

New Program Code **Modify Program Code**

Date: 5/31/2019

REQUESTOR CONTACT INFORMATION

Name Stuart Lau Campus Mānoa, UH
 Title Registrar Email stuartl@hawaii.edu
 Office/Dept Office of the Registrar Phone 956-5322

NEW PROGRAM CODE TO CREATE

Institution MAN - University of Hawaii at Manoa Campus MAN - University of Hawaii at Manoa
 Level UG - Undergraduate Effective Term _____

	Code (Max. Characters)	Description	Check if requesting new code:
College	(2) <u>40</u>	<u>College of Engineering</u>	<input type="checkbox"/> See Banner form STV_COLL
Department	(4) <u>ENGR</u>	<u>Engineering, Interdisciplinary</u>	<input type="checkbox"/> See Banner form STV_DEPT
Degree/Certificate	(6) <u>BS</u>	<u>Bachelor of Science</u>	<input type="checkbox"/> See Banner form STV_DEGC
Major	(4) <u>ENGS</u>	<u>Engineering Science</u>	<input checked="" type="checkbox"/> See Banner form STV_MAJR
Concentration	(4) _____	_____	<input type="checkbox"/> See Banner form STV_MAJR
Minor	(4) _____	_____	<input type="checkbox"/> See Banner form STV_MAJR

If a similar major/concentration code exists in Banner, please list the code: _____

Justification to warrant a new major/concentration code similar to an existing major/concentration code: _____

Is this major/concentration code being used the same way at the other UH campuses? Yes No
 Should this program be available for applicants to select as their planned course of study on the online application? *If yes, student may select the code as their only program of study.* Yes No

RULES PERTAINING TO FINANCIAL AID AND 150% DIRECT SUBSIDIZED LOAN LIMIT LEGISLATION

Is 50% or greater of the classes in this program offered at a location other than the Home Campus? Yes No
 Is this program/major/certificate financial aid eligible? Yes No
 Does this certificate qualify as a Gainful Employment Program (Title IV-eligible certificate program)? Yes No

See <http://www.ifap.ed.gov/GainfulEmploymentInfo/index.html>

Program Length

In academic years; decimals are acceptable. The length of the program should match what is published by the campus in any online and/or written publication.

4 years

Special Program Designations

See *Special Program Designations Code Definitions on IRAO Program Code Request webpage*

A B N P T U

Required Terms of Enrollment: Fall Spring Summer Extended

IRAO USE ONLY: DATE RECEIVED

ADDITIONAL COMMENTS

ATTACHMENTS

BOR Approved: Sole-credential Certificates, Associate (excluding ATS), Bachelor and Graduate Degrees, and sole credential certificates

- BOR Meeting Minutes & Supporting Documents Curriculum

Chancellor Approved: Concentrations, Certificates and Associate in Technical Studies (ATS) Degree

- Memo from Chancellor to notify Vice President for Academic Planning and Policy regarding program action.
 Curriculum

CERTIFICATES ONLY: Please check one (1) statement. This certificate is a...

- BOR approved certificate. BOR Meeting/Approval Date: _____
 Chancellor approved within an authorized BOR program. BOR Program: _____
 Chancellor approved CO in accordance with UHCCP 5.203, Section IV.B.10.

VERIFICATIONS

By signing below, I verify that I have reviewed and confirm the above information that is pertinent to my position.

Registrar
(Print Name)

Stuart Lau

Stuart Lau 6/21/19
Signature Date

Financial Aid Officer
(Print Name)

Jodie Kuba

Jodie Kuba 6/4/19
Signature Date

**For Community Colleges,
verification of consultation with
OVPCC Academic Affairs:**

Suzette Robinson

Signature Date



UNIVERSITY
of HAWAII
MĀNOA

Office of the Vice Chancellor for Academic Affairs

December 3, 2018

MEMORANDUM

TO: Roxie Shabazz
Assistant Vice Chancellor
for Enrollment Management

FROM: Michael Bruno
Interim Vice Chancellor
for Academic Affairs

A handwritten signature in black ink, appearing to read 'Michael Bruno'.

SUBJECT: Approval of Provisional Bachelor of Science in Engineering Science

This memo is to inform your office that the Board of Regents approved as provisional the Bachelor of Science in Engineering Science, effective **Fall 2019**. A copy of the proposal is attached for your information.

If you have questions concerning this new degree program, please contact Wendy Pearson, Program Officer, at 956-6145. Thank you for your attention to this matter.

Attachment

C: Interim Dean Riggs
Director Iboshi
Director Zhang
Registrar Lau
Catalog Coordinator Nakashima

2500 Campus Road, Hawai'i Hall 209
Honolulu, Hawai'i 96822
Telephone: (808) 956-8447
Fax: (808) 956-7115

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19151

Office of the Vice Chancellor for Academic Affairs



UNIVERSITY
of HAWAII
MĀNOA

UNIVERSITY OF HAWAII
MĀNOA

18 OCT 25 2018

October 24, 2018

RECEIVED

MEMORANDUM

TO: Lee Putnam, Chair
Board of Regents

18 OCT 25 8:23

VIA: David Lassner
President

UNIVERSITY OF HAWAII
PRESIDENT'S OFFICE

VIA: Donald Straney
Vice President for Academic Policy and Planning

VIA: David Lassner
Interim Chancellor

FROM: Michael Bruno
Interim Vice Chancellor for Academic Affairs
and Vice Chancellor for Research

SUBJECT: APPROVAL OF NEW PROVISIONAL BACHELOR OF SCIENCE
IN ENGINEERING SCIENCE AT THE UNIVERSITY OF HAWAII
AT MĀNOA

SPECIFIC ACTION REQUESTED:

It is respectfully requested that the Board of Regents approve as provisional the Bachelor of Science in Engineering Science in the College of Engineering at the University of Hawai'i at Mānoa.

RECOMMENDED EFFECTIVE DATE:

Effective Fall 2019.

ADDITIONAL COST:

The proposed program will leverage recent strategic investments in the hiring of Engineering faculty and will require additional nominal resources (lecturers) necessitated by an increase in overall enrollment. These investments, which amount to \$185,000, are funded through recent allocations from the central administration and reallocations within the College for greater efficiency.

PURPOSE:

The proposed Bachelor of Science in Engineering Science is designed to meet the demand, from students as well as industry professionals, for a more interdisciplinary approach to engineering education. Biomedical Engineering is currently the fifth most popular engineering major nationally, yet no ABET-accredited degree exists within the

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State. Aerospace Engineering is in extraordinarily high demand across the nation, with many aerospace companies across the country, some with offices here in the State. It is anticipated that the local industry here will grow as well, and graduates from this program will be able to help drive that growth.

The proposed program will allow the College and the university to be much more agile and strategic in the development and deployment of ABET-accredited engineering programs in high demand areas. Under this proposed program, students will be immediately enrolled in an ABET-accredited undergraduate degree program. As indicated earlier, the initial program concentrations will be Biomedical Engineering and Aerospace Engineering, two areas where there is high need and demand in the state and across the country.

BACKGROUND:

Pursuant to Board of Regents Policy 5.201: Instructional Programs, "The Board shall approve the establishment of all new instructional programs granting academic credit leading to a degree or credential, upon recommendation by the president."

The UHM College of Engineering offers ABET-accredited undergraduate degrees in Computer Engineering, Civil Engineering, Electrical Engineering, and Mechanical Engineering. The College also offers the MS and PhD in Civil Engineering, Electrical Engineering, and Mechanical Engineering.

To meet the demands of engineering program curricula for specific degrees, curricula in traditional engineering disciplines typically have little room for breadth outside of engineering. However, innovation often comes from a mixing of engineering with other disciplines, such as life, medical and other sciences. A more interdisciplinary approach to engineering, with greater collaboration with non-engineering disciplines, is highly desirable in engineering education today. The Engineering Science curriculum will be able to accommodate more mixing of engineering and other disciplines, all while allowing the students to graduate from an accredited engineering program.

The proposed BS in Engineering Science complements current engineering degrees by leveraging faculty and curricular resources. In addition, it provides the infrastructure to incubate new degrees in areas that are responsive to state needs and in areas where UHM is positioned to excel. As an example of this approach, the provisionally approved Bachelor of Science in Computer Engineering was initially established as a "computer track" within the BS in Electrical Engineering. Once demand for the degree grew, the Board of Regents approved the stand-alone BS in Computer Engineering in 2010. The degree is now fully accredited by ABET, with enrollment and outcomes that have exceeded projections.

The College plans to have the same success in emerging areas by establishing the Bachelor of Science in Engineering Science as an incubator for new programs. Employers are looking for more and more technologically skilled talent, and there are many opportunities for engineers with a more interdisciplinary background, be that in medical sciences, data analytics, or materials science and engineering and other areas.

The two initial tracks within the degree will be Biomedical Engineering and Aerospace Engineering.

As mentioned earlier, Biomedical Engineering is currently the fifth most popular engineering major nationally, yet no ABET-accredited degree exists within the state. Biomedical engineers are equipped to work in medical fields and are prepared to pursue graduate degrees in the biomedical sciences and medicine. Per Hawai'i Industry Sectors, the average salary is \$85,000 (and \$135K nationally). It is important to note that this effort is a collaboration with JABSOM, consistent with our strategic approach to encourage more multi-disciplinary, responsive degree programs, unbounded by traditional college and department silos.

Aerospace Engineering, offered in collaboration with the Hawai'i Space Flight Laboratory and the Hawai'i Institute of Geophysics & Planetology (SOEST), will prepare graduates for careers with the many aerospace companies across the country, some with offices here in the State. It is anticipated that the local industry here will grow as well, and graduates from this program will be able to help drive that growth. The average salary for aerospace engineers is \$94,000 (and \$160K nationally). Again, this program is an example of the multi-disciplinary, multi-college academic programs that we are seeking to encourage.

In the future, the College anticipates developing tracks in other emerging fields, such as cybersecurity and data science. If approved, the College will seek ABET accreditation for the BS in Engineering Science in 2021 (the earliest date possible). Graduation from an ABET-accredited program is required for professional engineering licensure (after gaining work experience).

Per the *Integrated Academic and Facilities Plan (IAFP)*, "UH Mānoa must also continue to meet the professional workforce needs of Hawai'i in areas such as education, medicine, nursing, law, business, social work and engineering. Work must continue to integrate education, innovation and scholarship, across disciplines, and to develop the next generation of Hawai'i's leaders." As an interdisciplinary program, the proposed BS in Engineering Science fits within the mission of the IAFP so that we meet the needs of the state and support the development of new industries for Hawai'i's next generation.

The proposed BS in Engineering Science is a priority for UHM as the degree creates the infrastructure for the campus to be strategic and agile in the development and deployment of engineering programs in high demand areas. While UHM offers the only ABET-accredited degrees in the state, Hawai'i students interested in biomedical engineering and aerospace engineering have to attend college on the U.S. continent, which ultimately is a loss for the state as many of these students do not return to Hawai'i. The UHM needs to be positioned to respond better to changes in industry, workforce needs, and student demand. The proposed program is a step towards that goal within the field of engineering. The BS in Engineering Science degree is included our 6-year academic master plan. Other programs included in the plan may be found in the attached document.

Lee Putnam
October 24, 2018
Page 4

Our studies indicate that enrollment will exceed 100 students with an average of 30 graduates/year by the fourth provisional year. The program will utilize recently approved allocations, and reallocated resources from within the College. UHM has invested in the hiring of engineering faculty in high demand areas over the last few years, with two new faculty slated to begin in January and in Fall of 2019. As the program leverages existing courses, we anticipate that new lecturers will be needed to add sections of introductory-level courses to meet demand. The faculty hires were funded through strategic investments from central administration and recent retirements. We will cover the additional lecturers through a reallocation of resources within the College and through the projected increase in tuition dollars as a result of an increase in student semester hours. All engineering students pay a \$500 program fee per semester. The fee will also apply to students in the proposed program. Current facilities are sufficient to support the increase in enrollment, which will represent an 8% increase in overall College enrollment.

The proposed Bachelor of Science in Engineering Science represents a new approach in being responsive to changes in industry and needs within the state. Through the establishment of tracks, UH Mānoa is positioned to be both agile and responsible in creating new programs in high demand areas where we are positioned to excel. Further, the proposed tracks in Biomedical Engineering and Aerospace Engineering will meet the immediate needs in the state by preparing future leaders to serve in emerging industries.

ACTION RECOMMENDED:

It is recommended that the Board of Regents approve as provisional the Bachelor of Science in Engineering Science in the College of Engineering at the University of Hawai'i at Mānoa.

Attachments

cc: Executive Administrator and Secretary of the Board Kendra Oishi
Interim Dean H. Ronald Riggs

Program Proposal
Bachelor of Science in Engineering Science

I. Program Purpose and Outcomes

Emerging and innovative technologies are developing and changing quickly, often outside of traditional engineering disciplines. Employers are looking for more and more technologically skilled talent, and there are many opportunities for engineers with a more interdisciplinary background, be that in medical sciences, data analytics, materials science, cybersecurity, and other areas. The BS in Engineering Science will allow students to follow a more interdisciplinary and nimble program than the traditional degree programs in the College of Engineering (CoE) can accommodate.

In addition to allowing for more interdisciplinary engineering education, the program is also designed to serve as an incubator for more targeted engineering degree programs through the development of specialized tracks. The initial program tracks are Biomedical Engineering (BME) and Aerospace Engineering (Aero). If a track is successful in enrollment and in meeting desired outcomes, the College will propose that these tracks become stand-alone degree programs in the future. While ABET, the engineering accreditation organization, recognizes 28 different programs (including Engineering Science); the College currently offers only four.¹ Through the proposed BS in Engineering Science, the College will be equipped to expand strategically our offerings based on student interest, state and workforce need, and our own capacity, allowing UH Mānoa to better compete with engineering programs across the country. In addition to flexibility in program offerings, there is another practical advantage to using this “incubator” approach. It is fairly easy for us to get the engineering science program ABET accredited because there are no specialized program criteria that we need to meet; we need meet only the general criteria that all accredited programs must meet. Hence, regardless of “track”, students will graduate from an ABET-accredited program. Once we are ready to establish a specialized program, everything will be in place for it to become ABET-accredited as well, and the transition for the students will be seamless.

Engineering accreditation by ABET requires all programs to have the following student outcomes and to assess rigorously the achievement of these 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;

¹ Civil Engineering, Computer Engineering, Electrical Engineering, and Mechanical Engineering.

- (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.

The above outcomes establish what the student will know and be able to do upon completion of the program.

The proposed program is consistent with the *Integrated Academic and Facilities Plan for the University of Hawai'i System*, approved by the Board of Regents on April 20, 2017. This program will help UH attract more high school students locally and nationally. For example, BME and Aero are areas where we already have faculty expertise but no program. BME is the 5th most popular engineering major nationally, with about 40% female students (our current ratio is about 22%, which is consistent with the national average over all engineering majors). Currently, Hawai'i students interested in BME and Aero must go out of state for the degree. These and other tracks will allow students to study more in their areas of interest and still graduate from an ABET-accredited program. As an additional opportunity for students to pursue an engineering degree, this program will also help retention and persistence of enrolled students. Engineering has already established pathways with the UH Community Colleges for transferring students. This new program will strengthen these pathways and create more opportunities for students across the System.

Evidence of Continuing Need for the Program

UH Mānoa offers the only ABET-accredited engineering degrees in the state, and engineering is critical to the continued development of Hawai'i's economy. Society is becoming ever more technological, and the need for engineers is increasing. In addition, engineering is becoming more interdisciplinary, as "engineering" is applied to more and more areas. Biomedical engineering is an example of a fairly recent discipline, especially when compared to the traditional fields of civil, electrical, and mechanical engineering. Over the last 10 years, the number of degrees awarded nationally in those three programs has increased 22%, 4%, and 60%, respectively. During the same time, however, the number of degrees awarded in biomedical engineering has increased 108%. Similarly, aerospace engineering has increased 36%. It is imperative that UH Mānoa adapt to new programs in engineering.

UH Mānoa engineering graduates are hired by large multinational firms, including Boeing, Raytheon, Northrup-Grumman, and Microsoft. Career opportunities are good. An engineering education teaches students to find realistic solutions to practical problems. This is a skill set that is transportable to a number of different fields. Many employers, especially in industries that do not align solely with a traditional discipline, are looking for employees with technical training and they will hire cross-discipline, i.e., they will hire

from multiple disciplines for the "same" job.

Engineering Science, designed as an interdisciplinary program, is broad enough to correspond with a variety of employment categories, and graduates can work in multiple areas. As sustainability considerations in design and operations become more and more required, engineers with special training will be needed, and this program would be able to accommodate a program of study that will fulfill this niche. In addition, graduation from an ABET-accredited program will allow graduates to pursue professional engineering licensure after gaining work experience. As baby-boom engineers retire, there will continue to be a need for new engineers to replace them.

As noted in the beginning, employers are looking for technically skilled workers outside of the traditional disciplines that we currently offer. For example, both Bank of Hawaii and American Savings Bank are interested in engineers with data analytics capabilities. Cybersecurity is another area in great demand in virtually all industries. Tremendous opportunities for engineers with more material science skills exist, as new materials are developed. The demand for engineers with a medical focus is set to explode as medicine becomes ever more technologically based. This program will allow students to focus on new and emerging areas of interest in ways that the traditional programs cannot allow.

Graduates following the BME track in Engineering Science will find opportunities in hospitals, which are in need of trained engineers to deal with the ever-increasingly sophisticated machines used for diagnostics and surgery. These graduates also will be well suited for graduate studies in biomedical sciences and medicine as well. This track is being developed in concert with JABSOM.

The track in Aerospace Engineering has been developed in collaboration with the Hawai'i Space Flight Laboratory and Hawai'i Institute of Geophysics & Planetology (SOEST). In addition to many aerospace companies, some with offices here, UH Mānoa itself may become a center for designing and launching small satellites. This program will be able to supply the technical workforce to support these activities, as well as provide the scientists with the technology they need to do their science.

Engineers with training in emerging areas such as cybersecurity and data science are becoming more and more sought after, including non-engineering industries. For example, we have met with the heads of Bank of Hawaii and American Savings Bank about their interest in engineering graduates, and the former comes regularly to our career fair. The program tracks will be carefully controlled to respond to emerging areas, market needs, and student interest. We anticipate that once the program is established there will be 30-50 graduates per year.

According to Hawai'i Industry Sectors, "Engineering, All Other" (which includes the interdisciplinary Engineering Science degree) has a "bright outlook," with 711 jobs projected in 2018. The average entry-level salary in the state is \$96K (\$97K nationally), with an overall average salary of \$128K (or \$153K nationally). For Biomedical Engineering, Hawai'i Industry Sectors projects 34 jobs/year, and over 22,000 nationally.

The average entry-level salary in the state is \$65K (\$85K nationally), with an overall average salary of \$85K (\$135K nationally). For Aerospace Engineering, Hawai'i Industry Sectors projects 195 jobs/year, and over 70,000 nationally. The average entry-level salary in the state is \$77K (\$110K nationally), with an overall average salary of \$94K (\$160K nationally).

The proposed Engineering Science program is designed to help UH Mānoa keep pace with and better respond to emerging industries and programs of study.

II. Program Organization

The BS degree program requires a minimum of 124 credit hours for the Biomedical Engineering Track and 124 credit hours for the Aerospace Engineering Track. Students must complete the College of Engineering requirements, which satisfy the University General Education Core Requirements. These courses total 51 credit hours. (A list is available upon request).

Program Requirements: Biomedical Engineering Track

Students in the Biomedical Engineering track must complete an additional 73 credit hours:

Biology, Chemistry, Biomedical Engineering (24)

- BIOL 171 + 171L Introduction to Biology (with Lab) (4)
- PHYL 141/141L Human Anatomy and Physiology/Lab (4)
- EE 480 Introduction to Biomedical and Clinical Engineering (3)
- BIOC 241 Fundamentals of Biochemistry (3)
- MICR 361 Introductory Bioinformatics (4)
- ENGR 396 Junior Vertically Integrated Project (3) or ME 481 (4)
- EE 496 Capstone Design Project (3) or ME 482 (3)

Mechanics (13)

- CEE 270 Applied Mechanics I (3)
- CEE 271 Applied Mechanics II (3)
- ME 371 Mechanics of Solids (3)
- ME 311 Thermodynamics (4)

Signal and Systems (18)

- EE 160 Programming for Engineers (4)
- EE 211 Basic Circuit Analysis I (4)
- EE 351/351L Linear Feedback Control Systems/Lab (4)
- ME 375 Dynamics of Machines and Systems and Lab (4)
- ME 402 Dynamics Systems Laboratory (2)

Math (6)

- MATH 302 Introduction to Differential Equations I (3)
- MATH 372 Elementary Probability and Statistics (3)

Core Electives (12, 6 from each of any two of the following core areas):

- ***Sensing***
BE 373 Transport Phenomena (3), BE 420 Sensors and Instrumentation for Biological Systems (3), EE 323 Microelectronic Circuits I (3)
- ***Thermodynamics and heat, mass transfer***
ME 322 Mechanics of Fluids and Lab (4), ME 422 Heat Transfer and Lab (4), ME 423 Mass Transfer (3) ME 360 Computational Methods in Engineering (3)
- ***Materials/Manufacturing***
ME 331 Materials Science and Engineering (3), ME 341 Manufacturing Processes and Lab (4)
- ***Medical/Chemistry***
CHEM 272/272L Organic Chemistry I/Lab (5), CHEM 273/273L Organic Chemistry II/Lab (4), PHYL 142/142L Human Anatomy and Physiology/Lab (4), MICR 461 Immunology (3)

Program Requirements: Aerospace Engineering Track

Students in the Aerospace Engineering Track must complete an additional 73 credit hours:

Aerospace, Aeronautics and Astronautics (20)

- ASTR 281 Astrobiology (3)
- ME 418 Power & Propulsion (3)
- ME 419 Astronautics (3)
- GG 460 Geological Remote Sensing (4)
- ME 481 Design Project I (4)
- ME 482 Design Project II (3)

Signal and Systems (18)

- EE 160 Programming for Engineers (4)
- ME 213 Introduction to Engineering Design (3)
- EE 211 Basic Circuit Analysis I (4)
- ME 375 Dynamics of Machines and Systems and Lab (4)
- ME 451 Feedback Control Systems (3)

Mechanics (17)

- CEE 270 Applied Mechanics I (3)
- CEE 271 Applied Mechanics II (3)
- ME 311 Thermodynamics (4)
- ME 322 Mechanics of Fluids and Lab (4)
- ME 371 Mechanics of Solids (3)

Math (9)

- MATH 302 Introduction to Differential Equations I (3),
- MATH 307 Linear Algebra and Differential Equations (3) or MATH 311 Introduction to Linear Algebra (3)
- ME 360 Computational Methods in Engineering (3)

Core Electives (9):

- ME 374 Kinematics/Dynamics of Machinery (3),
- ME 422 Heat Transfer and Lab (4)
- ME 404 Computational Fluid Mechanics (3)
- ME 424 Introduction to Gas Dynamics (3)
- ME 471 Experimental Stress Analysis (3)
- ME 473 Vibrations (3),
- ME 492 Special Topics in Mechanical Engineering: Orbital Mechanics (3)
- ME 492 Special Topics in Mechanical Engineering: Aerodynamics (3)
- EE 323 Microelectronic Circuits I (3)
- ME651 Automatic Control (3)
- ME 696 Advanced Topics in Mechanical Engineering: Guidance, Navigation & Control (3).

Notes:

1. All courses currently exist and will be offered regularly.
2. MATH 302 is taught over the summer, which will allow UHCC transfers to still graduate in 4 years.
3. CEE 270 is taught as CE 270 at the UH Community Colleges

Sample curriculum sheets for the Biomedical Engineering and Aerospace Engineering tracks are available upon request.

Because of the requirements of the engineering profession as specified in ABET-accreditation standards, specific training in certain areas of specialty is necessary for a BS degree in engineering, which increases the total required credit hours. Currently, the minimum credit hours required are 124 for the BS in Civil Engineering, 125 for the BS in Computer Engineering, 122 for the BS in Electrical Engineering, and 125 for the BS in Mechanical Engineering.

Admission and Transfer Policies

There is no additional admission policy to the engineering science program other than that of admission to the College of Engineering and UH Mānoa. Requirements for admission to UH Mānoa are described in the UH Mānoa Catalog. High school students applying to the College of Engineering should have completed high school course work including mathematics up to at least trigonometry, with preference for pre-calculus or high school calculus, and one year of high school chemistry and physics with a special emphasis on grades in these courses (B or better preferred). Students are encouraged to take Advanced Placement courses in these subject areas while in high school and to submit AP scores, but this is not required. The College also uses aptitude tests and high school records in its screening procedures.

Students who have not met the admissions requirements directly into an engineering major can enroll as pre-engineering (PREN) students. The College offers advising for PREN students, includes them on the email lists for announcements of College activities and events, and PREN students may register for lower division (100 and 200 level) engineering courses without special overrides, provided they meet the prerequisites.

As the demand for engineers in the State of Hawai'i's workforce continues to increase, the College has been looking at innovative academic pathways for students of all ages and educational backgrounds to obtain the necessary knowledge and course work to graduate with an accredited Bachelor of Science degree in engineering. One such pathway, through a Memorandum of Understanding (MOU), assists students who choose to begin their journey towards an engineering degree at a UH Community College for reasons ranging from tuition considerations to the need for preparatory course work. Freshmen who do not meet the admission requirements are also encouraged to enroll at one of the UH System Community Colleges in order to complete courses or meet grade requirements.

Through the MOU, students who successfully complete the Associate of Science in Natural Science (AS-NS) degree with a Pre-Engineering Concentration at a UHCC may transfer to the UHM College of Engineering with junior status. Transfer students must have completed ENG 100, MATH 241 and 242, PHYS 170/170L, and CHEM 161/161L and 162 or their equivalents and have an overall cumulative GPA of 3.0 or higher. In essence, the MOU provides a 4-year degree plan for engineering students who begin at a UH Community College. Annually, the College accepts 200+ transfer/AS-NS students, and a high percentage of these earn the BS degree, becoming productive members of the State's engineering community.

III. Student Demand

It is envisioned that students who will enroll in the program will include existing engineering students and new students. According to undocumented conversations with local practicing engineers who mentor high school students, there exist a number of students who are interested in pursuing biomedical or aerospace engineering related careers. Because of the lack of such engineering programs at UH, many of these students chose to attend colleges on the mainland and some of them had to select a different major when they eventually chose to attend UH. With the proposed degree program in place, we will be able to attract the students who would otherwise go to the mainland for college.

The College surveyed engineering students to gauge interest in the proposed program. The survey was conducted in four engineering courses, including one sophomore-level required course, two junior-level required courses, and one senior-level elective course. Of the 209 students surveyed, 141 (68%) agreed that they would like to see an Engineering Science major at UH Mānoa. Of the 141 students, 68 indicated that they would be interested in a biomedical engineering track and 64 would be interested in an aerospace engineering track. (The full survey results are available upon request.)

The survey revealed that 68% of the students who responded support the establishment of the new program. Out of the 141 students who are supportive of the program, there were 68 (48%) students expressing interest in the biomedical engineering track and 64 (45%) students expressing interest in the aerospace engineering track. Based on the student response, it can be estimated that around 20% of the 141 students will enroll in the program per year, plus 15 new students per year in the first few years. The estimated

enrollment is about 45. The number is expected to grow as the program becomes more widely known and new tracks are added. With current, recently approved, and reallocated resources, the program will accommodate 150 students.

In addition to new/transfer students, we do expect this program to attract students that might otherwise go to other programs. For example, we anticipate the BME program to be attractive to some students that are interested in medical school. It will be excellent preparation for that (a surprising number of physicians have a connection to engineering, either having started in engineering or even having graduated in it). Should they not get into medical school, they will have a degree that will prepare them well for the workforce. In addition, some may choose to stay in engineering rather than medical school.

Enrollment (fall headcount)	Previous Years			Current Year	Projected Years			
	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Projected: BS in Engineering Science					45	80	95	115
Engineering Undergraduates	1,336	1,357	1,359	1,351	1,371	1,401	1,436	1,470
Engineering Graduate Students	138	135	125	130	140	145	150	160
Degrees Awarded (per year)								
Projected: BS in Engineering Science Degrees						10	30	30
Engineering Undergraduate Degrees	243	275	260	265	270	280	310	315
Engineering Graduate Degrees	54	40	45	48	54	60	65	70

IV. Program Resources and Efficiency

UH Mānoa invested in several strategic hires over the last few years that have increased faculty expertise in the College to support the proposed program. As a result, faculty in the College are already active researchers in the areas to be included in the program, with additional faculty hires in biomedical engineering and aerospace engineering approved². The proposed program leverages and takes full advantage of courses currently offered in the College as well as in the College of Natural Sciences, the School of Ocean & Earth Science and Technology, and the John A. Burns School of Medicine. For BME, JABSOM was part of the planning process. They have agreed to allow students in the program to take the following courses: PHYL 141/141L, PHYL 142/142L, BIOC 241. Their faculty will also be

² A new faculty member in biomedical engineering begins in January 2019. We have approval to initiate a search for a new hire in aerospace engineering; that person is anticipated to begin in Fall 2019. Both hires are in the ME department.

involved in the capstone design projects. Similarly, for Aerospace we worked with the Hawai'i Space Flight Laboratory and the Hawai'i Institute of Geophysics & Planetology (SOEST). Researchers in these units have been very interested for some time in partnering with Engineering because of their need for more engineers focused on this area. They will be offering GG 460 and will be involved in the capstone design projects.

With the current course inventory and recent strategic hires, we are able to accommodate the projected increase in enrollment. Should enrollment increase beyond the projections, lecturers may need to be hired. These will be funded in part using the increase in tuition and fee revenue, and internal reallocations. It should be noted that the campus planning has Engineering growing to 1600 undergraduates in 5 years, which is a growth of about double of what this program is expected to bring (i.e., this program is projected to contribute somewhat less than 50% of that growth). Hence, we are well within the campus plans for engineering.

Initially, the program will be run out of the dean's office. We have a tenured assistant specialist who will help run the program. Ultimately, the program may join an existing department, or if it's wildly successful it could become a standalone department but that is far into the future. All courses and faculty are existing, and so teaching assignments and sections do not change. The ME and EE departments will share in the tuition funds derived from the students in the program proportionally to the enrollment in the respective courses of the departments.

All undergraduate students in Engineering pay a program fee of \$500 per fall/spring semester after the freshman year. The program fee will apply to students in the proposed BS in Engineering Science as well. Program fees support regular lab and equipment upgrades as well as lecturers and teaching assistants in the College in support of the labs.

The Department of Academic Services advises all undergraduate students in the College (including pre-majors), and current staff levels are sufficient to support the proposed program.

CURRENT ACADEMIC PERSONNEL	Current Year
Current Faculty FTE	52.25
Current Faculty Salaries (\$)	\$6,203,869
Current Lecturers (\$)	\$65,798
Current Graduate TAs	21

PROJECTED ACADEMIC PERSONNEL	Current Year	Projected Years				
	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Projected New Faculty FTE	1	1	0	0	0	0
Projected New Faculty Salaries (\$)	\$90,000	\$95,000	0	0	0	0
Projected New Lecturers (\$)	0	0	0	0	0	0
Projected New Graduate TAs	0	0	0	0	0	0

The College is funded through an allocation of tuition/special funds, general funds, summer

session allocations, and program and course fees, as indicated below. Extramural awards totaled \$3.9M (2017-18). The proposed program will both increase the efficiency of current resources and generate additional tuition revenue and program/course fees, especially insofar as it attracts students that would otherwise choose a university on the U.S. continent.

CURRENT RESOURCES/FUNDING	Current Year
Tuition/Special Fund Allocation	\$2,475,575
General Fund Allocation	\$7,436,291
Summer Session Allocation	\$86,973
Program/Course Fee Allocation	\$1,067,500

While the courses required for the program currently exist, we anticipate the need for additional sections of core courses as enrollment grows. The new faculty hires, existing lecturer pool, and tuition allocations will be sufficient to meet these needs, especially as student semester hours increase.

COURSES, SECTIONS, STUDENT SEMESTER HOURS (SSH) (Annual)								
	Previous Years			Current Year	Projected Years			
	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Projected New Courses	n/a	n/a	n/a	0	0	0	0	0
Projected New Sections	n/a	n/a	n/a	0	1	1	0	0
Projected New SSH	n/a	n/a	n/a	0	60	214	514	701
Current Courses Offered	221	228	106	225	225	225	225	225
Current Sections Offered	414	428	198	422	422	423	424	424
Current Annual SSH	21,651	22,644	11,008	22,260	22,464	22,814	23,201	23,401

The projected enrollment for this program is less than 8% of the current enrollment in the College. In addition, some portion of these students are anticipated to come from existing programs. As such, the new program will not put an additional or unmanageable burden on our facilities. Indeed, there is even possibility of it alleviating some of the demand. It is anticipated that some students will want to work with JABSOM and SOEST faculty for their capstone design projects; insofar as those students then work in the labs of those faculty it will reduce the demand on engineering facilities.

There is no other ABET-accredited engineering program that is similar at any UH campus. For the biomedical engineering track, the closest program is the biological engineering program in CTAHR. ABET classifies biological engineering and biomedical engineering as two distinct engineering majors with their own program criteria. The biological engineering program in CTAHR is focused on the design, production, and operation of engineered systems of which a major component is living organisms. The proposed biomedical engineering track emphasizes training in engineering and medical sciences for healthcare. There is no significant overlap between the two programs.

V. Program Effectiveness

The Engineering Science program will be evaluated using the assessments used by the Department of Electrical Engineering and the Department of Mechanical Engineering with appropriate modifications for the Engineering Science program. The Departments have the following assessments:

Course assessments: Every semester, the Department administers a student survey of all EE courses to determine the effectiveness of the course and its instructor. It also administers a student survey to determine the effectiveness of the course in achieving educational program outcomes. The curriculum linkages to program outcomes are available upon request.

Industrial Advisory Board: Both Departments have an Industrial Advisory Board made up of representatives from industry. They provide feedback from employers of our graduates about the undergraduate program. The board meetings are held regularly and cover an overview of the program including laboratory tours, and meetings with students. The Board provides a written report about the program to the Department.

Senior Project Report Assessments: The Engineering Science program will require a 3-credit senior project course, which is the capstone design course. The quality of a sample of projects is assessed every semester.

Performance Rubrics on EE/ME Courses: The Departments have implemented an assessment process of measuring the performance of students over a collection of EE/ME courses. The courses cover the student learning outcomes. The instructor for the course does the evaluation.

We will also survey our graduates to determine where they get their initial employment after graduation.

College of Engineering will apply for the Engineering Science program to be accredited by ABET, which is the national accreditation organization for engineering programs. Demonstrating effective assessment of student performance and a process for continuous improvement is a major part of achieving accreditation. The estimated earliest date for ABET accreditation is 2021. Curriculum maps used to indicate relationship of courses to program outcomes are available upon request.

VI. Conclusion

In summary, there is strong evidence of the need of an ABET-accredited, interdisciplinary engineering degree program at University of Hawai'i at Mānoa. As emerging technologies develop and change quickly, often outside of traditional engineering disciplines, this program will allow us and students to adapt more quickly than traditional programs. There are many employment opportunities for engineers with a more interdisciplinary background.

The planned tracks in Biomedical Engineering and Aerospace Engineering will not only provide additional educational opportunities to the students in Hawai'i, they will also attract more students nationally and internationally. The new program will provide engineers with necessary technical skillsets for the booming industry in healthcare and aerospace in Hawai'i, and thus will contribute to the state economy. Current resources and recent allocations are sufficient to ensure the successful launch of this program as well as secure accreditation in the near future.

The proposed BS in Engineering Science provides the infrastructure necessary for UH Mānoa to be more agile and strategic in launching new engineering programs that meet state and national need, particularly in areas where we are positioned to compete and to excel.