, but it also provides excellent opportunities for them to get to know each other.

- Campus events/meetings are assigned for credit in CET 100. This forces first year students to get out and go to sporting events, shows, club meetings, etc. The intent is for them to get familiar with the campus, the opportunities available, and to help them get out and meet other students/make friends.
- Summer orientation has been revised such that the presenter during orientation is also the instructor in the first year course to begin the relationship building sooner. A welcome process is used during orientation to get students to know each other. Students reported that it was valuable to meet their instructor during orientation since she was also the first face they saw in the fall.
- In class advising: Periodically, we discuss helpful tips for success in college in CET 100. For example, at the beginning of the semester we talk about time management and having a planner. Around the course registration time we cover the academic planner in MaineStreet as well as how to register, who their advisor is, etc. A few weeks before the engineering job fair, the career center comes in to discuss resumes and interviews and the resources they have available.
- Connecting first years with seniors- last fall we had one of our field trips at Hirundo while the seniors were working on capstone. This offered a great opportunity for the first years to see what the seniors are doing and to get to know them. One of the seniors took students one by one on the roller and showed them how to operate it.

In addition, two of our CET faculty are starting monthly lunch meetings for the minorities in our program to connect, get to know each other, and build support.

As part of our continuous improvement process within the School of Engineering Technology, we will be evaluating student feedback from these activities this fall. We will also track retention in this cohort and compare it to the previous co-hort to see if there is a rise in retention.