



**IUPUI**

DEPARTMENT OF BIOMEDICAL ENGINEERING

**GRADUATE HANDBOOK**

Dual Degree Program

Master of Science in Biomedical Engineering  
Purdue School of Engineering and Technology

And

Doctor of Medicine  
Indiana University School of Medicine

**Fall, 2023**

## **Amendments**

1. First version was approved by the BME faculty on August 16, 2021
2. Amended by the BME faculty on August 17, 2022
  - a. Add Appendix C. Sample Plans of Study (GS-6): Non-Thesis
  - b. Under Section 6 Guidelines for Course Selection: update the BME course offering cycles under each concentration area.

## TABLE OF CONTENTS

	Page
1. INTRODUCTION .....	1
2. APPLICATION AND ADMISSION TO THE DUAL DEGREE PROGRAM .....	1
3. MASTER'S IN BME DEGREE REQUIREMENT .....	1
4. THESIS AND RESEARCH OPTIONS .....	2
5. ADVISING AND ADVISORY COMMITTEE .....	3
6. GUIDELINES FOR COURSE SELECTION .....	3
7. MEDICAL SCHOOL COURSES .....	5
8. GRADE REQUIREMENTS .....	6
9. GRADUATION .....	6
10. PROGRAM SCHEDULE .....	6
Appendix A. Dual Degree Roadmap: Non-Thesis and Thesis .....	8
Appendix B. Tentative Plans of Study (GS-6): Non-Thesis and Thesis .....	10
Appendix C. Sample Plans of Study (GS-6): Non-Thesis .....	12

## 1. INTRODUCTION

The Department of Biomedical Engineering, Purdue School of Engineering and Technology and the Indiana University School of Medicine (IUSM), offer a dual degree program on the IUPUI campus that integrates a Master's degree program in Biomedical Engineering (BME) with the Doctor of Medicine degree program. The dual degree MD and MS BME program at IUPUI allows IUSM students the opportunity for in-depth training in engineering and technology relevant to the clinic and translational research. This program is available only to the IU School students located on the Indianapolis campus.

Students enrolled in the medical doctorate in Indianapolis will take a year away from the medical school curriculum to complete the necessary course work for the MS BME degree at IUPUI, thus allowing these students the benefit of earning a medical doctorate from Indiana University and a MS in BME from Purdue University at IUPUI within 5 years or less. MD students in this program will be advised by staff in IUSM and the IUPUI BME department to ensure a cohesive integration of the two programs of study.

This handbook addresses common questions from applicants and current students in this Dual Degree Program. Information is provided concerning the application process, establishing a program of study, required scholastic performance and general administrative expectations of the Department of Biomedical Engineering, IUPUI, and Purdue Graduate Schools. Once admitted into the MS BME program, it is imperative that students also refer to the *BME MS Graduate Handbook* for further guidelines.

## 2. APPLICATION AND ADMISSION TO THE DUAL DEGREE PROGRAM

School of Medicine students interested in this dual degree program should apply to the BME Master's program 1 to 2 semesters before they start the MS program (typically in the fall). Applications are reviewed by the BME Graduate Education Committee (GEC) and evaluated using the same requirements as other applicants. These guidelines are described in detail in the BME MS Graduate Handbook. One exception is that MCAT scores will be accepted in place of the GRE.

Students with a non-BME or non-engineering undergraduate degree who are accepted into the program may be offered introductory or co-requisite graduate level courses aimed at bridging any deficiencies in math and engineering, with a focus on their specific area of concentration.

## 3. MASTER'S IN BME DEGREE REQUIREMENT

The medical school curriculum will remain unchanged for students in the dual degree, but enrolled students in the MS degree will be able to count 12 credits from their medical studies towards the degree requirements for the BME program. Through this credit-sharing, medical students will therefore be able to complete the MS program in approximately one year.

The MS BME program requires a total of 30 credit hours, which includes graduate BME or other engineering courses, life science courses, as well as a mathematical or statistics courses. Medical school students can count 12 credit hours from their medical school program

toward the BME MS degree as part of this dual degree program. These courses will satisfy the graduate life science requirements.

For non-thesis students, the remaining 18 credit hours may include:

Graduate Biomedical Engineering courses (4 courses)	12 credits
Approved Graduate Engineering elective (1 course)	3 credits
Approved Graduate Mathematics or Statistics course (1 course)	3 credits

If a student is interested in completing a research thesis, a project can be developed with a faculty mentor and the remaining 18 credit hours include:

Graduate Biomedical Engineering courses (2 courses)	6 credits
Approved Graduate Mathematics or Statistics course (1 course)	3 credits
Thesis Research	9 credits

The four Graduate Biomedical Engineering courses are required for the MS BME Plan of Study as “Primary” courses. All other courses will be designated as “Related” courses as Engineering electives plus one required graduate math course, as described in the *BME MS Graduate Handbook*. Students in the dual degree program must also complete all the requirements of the MS BME degree program described in the *BME MS Graduate Handbook*.

#### **4. THESIS AND RESEARCH OPTIONS**

While the Master’s program consists primarily of two semesters of didactic coursework, it is possible to complete a thesis-based BME Master’s degree with this dual degree program. For IUSM students interested in completing a thesis project, they should arrange in advance with a faculty sponsor, and begin working on a research project as soon as possible.

For example, IUSM students will have an opportunity to start thesis research in the summer after their first year (between Year One and Two of Phase One). This summer experience would be a good introduction to BME research, which students can use to gain background experience and explore thesis research options. This work could also be counted as part of IUSM’s Indiana Medical Student Program for Research and Scholarship (IMPRS).

Specific thesis plan and schedule will be worked out with their research project mentor on an individual basis. Dual degree students electing to complete a thesis project are eligible for funding as a graduate research assistant or teaching assistant from the BME department, to help support tuition, insurance, and to provide a stipend.

Students interested in a shorter, semester long, research project, instead of a thesis project, have the option of taking BME 696 Advanced BME Project (typically 3 credit hours). If taken during that summer between year 1 and 2, IUSM students will first register BME 696 and the credits applied toward their MS degree program. See the *BME MS Graduate Handbook* for more details about thesis and other research options.

## 5. ADVISING AND ADVISORY COMMITTEE

Each student will be assigned a BME Faculty Advisor upon entering the program. For Non-Thesis students, the Director of the BME Graduate Program will serve as their Faculty Advisor, and assist the student in finalizing a Plan of Study to fulfill the degree requirements.

For Thesis students, the faculty member sponsoring student's thesis project will serve as advisor. The Faculty Advisor and student must establish a 3-member Graduate Research Advisory Committee to assist with Plan of Study and research project. Student planning to pursue the thesis-based MS degree must work closely with their advisor to plan out their program. Depending on the research project, it may take time outside of the 1-year time frame for Thesis students to complete the MD-MS dual degree program.

It is the responsibility of the BME Faculty Advisor and the Graduate Research Advisory Committee to assist the student in finalizing the Plan of Study, meeting degree requirements, and conducts all necessary examinations related to the thesis research project.

Medical school students are strongly advised to stay in touch with their Lead Advisor at IUSM regarding their progress in the BME MS program. They are also strongly advised to keep up their clinical experience during the MS program, by attending grand rounds and clinical conferences consistent with their course or research schedule.

## 6. GUIDELINES FOR COURSE SELECTION

Research interests of the BME faculty as well as the course offerings of the BME department can be categorized into three areas of concentration:

- Biomaterials / Tissue Engineering
- Biomechanics / Mechanobiology
- Bioinstrumentation / Neural Engineering / Biosignal Processing

All three areas focus on medical applications and clinical relevancy.

Classes will be chosen in consultation with the BME faculty advisor. Selection of classes will be dependent on student background: undergraduate degree, courses already taken, and area of interest. Overall course selection as well as project concentration should follow a theme or an area of concentration. These include: Biomaterials, Biomechanics, and Bioinstrumentation/Neural Engineering.

### **BME Course Offering Based on Area of Concentration**

#### **Biomaterials**

<i>Fall</i>	Cycle 1	BME 595 Engineering Principles of Biotechnology (Ji)
		BME 595 Polymers for BME Applications (Xie)
		BME 595 Tissue Engineering (Lin)
Cycle 2	BME 582 Advanced Biomedical Polymers (Xie)	
	BME 571 Drug Delivery (Ji)	
	BME 595 Tissue Engineering (Lin)	

<i>Spring</i>	Cycle 1	BME 595 Engineering Principles of Biomolecular Interaction (Lin) BME 595 Engineering Analysis of Tissues (Wallace)
	Cycle 2	BME 595 Cancer Engineering (Lin)

### **Biomechanics**

<i>Fall</i>	Cycle 1	BME 595 Vascular Biomechanics (Na) BME 595 Engineering Principles of Biotechnology (Ji)
	Cycle 2	BME 595 Cellular Mechanotransduction (Na) BME 571 Drug Delivery (Ji)
<i>Spring</i>	Cycle 1	BME 595 Molecular and Cellular Mechanics (Yokota) BME 595 Engineering Analysis of Tissues (Wallace)
	Cycle 2	BME 544 Musculoskeletal Biology and Mechanics (Wallace) BME 595 Biomolecular Engineering (Yokota)

### **Bioinstrumentation / Neural Engineering**

<i>Fall</i>	Cycle 1	BME 595 Cardiac Electrophysiology (Berbari) BME 595 Cellular Electrophysiology (Schild)
	Cycle 2	BME 527 Implantable Systems (Schild) BME 537 Experimental Methods in BME (Schild)
<i>Spring</i>	Cycle 1	BME 595 Embedded Bioinstrumentation (Yoshida)
	Cycle 2	BME 595 Neural Engineering (Yoshida)

### **Engineering Elective Courses**

Most IUPUI graduate courses at the 500 level and above offered by the Departments of Electrical and Computer Engineering and Mechanical and Energy Engineering are acceptable as approved engineering elective courses. Depending on the course content, some may not be approved as engineering electives. Please consult with your BME Faculty Advisor.

### **Mathematics or Statistics Elective Courses**

The BME Graduate Committee has reviewed and approved the following courses for inclusion in a Plan of Study for the MS Degree in BME.

<b>DEPARTMENT</b>	<b>Course #</b>	<b>Course Title</b>
MATH	51000	Vector Calculus
MATH	51100	Linear Algebra with Applications
MATH	52500	Intro to Complex Analysis
MATH	53700	Applied Math for Scientists and Engineers I
MATH	55200	Applied Numerical Methods II
STAT	51100	Statistical Methods I
STAT	51200	Applied Regression Analysis
STAT	51400	Design of Experiments
STAT	51900	Introduction to Probability

STAT	52300	Categorical Data Analysis
STAT	52800	Intro to Mathematical Statistics
PBHL	B561	Introduction to Biostatistics 1

Course selection will be done in consultation with the BME Faculty Advisor. See the *BME MS Graduate Handbook* for more details about course selections.

## 7. MEDICAL SCHOOL COURSES

As part of this dual degree program, Medical school students are allowed to transfer and count 12 credit hours from their medical school program toward the BME MS degree. These courses will satisfy the graduate life science requirements.

The IUSM pre-clinical courses include:

- Human Structure (9 credits)
- Molecules to Cells and Tissues (7 credits)
- Fundamentals of Health and Disease (6 credits)
- Neuroscience and Behavior (6 credits)
- Transitions 1 (2 credits)
- Host Defense (6 credits)
- Cardiovascular and Hematology (6 credits)
- Renal and Respiratory (6 credits)
- Gastrointestinal and Nutrition (6 credits)
- Musculoskeletal and Dermatology (2 credits)
- Endocrinology and Reproductive Biology (4 credits)

Medical school courses are transferred as GRDM-X. For example: Molecules to Cells and Tissues (cell and molecular biology; biochemistry and medical/clinical genetics) and Fundamentals of Health and Disease (basic principles of pharmacology, physiology and pathology) are an adequate substitute for biomedical courses: G715 (Biochemical Basis of Biological Processes), G716 (Molecular Biology and Genetics) and G717 (Cellular Basis of Systems Biology).

Students should consult with their IUSM Advisory Committee and follow their recommendation on what subset of these courses to transfer, based on their area of concentration in BME. Due to the nature of medical school course, credit hours may be split up. For example, all dual degree students can use the Human Structure course (9 credits) on a BME Plan of Study. In addition, student can transfer another 3 credits as described below:

- 3 out of the 7 credits of the Molecules to Cells and Tissues course for Biomaterials / Tissue Engineering concentration
- 3 out of the 6 credits of the Cardiovascular and Hematology course for Biomechanics / Mechanobiology concentration
- 3 out of the 6 credits of the Neuroscience and Behavior course for Bioinstrumentation/Neural Engineering/Biosignal Processing concentration



Please use the “Convert-Med-Grades PU Fillable” Form available from the IUPUI Graduate Office website or the BME department. Most IUSM instructors are familiar with generating the form for their classes. It is possible that not all medical school credits for one course are converted to Graduate credits. Credit hours may be split up.

## **8. GRADE REQUIREMENTS**

In the new medical school curriculum, the grading scale is Pass/Fail. (In the legacy curriculum the grading scale was H, HP, P and F.) The medical credit conversion form allows instructors to assign a letter grade for medical school courses. Upon full admission to the MS BME program, a minimum GPA of 3.00 will be required in the student's MS BME Plan of Study as described in the *BME MS Graduate Handbook*.

## **9. GRADUATION**

The Master's degree is awarded once students have successfully completed all the degree requirements: 30 credit hours, submission of all administrative forms, and a positive thesis defense, if applicable. Students would need to apply for graduation during the semester they are finishing their requirements. (A degree will not be automatically awarded without a graduation application.)

## **10. PROGRAM SCHEDULE**

Flexible program plans and schedules were developed with IUSM faculty to accommodate the schedule of medical students, including variable start dates, summer courses, and courses taken before enrolling in the dual degree program.

Medical students should apply the semester before they plan to start the dual degree program. Medical students should start the BME MS program when it is appropriate to break from the medical program, and return to it at the same point when the MS degree is complete.

For example, the BME MS program can readily fit between Phase 1 and Phase 2 of the IUSM MD program, before or shortly after medical school students start Clerkships that can last between 2 and 8 weeks each.

Some guidelines and recommendations from the IUSM are as follows:

1. All students take and pass United States Medical Licensing Examination (USMLE) Step 1 at the usual time in the IUSM program (end of Phase 1)
2. Students then proceed to the beginning of Phase 2 and complete Transitions 2, and 3 months of Clerkship education (not electives). This brings them to approximately end of July.
3. They begin graduate studies in August and conclude not later than middle of next May. During this time, students remain eligible for participation in a weekly clinical activity (if possible).
4. Students formally return to Clerkship education in August, completing 9 months of Clerkship education in April. They proceed to enter Phase 3 with other students.

5. Students could be offered an alternative early start date in June after completion of MS degree with the understanding that they may need to maintain enrollment through spring of their final year which could lead to some additional tuition cost that could be reduced based on existing "Medical Student Tuition Adjustment Policy."

Note: The alternate date reflects that many students would not want a gap in their training. Students accepted into the dual degree program will officially start their BME graduate program in the fall semester, although they can start taking elective graduate courses in the summer before and transfer those into the MS program afterward. IUPUI graduate courses follow standard academic schedule, so IUSM students have some flexibility in completing a 1 or 2 Clerkships before exiting the IUSM curriculum and transitioning fully to the MS program, starting in the fall (August).

IUPUI Summer sessions usually start first week of May for Summer I or last week of June for Summer II. Although no BME classes are offered during summer, other engineering and math courses that can be taken as electives are typically available. Thesis students can also continue their research project during this summer.

Schedule of courses will be individually chosen based on consultation with their IUSM Lead Advisor and BME faculty advisor. In all cases, BME MS curriculum can be completed in time for the medical students return to their IUSM curriculum at the same point where they exited.

## Appendix A. Dual Degree Roadmap: Non-Thesis and Thesis

### Biomedical Engineering MD/MS Non-Thesis Option

#### Optional: Summer after Phase One Year One

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Elective	BME 696	Advanced BME Projects	3

Total Credit Hour: 3

#### Fall Semester

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Primary	BME 595	Graduate Biomedical Engineering course	3
Primary	BME 595	Graduate Biomedical Engineering course	3
Elective	MATH	Approved Graduate Mathematics or Statistics course	3

Total Credit Hour: 9

#### Spring Semester

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Primary	BME 595	Graduate Biomedical Engineering course	3
Primary	BME 595	Graduate Biomedical Engineering course	3
Elective	ENG	Approved Graduate Engineering elective	3

Total Credit Hour: 9

#### **SUMMARY: Plan of Study with a Non-Thesis option**

	Credit Hours
<b>Approved Courses from IUSM Program</b>	<b>12</b>
Graduate Biomedical Engineering courses	12
Approved Graduate Engineering electives	3
Approved Graduate Mathematics or Statistics courses	3

Total Credit Hour: 30

Biomedical Engineering MD/MS Thesis Option
---

**Optional: Summer after Phase One Year 1**

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Elective	BME 696	Advanced BME Projects	3
Total Credit Hour:			3

**Fall Semester**

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Primary	BME 595	Graduate Biomedical Engineering course	3
Primary	BME 595	Graduate Biomedical Engineering course	3
Elective	MATH	Approved Graduate Mathematics or Statistics course	3
Total Credit Hour:			9

**Spring Semester**

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Elective	ENG	Graduate Biomedical Engineering course	3
Elective	BME 698	Thesis Research	3
Elective	BME 698	Thesis Research	3
Total Credit Hour:			9

**SUMMARY: Plan of Study with a Thesis option**

	Credit Hours
<b>Approved Courses from IUSM Program</b>	<b>12</b>
Graduate Biomedical Engineering courses	3 – 9
Approved Graduate Engineering courses s	0 – 3
Approved Graduate Mathematics or Statistics course	3
Thesis Research	6 – 9
Total Credit Hour:	30

## Appendix B. Tentative Plans of Study (GS-6): Non-Thesis and Thesis

**EXAMPLE: Non-Thesis Option**  
 Biomechanics Track  
 Biomedical Engineering MD/MS

### Optional: Summer after Phase One Year 1

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Elective	BME 696	Advanced BME Projects	3
Total Credit Hour:			<u>3</u>

### Fall Semester, 2011

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Primary	BME 595	Cellular Mechanotransduction	3
Primary	BME 595	Molecular and Cellular Mechanics	3
Elective	ME 523	Nanosystems Principles	3
Total Credit Hour:			<u>9</u>

### Spring Semester, 2022

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Primary	BME 595	Engineering Principles of Biotechnology	3
Primary	BME 595	Engineering Analysis of Tissues	3
Elective	MATH 511	Linear Algebra with Applications	3
Total Credit Hour:			<u>9</u>

### SUMMARY: Plan of Study with a Non-Thesis option

	Credit Hours
<b>Approved Courses from IUSM Program</b>	<b>12</b>
Graduate Biomedical Engineering courses	12
Approved Graduate Engineering electives	3
Approved Graduate Mathematics or Statistics courses	3
Total Credit Hour:	<u>30</u>

<p><b>EXAMPLE: Thesis Option</b>          Biomechanics Track          Biomedical Engineering MD/MS</p>
--

**Optional: Summer after Phase One Year 1**

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Elective	BME 696/697	Directed Reading or Advanced BME Projects	3
Total Credit Hour:			3

**Fall Semester, 2021**

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Primary	BME 595	Cellular Mechanotransduction	3
Elective	MATH 537	Applied Math for Scientists and Engineers I	3
Elective	BME 698	Thesis Research	3
Total Credit Hour:			9

**Spring Semester, 2022**

Primary /Elective	Course # (ex:BME595)	Course Title	Credit Hours
Primary	BME 595	Engineering Principles of Biotechnology	3
Elective	BME 698	Thesis Research	3
Elective	BME 698	Thesis Research	3
Total Credit Hour:			9

**SUMMARY: Plan of Study with a Thesis option**

	Credit Hours
<b>Approved Courses from IUSM Program</b>	<b>12</b>
Graduate Biomedical Engineering courses	9
Approved Graduate Engineering courses s	0
Approved Graduate Mathematics or Statistics course	3
Thesis Research	6
Total Credit Hour:	30

## **Appendix C. Sample Plans of Study (GS-6): Non-Thesis**