Duke UNIVERSITY | MECHANICAL ENGINEERING & MATERIALS SCIENCE

Undergraduate Program Handbook

2025-2026 Academic Year
This handbook is updated every year.
Students and faculty should always use the latest version of the handbook.

HIGHLIGHTS OF IMPORTANT CHANGES

- Fall 2012: Duke Courses Renumbered
- Fall 2013: Only SSH courses in the identified departments on Appendix 8 count toward the SSH requirement. These courses must also identify one of the following codes: ALP, CZ, SS, or FL.
- Fall 2014: EGR 305, even though it is cross listed with Econ, will NOT count toward the SSH requirement.
- Old course numbers have been removed.
- Fall 2018: EGR101L added to the ME Curriculum and free elective removed. AP and ½ credits are no longer to allowed to satisfy the remaining Free Elective
- Fall 2020: Detailed revisions; Math 218 to replace Math 216; Natural Science elective can include Data Science and some Math courses.
- Fall 2023: Certificate programs added; checklist and flowchart updated.
- Fall 2024: Additions to Natural Science electives list. EGR 103L replaced by EGR 105L.
- Fall 2025: Liberal Arts course requirements added, replacing SSH requirements for students matriculating Fall 2025 and later.

Table of Contents

Introduction

This handbook provides detailed information on the undergraduate program in Mechanical Engineering (ME) at Duke University. It covers the program mission, educational objectives, departmental major requirements, and Pratt School requirements. It contains advice and procedural guidelines for a number of student activities, such as research and independent study activities, and study abroad. It provides information for students planning to obtain a certificate in Aerospace Engineering, Energy and the Environment, Materials Science and Engineering, and Robotics and Autonomy. It also covers rules and information for students planning a Pratt minor in Electrical and Computer Engineering (ECE) or Energy Engineering, as well as planning a second major in Pratt with Biomedical Engineering (BME).

The undergraduate major in Mechanical Engineering at Duke University is one of the best programs in the United States, and a very popular major in the Pratt School of Engineering. The student population is diverse both geographically and culturally and is a cross-section of the very best students in the nation and from around the world. The program stresses fundamental understanding and project-based learning in the four primary disciplines that comprise Mechanical Engineering: Dynamics and Control, Fluid and Thermal Sciences, Materials Science, and Mechanics and Design. Exposure in depth and breadth to these areas prepares students for successful entry into industry and graduate schools.

The program provides preparation in the essential engineering topics while allowing wide flexibility for students to pursue their own specialized interests, including hands-on experience, research and independent study, certificates, minors, and second majors in engineering, the sciences and liberal arts, and study abroad.

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Mission

Mechanical engineers are concerned with the optimum use of materials, energy, time, and individual effort to serve societal needs through the design of machines, structures, and devices that employ mechanical, thermal, and electro-dynamic systems, and through better understanding of dynamic processes involving these systems. They have a wide involvement in many industries including aerospace, automotive, energy and power generation, biomechanical and biomedical engineering, construction, electronics, manufacturing, national defense, and transportation systems. Within these industries, the engineer might specialize in the design, analysis, automation, operation, or marketing of systems or services. The individual's contribution may lie anywhere in the spectrum from highly theoretical to eminently practical and often involves leadership as an engineering manager or organization executive. The department's mission is to prepare our students to serve society in this role in an ethical and conscientious manner.

Because mechanical engineers in industry and research engage in such a great variety of activities, their education is broadly based. Our goal is to graduate mechanical engineers who embody excellence in a broad sense. We expect our graduates to move to industry positions, or on to graduate study, or to carry the attributes of an engineering education into other disciplines. The mechanical engineering program includes mathematics and basic sciences, fundamentals and applications in several engineering sciences, and team-based experience in the process of design, where theory is applied in the context of real needs and limitations, and where judgment must be exercised.

Our mechanical engineering graduates should be able to think critically when solving problems and managing tasks and communicate effectively in multi-disciplinary professional environments. To be a responsible member of the engineering profession, each graduate must also be aware of social, ethical, environmental, and economic factors. Further, they must be aware of the constraints on engineering activity and understand the importance of these matters in a global context. We aspire to have our graduates exhibit intellectual depth and creativity, uphold high ethical standards, and show commitment to the betterment of society through service and professional work.

The curriculum capitalizes on the exceptional abilities of our select students to cultivate the learning, thinking, and problem-solving abilities needed to adapt, to develop, and to exercise responsible leadership through times of rapid change. The program provides firm preparation in the essential engineering topics while allowing wide flexibility for students to pursue their own specialized interests, and also to broaden their overall range of experiences.

Program Educational Objectives

Our specific Program Educational Objectives are to prepare our graduates to:

- identify and address significant needs and challenges in engineering and society, and effectively communicate solutions;
- advance in professional careers that may encompass a broad range of endeavors, both technical and non-technical;
- exhibit intellectual depth and creativity in employment, advanced education and research;
- uphold high ethical standards and show a commitment to the betterment of society through service and professional work.

Student Learning Outcomes

Our students will have the following capabilities upon completion of their degrees:

- An ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science, and mathematics
- 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
- An ability to communicate effectively with a range of audiences
- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- 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
- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Additionally, students will have applied principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations) to model, analyze, design, and realize physical systems, components or processes.

Pratt School of Engineering and Mechanical Engineering Major Requirements

As a program accredited by the Engineering Accreditation Commission of ABET (www.abet.org), the Mechanical Engineering curriculum must satisfy minimum requirements in mathematics, sciences, and engineering. In addition, the Pratt School of Engineering has requirements for all engineering students. To meet these constraints, the Department of Mechanical Engineering and Materials Science has developed specific requirements for undergraduate students. In summary, ME students need to take the following courses.

One Undergraduate Writing Course

Writing 101 or Writing 120 is required and taken by all Duke students during the first year.

Digital Computation and Computer Programming

All engineering students must take either EGR 105L or COMPSCI 201, if they have adequate prior programming experience. For students who matriculated before Fall 2024, this requirement was fulfilled by EGR 103L.

Engineering Design and Communication

EGR 101L is required of all engineering students during the first year (exceptions for late transfers).

One Chemistry Course
Students are required to take Chem 101DL or Chem 110DL, or have AP Credit[1] for Chem 20 or 21 (either score is acceptable for ME majors).

Two Physics Courses

Engineering students must take at least one Physics course post-matriculation, regardless of AP credit. Students with no AP credit will take the following:

- Physics 151L + Physics 152L

Students with a 4 or 5 on the AP[1] Physics C exam(s) earn Physics 25-*Mechanics*; and/or Physics 26-*Electricity & Magnetism*. For these students, the following options are available:

- For students interested in a second major or a minor in physics, following the recommendations for potential physics majors and minors is suggested (https://physics.duke.edu/undergraduate/course-selection/intro-placement).
- For students not planning a second major or a minor in physics who have credit for multivariable calculus, Physics 264L: Optics & Modern Physics is suggested.
- For students who do not yet have credit for multivariable calculus and are not planning a second major or minor in physics, the following options are recommended:
  Physics 152L, or
  An intermediate core physics course selected from: Physics 361, 362D, 363, 464, 513, or
  A gateway core physics course, selected from: Physics 305, 320L, 380, or 414.

NOTE: Students may not take Physics 151L at Duke and use AP[1] credit for Physics 152L.

Five Mathematics Courses

Students matriculating 2020 and earlier: Math 111L, 112L, 212, 216 or 218, and 353.

Students matriculating 2021 and later: Math 111L, 112L, 218D-2, 219, and 353.

AP Credit[1]: AP recommendations are as follows:

No AP: Follow math sequence above and begin with Math 111L
Math 21 AP: Begin with Math 122L in the Fall **or** Math 112L in the Spring
Math 21 AP **and** Math 22 AP: Begin with Math 218D-2, or
Math 21 AP **and** Math 22 AP: Waive AP for MATH 22 and begin with Math 122L

Common questions about mathematics placement are answered at the website:
https://math.duke.edu/undergraduate/course-placement.

Transfer credits examined on an individual basis.
NOTE: If students are advised by the Math department to skip any courses in the Math sequence listed above, *they must replace those courses with as many additional Math courses approved by the*

[1] *Students who use an AP credit as a prerequisite in order to take a higher-level class are not allowed to waive that AP credit later on and take the equivalent Duke course for credit. For example, PHY 152L is a prerequisite for EGR 224L. Therefore, a student with AP credit for Phy 26 could not take PHY 152L after EGR 224L has been taken.*

ME DUS. The total number of Math courses taken at Duke plus the number of AP and/or transfer credits must equal 5. Approved math courses include: Math 230, 238, 333, 342, 361S, 451S, 453, 541.

ME/Math majors: Students wishing to do a ME/Math second major/minor will need to take:

- Math 111L, 112L, and
- Either [212 + 221] or [221 + 222], and
- 356, in place of 353

Once students start the ME/Math sequence by taking Math 221, they must complete it. They cannot switch to the typical engineering math sequence due to overlapping course content. Consult the math department for additional required courses needed to complete the math major/minor requirements.

Five Social Sciences and Humanities (SSH) or Liberal Arts (LA) Courses

Students in the Pratt School of Engineering are required to have a minimum of 5 social sciences and humanities courses or 5 liberal arts courses.

For students who matriculated before Fall 2025, the specific requirements are:

- At least one course must be a social science (SS).
- The remaining (of the 5) courses must be selected from at least two of the following three areas: arts, literature, and performance (ALP), civilization (CZ), and foreign language (FL).
- At least two courses must be taken from the same *department* with at least one being at 200-level or higher. AP exams which have the Duke equivalent as a 200-level course will NOT count for the depth requirement.
- Skill courses cannot be used to fulfill the SSH requirements.
- At most, 2 of these 5 course credits can be met by any combination of 2 from the following options:
    - Advanced Placement (AP) Credit
    - International Placement Credit (IPC)
    - Duke courses only offered on a Satisfactory/Unsatisfactory grading basis.
- A list of Approved SSH Departments is provided in Appendix 10, Table A10
- SSH courses taken in an engineering or science department (e.g., Chemistry) count only if they are cross-listed in an SSH department.
- Some Trinity departments in technology and science, not in social science and humanities, have assigned SS, CZ, or ALP codes for some of their courses as an outreach to Trinity students. For this reason, the Pratt School is now requiring that the SS/H courses be taken only from one of the departments or programs listed in Appendix 10 Table A10.

AP credits do not carry course codes, however in the Pratt School of Engineering, Areas of Knowledge are attributed to AP exams. Some examples include, History (CZ), Psychology (SS), Political Science (SS), AP Language Courses (FL), English (ALP), Economics (SS), Music (ALP). Consult your Dean if you have questions about AP credit.

For students who matriculate in Fall 2025 or later, the specific requirements are:

- Each of the 5 courses must be a full-credit (1.0) course from a set of categories that includes Creating & Engaging with Art (CE), Humanistic Inquiry (HI), Interpreting Institutions, Justice & Power (IJ), Social & Behavioral Analysis (SB), and Language (LG).
- Each course must carry at least one code of CE, HI, IJ, SB, or LG.

- Each course must not otherwise count toward the requirements of the Pratt major(s).
- Completed courses must cumulatively cover at least four of the five codes (CE, HI, IJ, SB, LG).
- A Century Course that has two different codes may cover both of those codes, but still only counts as one of the five required courses.
- All courses taken to fulfill the Liberal Arts requirement (courses or codes) must be satisfied by taking courses post-matriculation. AP credits cannot satisfy the Liberal Arts requirement.
- Any course taken to satisfy the Liberal Arts requirement must be taken on a graded basis, unless the course is only offered on a selective Satisfactory/Unsatisfactory basis. For courses only offered on an S/U grading basis, up to two such S/U-only courses may contribute (course and/or code) to the Liberal Arts requirement.

Natural Science or Mathematics Elective for Mechanical Engineering Majors

Students must take an approved Natural Science (NS) elective as part of their requirement for nine math and science courses in the Pratt School of Engineering. Because the requirement is different in each of Pratt's four departments, ME students should be careful to satisfy the Mechanical Engineering requirements. The Natural Science elective is a component of the school's accreditation requirements. Restrictions on this elective are prescribed by each department, and by the accrediting society, which is the American Society of Mechanical Engineers (ASME) for mechanical engineering. In Mechanical Engineering this requirement can be fulfilled by Appendix 9, Table A9, which lists approved Mathematics, Data Science, and NS electives for ME.

Departments offering certain courses that can satisfy the requirement are Biology, Chemistry, Physics, and Earth and Climate Sciences. Certain courses in Data Science and in Mathematics can also satisfy this requirement. Chemistry or Physics courses used to satisfy the NS elective cannot also count to fulfill the other Pratt course requirements in those areas. Courses in other departments (e.g. Environmental Science) do not satisfy Pratt NS requirement.

The spirit of the requirement is that students should have broad science exposure at a fundamental level, as opposed to a very narrow topical or application level. Engineering courses never count, regardless of their level. Note that a Trinity NS code does not mean that the course will satisfy the Pratt NS requirement.

In exceptional cases an NS elective not on the list can be approved by the Director of Undergraduate Studies (DUS). Note that the MEMS faculty has stipulated that these exceptional cases must have a clearly stated mathematics or science prerequisite, and both the alternative course and its prerequisites must be at an appropriate level for engineering students.

Some AP courses, e.g. Biology, can fulfill the MEMS NS requirement. Some courses taken for Study Abroad can satisfy the MEMS NS requirement with prior approval of both the MEMS DUS and the DUS of the topically relevant department. Such courses may be approved as equivalent to a Duke course, or as being of appropriate level although there is no Duke equivalent.

ME Required Courses

For students in the Mechanical Engineering major, the following specific courses, or their approved alternatives, are required in addition to the overall school of engineering requirements:

Engineering Courses:

EGR 121L Engineering Innovation
EGR 201L Mechanics of Solids
EGR 224L Mechatronics
EGR 244L Dynamics

Mechanical Engineering Courses:

ME 221L Structure and Properties of Materials
ME 331L Thermodynamics
ME 344L Control Systems
ME 424L Mechanical Systems Design
ME 321L Analysis for Design
ME 336L Fluid Mechanics
ME 421L Mechanical Design
ME 431L Heat Transfer

Mechanical Engineering Technical Electives:

A minimum of two upper-level (400-level, or higher) ME electives are required to encourage depth in areas of particular interest. Students are encouraged to consult with their advisors when selecting areas of interest and electives. Students take elective courses to learn advanced knowledge in specific areas of mechanical engineering. A number of ME electives are offered on a regular basis, but the specific courses offered in a given semester depend to a degree on the availability of faculty.

Students should also check ME Special Topics Courses (ME 490) that vary each semester and should also consider taking 500-level courses that are open to advanced undergraduates and graduate students. Upper-level (300-level or higher) independent study courses, if supervised by an ME faculty member, can be counted as required ME Electives.

Upper-Level General Electives:

Two upper-level (200-level, or higher) elective credits are required.

- Unrestricted in content, in that they may be courses in either Pratt or Trinity.
- May not be AP credits.
- May be taken abroad with appropriate approval.
- Each must be a full credit course, not two half-credit courses

General Elective: One general elective course credit is required, unrestricted in content and level.

- Only this general elective can be taken on a Satisfactory/Unsatisfactory basis.
- AP credits are not permitted.
- Must be a full-credit course, not two half-credit courses.

ROTC Courses and the General and Upper-Level General Electives: Up to two ROTC courses taken in the junior or senior year can be used in any combination in these two free elective categories. ROTC courses are not allowed to fulfill other Pratt or ME requirements.

Mechanical Engineering Curriculum Information

The curriculum outlined to this point is also presented in three other forms, all in this document, and on the website: https://mems.duke.edu/students/bse-degree-planning/

- Curriculum Flow Chart, Figure 1
- Annotated Check Sheets, Table 1a and 1b
- Four-year charts that are Appendices 1-8 of this document

The curriculum follows a definite prerequisite structure. Prerequisites and co-requisites are clearly indicated on the Check Sheet and Flow Chart and implied in the sample four-year curriculum charts in the Appendices. The Flow Chart and Check Sheet are available to download separately at: https://mems.duke.edu/undergrad/degrees/planning.

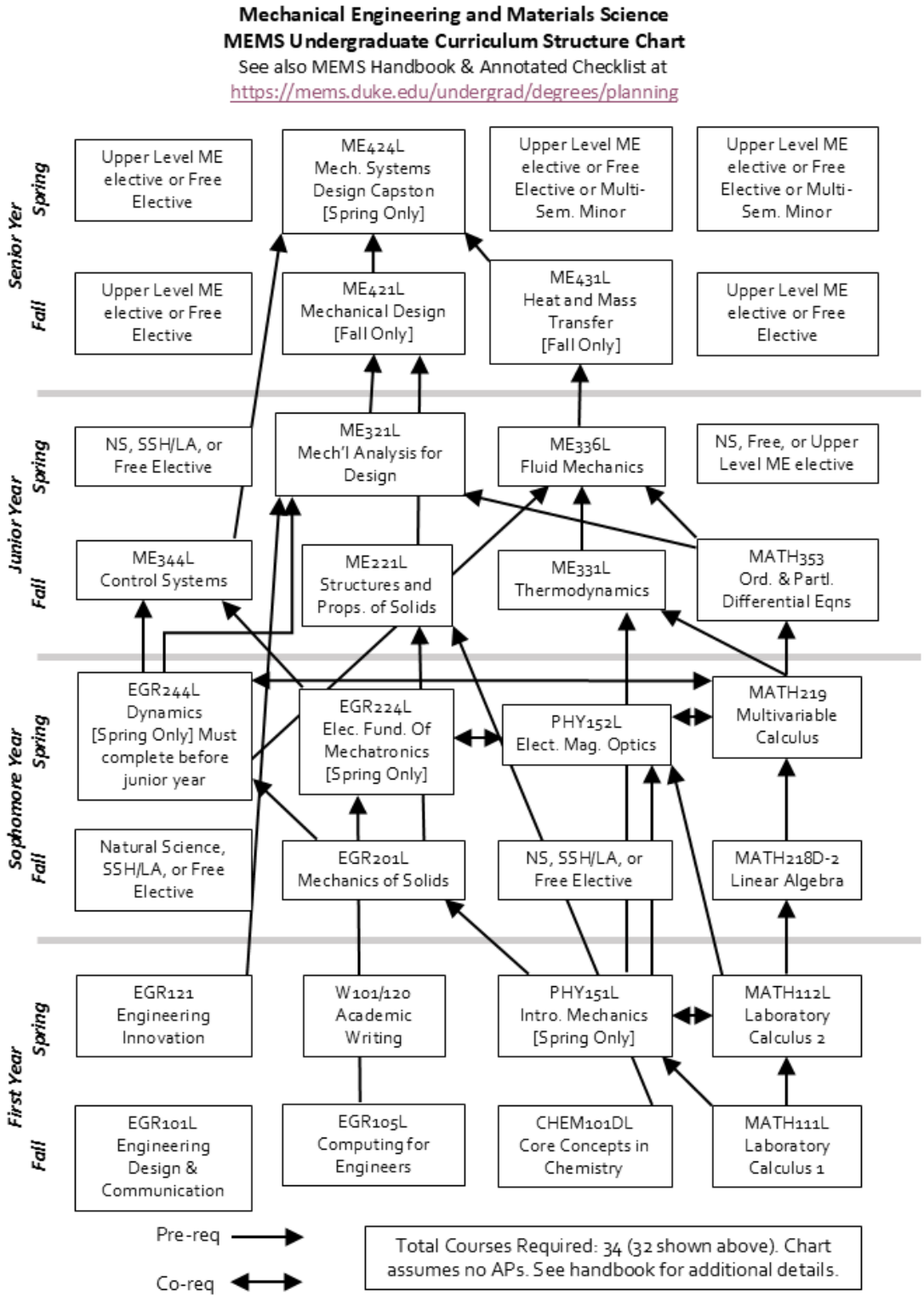

Figure 1 Mechanical Engineering Curriculum Flow Chart

Mechanical Engineering Annotated Check Sheet (for matriculation Fall 2025 and later)

		Date Taken	Grade	
	Writing			
1.	Writing 120			Required of all Duke 1st year students
	Mathematics and Natural Science			
2.	MATH 111L			5 Course Pratt Math Sequence.
3.	MATH 112			If 2 Math APs, must still take at least 3 Math
4.	MATH 218D-2			courses at Duke. Consult DUS if Math 219
5.	MATH 219			content is taken elsewhere.
6.	MATH 353			
7.	CHEM 101DL *[or AP CHEM 20/21 (18/19)]*			
8.	PHY 151L *[or AP PHY 25] First Year Spring*			If AP credit for BOTH PHY 25 & 26, then must take
9.	PHY 152L *[or AP PHY 26]*			certain higher level PHY courses w/ DUS approval for
10.	Natural Science / Data Science / Math Elective*			Physics requirement. This WILL NOT also satisfy the NS elective*
	Engineering			
11.	EGR 101L *take in fall of 1st year if possible*			Required for all Pratt 1st year students
12.	EGR 105L *[or CS201] take in 1st year if possible*			Computing taken by all Pratt 1st years
13.	EGR 121L *take in 2nd semester of 1st year if possible*			Req'd for MEMS (late soph. transfers consult DUS)
14.	EGR 201L *prereq for EGR 244L, ME 221L*			
15.	EGR 244L** *prereq for ME 336L & other jr courses*			SPRING ONLY – Must complete before junior year!
16.	EGR 224L *** *prereq for ME 344L*			SPRING ONLY
17.	ME 221L *req'd prereqs: CHEM & EGR 201L*			Must complete before senior year!
18.	ME 344L *** *prereq for ME 424L*			
19.	ME 331L *prereq for ME 336L*			Must complete before senior year
20.	ME 336L *prereq for ME 431L*			Must complete before senior year
21.	ME 321L **** *prereq for ME421L*			Must complete before senior year
22.	ME 421L **** *prereq for ME 424L*			FALL SENIOR YEAR ONLY
23.	ME 431L prereq for *ME 424L*			
24.	ME 424L **** *Capstone Design*			SPRING SENIOR YEAR ONLY
25.	400-level ME Technical elective 1 § _____			
26.	400-level ME Technical elective 2 § _____			

	Liberal Arts	**Code**			
27.	_____				5 courses req'd, each with 1+ of 5 codes (CE, HI, IJ, SB,
28.	_____				LG). At least 4 of the 5 codes must be included. For a
29.	_____				Century Course with 2 codes, both count, but course
30.	_____				counts as 1 course. No APs, optional S/U courses, or
31.	_____				courses counting toward other Pratt req's here.
	Upper-Level General Electives §§ (Two required)				
32.	_____				No APs here. Not necessarily engineering. Can also
33.	_____				satisfy certificate, minors, 2nd major requirements
	General Elective				
34.	_____				Full credit course only. No APs. No ½ credit courses

* Approved Natural Science courses in the MEMS Undergraduate Handbook; alternatives require DUS approval.

** All ME students must complete EGR244L Dynamics before rising to junior year.

*** 2-semester Mechatronics sequence. EGR 224L (only taught in Spring) is a firm pre-requisite for ME 344L.

**** 3-semester Mechanics & Design sequence. ME 321L Mechanical Analysis must be taken junior year as a firm pre-req for ME 421L (Fall only) which is a firm prereq for ME 424L Capstone Design (Spring only).

§ Courses must be at 400 level. Exception: Independent Study with ME faculty advisor counts. Independent study ME39X taken during junior year can count as an upper level ME Technical Elective. Sophomore level independent study does not count.

§§ Liberal Arts electives at the 200-level of higher may be used. Upper-level engineering electives can be used, as can additional math or science electives. Engineering electives at any level taken during freshman and sophomore years may be used.

Table 1a: Mechanical Engineering Annotated Check Sheet (Matriculation Fall 2025 or later)

Mechanical Engineering Annotated Check Sheet (for matriculation before Fall 2025)

		Date Taken	Grade	
	Writing			
1.	Writing 101			Required of all Duke 1st year students
	Mathematics and Natural Science			
2.	MATH 111L			5 Course Pratt Math Sequence.
3.	MATH 112			If 2 Math APs, must still take at least 3 Math
4.	MATH 218D-2			courses at Duke. Consult DUS if Math 219
5.	MATH 219			content is taken elsewhere.
6.	MATH 353			
7.	CHEM 101DL *[or AP CHEM 20/21 (18/19)]*			
8.	PHY 151L *[or AP PHY 25] First Year Spring*			If AP credit for BOTH PHY 25 & 26, then must take
9.	PHY 152L *[or AP PHY 26]*			certain higher level PHY courses w/ DUS approval for
10.	Natural Science / Data Science / Math Elective*			Physics requirement. This WILL NOT also satisfy the NS elective*
	Engineering			
11.	EGR 101L *take in fall of 1st year if possible*			Required for all Pratt 1st year students
12.	EGR 105L *[or CS201] take in 1st year if possible*			Computing taken by all Pratt 1st years
13.	EGR 121L *take in 2nd semester of 1st year if possible*			Req'd for MEMS (late soph. transfers consult DUS)
14.	EGR 201L *prereq for EGR 244L, ME221L*			
15.	EGR 244L** *prereq for ME 336L & other jr courses*			SPRING ONLY – Must complete <u>before</u> junior year!
16.	EGR 224L *** *prereq for ME 344L*			SPRING ONLY
17.	ME 221L *req'd prereqs: CHEM & EGR 201L*			Must complete <u>before</u> senior year!
18.	ME 344L *** *prereq for ME 424L*			
19.	ME 331L *prereq for ME 336L*			Must complete <u>before</u> senior year
20.	ME 336L *prereq for ME 431L*			Must complete <u>before</u> senior year
21.	ME 321L **** *prereq for ME421L*			Must complete <u>before</u> senior year
22.	ME 421L **** *prereq for ME 424L*			FALL SENIOR YEAR ONLY
23.	ME 431L prereq for *ME 424L*			
24.	ME 424L **** *Capstone Design*			SPRING SENIOR YEAR ONLY
25.	400-level ME Technical elective 1 § _____			
26.	400-level ME Technical elective 2 § _____			

		Area			
	Social Sciences and Humanities (SSH)				
27.	_____				Five required (each in one of 4 Areas of Knowledge
28.	_____				(SS, FL, CZ, ALP)). At least one SS and 2 from the 3
29.	_____				remaining Areas. For depth, two must be from the
30.	_____				same department, and one of those must be at the
31.	_____				200 level or higher. Limit of 2 APs here.

	Upper-Level General Electives §§ (Two required)			
32.	_____			No APs here. Not necessarily engineering. Can also
33.	_____			satisfy certificate, minors, 2nd major requirements
	General Elective			
34.	_____			Full credit course only. No APs. No ½ credit courses

* Approved Natural Science courses in the MEMS Undergraduate Handbook; alternatives require DUS approval.

** All ME students must complete EGR244L Dynamics before rising to junior year.

*** 2-semester Mechatronics sequence. EGR 224L (only taught in Spring) is a firm pre-requisite for ME 344L.

**** 3-semester Mechanics & Design sequence. ME 321L Mechanical Analysis must be taken junior year as a firm pre-req for ME 421L (Fall only) which is a firm prereq for ME 424L Capstone Design (Spring only).

§ Courses must be at 400 level. Exception: Independent Study with ME faculty advisor counts. Independent study ME39X taken during junior year can count as an upper level ME Technical Elective. Sophomore level independent study does not count.

§§ SSH electives at the 200-level of higher may be used. Upper-level engineering electives can be used, as can additional math or science electives. Engineering electives at any level taken during freshman and sophomore years may be used.

Table 1b: Mechanical Engineering Annotated Check Sheet (Matriculation before Fall 2025)

Majoring in Mechanical Engineering – Advice, Milestones, and Important Things to Know

Overview

The Mechanical Engineering curriculum provides an in-depth education in four broad primary engineering areas: mechanics, computational methods, and design; dynamics, control, and robotics; thermal and fluid sciences including energy and aerospace; materials science and biomaterials. There are thirteen required engineering courses (having either EGR or ME designations) all with laboratories, plus a requirement of at least two upper-level ME electives. Students must also complete the overall Pratt School of Engineering requirements of nine courses in Mathematics and Science. These departmental and school requirements were listed earlier beginning on page 8.

Students considering ME should be aware that the underlying structure of the ME curriculum differs from the curricula in other Pratt engineering departments. In the other departments students typically take a set of common core courses, unique to each department, and then choose from several "tracks" to specialize based on their specific area of interest. The pedagogical philosophy in ME is to provide a broad educational experience and to avoid over-specialization at the undergraduate level. ME students have ample opportunity to pursue their special interests in their choice of ME elective courses. In fact, their broad exposure from required courses can lead to more informed choices for areas of special interest. Our approach provides students with the broad knowledge, in-depth understanding, and versatility to deal with modern engineering systems, which are both complex and require multi-disciplinary skills.

ME Curriculum Structure and Rules

It is important to understand that ME has a *structured* curriculum, meaning that courses are to be taken in a prescribed sequence, with enforcement of prerequisites. This approach allows instructors to assume a certain level of knowledge coming into their courses. Students must understand that it is their professional responsibility to have command of the material in prior courses.

In practice, there is some flexibility in the enforcement of prerequisites. For some course sequences, a pre-requisite course can be treated as a co-requisite, but only if there is a compelling reason in the student's broader educational interest, or particular circumstances. The decision on these special cases is made by the Director of Undergraduate Studies (DUS), or the Associate DUS, who have access to the student's overall situation, and <u>not</u> by the course instructor or the student's academic advisor. Such decisions are always made in consultation with the student's Pratt academic Dean. Students should never deviate from the planned curriculum without formal approval; to do so can jeopardize their opportunity to continue in Mechanical Engineering. If a given student has been allowed an exception due to their circumstance, other students should never infer that a similar exception can apply to them. Furthermore, certain ME prerequisite sequences are "locked" because the courses are designed as a closely coupled multi-semester sequence where in-depth knowledge of the earlier course is assumed; no exceptions are made.

Specifically, the firmly locked sequences are:

- Physics 151L Mechanics or AP <u>before</u> EGR 244L Dynamics (offered Sophomore Spring; physics mechanics is a prerequisite)

- EGR 244L Dynamics (offered spring of Sophomore year only) is firmly required of all majors before advancing to junior year in ME. No exceptions beyond an approved summer course with lab makeup at Duke.
- EGR 224L Mechatronics (offered spring only, Sophomore or Junior year) before ME 344L Control Systems.
- ME 321L Analysis for Design (Fall or Spring Junior year) before ME 421L Mechanical Design (Senior Fall only) is firmly required of all majors before advancing to Senior year in ME.
- ME 421L Mechanical Design before ME 424L Systems Design (Senior Spring only). No exceptions; this is a two term Capstone Design sequence with senior design projects started in fall and finished in spring.

First Year

This first year of college is a time of intellectual and personal growth. Important keys to success are learning to understand material in-depth and developing good time management and study habits. Engineering is a profession, and this is the time to begin building a mental knowledge base and physical reference library, recognizing that what you learn at each step along the way must be retained, and everything builds on what came before.

During the first year, the academic focus is on courses in science and mathematics and on engineering design. All Pratt first-year students are required to take EGR 101L Engineering Design and Communication. Included in this multi-faceted course is a semester-long design project. Students work in small teams with a mentor to satisfy the needs of clients.

Following this course, Mechanical Engineering requires a hands-on, ME-skills-focused, design course EGR 121L Engineering Innovation. Pedagogically this course is structured so that every student acquires a broad range of skills to help advance successfully in our curriculum. It covers conceptualization, communication, fabrication, and multiple design project challenges, while teaching skills such as Computer Aided Design (CAD), 3-D printing, and much more. This course is an introduction to many aspects of mechanical engineering, and it is taught with a hands-on, project-based emphasis.

EGR 121L Engineering Innovation is required for Mechanical Engineering majors, usually taken in spring of the first year. The course can also be taken sophomore year, if need be, but not thereafter. Students who are unable to take EGR 121L through some circumstance, such as late transfers into ME, must take an additional upper-level ME elective in its place and must learn SolidWorks CAD on their own prior to taking the junior level course ME 321L Analysis for Design during junior year.

Good activities, beyond academic classes and labs, are student clubs related to engineering, e.g. the Duke Motorsports, Duke Electric Vehicles, student chapters of the American Society of Mechanical Engineers (ASME) and the American Institute of Aeronautics and Astronautics (AIAA), and many others. These activities allow first-year students to meet, interact with, and learn from upper-class engineering students, helping them become part of the Pratt community. Keep in mind that it is better to contribute substantially to one or two extra-curricular activities in depth, than to join too many things and be spread too thin.

First-year students sometimes express interest in early involvement with a research lab, which is certainly possible, but often not preferable to club activities, and should not take priority over course

work. Research lab participation is often more rewarding later when a student has more relevant technical background, appropriate skills, and intellectual maturity.

Sophomore Year

Beyond the next courses in Physics and Mathematics, key sophomore courses for Mechanical Engineers are EGR 201L Mechanics of Solids in the fall, which is a prerequisite for the foundational ME courses EGR 244L Dynamics and EGR 224L Mechatronics.

Important: EGR 244L Dynamics and EGR 224L Mechatronics are only offered in the spring, and they are prerequisites for junior level ME courses. Students whose circumstances prevent them from taking either EGR 244L or EGR 224L should consult their Academic Dean and the ME DUS to make an approved alternate plan, before the beginning of their sophomore spring semester; failure to do so can jeopardize future progress in the major. EGR 244L or an equivalent must be completed before rising to junior year.

In some circumstances EGR 224L Mechatronics can be delayed until spring of junior year, but the student must then take ME 344L Control Systems during the fall of senior year. These courses are never taken concurrently because Mechatronics and Controls form a two-semester locked sequence, with the material from Mechatronics assumed for Controls.

Students who are somewhat ahead due to AP credit should consider taking ME 221L Materials, or ME 331L Thermodynamics during sophomore year, or perhaps fulfill the MEMS/Pratt Natural Science requirement, described elsewhere.

Since ME students who study abroad usually do so the first semester of junior year, planning needs to occur during sophomore year; refer to the Study Abroad information beginning on page 26 of this handbook for details and advice.

Junior Year

By the end of junior year students should have completed the ME courses in Thermodynamics, Fluid Mechanics, Analysis for Design, Materials, and usually Control Systems. These ME courses are all offered in both Fall and Spring to provide scheduling flexibility for a variety of needs, including the possibility of a Study Abroad semester (equivalents of some of these courses may be taken abroad with prior approval). Students must have completed all required ME courses except for ME 431L Heat Transfer and the two-semester senior design sequence; the only possible exception being Controls, when Mechatronics is taken during junior spring.

During junior year, majors will likely take at least one ME elective. Students who are interested in an in-depth independent study experience can initiate that process by applying to become a Pratt Fellow, starting work in the spring semester, or perhaps by completing an Independent Study under the supervision of an ME advisor; a subsequent section discusses this possibility in detail. Important information and advice on independent study is provided in a later section.

During junior year, many ME majors plan their activities for the following summer by arranging for paid internships or summer jobs in a wide variety of companies, institutions and laboratories. Assistance is available through the Duke Career Center. Particularly desirable internships are competitive and often involve an interview process, so it is advisable to start planning during the fall semester.

Senior Year

During fall of senior year, all ME students must take the required courses ME 431L Heat Transfer and ME 421L Mechanical Design. In addition to required courses, technical electives are also taken during senior

year, and these are an excellent opportunity to pursue specific interest areas in depth through course selection or independent study.

During spring of senior year all students must take the capstone course ME424L Mechanical Systems Design. The two-semester senior design sequence, ME 421L Mechanical Design and ME 424L System Design, constitutes a very substantial, applied, hands-on experience spanning more than a semester as they work in small teams; a variety of different projects are represented.

Note that the design courses can only be taken sequentially. Senior design teams are formed, and projects are identified and initiated in the fall, and projects are completed in the spring. Design teams undertake a wide variety of projects. The MEMS philosophy for senior capstone design is that projects must be *engineered* and *analyzed* utilizing skills acquired in the student's prior education; these are not just construction projects.

Students are advised that senior year is often quite busy, even beyond the demands of advanced course work, since it is also the time for planning the future beyond Duke. Graduate school applications and graduate fellowship applications are typically due in the second half of the fall semester, and proper preparation can take considerable time. Similarly, job interviews take place in both fall and spring semesters, and these often involve travel to potential job sites. Students need to communicate with their instructors about any travel that may impact course attendance and understand that it is their responsibility (and not the instructor's) to deal with the situation and schedule accordingly.

Fulfilling Requirements for Graduation

During their undergraduate education, ME students should be careful to understand their curriculum requirements, stay on track, and be in touch regularly with their ME Advisor and their Pratt Academic Dean. Certain matters are subject to DUS approval, and students should be sure to engage the DUS when needed. The Academic Deans and the Directors of Undergraduate Study work closely together. A definitive review of student completion of major requirements by the DUS and the Deans is undertaken before the second semester of senior year. Prior to graduation, the DUS certifies each student's record. Approval for second majors, minors, and certificates is the responsibility of the DUS or Coordinator in the appropriate department, and not the responsibility of the ME DUS.

Independent Study and Pratt Fellows Program

MEMS students can take independent study courses for academic credit during junior and senior year, when they can count as upper-level ME electives. To count as an ME elective (ME 39x or ME 49x) there is a firm rule that the project must have an advisor on the MEMS faculty, and the project must have substantial upper-level Mechanical Engineering content. If the ME faculty member advising a project agrees, Independent Studies can be taken during the sophomore year, but under an EGR number, without counting as an upper-level ME elective.
The upper-class years are the best time to undertake such activities, since the student has more intellectual maturity and a broader set of engineering skills to bring to the project. Many ME independent studies are research related, although many have a significant design component.

There are several educational benefits to doing an independent study project. Beyond learning new project-related material, such projects typically require the student to draw on knowledge from a range of engineering disciplines, very similar to the work experience of professional engineers. Independent projects typically pose more complex problems than found in a typical course setting, often with several

viable solutions. Working with a faculty mentor is also an opportunity to get to know them personally, observe their thinking process and problem-solving strategies, and likely see creative approaches being developed. The greatest gain occurs when both the student and the advisor share a strong commitment to the project. There is the added benefit that building a relationship with your advisor will provide a valuable reference for applications to graduate school and for employment.

There are two types of opportunities: ME independent study taken on a semester-by-semester basis; and the Pratt Fellows program which typically involves a (paid) summer commitment. Each has advantages and disadvantages, depending on the needs of the particular student.

ME Independent work usually takes place during the fall-spring academic year and may encompass project types ranging from basic research activity to design and development projects. An advantage is more flexibility regarding project type, and the summer is left free for other activities such as internships, which are often most beneficial in the summer after junior year. A disadvantage can be shorter project duration, so it is best to have the independent study extend over more than one semester, giving adequate time to pursue the project in depth. Students should feel free to approach faculty members, whether or not they already know them, about independent work opportunities in areas of interest. Within a general area, the faculty member is often the best person to define the specific project and set realistic goals.

The Pratt Fellows program involves a competitive selection process and usually commits the student to three academic semesters starting in the middle of junior year, plus a nine-week paid summer commitment. Students apply to work on specific projects proposed by faculty in descriptive paragraphs. An advantage is that there is time for a very in-depth research experience, which can lead to a very positive experience. Such a strong research experience can be excellent preparation for graduate school. Disadvantages include being unavailable for a summer internship, and that there is a considerable multi-semester time investment in one activity. On balance, the Pratt Fellows program is an excellent choice for students who wish to assess their interest and aptitude for in-depth research and are planning to continue their education beyond the BSE degree.

Students are strongly advised to enter any type of independent study with a clear understanding of the overall level of commitment. It is important to have an up-front understanding with the faculty advisor/mentor about the following: project goals and schedule; basis for grading; expected number of hours per week; frequency of meetings; and whether the student will be working directly for the faculty member (usually best), or more for a postdoc or graduate student.

A common problem students experience with independent study projects is time management. Since the independent study is often the largest project the student has undertaken, there is a tendency to underestimate how much time and effort will really be required. Understandably, there is also a tendency to postpone project work due to short-term deadlines in other courses. Without careful time management, the result can be a hasty ending to the project without fully achieving goals.

Finally, regarding research projects, students are advised to consider the difference between working in a research lab as an assistant to a more experienced investigator and actually doing research - the latter being the primary goal. One is doing research when sufficiently well-versed in the activity to make intellectual contributions to the direction and allocation of human and material resources for the research effort. To make such contributions requires intellectual maturity and dedication to the activity.

Graduation with Departmental Distinction (GWDD)

The Graduation with Distinction Award is presented to the Pratt students who, in the opinion of the ME Department and a committee of the faculty, have demonstrated exceptional achievement in the areas of their special interest by conducting independent research and presenting the research project with a distinguished piece of writing and an oral presentation. ME students who have a final grade point average of 3.6 or higher and have taken an ME independent study senior year, or are participating in the Pratt Research Fellow Program, are eligible. A project from a ME course or an independent study course does not automatically qualify. To determine the suitability of your proposed project, students are advised to speak with their project supervisor(s). Students who have successfully completed the GWDD requirements are individually cited at the Pratt School Graduation Ceremony.

A Mechanical Engineering student can receive Graduation with Departmental Distinction, which is designated on their final transcript, by satisfying the following requirements:

- GPA of at least 3.75 upon graduation
- Completion of an Independent Study during senior year for at least one full semester (preferably more), supervised by a MEMS faculty member (primary or secondary).
- Completion of a graduate level course (500-level or higher) broadly related to the project topic. Pratt Fellows with three in-depth semesters of study are not held to this requirement.
- Preparation of a professional quality paper written in specified format describing the work (if required by the faculty supervisor), to be evaluated by the MEMS Faculty GWDD Committee
- Preparation and presentation of a research poster for the GWDD Poster Session, along with a one-page abstract and completion of the online GWDD application
- Approval by the GWDD faculty committee upon review of the work and presentation. This committee determines whether the work meets the GWDD standard.

Specifically excluded from MEMS GWDD are projects done in groups, unless individual contributions can be clearly delineated, and the GWDD student's work can be identified as equivalent to a stand-alone independent contribution. Also not permitted is work completed prior to senior year, and work conducted off campus as part of a summer job or internship.

Second Major, Minor, and Certificate Programs

Opportunities exist for students with AP credits to combine the ME major with a second major, minor, or certificate, either from another Pratt Department, or from the Trinity College. (A certificate is similar to a minor but offered for interdisciplinary study.) To do so, the students must meet the same requirements as those for the ME major plus the specific requirements from other departments or programs outlined in the Undergraduate Bulletin:

https://registrar.duke.edu/university-bulletins/undergraduate-instruction

The additional requirements usually consist of 10 courses for a second major, 5 courses for a minor, and 6 courses for a certificate. Some of these courses can be double counted towards both the ME degree and the second major, minor or certificate in the Trinity College. For example, two courses required for the second major in economics may be counted as two of the five SSH courses required for the ME degree. To reduce the workload for obtaining the second major, minor, or certificate in the Trinity

College during the regular academic semesters, students can either take the required Trinity courses as unrestricted electives in the ME curriculum or take them in the summer.

Some mechanical engineering majors complete an engineering certificate, such as the Aerospace Certificate (hosted by the ME department), or other certificates in Pratt, such as Architectural Engineering (hosted by the CEE department), or the university-wide Energy and Environment Certificate. Also available are engineering minors in Electrical & Computer Engineering and in Energy Engineering. A few students complete a second major in BME. Further information can be found by following links from the MEMS departmental website, from the individual websites of other Pratt departments and programs, from the Pratt School of Engineering website, or from the overall Duke University website.

Whether considering a certificate, minor, or second major, students are advised to reflect carefully on their motives and long-term objectives, because such decisions place constraints on their overall educational experience. In many cases a better educational outcome can be obtained by judiciously selecting courses in areas of interest beyond the primary major.

For second majors within engineering, students are strongly advised to discuss the requirements, details, and potential issues with the Directors of Undergraduate Study of both departments (see departmental websites for DUS contact information).

Contact Information for Certificates and Minors:

Aerospace Engineering Certificate: Dr. Hall (kenneth.c.hall@duke.edu)

https://mems.duke.edu/undergrad/degrees/certificates/aerospace-engineering

Energy and the Environment Certificate: Dr. Knight (jknight@duke.edu)

https://gendell.pratt.duke.edu/undergraduate-certificate-energy-and-environment

Materials Science and Engineering Certificate: Dr. Guilleminot (johann.guilleminot@duke.edu)

https://mems.duke.edu/undergrad/degrees/certificates/materials-science-engineering

Robotics and Autonomy Certificate: Dr. Oca (siobhan.rigby@duke.edu)

https://mems.duke.edu/undergrad/degrees/certificates/robotics-automation

Electrical and Computer Engineering Minor: Dr. Gustafson (mrg@duke.edu)

http://www.ece.duke.edu/undergrad/minor *See also ECE Undergraduate Program Handbook*

Energy Engineering Minor: Dr. Knight (jknight@duke.edu)

http://energy.pratt.duke.edu/

Aerospace Engineering Certificate Program

The Aerospace Engineering Certificate is hosted by MEMS, but open to all Pratt students. The Aerospace Certificate provides undergraduate students with an understanding of fundamental principles in the several disciplines including fluid mechanics and aerodynamics, dynamics and control, structures and materials, thermodynamics and propulsion, plus courses that address specific aerospace technologies for flight and space vehicles. In addition to coursework, the program offers upperclassmen opportunities for independent research for academic credit under the supervision of a faculty member

affiliated with the program, either through Independent Projects under faculty supervision, or through the Pratt Fellows Program.

All engineering undergraduates are eligible to participate in the program and qualify for certification. Although MEMS is the host department, there is a concerted effort to engage students from other departments, and to provide flexibility to help majors in other departments meet the program standards while maintaining program focus and quality. Each upper class mechanical engineering student in the Aerospace Certificate Program has the option of being assigned an academic advisor who is affiliated with the program. Successful completion of the Aerospace Certificate Program is noted on the student's academic transcript.

The certificate program focuses on upper class courses. Seven Courses must be completed to earn Aerospace Engineering Certificate and the requirements are described in detail on the ME departmental website:
https://mems.duke.edu/undergrad/degrees/certificates/aerospace-engineering .

All students must take:

- ME 472 Aircraft Performance (the *cornerstone* course)
- At least one course from a *restricted list*: Aerospace Structures, Compressible Flow, Aerodynamics, Mobile Powerplants, Engineering Acoustics
- Two additional *supplementary* technical courses broadly related to the Aerospace field. Both can be counted as the required upper-level ME electives if they are ME courses. Upper-level Independent Study courses with an Aerospace emphasis can qualify as supplementary electives. Relevant technical courses in other areas of Engineering, or in Physics or Mathematics can be used subject to approval by the certificate coordinator. Some upper-level courses taken abroad can be used subject to prior approval.
- One upper-level course (200 level or above) offered by Trinity College related to one of the following subjects: History applicable to the role of technology and science; Public Policy applicable to the use and impact of technology; or Economics applicable to large or international corporate structures. This Trinity course can also be used for part of the Pratt SSH/LA requirement. Some appropriate courses taken abroad can be used subject to prior approval for the certificate, and approval by the appropriate Trinity DUS.

Energy and the Environment Certificate Program

The Certificate in Energy and the Environment is designed to provide Duke undergraduates with an understanding of the breadth of issues that confront our society in its need for clean, affordable and reliable energy. An expertise in energy will expand career options in the private, non-profit, government and academic sectors. The goal of the Certificate is to develop innovative thinkers and leaders who understand the energy system as a whole and the important interconnections among policy, markets, technology and the environment.

Energy use is a multi-faceted problem, which draws upon the perspectives and expertise of a variety of disciplines. The Certificate in Energy and the Environment is therefore similarly interdisciplinary. Requirements are described in detail on the certificate website:

https://gendell.pratt.duke.edu/undergraduate-certificate-energy-and-environment. All students must take:

- ECS/ENVIRON/ENERGY 231. Energy and the Environment (the core course, offered every fall)
- Three elective courses, one from each area: Markets and Policy, Environment, Energy Science and Technology (options listed on the certificate website)
- One additional elective course (selected from the elective course list, or alternative approved course)
- One capstone project course (see details on the certificate website)

Materials Science and Engineering Certificate Program

The Certificate in Materials Science and Engineering is designed for students to learn the scientific and engineering principles related to the fundamental structures, properties, and technological applications of materials. Expert faculty teach from multiple disciplines, such as Mechanical Engineering & Materials Science, Electrical & Computer Engineering, Biomedical Engineering, Chemistry, and Physics. Upper-level undergraduate students enrolled in both the Pratt School of Engineering and Trinity College of Arts & Sciences are eligible to complete this certificate.

Each upper-class undergraduate student in the Certificate Program is assigned an academic advisor who is affiliated with the program. Requirements are described in detail on the certificate website: https://mems.duke.edu/undergrad/degrees/certificates/materials-science-engineering.

All students must take:

- Two centerpiece courses: ME 221 Structures and Properties of Solids (fall only) OR BME 221 OR CHEM 548 OR PHY 516; AND ME 412 / CHEM 512 Modern Materials (fall only) OR ME 490 Statistical Thermodynamics of Materials (spring only) OR ME 490 AI for Materials (fall only)
- Four elective courses, two of which can be required in the student's home department for the major (options listed on the certificate website), one course must be outside the student's major department
- One SSH/LA course, which must be approved by the certificate coordinator

Robotics and Autonomy Certificate Program

The objective of this multi-disciplinary program is to educate students in the engineering principles related to robotics and automation. This certificate program is available to students enrolled the Pratt School of Engineering.

Robotics is an exciting and rapidly expanding field at the interface of Mechanical Engineering, Electrical Engineering, Biomedical Engineering and Computer Science. Robots are intelligent machines that can infer, reason, and act in the real world. Using large amounts of data, they can learn from their experiences and improve their performance. To integrate robots effectively and safely into our world, robots must accept naturally expressed instruction from humans, adapt and respond to unpredictable situations, and interact with each other and humans to accomplish collaborative tasks. These systems will soon be able to replace humans in hazardous environments and tedious jobs, provide them with up-to-the-minute situational awareness, and assist them in difficult or repetitive tasks - enhancing human capabilities. For automation through robotics to be successful, engineers must understand the downstream ethical implications of their technical decisions. Robotics professional and research

opportunities are growing in arenas such as autonomous vehicles, space exploration, automated manufacturing, collaborative robots, and surgical and rehabilitation robotics.

This program prepares upper-level undergraduate students to tackle multidisciplinary robotics challenges in a wide range of professional settings, from academia to industry to national labs. The Certificate Program provides undergraduate students with an understanding of fundamental principles in the several disciplines including robot kinematics and dynamics, robot mechatronics, ethics in automation, control, plus specific courses that address targeted applications of robotics in a range of technologies, from medical robotics to ocean engineering. In addition to course work, the program offers upperclassmen opportunities for independent research for academic credit under the supervision of a faculty member affiliated with the program, e.g. through Independent Projects courses or through the Pratt Fellows Program. Students are encouraged to participate in student groups, like Duke Robotics. Students are also encouraged to broaden their exposure by attending robotics and automation related speakers of the MEMS, BME and ECE seminar series given by visiting faculty and researchers. Each upper-class undergraduate student in the Robotics and Automation Certificate Program is assigned an academic advisor who is affiliated with the program.

Requirements are described in detail on the certificate website: https://mems.duke.edu/undergrad/degrees/certificates/robotics-automation . All students must take:

- ECE 383 / ME 442 Introduction to Robotics (fall only)
- ME 555 Robot Studio (spring only)
- One course from Control & Dynamics Track: Linear Control Systems, Dynamics, Intermediate Dynamics, Model Predictive Control
- One course from Machine Learning Track: Data Driven Dynamical Systems and Control, Robot Learning, Introduction to Machine Learning, Machine Learning and Imaging, Elements of Machine Learning, Advanced Topics in CEE Dat Science
- ME 555 Ethics of Case Studies in Robotics and Automation (in Breadth Track)
- One additional course from either Control and Dynamics Track, Machine Learning Track, or Breadth Track (Breadth Track includes: Medical Robotics and Surgical Technologies, Computer Vision, Ocean Engineering, Rainforest Engineering, Image and Video Processing, Robotics related Independent Study project in ME or ECE)
- One SS/H or LA course in the following areas: History (if applicable to the role of technology and science), Public Policy (if applicable to the use and impact of technology), Economics. Course must be approved by the certificate coordinator; other course options will be considered on an individual basis with consideration given to their relevance to the field.

Planning for Study Abroad

A number of ME students choose to study abroad for a semester. In the vast majority of cases this takes place in the first semester of junior year. Many fewer students go in the second semester of junior year, and a few students go during the spring semester of their sophomore year to the Duke in Berlin program.

Fall junior year is the point where the MEMS curriculum has the most flexibility to accommodate students studying abroad, and at this point it is usually easiest to match courses abroad to MEMS required courses. Courses such as Thermodynamics, Materials, and Fluid Mechanics are common to

engineering curricula around the world, and these are often taken early junior year in the MEMS curriculum.

The Global Education Office holds an information session on an evening in October, and all interested Pratt students, especially sophomores, should attend. The session is announced in advance by email to Pratt students and is held in a convenient location. Students who plan to study abroad should also have an individual meeting with staff from the Global Education Office. There are restrictions on grade point average and academic standing. Considerable advance planning is required, and it helps if the student is at least a little bit ahead in coursework.

Initial planning for study abroad should usually include more than one choice of locale, country and university. Final planning should include multiple curricular choices since, unlike most US universities, sometimes courses at foreign universities are unexpectedly cancelled or subject to significant content change without warning.

MEMS students may take at most two courses abroad related to the major. The remainder of courses taken abroad fulfill other requirements. Alternatively, students may take one required course and one course equivalent to an upper level (400-level or higher) ME technical elective. In special cases, with approval of the Director of Undergraduate Studies (DUS), students may take two required courses plus one upper-level ME elective. The latter case might occur when there is an opportunity to study a subject not normally offered at Duke, or a course to help fulfill a certificate requirement that goes beyond the basic ME curriculum. Note that the two required upper-level ME electives cannot both be taken abroad, unless an additional upper level elective is taken at Duke. The approval of the MEMS DUS, not just the student's advisor, is required for all special cases.

The Office of Global Education maintains a list of study abroad courses that have been pre-approved as equivalent to Duke courses (https://courseapproval.studyabroad.duke.edu/cgi-bin/study.pl). Any courses outside this list must be approved by the MEMS DUS if they are to satisfy requirements of the MEMS curriculum. Courses not related to MEMS requirements must either appear on the pre-approved list or be pre-approved by the DUS in the appropriate Duke department.

To obtain approval from the DUS for a course not in the Global Education database, the following information is required: course title, descriptive paragraph, detailed syllabus, name and author of the required text(s), year-level of the course at that university (e.g. taken by 3rd year students), and whether the course has a laboratory and, if so, how often it meets. Students are forewarned that while this information is usually easy to obtain from US universities, it is often more challenging when dealing with foreign universities, and so it is important to start gathering this information in advance. The Global Education Office may be helpful if you encounter difficulty obtaining specific information for courses abroad. Please understand that the DUS will be unwilling to search for this information on your behalf and needs to be presented as a complete package with easy access to all information (electronically or hard copy). Also note that there is no guarantee that a particular university will actually offer the desired courses, or that they are offered in the appropriate semester, so the student must adjust plans accordingly.

A particular problem for Mechanical Engineering students is the approach to teaching Thermodynamics and Fluid Mechanics at some universities abroad. At Duke, like most US universities, these courses are taught as separate entities, with Thermodynamics as a prerequisite for Fluid Mechanics, both taken before the end of junior year. Both are prerequisites for the Heat Transfer course taken senior year. At some foreign universities, the topics are taught in a mixed form, most commonly as a two-semester

sequence called "Thermofluids," or sometimes with Fluids and Heat Transfer combined. Courses in such hybridized sequences are never approved as equivalent to Duke's Thermodynamics and Fluids courses. Furthermore, all MEMS students are required to take Heat Transfer at Duke first semester senior year.

Making up Labs after Study Abroad

The majority of ME required courses involve a laboratory component, hence the "L" following the number in the course designation. Often technical courses abroad do not have a laboratory component, or the "lab" is minimal or inadequate. In this common occurrence, the student must make up the lab component of the course upon return to Duke, during the next semester if at all possible. To do so, the student does not register for the Duke course but rather contacts the instructor and arranges to attend one of the laboratory sections. MEMS faculty are familiar with this arrangement, but the student should contact the MEMS DUS if a problem arises. The student must participate in all laboratory aspects of the course, e.g. working in a lab group, collecting and analyzing data, writing lab reports, etc. When the lab period is used for a non-laboratory purpose, such as homework help sessions, test review, testing, etc., then the student is not obligated to attend. At the end of the semester, the course instructor must send an email to the MEMS DUS and the student's Academic Dean stating that the student participated in and passed all aspects of the laboratory portion of the course. The instructor is not required to submit a letter grade. Only when this has occurred will credit for the study abroad course appear on the transcript.

4 + 1 BSE/MS Program (Five-Year Combined Bachelor/Master's Degree Program)

The 4+1 Program offers a five-year option that combines the Bachelor of Science (B.S.E) and one of several master's level options: the Master of Engineering (M.Eng.), the Master of Engineering Management (MEMP), or the Master of Science (MS) degree in Mechanical Engineering. This program provides an excellent opportunity for students to go beyond their undergraduate education by experiencing additional course work, in-depth research experience, or advanced training in mechanical engineering combined with business-related courses. In addition to completing both degrees in five years, students do not pay the graduate tuition for their graduate courses taken in the senior year.

http://www.pratt.duke.edu/undergrad/degree-programs/bse-masters.

4 + 1 BSE/MS Program degree requires that students fulfill the standard degree requirements for Bachelor of Science plus an additional 30 units of upper-level courses suitable for a graduate degree. (In the Graduate School, a 3-hour/week course is counted as 3 units.) Up to 15 graduate course units (5 graduate courses) out of the 30 units can be taken in the senior year, provided that these courses are not used to fulfill the bachelor's degree requirements and they are not Independent Study courses. If you complete two or more courses toward your MS degree before completing your senior year, you can easily complete the remaining graduate courses in one year beyond your BSE.

Students considering combined degree options should consult their Undergraduate Academic Dean and the Directors of Graduate Study for specific programs to be sure that all requirements and constraints are clearly understood. To complete both bachelor's and master's degrees in five years:

- Develop course plans for your senior year and for one graduate year with your academic advisor and obtain Director of Masters Studies (DMS) approval.
- Take the GRE exam in the Fall of your Senior year.

- Apply for admission to the appropriate school during the Fall of your Senior year.

Apply online here (https://pratt.duke.edu/grad/apply), or apply directly to the Pratt School of Engineering for the M.Eng. or MEMP.

Advising

Assignment of ME advisors: After the first year, the student's advisor within the MEMS department is assigned. To declare the major, students complete an online form at the Academic Plan Change Form in DukeHub. This form can also be used to declare second majors, minors, and certificates.

When possible, the assignment of ME faculty advisors is based upon the interests expressed by the students (e.g., aerospace, energy, materials science, etc.), although the need to balance the number of advisees per faculty is also a consideration. Each ME faculty member advises an average of twelve students. A student is always welcome to request a change of advisor from the DUS if they desire.

Each semester the student meets with their faculty advisor to discuss: courses for the following semester, any concerns or problems that they are having academically, and questions about the field of mechanical engineering that they may be interested in exploring further and/or career options within a particular field of mechanical engineering. The advisor also reviews the student's academic report and maintains a record of the student's current academic plan. The student is responsible for informing the advisor of any changes in the plan. The student should be sure the advisor knows of any special problems, including personal issues or circumstances, that may affect academic performance or be of concern to their well-being.

To schedule an appointment with your advisor, using email is the best approach.

The Advisor, the Director of Undergraduate Studies, and the Academic Deans: The Faculty Advisor is the primary contact point for the student, and most routine matters can be handled at that level. The role of the DUS is to set overall academic policy for MEMS and to address special issues unique to individual students, including approvals for academic content of courses taken elsewhere, special circumstances involving modification of prerequisite rules, etc. The Academic Deans serve as a further resource to the student and work in concert with the DUS on a variety of matters. Students wishing to develop a long-term curricular plan should meet with their academic dean. The academic deans also address matters of credit transfer, academic difficulty, disciplinary matters, student wellness, etc.

At the departmental level, students are always welcome to provide the DUS with constructive feedback about the curriculum and their overall educational experience in Mechanical Engineering.

First-year Advising: In addition to individual meetings with first-year faculty advisors (also called 360 Coaches), first-year students interested in ME are invited to an orientation presented by the ME Director of Undergraduate Studies (DUS) in the fall of their first year. The presentation covers the degree requirements, commonly asked questions, and an overview of departmental activities related to the undergraduate experience. The other Pratt departments hold similar sessions.

Career advising: Students can discuss their career plans with their advisors and with other departmental faculty. In addition, the Duke University Career Center is available for career advising

and assistance with job searches for summer internships and/or permanent employment. https://careerhub.students.duke.edu/

Information on Internships, Employment, and Graduate School Opportunities

Information on internship and employment opportunities is posted on the website of the Duke University Career Center: https://careerhub.students.duke.edu/. Located in the Bryan Center, the Career Center organizes various career-related activities. These include (a) career advice sessions, (b) industrial interview events, (c) graduate school recruiting events, and (d) workshops and seminars on internship and employment that are specific for engineering. The Career Center provides career advising for STEM undergraduates and hosts career skills workshops and industry programming in those fields and are announced via emails and posted on the monitors in the engineering buildings. In addition to the Career Center, the Director of Industry and Corporate Relations, Kirsten Shaw (kirsten.shaw@duke.edu), can help Pratt students connect with corporations for internship opportunities. For more information about summer opportunities for students, see: https://experiences.duke.edu/

When information on internships, employment, and/or graduate school opportunities is sent directly to the ME faculty or the department, the information is distributed to declared ME students via email.

It should be noted that student co-op activities that entail taking a semester off during the academic year are rare among Duke students, although common at some other universities, particularly state schools. The Pratt School of Engineering does not have a co-op program. Most Duke engineering students complete their degree in four years, and the curriculum is structured on this assumption. Stepping away from this can create significant challenges. Summer internships provide the most common applied industrial exposure for Duke students.

APPENDICES

The following Appendices provide sample tables for the major, a certificate, and second majors, in addition to a list of allowable Natural Science Electives, and a list of allowable SSH departments and programs. All tables assume no AP credit, unless otherwise noted.

APPENDIX 1

Table A1

ME Major

Freshman Year	
Fall Semester	**Spring Semester**
Chemistry 101DL Core Concepts in Chemistry	EGR 121L Engineering Innovation
EGR 105L Computational Methods in Engineering	Math 112L Introductory Calculus II
Math 111L Introductory Calculus I	Physics 151L Introductory Mechanics[1]
EGR 101L Engineering Design and Communication	Writing 101/120
Sophomore Year	
Fall Semester	**Spring Semester**
EGR 201L Mechanics of Solids	Physics 152L Intro Electric, Magnet, Optics[1]
Math 218D-2 Linear Algebra[2]	EGR 224L Mechatronics
Natural Science Elective[3] or SSH/LA Elective[5]	EGR 244L Dynamics
Social Science or Humanities Elective[5]	Math 219 Multivariable Calculus[2]
Junior Year	
Fall Semester	**Spring Semester**
ME 221L Intro to Material Science	ME 336L Fluid Mechanics
Math 353 Ordinary and Partial Differential Eqn[2]	Natural Science Elective[3] or SSH/LA Elective[5]
ME 344L Control of Dynamic Systems (or in spring)	ME 321L Analysis Mechanical Design
Natural Science Elective[3] or SSH/LA Elective[5]	Elective[4]
ME 331L Thermodynamics	Elective[4]
Senior Year	
Fall Semester	**Spring Semester**
ME 421L Mechanical Design	ME 424L Mechanical Systems Design
ME 431L Heat and Mass Transfer	Mechanical Engineering Elective
Mechanical Engineering Elective	SSH/LA Elective[5]
SSH/LA Elective[5]	Elective[4]

1. See also the Physics requirements on pp. 9.

2. Students with ME/Math second-major need to take Math 221/ 222/356 in place of Math 218D-2/219/353. Students who start the Math second major sequence are not allowed to switch back to the engineering sequence.

3. Selected from the Natural Science Electives listed in Appendix Table A7.

4. Two of these 3 Electives must be at the 200-level or above. One can be at any level, but must be a single full-credit course taken at Duke (not an AP)

5. Social Science or Humanities (SSH) or Liberal Arts (LA) Electives must fulfill requirements as specified on pp. 10-11.

APPENDIX 2

Table A2

ME Major with Aerospace Certificate

Freshman Year	
Fall Semester	**Spring Semester**
Chemistry 101DL Core Concepts in Chemistry	EGR 121L Engineering Innovation
EGR 105L Computational Methods in Engineering	Math 112L Introductory Calculus II
Math 111L Introductory Calculus I	Physics 151L Introductory Mechanics[1]
EGR 101L Engineering Design and Communication	Writing 101/120
Sophomore Year	
Fall Semester	**Spring Semester**
EGR 201L Mechanics of Solids	Physics 152L Intro Electric, Magnet, Optics[1]
Math 218D-2 Linear Algebra[2]	EGR 224L Mechatronics
Natural Science Elective[3] or SSH/LA Elective[5]	EGR 244L Dynamics
SSH/LA Elective[5]	Math 219 Multivariable Calculus[2]
Junior Year	
Fall Semester	**Spring Semester**
ME 221L Introduction to Material Science	ME 336L Fluid Mechanics
Math 353 Ordinary and Partial Differential Eqn[2]	Natural Science Elective[3] or SSH/LA Elective[5]
ME 344L Control of Dynamic Systems	ME 321L
SSH/LA Elective[5] or Core Aerospace Elective	ME 472 Aircraft Performance (Required Course for Aero Cert.)
ME 331L Thermodynamics	SSH/LA Elective[5] or Core Aerospace Elective
Senior Year	
Fall Semester	**Spring Semester**
ME 421L Mechanical Design	ME 424L Mechanical Systems Design
ME 431L Heat and Mass Transfer	Mechanical Engineering / Aerospace Certificate Elective[6]
Mechanical Engineering / Aerospace Certificate Elective[6]	SSH/LA Elective[5]
SSH/LA Elective[5]	Elective[4] or Aerospace Certificate Elective[6]

1. See also the Physics requirements on pp. 9.

2. Students with ME/Math second-major need to take Math 221/ 222/356 in place of Math 218D-2/219/353. Students who start the Math second major sequence are not allowed to switch back to the engineering sequence.

3. Selected from the Natural Science Electives listed in Appendix 7-Table A8.

4. Must be a single, full-credit course at the 200-level or above, taken at Duke (not an AP). May satisfy one of the two required supplementary technical courses for the Aerospace certificate.

5. Social Science or Humanities (SSH) or Liberal Arts (LA) Electives must fulfill requirements as specified on pp. 10-11. One of these electives must meet Trinity course requirement for the Aerospace Certificate, see page 23.

6. Two Mechanical Engineering Electives required; one or two of these may also count toward the two required supplementary technical courses for the Aerospace certificate.

APPENDIX 3

Table A3

ME Major with BME 2nd Major (note 38 courses required)

Freshman Year	
Fall Semester	**Spring Semester**
Chem 101DL Core Concepts in Chemistry	Bio 201L Gateway to Biol: Molecular Biology
EGR 105L Computational Methods in Engineering	Math 112L Introductory Calculus II
Math 111L Introductory Calculus I	Physics 151L Introductory Mechanics[1]
EGR 101L Engineering Design and Communication	EGR 121L Engineering Innovation
	Writing 101/120
Sophomore Year	
Fall Semester	**Spring Semester**
BME 244L Quant Physiology with Biostat Appl	ECE 110L Fund Electr and Comput Eng
EGR 201L Mechanics of Solids	ME 221L Structure and Properties of Solids or BME 221L
Chem 210DL Mod Apps Chem Principles or Chem 201DL Organic Chemistry	Math 219 Multivariable Calculus
Math 218D-2 Linear Algebra	EGR 244L Dynamics
SSH/LA Elective[4]	Physics 152L Intro Electric, Magnet, Optics[1]
Junior Year	
Fall Semester	**Spring Semester**
BME 260L Modeling Cellul and Molecul Systems	ME 336L Fluid Mechanics
BME 271 Signals and Systems or ECE 280L (54L)	BME 354L Biomed Electronics and Measurement II
Math 353 Ordinary and Partial Differential Eqn	BME 302L Fund Biomechanics/Biomaterials
ME 331L Thermodynamics	ME 321L Analysis for Design
SSH/LA Elective[4]	
Senior Year	
Fall Semester	**Spring Semester**
ME 421L Mechanical Design	ME 424L Mechanical Systems Design[3]
ME 431L Heat and Mass Transfer	Mechanical Engineering Elective
ME 344L Control of Dynamic Systems	Biomech/Biomat Area Elective
Mechanical Engineering Elective	SSH/LA Elective[4]
SSH/LA Elective[4]	SSH/LA Elective[4]

1. See also the Physics requirements on page 9.

2. See BME Handbook, Table 3B, page 33

3. ME 424L with BME project.

4. SSH or LA Electives must fulfill requirements as specified on pp. 10-11.

APPENDIX 4

Table A4

ME Major with Energy and the Environment Certificate

Freshman Year	
Fall Semester	**Spring Semester**
Chemistry 101DL Core Concepts in Chemistry	EGR 121L Engineering Innovation
EGR 105L Computational Methods in Engineering	Math 112L Introductory Calculus II
Math 111L Introductory Calculus I	Physics 151L Introductory Mechanics[1]
EGR 101L Engineering Design and Communication	Writing 101/120
Sophomore Year	
Fall Semester	**Spring Semester**
EGR 201L Mechanics of Solids	ME 221L Intro to Material Science or E&E Elective[3]
Math 218D-2 Linear Algebra	EGR 224L Mechatronics
ECS 231 / ENVIRON 231 / ENERGY 231	EGR 244L Dynamics
SSH/LA Elective[4]	Math 219 Multivariable Calculus
	Physics 152L Intro Electric, Magnet, Optics[1]
Junior Year	
Fall Semester	**Spring Semester**
E&E Elective[3] or ME 221L Intro to Material Science	ME 336L Fluid Mechanics
Math 353 Ordinary and Partial Differential Eqn	Natural Science Elective[2]
ME 344L Control of Dynamic Systems	ME 321L Analysis for Mechanical Design
SSH/LA Elective[4] or E&E Elective[3]	E&E Markets & Policy / SSH / LA Elective[4]
ME 331L Thermodynamics	
Senior Year	
Fall Semester	**Spring Semester**
ME 421L Mechanical Design	ME 424L Mechanical Systems Design
ME 431L Heat and Mass Transfer	Mechanical Engineering Elective
Energy Science/Technology Elective[6]	SSH/LA Elective[4]
SSH/LA Elective[4]	E&E Elective[3]

1. See also the Physics requirements on pp. 9.

2. Selected from the Natural Science Electives listed in Appendix Table A8.

3. One of these 2 E&E electives must be in the Environment Area (as described on E&E Certificate website); the other is selected from the larger elective list or alternate approved course.

4. SSH/LA Electives must fulfill requirements as specified on pp. 10-11. E&E Electives that fulfill SSH/LA could be used toward the SSH/LA requirement.

6. Chosen to satisfy Mechanical Engineering Elective criteria.

APPENDIX 5

Table A5

ME Major with Materials Science and Engineering Certificate

Freshman Year	
Fall Semester	**Spring Semester**
Chemistry 101DL Core Concepts in Chemistry	EGR 121L Engineering Innovation
EGR 105L Computational Methods in Engineering	Math 112L Introductory Calculus II
Math 111L Introductory Calculus I	Physics 151L Introductory Mechanics[1]
EGR 101L Engineering Design and Communication	Writing 101/120
Sophomore Year	
Fall Semester	**Spring Semester**
EGR 201L Mechanics of Solids	Physics 152L Intro Electric, Magnet, Optics[1]
Math 218D-2 Linear Algebra[2]	EGR 224L Mechatronics
SSH/LA Elective[4] or Natural Science Elective[3]	EGR 244L Dynamics
SSH/LA Elective[4]	Math 219 Multivariable Calculus[2]
Junior Year	
Fall Semester	**Spring Semester**
ME 412L Modern Materials	ME 336L Fluid Mechanics
Math 353 Ordinary and Partial Differential Eqn[2]	Natural Science Elective[3] or SSH/LA Elective[4]
ME 344L Control of Dynamic Systems	ME 321L Analysis for Mechanical Design
ME 221L Intro to Material Science	SSH/LA Elective[4]
ME 331L Thermodynamics	Elective[5] or MS&E Elective[6]
Senior Year	
Fall Semester	**Spring Semester**
ME 421L Mechanical Design	ME 424L Mechanical Systems Design
ME 431L Heat and Mass Transfer	Mechanical Engineering Elective
Elective[5] or MS&E Elective[6]	SSH/LA Elective[4]
SSH/LA Elective[4]	MS&E Elective[6]

1. See also the Physics requirements on pp. 9.

2. Students with ME/Math second-major need to take Math 221/ 222/356 in place of Math 218D-2/219/353. Students who start the Math second major sequence are not allowed to switch back to the engineering sequence.

3. Selected from the Natural Science Electives listed in Appendix Table A8.

4. SSH/LA Electives must fulfill requirements as specified on pp. 10-11. The MS&E Elective that satisfies the SSH/LA requirements could be used toward the SSH requirement.

5. Elective must be a single, full-credit course at the 200-level or above, taken at Duke (not an AP)

6. One must be chosen to satisfy Mechanical Engineering Elective criteria; the other must be outside ME Department.

APPENDIX 6

Table A6

ME Major with Robotics and Autonomy Certificate

Freshman Year	
Fall Semester	**Spring Semester**
Chemistry 101DL Core Concepts in Chemistry	EGR 121L Engineering Innovation
EGR 105L Computational Methods in Engineering	Math 112L Introductory Calculus II
Math 111L Introductory Calculus I	Physics 151L Introductory Mechanics[1]
EGR 101L Engineering Design and Communication	Writing 101/120
Sophomore Year	
Fall Semester	**Spring Semester**
EGR 201L Mechanics of Solids	Physics 152L Intro Electric, Magnet, Optics[1]
Math 218D-2 Linear Algebra[3]	EGR 224L Mechatronics
Natural Science Elective[4]	EGR 244L Dynamics
SSH/LA Elective[2]	Math 219 Multivariable Calculus[3]
Junior Year	
Fall Semester	**Spring Semester**
ME 442 Introduction to Robotics	ME 336L Fluid Mechanics
Math 353 Ordinary and Partial Differential Eqn[2]	SSH/LA Elective[2]
ME 344L Control of Dynamic Systems	ME 321L Analysis for Mechanical Design
ME 221L Intro to Material Science or E&E Elective[4]	ME 555 Robot Studio
ME 331L Thermodynamics	SSH/LA Elective[2]
Senior Year	
Fall Semester	**Spring Semester**
ME 421L Mechanical Design	ME 424L Mechanical Systems Design
ME 431L Heat and Mass Transfer	Robotics & Automation Elective[5]
Robotics & Automation Elective[5]	SSH/LA Elective[2]
SSH/LA Elective[2]	ME 555 Ethics of Case Studies in Robotics & Automation

1. See also the Physics requirements on pp. 9.

2. Social Science or Humanities Electives must fulfill requirements as specified on pp. 10-11. An R&A Elective that also satisfies SSH/LA requirements could be used toward the SSH requirement.

3. Students with ME/Math second-major need to take Math 221/ 222/356 in place of Math 218D-2/219/353. Students who start the Math second major sequence are not allowed to switch back to the engineering sequence.

4. Selected from the Natural Science Electives listed in Appendix Table A8.

5. Chosen to also satisfy Mechanical Engineering Elective criteria.

APPENDIX 7

Table A7.

ME Major with Energy Engineering Minor

Freshman Year	
Fall Semester	**Spring Semester**
Chemistry 101DL Core Concepts in Chemistry	EGR 121L Engineering Innovation
EGR 105L Computational Methods in Engineering	Math 112L Introductory Calculus II
Math 111L Introductory Calculus I	Physics 151L Introductory Mechanics[1]
EGR 101L Engineering Design and Communication	Writing 101/120
Sophomore Year	
Fall Semester	**Spring Semester**
EGR 201L Mechanics of Solids	EGR 224L Mechatronics
Math 218D-2 Linear Algebra	EGR 244L Dynamics
SSH/LA Elective[5]	Math 219 Multivariable Calculus[2]
SSH/LA Elective[5]	ME 331L Thermodynamics
ME 221L Intro to Material Science	Physics 152L Intro Electric, Magnet, Optics[1]
Junior Year	
Fall Semester	**Spring Semester**
ENRGYEGR Elective[4]	ME 336L Fluid Mechanics
Math 353 Ordinary and Partial Differential Eqn[2]	Natural Science Elective[3]
ME 344L Control of Dynamic Systems	ME 321L Analysis for Mechanical Design
ME 461 Energy Engineering and the Environment	SSH/LA Elective[5]
SSH/LA Elective[5]	
Senior Year	
Fall Semester	**Spring Semester**
ME 421L Mechanical Design	ME 424L Mechanical Systems Design
ME 431L Heat and Mass Transfer	Mechanical Engineering Elective
Mechanical Engineering / ENRGYEGR Elective[6]	SSH/LA Elective[5]
ENRGYEGR Elective[4]	ENRGYEGR Elective[4]

1. See also the Physics requirements on pp. 9.

2. Students with ME/Math second-major need to take Math 221/ 222/356 in place of Math 218D-2/219/353. Students who start the Math second major sequence are not allowed to switch back to the engineering sequence.

3. Selected from the Natural Science Electives listed in Appendix Table A8.

4. Energy Minor Electives must be chosen to satisfy the current minor distribution requirements. Electives could also count as the Upper-Level Electives and/or Unrestricted Elective, in accordance with ME elective rules.

5. SSH/LA Electives must fulfill requirements as specified on pp. 10-11.

6. Energy minor elective that is also ME upper-level elective

APPENDIX 8

Table A8.
ME Major with ECE Minor

ME Major with the Electrical and Computer Engineering Minor

The basic requirements for a minor in ECE *(see also ECE Handbook)* include three courses at the foundational/core level and two upper-level courses. Below are major specific modifications (e.g., courses that are disallowed for the Minor in ECE because students are required to take essentially equivalent courses for their primary major).

ME Major/ECE Minor: Path #1 -- If EGR 224L has been taken, then:

- **Core courses (choose at least one and up to three)[1]:**
  - ECE 230L Microelectronic Devices & Circuits
  - ECE 250L Computer Architecture
  - ECE 270L Electromagnetic Fields
- **Upper-Level Courses:** take a minimum of two upper-level courses[2]. Students may choose to replace up to two (of three) ECE courses with additional upper-level ECE courses to meet the minimum requirement of 5 ECE courses.

1. *An ME major cannot take ECE 110L or ECE 280L, however, EGR 224L will satisfy prerequisites in lieu of ECE 110L and ECE 280L.*
2. *Because the ME major requires courses essentially equivalent to ECE 110L and ECE 280L, a student majoring in ME can choose to reduce the number of ECE core courses taken to fulfill Minor requirements to as few as one, and take additional upper-level courses to meet the minimum requirement of 5 ECE courses.*

ME Major/ECE Minor: Path #2 -- If ECE 110L has been taken, then:

- Student should take ECE 280L in lieu of EGR 224L to satisfy ME major requirement, but ECE 280L will not count toward the ECE minor.
- **Core courses (choose at least two, and up to three):**
  - ECE 110 Fundamentals of ECE
  - ECE 230L Microelectronic Devices and Circuits
  - ECE 250L Computer Architecture
  - ECE 270L Electromagnetic Fields
- **Upper Level Courses**: take a minimum of two upper-level courses[1]. Students may choose to replace one (of three) ECE core courses with an additional upper-level ECE course to meet the minimum requirement of 5 ECE courses.

[1] *Because the ME major requires a course essentially equivalent to ECE 280L, a student majoring in ME can choose to reduce the number of ECE core courses taken to fulfill Minor requirements to as few as two, and take additional upper-level courses to meet the minimum requirements of 5 ECE courses.*

APPENDIX 9

Table A9. MEMS Approved Natural Science Courses for Mechanical Engineering Majors

Higher level courses in these areas are subject to DUS Approval

(Note: A Trinity NS code does NOT apply to the Pratt Natural Science Requirement)

Course No.	Title	Description
MATH 238L	Data Analysis and Decision Science	A mathematically rigorous and broad foundation for key concepts in probability and statistics, as well as the application of probability and statistics to the mathematical modeling of non-deterministic systems. The main motivation of the course is to show how these concepts are fundamental to a variety of current data analysis techniques, and to demonstrate applications of these techniques in situations relevant to all engineering majors.
MATH 230 or 230S	Probability Or Probability Inquiry Based Learning Seminar	Probability models, random variables with discrete and continuous distributions. Independence, joint distributions, conditional distributions. Expectations, functions of random variables, central limit theorem. Prerequisite: Calculus II OR credit for multivariable calculus (Mathematics 202, 212, 219, or 222).
MATH		300-level or above (not including 353, 356)
BIO 20	AP/IB/IPC Credit	Advance Placement, International Baccalaureate, and International Placement credits, with the appropriate score, will receive BIO 20 credit on the Duke transcript.
BIO 201L	Gateway to Biology: Molecular Biology	Introduces major concepts in biology through the lens of molecular biology. Molecular mechanisms that comprise the Central Dogma and variants. DNA structure and function, replication, transcription, and translation. Protein synthesis, folding, structure and function. Supporting topics related to the structure of cells, metabolism and energetics. Integration of physical and quantitative principles to molecular biology. Relevance to human diseases and the biotechnology industry. Laboratory includes an introduction to recombinant DNA technology. Prerequisite: Chemistry 101DL, or equivalent.
BIO 202L	Genetics and Evolution	Introduction to principles transmission genetics and evolution. Includes Mendelian and non-Mendelian inheritance, quantitative genetics, genetic mapping, evidence for evolution, natural selection, genetic drift, kin selection, speciation, molecular evolution, phylogenetic analysis. Relevance to human family and social structure, evolution of infectious disease, human hereditary disorders, social implications of genetic knowledge.
BIO 205	Marine Megafauna	Ecology, systematics, and behavior of large marine animals including giant squid, bony fishes, sharks, sea turtles, seabirds, and marine mammals. Relations between ocean dynamics, large marine animals, and their role in ocean food webs. Impact of human activities and technological advancement on populations. Economic, social, and policy considerations in the protection of threatened species. Prerequisite: AP Biology, Introductory Biology, or consent of the instructor.
BIO 267	Behavioral Ecology and the Evolution of Animal Behavior	How animal behavior is shaped by natural selection, historical factors, and ecological constraints. These factors considered in the context of mating systems, parental care, foraging, and other current issues in behavior. Recommended prerequisite: Biology 202L or 203L.
BIO 271	Marine Biology and Ecology: Fantastic Sea Creatures and Where to Find Them	Broad foundational knowledge of marine biology with an emphasis on ecology and evolution of marine organisms. Core areas include biodiversity, adaptations to marine environments, population & community ecology, ecosystem processes and services, and human forcing in marine systems. Survey of biodiversity in marine systems spanning microbes to marine mammals, emphasizing taxonomy, habitats and evolutionary history. Explore how marine communities interact with the physical environment to generate ecosystems and accompanying services spanning coastal/estuarine, blue water, and the deep sea. Examine population dynamics, population interactions and the consequences of those interactions.

BIO 318	Human Evolutionary Genetics	Topics include: population differences in disease risk; adaptation to local environments and pathogens; identifying regions of the genome underlying traits; models of neutral variation, migration, and genetic ancestry.
BIOLOGY		300-level or above with DUS approval
CHEMISTRY		200-level or above with DUS approval
CHEM 201DL	Organic Chemistry	The structures and reactions of the compounds of carbon and the impact of selected organic compounds on society. Laboratory: techniques of separation, organic reactions and preparations, and systematic identification of compounds by their spectral and chemical properties. Prerequisite: Chemistry 101DL, or 110DL, or 21
CHEM 210DL	Modern App of Chem Principles	Modern applications of chemistry in context of larger scientific theme, e.g. in biology, materials science, or environmental chemistry. Revisits core concepts from CHEM 101L, incorporating additional topics including intermolecular interactions, phases of matter, solutions, quantitative treatment of aqueous equilibria, electron transfer reactions, and inorganic and coordination chemistry. Laboratory illustrates experimental approaches to modern problems in biological, materials, and environmental chemistry, as well as analytical and synthetic techniques. Prerequisite: Chemistry 101L.
ECON 104D	Statistical Foundations of Econometrics and Data Science	Rigorous introduction to statistical concepts that underpin econometrics. Course emphasizes conceptual understanding, uses mathematics to illustrate ideas, and applies ideas to examples from economics broadly construed. Students analyze data to reinforce understanding. Topics include experimental and non-experimental research designs; modern approaches to summarizing data; random variables, probability, expectations, density and distribution functions; sampling; estimation; inference and hypothesis testing; introduction to linear regression. First course in two-semester econometrics sequence. Prerequisite: Mathematics 21, 106L,111L, 112L, 121, 122, 122L, 202, 202D, 212, or 222.
ECS 201L	The Solid Earth: Minerals, Rocks & Structural Geology	Description and interpretation of minerals, rocks and geologic structures. Lectures on theoretical aspects, lab on practical applications and use of petrographic microscope. Prereq: Earth & Ocean Sciences 101 or consent of instructor.
ECS 202	Ocean and Atmosphere Dynamics	Introduction to the dynamics of ocean and atmospheric circulations, with particular emphasis on the global climate cycle. Prerequisites: Mathematics 111, Physics 153L or consent of instructor.
ECS 204	Evolving Earth and Life	
ECS 211L	Remote Sensing for Earth and Environmental Science	Topics include data acquisition and pre-processing, image enhancement, data classification, and visualization. The emphasis is on pixel-based raster spectral data (such as satellite or drone imagery) and other types, such as lidar, radar, and structure-from-motion (SfM) are also addressed in lectures and lab exercises.
ECS 365	Weather and Climate	Introduction to weather and climate. Topics include atmospheric structure, composition, circulation and energy properties; severe weather events such as cyclones, hurricanes, and tornadoes; ozone depletion; natural climate variability; climate change and global warming. Instructor consent required.
PHYS 153L*	Application of Physics: A Modern Perspective	Intended principally for students in engineering and the physical sciences as a continuation of Physics 152L. Topics include: mechanics from a microscopic perspective, the atomic nature of matter, energy, energy quantization, entropy, the kinetic theory of gases, the efficiency of engines, electromagnetic radiation, the photon nature of light, physical optics and interference, waves and particles, applications of wave mechanics. Prerequisites: Physics 52L and Mathematics 212L or the equivalents. ** PHYS 153L only counts in the NS Elective spot when Phys 152L has been taken at Duke – and NOT when AP for Phys 151L and 152L exist. The reqm't of one Physics course at Duke is separate from the NS reqm't.*

PHYS 305	Intro to Astrophysics	Basic principles of astronomy treated quantitatively. Cosmological models, galaxies, stars, interstellar matter, the solar system, and experimental techniques and results. Prereqs: Mathematics 212 and Physics 264L or consent of instructor. Math 218 is strongly recommended.
PHYS 361	Intermediate Mechanics	Newtonian mechanics as the intermediate level. Lagrangian mechanics, linear oscillations, chaos, dynamics of continuous media, motion in noninertial reference frames. Prerequisites: Mathematics 216 or equivalent (may be taken concurrently).
PHYS 363	Thermal Physics	Thermal properties of matter treated using the basic concepts of entropy, temperature, chemical potential, partition function, and free energy. Topics include the laws of thermodynamics, ideal gases, thermal radiation and electrical noise, heat engines, Fermi-Dirac and Bose-Einstein distributions, semiconductor statistics, kinetic theory, and phase transformations. Also taught as Electrical and Computer Engineering 311. Prerequisite: Physics 264L.
PHYS 513	Nonlinear Dynamics	Introduction to the study of temporal patterns in nonequilibrium systems. Theoretical, computational, and experimental insights used to explain phase space, bifurcations, stability theory, universality, attractors, fractals, chaos, and time-series analysis. Each student carries out an individual research project on a topic of nonlinear dynamics and gives a formal presentation of the results. Prerequisites: Computer Science 101, Mathematics 216, and Physics 161L, 162L, or equivalent. Instructor: C-L: Computer Science 524.
PHYSICS		200-level or above with DUS approval

Appendix 10

Table A10: Approved Social Science and Humanities Departments and Programs

In recent years there has been a proliferation of non-social science and non-humanities departments (including some engineering departments) applying for and receiving SS, CZ, or ALP Areas of Knowledge codes for some of their courses. These particular codes, therefore, are no longer exclusive to social science and humanities departments as they once were. Given that the five SS/H courses are intended to allow you to explore in breadth and depth disciplines of social sciences and humanities, the Pratt school requires (effective for students matriculating before Fall 2025) that SS/H courses must be taken from, or cross-listed with, one of the following departments or programs (see the list of exceptions that follow):

Department/Program	**Subject Code(s)**
African & African American Studies	AAAS
Art, Art History, and Visual Media Studies	ARTHIST, HCVIS, ARTSVIS, VMS
Asian and Middle Eastern Studies	AMES, ARABIC, CHINESE, HEBREW, HINDI, JPN, KOREAN, PERSIAN, TIBETAN
Cinematic Arts	CINE
Classical Studies	CLST, GREEK, LATIN
Cultural Anthropology	CULANTH
Documentary Studies	DOCST
East Asian Studies	EAS
Economics	ECON
Education	EDUC
English	ENGLISH
Study of Ethics	ETHICS
Evolutionary Anthropology	EVANTH
Gender, Sexuality, and Feminist Studies	GSF
Germanic Languages and Literature	GERMAN
History	HISTORY
Innovation & Entrepreneurship	I&E
International Comparative Studies	ICS
Jewish Studies	JEWISHST
Latin American Studies	LATAMER
Linguistics	LINGUIST
Literature Program in Global Cultural Studies	LIT
Markets and Management Studies	MMS
Medieval and Renaissance Studies	MEDREN
Music	MUSIC
Philosophy	PHIL
Political Science	POLSCI
Psychology and Neuroscience	PSY
Public Policy Studies	PUBPOL
Religious Studies	RELIGION
Romance Studies	ROMST, CREOLE, FRENCH, ITALIAN, PORTUGUE, SPANISH
Slavic and Eurasian Studies	SES, POLISH, RUSSIAN, TURKISH, UKRAIN
Sociology	SOCIOL
Theater Studies	THEATRST

Please note that, as illustrated above, individual departments and programs may constitute one *or more* subject codes.

EXCEPTIONS

EGR 305/ECON 212: Even though EGR 305 is cross listed with ECON (within the economics department) it cannot be used toward the SS/H requirement.