RENSSELAER POLYTECHNIC INSTITUTE

School of Engineering

Biomedical Engineering

Undergraduate Student Handbook

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Biomedical Engineering

Biomedical engineering is a discipline that advances knowledge in engineering, biology and medicine, and improves human health through activities that integrate the engineering sciences with the biomedical sciences and clinical practice. In other words, biomedical engineering is a multidisciplinary field combining engineering, basic sciences and medicine.

Biomedical engineering produces a better understanding of
- How the body works.
- How the body becomes diseased.
- Ways to prevent/protect the body from disease.
- Novel mechanisms to reverse the disease process.
- Novel ways to repair diseased tissue.
- New devices to replace diseased tissue.

Biomedical Engineers develop devices and procedures that solve medical and health-related problems by combining their knowledge of biology and medicine with engineering principles and practices. Many do research, along with medical scientists, to develop and evaluate systems and products such as artificial organs, prostheses (artificial devices that replace missing body parts), instrumentation, medical information systems, and health management and care delivery systems. Biomedical engineers also may design devices used in various medical procedures, imaging systems such as magnetic resonance imaging (MRI), and devices for automating insulin injections or controlling body functions. Some specialties within biomedical engineering are biomaterials, biomechanics, medical imaging, rehabilitation engineering, and orthopedic engineering.

Biomedical Engineers are expected to have employment growth of 27% over the next decade, much faster than the average for all occupations. The aging of the population and a growing focus on health issues will drive demand for better medical devices and equipment designed by biomedical engineers. Along with the demand for more sophisticated medical equipment and procedures, an increased concern for cost-effectiveness will boost demand for biomedical engineers, particularly in pharmaceutical manufacturing and related industries.

The median salary for biomedical engineers, according to the US Department of Labor (http://www.bls.gov/ooh/architecture-and-engineering/home.htm), was $88,550 as of 2018.

RPI BMED Educational Objectives

Rensselaer's Biomedical Engineering Department's mission is "to educate the biomedical engineering leaders of tomorrow who will apply fundamental engineering principles to the responsible solution of problems in biology and medicine, to contribute to human disease management, and to bring engineering innovation and technology to the clinic while creating knowledge and enhancing global prosperity."

Graduates of the Biomedical Engineering Program will:
1. Be engaged in professional practice in industry, academia or government related to biomedical engineering; and/or
2. Have enrolled in an academic program pursuing a graduate, medical, law, business, or other professional post-graduate degree.

Contact List for Biomedical Engineering

Department Head:	Juergen Hahn (hahnj@rpi.edu)	JEC 7052
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Biomedical Engineering Faculty

Research Areas and Related Faculty

	Biofabrication and Biomanufacturing	Biomedical Imaging and Image Analytics	Biomolecular Science and Engineering	Musculoskeletal Biomechanics and Mechanobiology	Systems Biology and Healthcare Analytics	Tissue Engineering and Regenerative Medicine
Primary Faculty						
Elizabeth Blaber				√		√
David Corr	√			√		√
Ryan Gilbert	√					√
Juergen Hahn	√		√		√	
Mariah Hahn			√	√		√
Xavier Intes		√				
Deanna Thompson			√			√
Deepak Vashishth	√		√	√	√	√
Leo Wan	√		√	√		√
Ge Wang		√				
Pingkun Yan		√			√	
Joint Faculty						
Steven Cramer			√			
Suvranu De					√	
Jonathan Dordick	√		√			√
Richard Gross			√			
Robert Linhardt			√			
Edmund Palermo			√			√
Douglas Swank			√	√		

Bachelor's Degree

The bachelor's degree is awarded to students who have pursued successfully, as evaluated by the faculty, a plan of study that encompasses several disciplines. Each plan of study has at least two objectives: first, to reach a pre-professional standing or fundamental mastery in a selected discipline; second, to develop some grounding in knowledge found in liberally educated persons, an appreciation of technology and science, and an openness to ongoing learning.

General Requirements:

- The number of courses and credit hours is prescribed by each curriculum. Minimum requirements are **128 credits for engineering**.
- The minimum grade point average (GPA) is **2.0**.
- To receive a baccalaureate degree, a student must have been admitted to the curriculum corresponding to the degree, must have satisfied the curriculum requirements, and must be enrolled in that curriculum at the time the degree is granted.
- The course content in physical, life, and engineering sciences must total a minimum of **24 credit hours**. For information on additional requirements see the School of Science section of the course catalog.
- The course content in humanities and social sciences must total a minimum of **24 credit hours**, including the **20 credits** required by the school of HASS and **4 credits** by taking the three courses in Professional Development sequence. For information on additional requirements see the School of Humanities, Arts, and Social Sciences section of the course catalog.
- Every student is required to take at least **two** communication-intensive courses. At least one of these must be in the students' major (automatically fulfilled by BME Design) and at least one of the courses must be taught in the School of Humanities, Arts, and Social Sciences.
- The minimum course concentration in the area of the selected discipline is prescribed by each curriculum but **cannot be less than 30 credit hours**.
- At least **24 credit hours are to be elective**, of which no less than **12 credit hours** are unrestricted electives.
- The student must be registered full-time for a minimum of four semesters. Two semesters of part-time study at Rensselaer will be considered equivalent to one semester of full-time study. In addition, the student must complete a minimum of **48 credit hours** at Rensselaer, all of which will be applied to the baccalaureate degree. If a transfer student elects to study abroad or enroll in the co-op program, no more than 12 such credits may apply to the 48 needed for the bachelor's degree. The student's Plan of Study at Rensselaer must include at least 16 credits of courses above the 1000 level in the major field, or in an approved concentration.
- The student must be careful to satisfy Institute HASS requirements.

Academic Information and Regulations:

The Institute requires a degree candidate to earn the last 30 credits in courses completed on this campus or through a program formally recognized by the Institute. Transfer courses are limited to two courses or eight credits counting toward the student's last 30 credits and require approval of the director of the Advising and Learning Assistance Center.

Baccalaureate candidates must have passed all of the prescribed academic work and have satisfied the fee requirements. Candidates must also be in good academic and disciplinary standing. Undergraduate students on probation at the time of completion of course work may be required to meet certain

stipulations for removal from probation. However, such requirements may be waived for those students whose cumulative GPAs satisfy the baccalaureate degree requirements. In general, a term's work with grades of not less than C will be required in programs arranged by the Committee on Academic Standing. The director of the Advising and Learning Assistance Center will state requirements to the students in writing.

Degree candidates must be registered during the semester in which they intend to graduate and must file a degree application with the registrar by the dates specified in the academic calendar. Students who previously applied for graduation but did not complete all their requirements on time must submit a new application specifying the new date of graduation.

Pre-med Option:

Biomedical Engineering students who plan to go on to medical school can follow the pre-med template shown on page 9 of this handbook. Following this template allows students to meet all requirements for taking the MCAT after their third year in the program and also ensures that all requirements for medical schools are met by the end of the fourth year. It should be noted that following the pre-med option will automatically satisfy all requirements for the traditional BME B.S. degree as the only difference is that the free electives and HASS electives are more constrained for the pre-med option to meet the MCAT/medical school requirements. One result of this is that the traditional BME B.S. degree requires 128 credit hours while the BME B.S. degree with the pre-med option requires 133 credit hours.

There is no formal process for declaring that one does want to participate in the pre-med option, however, it is strongly encouraged that you let the administrative staff of the department and your advisor know so that (a) your advisor can be switched to the pre-med advisor, (b) you can be added to the pre-med mailing list, and (c) the registrar can enable a Degree Works report for pre-med. Please note that admission to medical school is selective and that historically GPAs above 3.5 are required to successfully gain admission.

Physician Engineer (B.S./M.D.):

The Biomedical Engineering Department, in conjunction with Albany Medical College, also offers the Physician Engineer program in which students are able to earn a B.S. in Biomedical Engineering from Rensselaer and an M.D. from Albany Medical College in 8 years. The MCAT requirement is waived for this combined program.

A separate application for this program is needed, where students apply just before the Arch, i.e., by May 31 of their second year. Application requirements are that a student follows the BME B.S. pre-med template, has a GPA > 3.5, has a strong interest in research, and is on track to meet all degree requirements. The application material consists of a one-page statement of purpose, a letter of recommendation, an official transcript, and a waiver/release form allowing the BME Department to obtain your application material. Application materials should be submitted to the departmental staff. Applications are reviewed by the department and a decision will be made during the summer of the second year. Selected students will be invited to interview at Albany Medical College in the second half of this summer and will be informed about their application before the beginning of the third year. Students admitted to the program need to participate in The Arch and plan to spend their "away" semester in the Personal Care Assistant program at AMC to start/increase their hours of patient contact. Students will receive a B.S. in BME from Rensselaer after the fourth year and a M.D. from Albany Medical College after the eighth year. Please note that this program is <u>very</u> selective.

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Double Degrees:

A student may become a candidate for a second baccalaureate degree when he or she has completed: (1) the equivalent of at least two terms (30 credit hours) of additional work beyond the requirements of a single degree, and (2) the courses in the department in which the student is registered and such other courses as are required for the second degree.

From the BME department's perspective, students considering a Double Degree may want to instead consider a Co-terminal or regular Master's degree where they obtain a B.S. in Biomedical Engineering and an M.Eng. in BME or another discipline. The ability to obtain a graduate level degree by taking 30 credits beyond the Bachelor's degree should be seriously considered rather than taking 30 additional credits and still ending up with a Bachelor's degree.

Dual Majors:

Undergraduate students who fulfill all the degree requirements for two curricula and who have met the conditions below will have completed a dual major. They will receive one diploma noting both majors.
- The student must designate a first-named and second-named major in writing at least one semester prior to graduation, and have the appropriate department(s) approve this designation prior to filing the dual major form with the registrar.
- Each student will be assigned an advisor in each department who will monitor progress towards degrees in that department.
- The degree clearance officer in each department will certify that the student has met the degree requirements in that department.
- The 24-credit-hour mathematics/science requirement and the 24-credit-hour humanities and social sciences requirement will satisfy the Institute requirements for both majors.

It should be noted that a dual major needs to meet all requirements for a BME B.S. degree to be awarded this degree in addition to meeting all requirements for the other degree. Accordingly, the BME department discourages dual majors as the likelihood for a student to complete the degree in eight semesters is not very high. Students would be better served to enter the Co-terminal program in their 3rd/4th year and obtain a B.S. in Biomedical Engineering and an M.Eng. in BME or another discipline.

Co-Terminal Degree and Master Degree:

The Biomedical Engineering Master Degree program focuses on engineering fundamentals at an advanced level. In consultation with their faculty advisor, individuals must develop a Plan of Study that satisfactorily meets Institute and Departmental requirements to earn the Master degree. A grade of B or better must be achieved to fulfill a course requirement.

Students interested in pursuing a co-terminal Master's Degree in Biomedical Engineering are required to submit the application materials to the Biomedical Engineering Department for consideration. Students must apply during the student's 1st semester of their senior year (by October 30 for expected May graduation and by April 15 for expected December graduation) and must have a GPA $\geq$ 3.3 for consideration to the co-terminal program. Please refer to the graduate handbook for details. Co-terminal MEng applications should be submitted through Slate (https://apply.rpi.edu/apply/). Applications will be reviewed once a month during the academic year.

Information about Master degree:
The Biomedical Engineering Department offers two different routes for Master degrees: (1) The Master of Science (M.S.) is a Master degree that requires a thesis; (2) the Master of Engineering (M.Eng.) is a coursework-only Master degree. The M.Eng. is generally recommended for students who do not plan further graduate studies or who are pursuing a co-terminal degree.

Students pursuing a Master degree must complete a minimum of 30 credit hours. The minimum number of credits for coursework for a M.S. is 21 and for an M.Eng is 30. At least 3 BME classes at the 6000-level are required for the coursework and no more than 2 classes at the 4000-level can be included. Additionally, one course in the life sciences (biology or physiology) and one course in advanced math/statistics are required. In consultation with their advisor, students must develop a Plan of Study that satisfactorily meets Institute requirements and Departmental requirements.

The minimum course work requirements for a M.S. degree with thesis are as follows:

	Credit hours	
Advanced Mathematics or Statistics	3-4	(1 course)
Advanced Life Sciences	3-4	(1 course)
Technical Depth Courses*	13-15	(4-5 courses)

(*minimum of 3 courses should have the prefix BMED and be at the 6000-level; remainder needs to be engineering or science courses)

SUBTOTAL	**21**
Thesis	9
TOTAL	**30**

The minimum course work requirements for a M.Eng. (Coursework-only) are as follows:

	Credit hours	
Advanced Mathematics or Statistics	3-4	(1 course)
Advanced Life Sciences	3-4	(1 course)
Technical Depth Courses*	13-15	(4-5 courses)

(*minimum of 3 courses should have the prefix BMED and be at the 6000-level; remainder needs to be engineering or science courses)

SUBTOTAL	**21**
Additional coursework*	9

(*Can include up to 3 credit hours of directed studies; courses should be relevant to the degree → work with your advisor on the selection of appropriate courses)*

TOTAL	**30**

Co-Terminal Degree Frequently Asked Questions

Admission
When do I apply?
Co-terminal applications must be submitted during the student's 1st semester of their senior year (by October 30 for expected May graduation and by April 15 for expected December graduation). Applicants must have 90 credits (in progress or earned) of coursework towards their undergraduate degree.

Where do I find a Plan of Study?
The Plan of Study is available on-line at the Office of Graduate Education website Plan of Study Form.

What if the courses I list on the Plan of Study change?
If the courses listed change, an updated plan must be filed with the Department, the Office of Graduate Education, and the Office of the Registrar.

Financial Aid, Tuition and Fees
Can I receive Undergraduate Financial Aid?
You can no longer be considered for federal Undergraduate Financial Aid as you will have received a B.S. degree prior to starting the co-terminal year. However, you will be eligible for a graduate level Federal Direct student loan. The form and requirements are the same for federal undergraduate/graduate financial aid. Also, you will remain eligible for the RPI financial aid during the two semesters of graduate coursework.

Can I be considered for a TA or RA?
Co-terminal students are not eligible for a TA or RA.

Academic
When/how does a student get assigned a graduate advisor?
Co-terminal students will continue to work with their undergraduate advisor and should contact the department to be assigned a graduate advisor.

How many credits will I be eligible to register for?
While you can register for 21 hours per semester before you receive your BS degree, the maximum number of credits for the graduate portion of your study is 15 credits per semester.

Can I become a part-time student in the Co-Terminal Program?
Co-terminal student must remain as full time students and cannot shift to part-time status.

When do I receive my B.S. degree? I was supposed to graduate in May but I will be completing 2 more semesters to receive my Master's degree under the co-terminal program?
You will receive your B.S. degree after completing the B.S. requirements, i.e., after 8 semesters. The M.Eng. degree will be awarded at the end of your 10th semester. You should file a degree application with the Office of the Registrar for each degree at the beginning of the semester in which you will actually graduate. See the academic calendar for deadline information.

Can I use a course for both my undergraduate and graduate degree?
No - credits applied toward satisfying requirements of the undergraduate degree cannot be used to satisfy the requirements for the master's degree.

Can I still designate courses as Pass/No Credit?
Co-terminal students are subject to graduate degree program guidelines after they've earned the minimum number of credits required for their bachelor's degree (128 for BME). Any courses taken after a student has reached the minimum, will be subject to graduate level policies, and graduate policies prohibit designating a graduate course as Pass/No Credit.

Can I participate in the Commencement ceremony with my class?
Yes, as you will receive your B.S. degree together with the rest of your class.

Program Templates
Traditional BME Baccalaureate Program

First Year

Fall		Credit hours	Spring		Credit hours
ENGR 1100	Intro to Engineering Anal	4	ENGR 1300	Engineering Processes	1
CHEM 1100	Chemistry I	4	MATH 1020	Calculus II	4
MATH 1010	Calculus I	4	PHYS 1100	Physics I	4
	HASS Elective[1]	4	BIOL 2120	Intro to Cell and Mol Biology	3
ENGR 1200	Eng Graphics and CAD[6]	1	BIOL 2125	Intro to Cell and Mol Biology Lab	1
				HASS Elective[1]	4

Second Year

Fall		Credit hours	Spring		Credit hours
BMED 2050	Programming for BME	3	ENGR 2600	Mod. & Analysis of Uncertainty	3
PHYS 1200	Physics II	4	BMED 2100	Biomaterials Science and Eng	4
MATH 2400	Intro to Differential Eq	4	BMED 2540	Biomechanics	4
MATH 2010	Multi. Calc and Mat Alg	4	BMED 2300	Bioimaging and Bioinstrument	4

The Arch: Summer Here

BMED 4200	Modeling of Biomed Sys	3
BMED 4250	Biomed. Trans. Phenom.	4
ENGR 4010	Profess. Dev: Leadership	1
	HASS Elective[1]	4
	Free Elective [4]	3

Third Year (either Fall or Spring can be the "Away Semester")

Fall/Spring		Credit hours
BMED 4500	Advanced Systems Phys.	4
	BME Tech. Elective I	3
ENGR 2050	Intro to Eng Design	4
STSO 4100	Profess. Dev: Tech Issues[2]	2
	Free Elective [4]	3

Fourth Year

Fall		Credit hours	Spring		Credit hours
BMED 4010	Bioeng Lab[3]	4	BMED 4600	BME Design[5]	3
BMED 4260	BME Prod Dev and Com	3		Free Elective [4]	3
	BME Tech. Elective II	3		BME Tech. Elective III	3
	Free Elective [4]	3		BME Tech. Elective IV	3
	HASS Elective[1]	4		HASS Elective[1]	4

The minimum number of credit hours for the degree is 128

[1] Placement of humanities and social science electives can be varied with free electives.

[2] For a list of courses that satisfy the Professional Development – Technical Issues & Solutions requirement, refer to the link "Professional Development Courses" on the Registrar's "Academic Planning" web page. It should be completed before the capstone design course.

[3] BMED 4010 may be taken in either Spring Year 3, Fall Year 4, or as part of the Summer Arch.

[4] The minimum total credit hours of free electives is twelve (12), with no restrictions on the included number of 3 and 4 credit hour courses.

[5] Capstone is a writing-intensive course.

[6] ENGR 1400 may be taken as alternative to ENGR 1200. This course may be taken either semester.

Pre-med BME Baccalaureate Program

First Year

Fall		Credit hours	Spring			Credit hours
ENGR 1100	Intro to Engineering Anal	4	ENGR	1300	Engineering Processes	1
CHEM 1100	Chemistry I	4	MATH	1020	Calculus II	4
MATH 1010	Calculus I	4	PHYS	1100	Physics I	4
BIOL 1010	Intro to Biology	3	BIOL	2120	Intro to Cell and Mol Biology	3
BIOL 1015	Intro to Biology Lab	1	BIOL	2125	Intro to Cell and Mol Biology Lab	1
ENGR 1200	Eng Graphics and CAD[4]	1	CHEM	1200	Chemistry II	4

Second Year

Fall		Credit hours	Spring			Credit hours
BMED 2050	Programming for BME	3	ENGR	2600	Mod. & Analysis of Uncertainty	3
PHYS 1200	Physics II	4	BMED	2100	Biomaterials Science and Eng	4
MATH 2400	Intro to Differential Eq	4	BMED	2540	Biomechanics	4
CHEM 2250	Organic Chemistry I[6]	3	BMED	2300	Bioimaging and Bioinstrument	4
CHEM 2230	Organic Chemistry Lab I	1				
MATH 2010	Multi. Calc and Mat Alg	4				

The Arch: Summer Here

BMED 4200	Modeling of Biomed Sys	3
CHEM 2260	Organic Chemistry II	3
CHEM 2240	Organic Chemistry Lab II	1
BCBP 4760	Molecular Biochemistry I	4
STSS 2520	Sociology	4

Third Year

Fall		Credit hours	Spring			Credit hours
"Away Semester"			BMED	4500	Advanced Systems Physiology	4
			BMED	4250	Biomedical Transport Phenomena	4
			PSYC	1200	General Psychology	4
			ENGR	2050	Intro to Eng Design	4
			ENGR	4010	Profess. Dev: Leadership[1]	1

Fourth Year

Fall		Credit hours	Spring			Credit hours
BMED 4010	Bioeng Lab[2]	4	BMED	4600	BME Design[3]	3
BMED 4260	BME Prod Dev and Com	3			BME Tech. Elective III	3
	BME Tech. Elective II	3			BME Tech. Elective IV	3
	HASS Elective[5]	4			HASS Elective[5]	4
STSO 4100	Profess. Dev: Tech Issues[1]	2			HASS Elective[5]	4

The minimum number of credit hours for the degree is 133

[1] For a list of courses that satisfy the Professional Development – Technical Issues & Solutions requirement, refer to the link "Professional Development Courses" on the Registrar's "Academic Planning" web page. It should be completed before the capstone design course.

[2] BMED 4010 may be taken in either Spring Year 3 or Fall Year 4.

[3] Capstone is a writing-intensive course.

[4] ENGR 1400 may be taken as alternative to ENGR 1200. This course may be taken either semester.

[5] Two of the HASS Electives need to be either COMM, LITR, or WRIT to satisfy the English requirement that most medical schools have.

[6] Organic Chemistry I counts as BME Tech Elective I

BME Baccalaureate Program with Minor in Management

The BS with Minor in Management can be completed by following the traditional BME Baccalaureate template and choosing appropriate classes from the Lally School for the four Free Electives. A list of acceptable classes for the different Management Minor programs can be found at https://lallyschool.rpi.edu/programs/undergraduate-programs/bs-business-management.

BME Baccalaureate Program with Minor in Data Science

The BS with Minor in Data Science can be completed by following the traditional BME Baccalaureate template and choosing appropriate classes for the BME Technical Electives as well as some of the Free Electives. Note that the Data Science minor, while distinct from the Biomedical Data Science specialization area described below, synergizes well with this particular specialization. A list of acceptable classes for the Data Science Minor can be found at https://ise.rpi.edu/programs/undergraduate.

BME Bachelor's Degree Requirements

Core BME Courses (and recommended semesters for taking them)

All of these courses are required for a BME degree and they need to be taken for a letter grade. No substitutions with other courses offered at Rensselaer are allowed.

BMED	2050	Programming for BME	(3CR) (F2, S2)
BMED	2100	Biomaterials Science and Engineering	(4CR) (S2)
BMED	2540	Biomechanics	(4CR) (S2)
BMED	2300	Bioimaging and Bioinstrumentation	(4CR) (S2)
BMED	4200	Modeling of Biomedical Systems	(3CR) (F3, S3, or Summer of The Arch)
BMED	4250	Biomedical Transport Phenomena	(4CR) (F3, S3, or Summer of The Arch)
BMED	4010	BME Lab	(4CR) (S3, F4, or Summer of The Arch)
BMED	4500	Advanced Systems Physiology	(4CR) (S3)
BMED	4260	BME Product Devel. & Commercialization	(3CR) (F4)
BMED	4600	BME Design	(3CR) (S4)

BME Technical Electives

Four courses need to be taken to satisfy the BME Technical Elective requirement. These courses need to be 3 or 4 credit hour courses and they have to be taken for a letter grade. The BME Technical Elective courses can be chosen from the attached list or they can be any formal 4000-level BMED course, i.e., no "Studies in BME", "Topics in BME" or research courses. At least two of the four BME Technical Elective courses must be 4000-level or higher. It is not possible to take the same course at the 4000- and 6000-level, nor is it possible to get credit twice for a course (once as a free elective and once as a technical elective). BME Technical Electives can be taken to either add depth or to add breadth to the degree.

Class Number	Class Name	# Credit Hours	Offered in Fall/Spring/ Summer of The Arch	Recommended for Specialization Area				
				Biomaterials	Biomechanics	Biomedical Data Science	Bioimaging	Medical Devices
BMED 4410/6410	BioMEMS	3	S	X				X
BMED 4440/6440	Biophotonics	3	S				X	
BMED 4450/6450	Drug and Gene Delivery	3	F	X				
BMED 4460/6460	Biological Image Analysis	3	S			X	X	
BMED 4470/6470	Biostatistics for Life Science Applications	3	F	X	X	X	X	X
BMED 4480/6480	Biomedical Data Science	4	S			X		
BMED 4510/6510	Mechanobiology (not offered every year)	3	S	X	X			
BMED 4540	Biomechanics II	4	F		X			
BMED 4550/6550	Cell Biomechanics	3	F		X			
BMED 4580/6580	Biomedical Fluid Mechanics	3	F		X			
BMED 4590/6590	Medical Imaging	3	F				X	
BMED 4650/6650	Introduction to Cell and Tissue Engineering	3	S	X				
BMED 4660/6660	Muscle Mechanics and Modeling	3	S		X			
CHEM 2250	Organic Chemistry I	3	F, SA	X				
ECSE 2010	Electric Circuits	4	F, S, SA				X	X
ECSE 2410	Signals and Systems	3	F, S, SA				X	X
ECSE 4090	Mechatronics	3	F					X
ECSE 4480	Robotics I	3	F					X
ENGR 2300	Electronic Instrumentation	4	F, S, SA			X	X	X
ENGR 2350	Embedded Control	4	F, S, SA			X		X
ISYE 4330	Design of Experiments	3	F			X		
MANE 4030	Elements of Mechanical Design	4	F, S, SA		X			X
MANE 4050	Modeling and Control of Dynamic Systems	4	F, S, SA			X	X	X
MANE 4240	Introduction to Finite Elements	3	F, S		X	X		X
MANE 4670	Mechanical Behavior of Materials	3	F		X			
MANE 6480	Health Physics and Medical Aspects of Radiation (not offered every year)	3	S				X	
MTLE 2100	Structure of Engineering Materials	4	S	X				
MTLE 4050	Introduction to Polymers	3	F	X				

MTLE 4250	Mechanical Properties of Materials	4	S, SA	X			
MTLE 4470	Biology in Materials Science	3	S	X			
MTLE 4720	Applied Mathematical Methods in Materials	3	F	X	X		

BME Technical Electives and Specialization Areas

To fulfill the BME Technical Elective requirement, students can take any combination of four courses from the list above provided that at least two of the four courses are 4000-level or higher. However, students may want to specialize in certain areas. The recommended courses for five different specialization areas (biomaterials, biomechanics, bioimaging, biomedical data science, and medical devices) are listed below:

Biomaterials Specialization:
CHEM 2250   Organic Chemistry I   (3CR) (F, Summer)
MTLE 2100   Structure of Engineering Materials   (4CR) (S)
Plus an additional two recommended electives for the biomaterials area from the table above.

Biomechanics Specialization:
BMED 4540   Biomechanics II   (4CR) (F)
BMED 4580   Biomedical Fluid Mechanics   (3CR) (F)
Plus an additional two recommended electives for the biomechanics area from the table above.

Biomedical Data Science Specialization:
BMED 4470   Biostatistics for Life Science Applications   (3CR) (F)
BMED 4480   Biomedical Data Science   (4CR) (S)
Plus an additional two recommended electives for the biomedical data science area from the table above.

Bioimaging Specialization:
ECSE 2010   Electric Circuits   (4CR) (F, S, Summer)
ECSE 2410   Signals and Systems   (3CR) (F, S, Summer)
Plus an additional two recommended electives for the bioimaging area from the table above.

Medical Devices Specialization:
ENGR 2300   Electronic Instrumentation   (4CR) (F, S, Summer)
MANE 4030   Elements of Mechanical Design   (4CR) (F, S, Summer)
Plus an additional two recommended electives for the medical devices area from the table above.

Students who complete all of the BME Technical Electives for a specialization will, upon request, receive a certificate from the Department of Biomedical Engineering indicating that they have met the requirements.

HASS Core Program: School of Engineering Requirements

Undergraduate students must have an area of focus in their HASS studies that is accomplished by completing an approved 12-credit sequence, known as the HASS Integrative Pathways. Some students will satisfy a modified version of this requirement.

The HASS Integrative Pathways were created to enhance students' HASS Core curriculum by bringing intentionality and depth to the requirements. The themes of the pathways vary in their intentionality; some

are interdisciplinary, while others focus on a single discipline, providing students with significant options for their coursework. In addition to providing a more in-depth focus to the HASS Core, many Integrative Pathways can be transformed into minors with relative ease.

The complete list of pathway titles, descriptions, and associated courses can be found https://info.rpi.edu/hass-pathways/pathways-topics. Information about compatible minors can also be found on this page.

Advising

Faculty Advisor

Each undergraduate student has their own faculty advisor who should be the first line of contact if there are questions or problems. If your advisor is not available or if you have further questions, you may contact the advising coordinator for the department in room JEC 7048.

Student's Responsibilities

- To know their advisor's office hours and advising schedule.
- To make an appointment and prepare for registration advising by reviewing the Catalog, Class-Hour Schedule, and Degree Works schedule.
- To formulate questions regarding curriculum, course selections, career options, etc.
- To be aware of their academic and personal needs and to seek assistance when needed.
- To understand that the role of their advisor is to advise them, not to make decisions for them. Each student needs to realize that it's his or her education at stake, and that, with advisement, *they* are ultimately responsible for making any final decisions.

Advisor Responsibilities

- To be accessible to students throughout the year at posted office hours. If an advisor will be away from campus for an extended period of time, he or she should post the names and office locations of alternate advisors outside their offices, so that students will have other advising resources.
- To set aside designated times for registration advising and individual discussions.
- To be knowledgeable about current curriculum requirements, academic policies and procedures, referrals and resources on campus, and career opportunities in the major field.
- To guide students through academic programs that will complement their personal, educational, and professional interests.

Useful Advising Links

- Advising and Learning Assistance Center
- Career Development Center
- Co-Op / Internships
- Course Catalog
- International Programs
- Registrar Forms
- Student Handbook
- Student Information System

The HUB

The SoE Student Services HUB is a great place for freshmen and sophomore engineering students to find answers to their most pressing academic and career related questions. The HUB is located in the Ansell Lounge on the third floor in the Jonsson Engineering Center (JEC). The HUB is comprised of experience faculty and staff members who specialize in many of the different engineering majors. The HUB is open weekdays during the academic year during the following hours: Monday- Friday 9:00am-4:30pm

HUB personnel have been trained to answer questions regarding all engineering majors, including required courses, prerequisites, different concentrations, optimal time for co-ops and internships, traveling abroad, etc. Each personnel member will have access to students' Degree Works reports and will be able to supply the student with the best advice, or refer them to a more knowledgeable source. HUB personnel will not be able to sign Student-Advisor Meeting (SAM) requirements for students. Their job is to supplement, not replace, the student's appointed academic advisor.

Registration

When: Registration for the Spring semester generally occurs in early November. Registration for the Fall semester occurs the preceding Spring, usually in early April. Exact dates are included in the Academic Calendar.

How: Use the Student Information System (SIS) to register for your courses.

Where: There are no assigned rooms for registration. You can register for your classes using any computer with Internet access.

Time Tickets

As a student here at Rensselaer, you are issued a "time ticket," which assigns you a specific window of time during which you may register for the next semester. Your time ticket will be sent to your RPI email address, 2 - 3 weeks before registration.

Your registration time is assigned based on the number of credit hours you have **earned** as a student. The table to the right shows the range of earned credit hours associated with each class. Please note that classes which are still in progress or courses which have been graded as "incomplete" do *not* count towards earned credits, nor do transferred courses and Advanced Placement (AP) credits.

School of Engineering	
Freshman	0 - 30
Sophomore	31 - 60
Junior	61 - 95
Senior	96 - 128

You should receive your time ticket via e-mail approximately four weeks prior to the scheduled registration period. In addition to making the registration assignment, this e-mail message notifies you of any existing holds which may prevent you from registering if you do not resolve them.

Degree Works

You can monitor your progress at any time by logging on to the Degree Works System. The information provided is tailored according to the program you follow (e.g. BS-BMED) and summarizes how much of your degree you have completed. In addition to that, it lists all core courses, divided into the categories, *i.e*. Math/Science Core, Humanities, Arts and Social Sciences, Engineering Core, BME Core, BME Technical Electives and Free Electives. You can use the Degree Works template to plan the sequence of courses to complete your degree. The Degree Works report can be accessed via the main menu of the Student Information System (SIS).

Registration Frequently Asked Questions

<u>What do I do if a class I want to register for is full?</u>
Meet with the instructor of the course and request to be admitted to the course. If the class is a core/required course every effort will be made to accommodate the request. If this is an elective course you may be asked to take it in a subsequent semester or choose a different elective that satisfies the degree requirements.

<u>How do I add/drop a course?</u>
You may use the <u>Student Information System (SIS)</u> to add or drop courses. Generally speaking, from the beginning of the semester, you will have **two weeks to add** courses and **eight weeks to drop** them. Please refer to the Academic Calendar for specific add and drop deadline dates.

If you wish to petition to add or drop classes after the published deadline, you may do so using a <u>Late Add/Drop Form</u>. Please note that after the instructor's signature (if required), the form must also be approved by the Advising and Learning Assistance Center.

Prerequisite Chart

Course		**Pre requisite**
Biology, Chemistry, Math, Physics:		
BIOL 2120	Introduction to Cell and Molecular Biology	None
BIOL 2125	Introduction to Cell and Molecular Bio. Lab	None
CHEM 1100	Chemistry I	None
MATH 1010	Calculus I	None
MATH 1020	Calculus II	MATH 1010
MATH 2010	Multivariable Calculus and Matrix Algebra	MATH 1020
MATH 2400	Differential Equations	MATH 1020
PHYS 1100	Physics I	None
PHYS 1200	Physics II	PHYS 1100, co-req MATH 1020
Engineering Core Courses:		
CSCI 1190	Beginning Programming for Engineers	None
ENGR 1100	Intro to Engineering Analysis	None
ENGR 1200	Engineering Graphics and CAD	None
ENGR 1300	Engineering Processes	None
ENGR 2050	Intro to Engineering Design	ENGR 1100 and either ENGR 1200 or ENGR 1400, co-req PHYS 1200
ENGR 2600	Modeling and Analysis of Uncertainty	MATH 1010
ENGR 4010	Professional Development: Leadership	None
STSO 4100	Professional Development: Tech Issues	None
BME Core:		
BMED 2050	Programming for BME	ENGR 1100
BMED 2100	Biomaterials Science and Engineering	None
BMED 2300	Bioimaging and Bioinstrumentation	PHYS 1200
BMED 2540	Biomechanics	ENGR 1100
BMED 4010	BME Lab	BMED 2100, BMED 2300, BMED 2540
BMED 4200	Modeling of Biomedical Systems	MATH 2400, PHYS 1200, BMED 2050
BMED 4250	Biomedical Transport Phenomena	ENGR 1100, PHYS 1100, MATH 2400
BMED 4260	BME Product Devel. & Commercialization	ENGR 2050, Senior standing

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| BMED 4500 | Advanced Systems Physiology | BIOL 2120 |
| BMED 4600 | BME Design | BMED 4260 |

BME Technical Elective Courses:

BMED 4410	BioMEMs	Junior or Senior standing
BMED 4440	Biophotonics	PHYS 1200
BMED 4450	Drug and Gene Delivery	BMED 2100
BMED 4460	Biological Image Analysis	BMED 2300
BMED 4470	Biostatistics for Life Science Applications	MATH 2010 and ENGR 2600
BMED 4480	Biomedical Data Science	MATH 2010 and ENGR 2600
BMED 4510	Mechanobiology	BMED 2540
BMED 4540	Biomechanics II	BMED 2540 or ENGR 2530
BMED 4550	Cell Biomechanics	BMED 2540 or ENGR 2530
BMED 4580	Biomedical Fluid Mechanics	BMED 4250 or ENGR 2250
BMED 4590	Medical Imaging	BMED 2300 or approval of instructor
BMED 4650	Intro to Cell and Tissue Engineering	BMED 4250 or ENGR 2250 and either BMED 2540 or ENGR 2530
BMED 4660	Muscle Mechanics and Modeling	None
ECSE 2010	Electric Circuits	MATH 2400, PHYS 1200
ECSE 2410	Signals and Systems	ECSE 2010
ECSE 4090	Mechatronics	ENGR 2350, ECSE 2410, and Senior standing
ECSE 4480	Robotics I	MATH 2400 and either MATH 2010 or ENGR 1100
ENGR 2300	Electronic Instrumentation	PHYS 1200, co-req MATH 2400.
ENGR 2350	Embedded Control	CSCI 1010 or CSCI 1100 or CSCI 1190
MANE 4030	Elements of Mechanical Design	MATH 2400, and either ENGR 2530 or BMED 2540
MANE 4050	Modeling and Control of Dynamic Systems	MATH 2400, PHYS 1200
MANE 4240	Introduction to Finite Elements	ENGR 2250 or ENGR 2530 or ECSE 4160
MANE 4670	Mechanical Behavior of Materials	ENGR 2530
MANE 6480	Health Phys, & Med. Aspects of Radiation	None
MTLE 2100	Structure of Engineering Materials	ENGR 1600 or equivalent (BMED 2100)
MTLE 4050	Introduction to Polymers	None
MTLE 4250	Mechanical Properties of Materials	ENGR 1600, MTLE 2100
MTLE 4470	Biology in Materials Science	ENGR 1600
MTLE 4720	Applied Math. Methods in Materials	MATH 2400, and access to Mathematica

Pre-med Courses (pre-requisites adjusted to satisfy pre-med requirements):

BIOL 1010	Introduction to Biology	Co-req BIOL 1015
BIOL 1015	Introduction to Biology Lab	Needs to be taken with BIOL 1010
CHEM 2250	Organic Chemistry I	CHEM 1100 or 1110
CHEM 2230	Organic Chemistry Lab I	Needs to be taken with CHEM 2250
CHEM 2260	Organic Chemistry II	CHEM 2250
CHEM 2240	Organic Chemistry Lab II	Needs to be taken with CHEM 2260
BCBP 4760	Molecular Biochemistry I	CHEM 2250 and either BIOL 1010 or BIOL 2120
PSYC 1200	General Psychology	None
STSS 1520	Sociology	None

Undergraduate Research Program (URP)

Rensselaer's Undergraduate Research Program (URP) provides real-world, hands-on research experience for students like you. Through this unique program, you have the opportunity to work directly with a faculty member on a bona fide research project.

The program offers many advantages and the opportunity to:
- work on a project whose impact could be worldwide and can lead to patents and/or grants
- interact with some of the most informed and learned professors in the world
- apply knowledge gained in the classroom to actual problems and research situations
- network with faculty beyond the classroom, opening the door to other opportunities
- gain critical leadership, team-building and critical thinking skills
- establish industry connections that could lead to a co-op or future employment
- distinguish yourself from your peers
- publish as an undergraduate
- receive course credit in a more dynamic way or supplement your income

URP info: https://info.rpi.edu/undergraduate-research/undergraduate-research-program-academic-year

Rensselaer has a very strong Undergraduate Research Program. This is a program that allows students to work in a professor's laboratory for credit or hourly pay. On average, over 30% of students are taking advantage of these opportunities during their Rensselaer career.

The program offers many advantages and the opportunity to:
- work on a project whose impact could be worldwide and can lead to patents and/or grants
- apply knowledge gained in the classroom to actual problems and research situations
- network with faculty beyond the classroom, opening the door to other opportunities
- gain critical leadership, team-building and critical thinking skills
- publish as an undergraduate
- receive course credit in a more dynamic way or supplement your income

How to find a project
Most URP projects are found through direct contact with the faculty member supervising the research. Most undergraduates find projects from faculty members from whom they have taken classes. A good place to start your search is to determine a faculty member with whom you may want to work on a project. Check their website to investigate their field of research. If it sounds interesting, approach them about a possible URP project.

What if I have my own idea for a project?
You may work with a faculty member on an existing research project or on a project based on your own ideas. If you want to pursue your own project, find a faculty advisor who may be interested in your topic since you will be required to have a project advisor.

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For credit or funding?
You can earn from one to four credit hours per semester for your participation in the URP. The number of credit hours you earn is negotiable between you and your faculty sponsor. If you choose this option you and your sponsor need to:

- Determine how many credit hours you will earn
- Decide exactly what is expected of you, such as your time commitment, the type of work to be submitted, etc.
- Agree on how your grade will be determined
- In the past, students who have participated in the URP for pay have earned up to $3,000 per semester. The majority of participants earn $400 per semester.

URP funding comes from two sources:

- Your sponsoring faculty member or department
- The Office of Undergraduate Education

The faculty sponsor or department is responsible for the financial support of your research. In addition, the Office of Undergraduate Education pays URP participants a maximum of $400 per semester in the form of matching funds.

Most projects expect eight to twelve hours of work per week.

The URP application should be submitted to the Department Coordinator, who:

- Checks the URP Application for completeness
- Fills out your payroll paperwork
- Forwards your application and payroll paperwork to the Office of Undergraduate Education for approval
- Will set up a schedule for reporting your hours. You must submit your hours to the Department Coordinator within the same payroll period that you worked. Please keep in mind that if you work and submit hours that exceed your funding allotment, you will not be paid for those hours. Pay checks are issued every other Friday

Co-op Opportunities

Numerous Co-op opportunities exist. Please speak to the Center for Career and Professional Development (http://rpi.edu/dept/cdc/) to learn more about these opportunities.

International Programs

Rensselaer Education Across Cultural Horizons, or REACH, is part of Rensselaer's initiative to provide all undergraduate students with an international experience. Initially launched in spring 2009 as an exchange program for engineering students, REACH has evolved to include all international opportunities for undergraduates, including semester-long study abroad and exchange opportunities, short-term and faculty-led international programs, and other international experiences such as internships and service learning. All students are encouraged and expected to take advantage of some sort of international experience during their four-year undergraduate education.
The web site for Office of International Programs can be found here:
https://info.rpi.edu/international-programs

Academic Requirements and Eligibility - Generally a 3.0 minimum GPA is required. More importantly, students must make sure that a period of study abroad will not delay their graduation date. Although students typically study abroad during the junior year, sophomores and seniors may be eligible.

Application procedures and deadlines - Generally an RPI study abroad application and official transcript as well as an application from the host institution are required. Deadlines vary by program but are typically September for spring and February for fall. You should begin the research process at least one semester prior to the semester of application.

Fees and Billing - Students who participate in affiliated study abroad or exchange programs are charged the cost of regular RPI tuition for their term(s) abroad. Some programs carry an additional fee. Unless otherwise noted, transportation, housing and other living expenses are paid directly by each student and are not billed by RPI.

Financial Aid - With the exception of work-study money, all forms of financial aid can be applied to Rensselaer-affiliated programs. Students must maintain full-time status (the equivalent of 12 Rensselaer credits or above) in order to be eligible for financial aid.

Grades and Credit - Full credit is granted for courses completed with a grade of C- or above. All courses must be approved by the relevant academic department in order for the transfer of credit to take place. With the exception of the Architecture programs, grades earned overseas are not factored into the GPA.
It is important for students to work with their advisor when applying to study abroad. Course mapping for selected REACH programs has been completed but this has not been completed for all of the universities involved. Mapping for the engineering focused schools can be found at: http://sis.rpi.edu/trfequiv/transfer_equiv.pdf

Study Abroad FAQs can be found at: https://info.rpi.edu/international-programs/study-abroad-and-exchange-opportunities

Professional and Student Societies

There is currently a very active student chapter of the Biomedical Engineering Society (BMES). The chapter plans many activities throughout the school year including informational meetings, student-faculty mixers, lunches with faculty, and field trips to local industry. One of the BME faculty serves as the faculty advisor for the chapter.

Students who become members of the student chapter of the BMES will also receive literature from the National BMES.

Frequently Asked Questions

When can I choose a minor?
A minor can be chosen anytime as long as the requirements for the minor can be completed before graduation.

Can BME students do a pre-medical, or pre-dental program?
BME students can do pre-medical or pre-dental curricula during their undergraduate program at RPI. The pre-medical program is shown above. The pre-dental program can be constructed with the advisor.

Is it reasonable for BME students to graduate in four years?
It is not only reasonable but it is highly recommended and accomplished by a majority of the students. The suggested four year curriculum is shown above. Studying a semester abroad or doing a co-op experience for one semester is possible without delaying graduation as long as these activities are done as part of the "away semester" of the Summer Arch.

Can a BME dual major in other fields?
A BME student can dual major in other fields. The student will have two advisors, one from BME and the other from the dual major. Normally the number of credits needed to complete a dual major is substantially higher than the number of credits needed to complete the BME major only. Please note that we cannot guarantee that there are no scheduling conflicts arising from the dual major (while we avoid scheduling conflicts for BME classes). In general we recommend the co-terminal option, BS in BME and MS in BME or another field, over obtaining dual majors with BME as the amount of coursework and scheduling makes it very difficult to complete a dual major in eight semesters.

Is the BME program accredited?
The BME program is accredited by ABET, the Accreditation Board for Engineering and Technology, which is the organization that accredits all engineering programs.

To whom should I speak about doing a term abroad?
You may speak to your advisor, the advising coordinator for the department (JEC 7048) or contact the Office of International Programs.

To whom should I speak about the premed requirements?
You may speak to the premed advisor.

How do I find out about the URP program and who has open positions?
You can begin by speaking with your advisor. You can also speak with faculty that are in the concentration area that you are interested in doing a URP.

If I do a Co-op, which semester should I choose and how will it affect my schedule?
Most students choose the fall or the spring semester of their junior year for a Co-op. It is advisable to do a Co-op during the "away semester" of the junior year.

By when does a student need to choose a major?
Most students choose a major when entering their freshman year at RPI. For those students who do not choose a major at that time, they become an undeclared student and are given an advisor who can guide them toward making an informed choice of major. This decision should be made by the end of their freshman year.