**J. CRAYTON PRUITT FAMILY**
**DEPARTMENT OF BIOMEDICAL ENGINEERING**
**(BME)**

# GRADUATE GUIDELINES

## 2013/2014

This Guide contains information that supplements the University's Graduate Catalog which is the primary document governing all academic programs. Although every effort has been made to maintain accuracy, the Department of Biomedical Engineering reserves the right to correct errors when found, without further notice to students. The presence of errors will not affect the application of the rules and requirements applicable to all students.

# GRADUATE GUIDELINES

**Department of Biomedical Engineering**
**University of Florida**
**Gainesville, Florida 32611**

## Department Administration

**Dr. Christine Schmidt**
Professor & Chair

**Dr. Johannes van Oostrom**
Associate Professor &
Associate Chair

**Dr. David Hintenlang**
Associate Professor &
Graduate Coordinator

**For Information:**
**Graduate Student Office**
Andrea Fabic
Academic Services Coordinator
JG53 Biomedical Sciences Building
PO Box 116131
Gainesville, FL 32611-6131
Tel: (352) 273-8096
Fax: (352) 273-9221
Email:gss@bme.ufl.edu

# TABLE OF CONTENTS

# OBJECTIVES AND OVERVIEW OF THE DEPARTMENT

The mission of the Department of Biomedical Engineering (BME) is to educate students with strong engineering and science backgrounds for Master's and/or PhD degrees in Biomedical Engineering so that they can productively apply their training to the solution of engineering problems in the fields of medicine, biology and related fields.

## Biomedical Engineering Objectives

1. Provide students with a broad knowledge base of biomedical engineering and specialized knowledge and experience in at least one of the core areas: Biomechanics, Tissue Engineering, Biomedical Imaging and Signal Processing, Cardiac Engineering, Neural Engineering, BioMicro-Electromechanical Systems, and Medical Physics.

2. Provide students with the ability to apply fundamental engineering principles from several traditional engineering disciplines to identify, analyze, and solve clinical problems and improve health care.

3. Provide students with the ability to design and conduct scientific and engineering experiments, and to analyze and interpret the resulting data.

4. Provide students with experience and understanding of design requirements and constraints in the clinical and biological science environment, including technology transfer.

5. Provide students with the skills needed to communicate effectively, work collaboratively, and understand their professional and ethical responsibilities and the impact of clinically significant engineering solutions in a societal and economic context.

The Department of BME is interdisciplinary and collaborative, with departments in the College of Engineering (COE) and College of Medicine (COM) acting as partners in the education of Biomedical Engineers.

In addition to a general BME degree program, a concentration in Medical Physics is also offered.

Biomedical Engineering students are admitted to the Graduate School through the Department of BME. The BME Academic Committee reviews and makes all decisions regarding admission to the Department of BME. Each student's research advisor must hold a Faculty appointment in the Department of BME. Supervisory committees for BME students normally include at least one member of the Faculty from the College of Engineering and one member of the Faculty from the College of Medicine. Students interested in the Medical Physics concentration must specifically apply to the concentration.

# GRADUATE FACULTY

*Department Chair:* C.E. Schmidt. *Associate Chair:* J.H. van Oostrom. *Graduate Coordinator:* D.E. Hintenlang. *Distinguished Professors:* P.M. Pardalos, J.C. Principe. *Professors:* C.D. Batich, W.E. Bolch, F. Bova, A.B. Brennan, P.R. Carney, R.B. Dickinson, M. Ding, J. Dobson, A.S. Edison, J.R. Fitzsimmons, B.J. Fregly, E.P. Goldberg, J.G. Harris, H. Jiang, C. Liu, T.H. Mareci, J.J. Mecholsky, R.J. Melker, J. Palta, W.M. Phillips, C. Rinaldi, J.D. Stewart, R. Tran-Son-Tay, B.C. Vemuri, B.C. Wheeler, H. Xie. *Associate Professor*s: S.A. Banks, L. Brateman, Z.H. Fan, J. Forder, D.R. Gilland, L.B. Gower, D.E. Hintenlang, B.G. Keselowsky, C. Klodell, J. Li, Z. Li, P. McFetridge, B.K. Ormerod, W.S. Properzio, S. Samant, M. Sarntinoranont, Y. Tseng, D.E. Vaillancourt, J.H. van Oostrom. *Assistant Professor*s: K. Allen, M. Arreola, A. Gunduz, K. Hintenlang, G. Hudalla, T. Lele, W. O'Dell, P. Rashidi, L. Rill, B. Sharma, R. Sitaram, S. Talathi. *Research Faculty*: T.B. DeMarse,

# INTRODUCTION

The Department of Biomedical Engineering (BME) at the University of Florida offers the Master of Engineering (ME), the Master of Science (MS) and the Doctorate of Philosophy (PhD) degrees in Biomedical Engineering. In addition to the general BME program, a concentration in Medical Physics is offered. The Graduate Guidelines detail the policies and regulations governing these programs and should be used in conjunction with the University of Florida Graduate Catalog. It is **the responsibility of the student** to be familiar with both publications and to adhere to the stated rules.

# REQUIREMENTS FOR DEGREES

Unless otherwise specified, for any master's degree, the student must earn a minimum of 30 credits as a graduate student at the University of Florida. No more than 9 of the 30 credits (earned with a grade of A, B+, or B) may be transferred from institutions approved by the University of Florida. A minimum of 90 credits beyond the bachelor's degree is required for the Ph.D. degree. All master's degrees counted in the minimum must have been earned in the last seven years. (Graduate Catalog - Course Requirements).

All coursework within the College of Engineering (COE) and College of Medicine (COM) will count as elective credits toward the degree requirements for the MS, ME and PhD degrees.

A summary of the pertinent degree requirements are shown in the table.

| SCH (Semester Credits Hour) Requirements (minimum number) | Master (Thesis) | Master (Non-thesis) | Doctor of Philosophy | Medical Physics concentration [i] |
|---|---|---|---|---|
| Total SCH | 30 [a] | 30 [a] | 90 [a,b] | 39 MS/90 PhD |
| BME Core Requirements | 21 | 21 | 21 | |
| BME Electives | 3 | 6 | 6 | |
| Research/Special Project | (var) | (var) | (var) | (var) |
| Supervisory committee members (minimum number) | 3 | 1 [c] | 4 | Same as BME |
| Qualifying Exam | None | None | yes [d] | Same as BME |
| Final Exam | Oral [e] | Written [f] | Oral [g] | Same as BME |
| Time limit for completing degree | 7 years | 7 years | 5 years [h] | Same as BME |

a. Beyond BS
b. May include credit hours from Master's program
c. Will supervise non-thesis final project examination
d. Two-part exam. Must be taken within 2 calendar years from entry. Record holds will be enforced.
e. On Thesis and course work
f. Project examination content determined by the student's supervisory committee
g. On Dissertation and course work
h. 5 years from admission to candidacy.
i. MS Course requirements shown. PhD students must have the equivalent of courses specified in the MS Medical Physics curriculum and then follow the general BME PhD for research

# GENERAL REGULATIONS

## Graduate Assistantships and Fellowships

Graduate Assistantships are available to students in good academic standing (GPA of at least 3.0) through individual academic units. Stipend rates paid are determined by the employing academic unit. Interested students should ask their academic-unit offices about the availability of assistantships and the procedure for making application. Prospective students should write directly to their major academic units.

Graduate assistants are responsible for paying applicable student fees per semester credit hour and will be financially liable for excess credits beyond the required registration. If a student on appointment drops below the required registration at any time in the semester, the student becomes financially liable for the entire registration. (Graduate Catalog – Registration Requirements)

## Registration Requirements

Graduate students on appointments as graduate research assistants with an FTE between .25 and .74 are required to register for 9 credits in the Fall/Spring term and 6 in the summer C term (or 3 in summer A and 3 in summer B).

Full-Time Registration - Students may be considered full-time with a registration of 9-12 credits. Students not on appointment may want to enroll full time to finish their degrees in the minimum timeframe or may be required to enroll full time by external funding agencies or their academic units.

To register for each term, a completed Semester Registration Form must be submitted to the Graduate Student Office (GSO) by 5:00PM on the published registration deadline. Record holds will be enforced. If the registration includes elective, research or independent study course(s), the signature of the student's advisor must be obtained. The Semester Registration Form can be found on the BME website (www.bme.ufl.edu) under *student forms*. Students have access to their degree audit online at www.isis.ufl.edu. Research credits are graded as S/U.

During the term in which the final examination is given and during the term the degree is awarded, a student must be registered for **at least three credits** in fall or spring and **two credits** in the summer in the following courses for each degree option. Masters thesis students must enroll in 6971 and doctoral students must enroll in 7980. Nonthesis Masters students must enroll in course work that counts toward the graduate degree. The minimum final term registration is applicable to all graduate students. The Graduate School will not accept petitions to this policy. (Graduate Catalog – Registration Requirements). Graduate assistants who must register for a certain number of credits as stated in their letter of appointment, must still comply with their required registration.

Students who complete all graduate degree requirements during a given semester, but narrowly miss a deadline specified by the Graduate School due to an unforeseeable event, may receive their degree in the following semester without registering for the minimum three credits (clearing prior). Please see the GSO for clear prior deadlines for the appropriate term.

## Add/Drop

Courses may be dropped or added during the drop/add period without penalty. This period typically lasts five UF calendar days, or two days for summer sessions, beginning with the first day of the semester (exact dates available on www.registrar.ufl.edu). Classes that meet for the first time after the drop/add period may be dropped without academic penalty or fee liability by the end of the next business day after the first meeting. This does not apply to laboratory sections. After this period, a course may be dropped and a W will appear on the transcript. **Students become financially liable for any course added or dropped after the deadline, including students with fee waivers.**

**Retaking Courses** – Graduate students may repeat courses in which they earn failing grades. Grade points from both the initial failed attempt and the first attempt earning a grade of C or better are included in computing the grade point average. The student receives credit for the satisfactory attempt only. (Graduate Catalog – Registration Requirements).

## Courses and Credits

Undergraduate courses (1000-4999) may not be used as any part of the graduate degree requirements. Courses numbered 5000 and above are limited to graduate students. Courses numbered 7000 and above are designed primarily for advanced graduate students.

No more than five credits each of 6910 (Supervised Research) and 6940 (Supervised Teaching) may be taken by a graduate student at the University of Florida. Generally graduate courses may not be repeated for credit. However, there is no limit on courses number 6971, 7979, and 7980. Other courses that may be repeated for credit are designated by max: immediately following the semester credit designation. Course numbers 6971 (Masters Research), 7979 (Advanced Research), and 7980 (Doctoral Research) will not count toward the Masters Non-Thesis degree.

**Professional Work** – Graduate students may receive credit toward their degrees for courses in professional programs (e.g., J.D., D.V.M., or M.D.) when their advisors and graduate coordinators certify that the course work is appropriate for their programs and when the students receive permission from the academic units and colleges offering the courses. A list of such courses for each student must be filed with the Graduate Student Records (106 Grinter) and is limited to a maximum of 9 credits toward the master's degree and 30 credits toward the doctorate. (Graduate Catalog - Courses and Credits).

If a student needs to have any courses that are not considered Graduate Level, i.e., 3000-4000 level, the Graduate Coordinator should make approvals before the student registers for the course. It is crucial that BME students have an overall comprehensive understanding of the curriculum and be able to master it well. If a student lacks in a particular area the Graduate Coordinator should suggest courses to enhance this student(s) education to the benefit of that student and his/her matriculation and experience through the Graduate Program in BME.

## Grades

The only passing grades for graduate students are A, A-, B+, B, B-, C+, C, and S. C+ and C grades count towards a graduate degree if an overall GPA of at least 3.0 is maintained. Grade points are not designated for S and U grades; these grades are not used in calculating the grade point average. All letter graded courses taken as a graduate student, except 1000 and 2000 level courses, are used in calculating the cumulative grade point average.

## Preparation for Final Semester

It is the student's responsibility to ascertain that all requirements have been met and that every deadline is observed. Deadline dates are set forth in the University Calendar and by the college or academic unit. These dates can be found online at the Graduate School website.

Students must notify the BME GSO of graduation plans no later than the registration deadline of the final term. At the beginning of the final term students must also file a degree application online through ISIS and must meet minimum registration requirements. Non-thesis Master's students must complete the Master's Non-Thesis Final Project Form (on BME website under *student forms*) within the first three weeks of the final term. PhD Students should obtain the Checklist for Doctoral Dissertations and Master's students should obtain the Checklist for Master's Theses from the Graduate School website: http://graduateschool.ufl.edu/graduation/thesis-and-dissertation For deadline information regarding submissions to the Graduate Editorial Office, please visit: http://helpdesk.ufl.edu/application-support-center/graduate-editorial-office/ When the dissertation or thesis is ready to be put in final form, the following website offers formatting information: https://asc.helpdesk.ufl.edu/.

# MASTER'S DEGREE

The Department of BME offers both thesis and non-thesis options for the Master's degree. A student seeking the Master's degree with a thesis option is required to pass an oral final exam, and the non-thesis Master's student is required to pass a written comprehensive examination.

Students may choose a thesis or nonthesis option for the Master of Engineering (M.E.) degree. The Medical Physics Concentration is not available for the M.E. degree. To be eligible for admission to the M.E. program students must have earned a bachelor's degree from an ABET-accredited college or they must complete articulation work for equivalence. Admission requirements of the Graduate School must be met. Students who do not meet the ABET requirement may be admitted to the Master of Science program. The nonthesis M.E. degree is a 30-credit course-work only degree (practice-oriented project or capstone course may be included in the 30 credits). At least 15 credits must be in the student's major at the 5000 level or higher. The Thesis option requires 30 credits of course work which may include up to 6 semester credits of research numbered 6971 in all academic units. At least 12 credits, excluding 6971, must be in the student's major field of study. (Graduate Catalog - Master of Engineering).

**Time Limitation** - All work, including transferred credit, counted toward the master's degree must be completed during the seven years immediately preceding the date on which the degree is awarded. (Graduate Catalog - General Regulations).

## Admission Requirements

The students admitted to the Department of BME for the Master's degree will in general be expected to have an undergraduate upper division grade point average of at least 3.4 on a 4.0 scale, a competitive GRE verbal and quantitative score, where applicable, a TOEFL score of no less than 550 for the paper based, 213 for the computer based test or 80 for the internet based.

## Course Requirements

Graduate credit is awarded for courses numbered 5000 and above. The program of course work for a master's degree must be approved by the student's advisor, supervisory committee, or faculty representative of the academic unit. No more than nine credits from a previous master's degree program may be applied toward a second master's degree. These credits are applied only with the written approval of the Dean of the Graduate School.

## Degree Requirements

Unless otherwise specified, for any master's degree, the student must earn a minimum of 30 credits as a graduate student at the University of Florida. No more than 9 of the 30 credits (earned with a grade of A, B+, or B) may be transferred from institutions approved for this purpose by the Dean of the Graduate School. At least half of the required credits, exclusive of 6971, must be in the field of study designated the major. (Graduate Catalog – General Regulations).

## Transfer of Credit

If appropriate, submit a Transfer Petition to the BME Academic Committee, only graduate-level (5000-7999) work, earned with a grade of B or better, is eligible for transfer of credit. S/U coursework is **not eligible** for transfer credit. A maximum of 15 transfer credits are allowed. These can include no more than 9 credits from institution/s approved by UF, with the balance obtained from postbaccalaureate work at the University of Florida (Graduate Catalog - General Regulations). All courses must have a designation (i.e. engineering requirements, engineering electives, Department requirements, etc.).

## Supervisory Committee

The supervisory committee should be appointed as soon as possible after the student has been admitted to the Graduate School **but in no case later than the second semester of graduate study.** (Graduate Catalog - General Regulations).

Their duties are to advise the student, to check on the student's qualifications and progress, to supervise the preparation of the thesis, and to conduct the final exam. The student is responsible for forming a Supervisory Committee and providing the names of the committee members to the Department of Biomedical Engineering Graduate Student Office. The function of the committee is to guide the student through his/her thesis research and to administer the final examination.

The supervisory committee for a master's degree with a thesis must consist of at least three members selected from the Graduate Faculty. At least two members including the chair must hold an academic appointment in the Department of BME. All BME Graduate Thesis students must have a core BME Faculty Member as a member of their supervisory committee. The chairperson is the student's academic advisor and should advise the student in the selection of other members.

The supervisory committee for a master's degree without a thesis may consist of one member of the BME graduate faculty. The chairperson must be affiliated with the Department of BME and is the one who advises the student.

## *Thesis*

Candidates for the master's degree with thesis must prepare and present a thesis acceptable to their supervisory committees and the Graduate School. The candidate should consult the Graduate School Editorial Office for instructions concerning the form of the thesis. The University Calendar specifies final dates for submitting the original thesis to the Graduate School. (Graduate Catalog - Master of Arts and Master of Science).

## Final Examination Procedures

No earlier than the semester preceding graduation, the supervisory committee will give the student an oral examination on the thesis, major and minor subjects, and matters pertaining to his/her field of study.

The student should let the GSO know of their graduation intentions the semester prior to graduation. This will allow time for course requirement checks. It is imperative that copies of the student's thesis be given to the supervisory committee at least one week in advance of the final examination. The Department of BME must receive date, time, title, location, and abstract two weeks prior to the defense date. Graduation may be delayed for those who do not adhere to this rule. All supervisory committee members and the candidate must be present at the final examination. At the time of the examination, all committee members should sign the signature pages and the Final Examination Report.

These may be retained by the supervisory chair until acceptable completion of corrections. The student's advisor will pick up necessary forms at the Department of BME. The Chair of your Supervisory Committee should return the Final Examination Form to the Department of BME.

# *Non-Thesis*

The general BME ME and MS non-thesis master's degrees require 30 hours of course work. The medical physics concentration requires a minimum of 39 hours of course work.

## Final Examination Procedures

For the MS/ME degree, a comprehensive written or oral examination is required. This examination must occur no earlier than the term before the degree is awarded. Results of the examinations are not final until reviewed by the Graduate Coordinator. If the student fails the examination, he/she must retake the examination at the next scheduled time. The exam may be retaken only once. The examination consists of the successful completion of a project designated by a BME faculty member. At the beginning of the semester the final project form is filled out by the student and faculty member and must be submitted to the GSO no later than the third week of the final term. Final signoff is done on the same form at the end of the semester and is resubmitted back to the GSO by the posted final exam deadline. A student can take BME6907 to earn up to 3 credits for the final project.

If a General BME Masters student applies to the PhD program and is accepted, he/she may choose to take the PhD Oral & Written Qualifying Examination and, upon successful completion, satisfy the Master's Non-Thesis and the PhD Oral & Written Qualifying Examination simultaneously.

# CURRICULUM FOR MASTERS DEGREES
DEPARTMENT OF BIOMEDICAL ENGINEERING

## General BME: Graduate Curriculum

| BME Core required (11 Credit Hours) | | Credits |
|---|---|---|
| BME5401 | Biomedical Engineering & Physiology I | 3 |
| BME6010 | Clinical Preceptorship | 3 |
| BME 6936 | BME Seminar (Fall and Spring) | 2 |
| BME Core Math requirement (choose 1 of 2): | | |
| BME5703 | Statistical Methods for BME | 3 |
| or BME5704 | Advanced Computational Methods for BME | 3 |

BME Core Electives (9 Credit Hours)

A BME Core Elective is any graduate course having a BME prefix (excluding BME 6905, BME 6910,BME 6940, BME 6971, BME 7979, BME 7980).

BME Electives (10 Credit Hours)

All BME elective courses require approval from the student's supervisory committee (chair). Allowable courses are all graduate courses offered by the COE or COM.

BME Research

Research under the supervision of a supervisory committee is conducted by students in the MS Thesis and PhD programs. MS Thesis research is conducted under the BME 6971 (Research for Master's Thesis). Research and projects completed as part of a non-thesis MS program are considered to be the final examination for the MS degree for non-thesis students and are conducted under BME 6907 (BME Project). PhD Dissertation research is conducted under BME 7979 prior to completing the Qualifying Exam and BME 7980 once the qualifying exam is completed.

BME Graduate Seminar

MS Students are required to enroll in BME 6936 Fall and Spring semester of their first year. PhD students may defer the required enrollment in BME 6936 to later years, but must enroll in a Fall and Spring offering.

Program Credit Totals

MS/ME: 30 credits

## Medical Physics Concentration

| | FIRST FALL SEMESTER | CREDITS |
|---|---|---|
| BME 6535 | Radiological Physics, Measurements and Dosimetry | 3 |
| BME 6590 | Medical Physics | 3 |
| BME 6533 | Radiological Anatomy | 3 |
| | *Total:* | *9* |
| | **FIRST SPRING SEMESTER** | |
| BME 6591 | Therapeutic Radiological Physics I | 3 |
| ENU 6657 | Diagnostic Radiological Physics I | 3 |
| ENU 5626 | Radiation Biology | 3 |
| | *Total:* | *9* |
| | **FIRST SUMMER SEMESTER** | |
| BME 6592 | Therapeutic Radiological Physics II | 3 |
| | **Elective Course Offerings**** | |
| ENU 6652 | Diagnostic Radiological Physics III | 3 |
| | *Total:* | *3-6* |
| | **SECOND FALL SEMESTER** | |
| ENU 5658 | Imaging System Analysis | 3 |
| BME 6936 | Biomedical Engineering Seminar | 1 |
| BME 6505 | Diagnostic Radiological Physics II | 3 |
| | **Elective Course Offerings**** | |
| BME 6593 | Therapeutic Radiological Physics III | 3 |
| | *Total:* | *7-10* |
| | **SECOND SPRING SEMESTER** | |
| ENU 6636 | Medical Radiation Shielding and Protection | 3 |
| ENU 6659 | Nuclear Medicine Physics | 3 |
| BME 6936 | Biomedical Engineering Seminar | 1 |
| BME 6971 | Masters Research* | 3 |
| BME 6907 or | Non-thesis Research Projects* | |
| | **Elective Course Offerings**** | |
| ENU 6623 | Radiation Dosimetry | 3 |
| | *Total:* | *10-13* |
| | **Total Hours** | **41 min** |

* A minimum of 3 hours of either Masters Research or Non-Thesis Research must be completed as part of the graduate program. It is suggested that students begin their research in the first summer, but may be varied at the discretion of the student's research advisor and supervisory committee. It is anticipated that most students will register for additional research credits throughout their academic program. Thesis students must take BME6971 in their finalterm.

** Students must complete one of the Elective Course Offerings

# DOCTOR OF PHILOSOPHY DEGREE

## Admission Requirements

The students admitted to the Department of BME for the PhD degree will in general be expected to have undergraduate work and graduate work (if taken) equivalent to a 3.4 GPA on a 4.0 scale, a competitive GRE verbal and quantitative score, where applicable, a TOEFL score of no less than 550 for the paper based, 213 for the computer based test, or 80 for the internet based test. The admissions application must also include at least three strong letters of recommendation and a statement of purpose. The statement-of-purpose should include the field of study that you wish to pursue, your intended area of specialization, describe your career goals and why you have selected the University of Florida and the Department of BME.

## Appointment of Supervisory Committee

Upon acceptance into the PhD program, the student has two semesters to identify a professor willing to guide the dissertation research. If no such professor can be found the student can be dismissed from the PhD program. Each student is encouraged to complete this as soon as possible but **no later than the second semester**.

Supervisory committees are nominated by the department chairperson, approved by the dean of the college concerned, and appointed by the Dean of the Graduate School. The dean of the Graduate School is an ex-officio member of all supervisory committees.

**Duties and Responsibilities** – Duties of the supervisory committee follow:

1. To inform the student of all regulations governing the degree sought. It should be noted, however, that this does not absolve the student from the responsibility of informing himself/herself concerning these regulations.
2. To meet immediately after appointment to review the qualifications of the student and to discuss and approve a program of study.
3. To meet to discuss and approve the proposed dissertation project and the plans for carrying it out.
4. To give the student a yearly letter of evaluation in addition to the S/U grades awarded for the research courses 7979 and 7980. The Chair should write this letter after consulting with the supervisory committee.
5. To conduct the qualifying examination or, in those cases where the examination is administered by the academic unit, to take part in it. In either event the entire committee must be present with the student for the oral portion of the examination. This examination must be given on campus.
6. To meet when the work on the dissertation is at least one half completed to review procedure, progress, and expected results and to make suggestions for completion.
7. To meet on campus when the dissertation is completed and conduct the final oral examination to assure that the dissertation is a piece of original research and a contribution to knowledge. No fewer than four faculty members, including all

members of the supervisory committee shall be present with the candidate for this examination. Only members of the official supervisory committee may sign the dissertation and they must approve the dissertation unanimously. (pg 35 Graduate Catalog).

**Membership -** The supervisory committee for a candidate for the doctoral degree shall consist of no fewer than four members selected from the Graduate Faculty. At least two members, including the chair, will be from BME, and at least one member will be drawn from a different educational discipline, unaffiliated with the Department of BME. At least one member should be from the College of Medicine or other health-related college. All BME Graduate PhD students must have a core BME Faculty Member as a member of their supervisory committee. After the committee has been determined, a signed copy of the Supervisory Committee form must be filed with the GSO.

## Course Requirements

The course requirements for doctoral degrees vary from field to field and from student to student. A minimum of 90 credits beyond the bachelor's degree is required for the Ph.D. degree in all fields. All master's degrees counted in the minimum must have been earned in the last seven years.

## Transfer of Credit

See the Graduate Catalog for transfer of credit policy. Students should contact the GSO to begin the process of transferring credits from a previous degree. Once departmental approval is received a petition to the Graduate School is submitted by the department. This petition can not be submitted until final transcripts have been received in the Office of Admissions. All such transfer requests must be made by petition of the BME academic committee no later than the third semester of Ph.D. study.

## Registration in Research Courses

Advanced Research (7979) is open to doctoral students who have not yet been admitted into candidacy (7 and 8 classifications). Students enrolled in 7979 during the term they qualify for candidacy will stay in this registration unless the academic unit elects to change their enrollment to Research for Doctoral Dissertation (7980). Research for Doctoral Dissertation (7980) is reserved for doctoral students who have been admitted to candidacy (9 classification). (Graduate Catalog - Registration in Research Courses).

## Annual Evaluation for PhD Students

The Supervisory Committee Chair, in consultation with the other committee members, will give each PhD student a yearly written evaluation of his/her progress towards his/her degree. The student is given an opportunity to discuss the evaluation with his/her Supervisory Committee Chair. Copies of this evaluation and of student comments are placed in the student's academic file.

## Qualifying and Admission to Candidacy Examinations

**Prequalifying Departmental Exam**:
The General BME program prequalifying exam consists of an oral examination by a committee of 3 Core BME faculty members, which can include the committee chair if he/she is a Core BME faculty member. The student will give a 15-20 minute oral presentation about the research done so far. The examination committee will follow the presentation with questions on the research and its relevant background. The prequalifying departmental examination must be taken in the beginning of the student's fourth major semester (not counting the summer semester). Typically this will be in the student's second Spring semester. Examinations of participating students will be done with-in a one week period at the beginning of the term. If this deadline is missed, a registration hold will be placed on the student's record, which will be released if an extension to this deadline is successfully petitioned with the Academic Committee. The result of the examination is pass/fail. If a student fails, a second examination can be scheduled if recommended by the students' supervisory committee.

The Medical Physics program prequalifying exam consists of a written examination that comprehensively evaluates the subject material embodied in the MS Curriculum. The result of the examination is pass/fail. If a student fails, a second examination can be scheduled if recommended by the students' supervisory committee.

The Qualifying and Admission to Candidacy Examinations must be taken within two calendar years from admission to the PhD program. The Qualifying Examination consists of a written research proposal, which is defended orally. After passing the prequalifying department exam, the student will prepare a written, independent research proposal. This research proposal will be defended before the end of the student's second year. If this deadline is missed, a registration hold will be placed on the student's record, which will be released if an extension to this deadline is successfully petitioned with the Academic Committee. The current policy for these examinations can be found on the web at:
http://www.bme.ufl.edu/academics/graduate/qualexam.

## Final Examination and Doctoral Dissertation

Within six months prior to graduation and after the submission of the dissertation and completion of all other prescribed work for the degree, the doctoral candidate will be given a final examination by his/her supervisory committee. The PhD final examination consists of an oral defense of the research results that are described in the doctoral dissertation.

The Department of BME should be informed of the examination 2 weeks prior to the time that the dissertation is submitted. This will ensure sufficient time to process the Final Examination Report. Copies of the student's dissertation must be given to the supervisory committee members at least one week in advance of the final examination. **Graduation may be delayed for those who do not adhere to this rule.**

At the time of the defense, all committee members should sign the signature pages in the dissertation and sign the Final Examination Report. The final exam report is to be returned to the GSO for forwarding to the College Dean's office and the Graduate School. PhD Students should obtain the Checklist for Doctoral Dissertations from the Graduate School website:
http://gradschool.rgp.ufl.edu/editorial/introduction.html. This website also offers formatting guidelines when the dissertation is ready to be put in final form.

All work for the PhD degree must be completed within five calendar years after the completion of the PhD qualifying exam.

# CURRICULUM FOR DOCTOR OF PHILOSOPHY DEGREE

DEPARTMENT OF BIOMEDICAL ENGINEERING

The Ph.D. Curriculum largely consists of research performed under supervision of a supervisory committee culminating in the defense of a dissertation. Requirements for the Ph.D. include:

- all courses (or equivalent subject coverage) from the respective BME or Medical Physics MS curriculum
- Supervised Teaching: PhD students are required to enroll for two semesters of BME 6940 Supervised Teaching for a total of 6 credit hours.
- pass pre-qualifying and qualifying exams
- Research credits (BME7979 before qualifying exam, BME7980 after qualifying exam passed)
- additional coursework as specified by the supervisory committee
- a minimum of 90 credits
- successful defense of a dissertation

# BME COURSES AND ELECTIVES

## General BME Program Core Courses:

**BME 5401 - Physiology** (3) The course covers the physiology of cells, bones and circulatory system from a Biomaterials, Biomechanics, Cellular & Tissue Engineering perspective.
**BME 6010 - Clinical Preceptorship** (3) Departmental approval required for registration. The Clinical Faculty have unique insights into the restraints on current medical practice imposed by conditions, which may be changed by application of engineering principles. Students shadow a clinical faculty member in a clinic and work with an engineering faculty member to examine some of these practices and restraints with a goal to propose and evaluate possible improvements.
**BME 6936 - Biomedical Engineering Seminar** (1) The seminar provides state of the art reports on engineering research and clinical experience. It is designed to inform students and faculty of current developments, opportunities, and needs in the field. Faculty are encouraged to attend.

**General BME Core Math Requirement:**

**BME 5703 - Statistical Methods for BME** (3) This course covers computational methods needed for biomedical engineering research. Students will be acquainted with a variety of techniques for analyzing and modeling experimental data arising in molecular, cellular, physiological, and pathological systems encountered in typical laboratory and clinical settings.
**BME 5704 – Advanced Computational Methods for BME** (3) This course covers advanced mathematics from a biomedical engineering perspective. Linear and nonlinear systems, partial differential equations, optimization and inverse problems will be discussed. Advanced mathematical techniques are increasingly needed in today's biomedical engineering. For example, one needs a nonlinear system to describe a model or problem in neural engineering. Finite element has been a powerful numerical method to deal with many problems in biomechanics and biomaterials where partial differential equations are involved. Inverse problems are common almost everywhere in the field of biomedical imaging. This course is geared towards the applications of the advanced mathematical techniques to various biomedical engineering problems.

**BME Electives**

**BME 6330 - Cellular & Tissue Engineering** (3) Application of engineering principles toward understanding property-function relationships in cells and tissues. Manipulation of cell and tissue properties or the design of bioartificial substitutes to alter, restore, or improve cell and tissue function.
**BME 6360 – Neural Engineering** (3) Neural Engineering represents the application of Engineering to neuroscience including such diverse areas as neural tissue engineering, models of neural function, and neural interface technology. This course will focus on these areas primarily in the context of neural interfaces/prosthetics beginning with basic neural physiology and models of neural mechanisms to the advanced neural interfaces currently being developed and or produced commercially by the field.
**BME 6502 – Intro to Medical Imaging** (3) This course covers modern medical imaging technologies from a biomedical engineering perspective. The physics, mathematics, instrumentation and clinical applications of all common medical imaging modalities including x-ray radiography, computed tomography (CT), ultrasound imaging, positron emission tomography (PET), and magnetic resonance imaging (MRI) will be discussed. Emerging imaging modalities including diffuse optical tomography (DOT), optical coherence tomography (OCT) and photoacoustic tomography (PAT) will also be introduced.

**BME 5500 - Biomedical Instrumentation** (3) Prereq: Basic knowledge of physics and calculus is required. This course will present all the major methods for measuring physiological signals from the human body. Whenever possible, actual physiological monitors will be used for the students to try out.

**BME6938- Stem Cell Engineering (3)** Topics will include an historical review of stem cell research and policies surrounding it, current stem cell sources, strategies and reviews of current stem cell research. This information is essential for Biomedical Engineers to understand in their attempts to repair/rebuild the human body after injury or disease.

**BME6938- Multivariate Signal Processing** (3) Prereq: Knowledge of multivariate calculus and basic knowledge of probability and statistics is required. This course deals with statistical analysis of biomedical signals from a multivariate time series analysis perspective. Starting from the theory of stochastic processes we introduce analysis concepts and methods both in the time domain and in the spectral domain. Whenever possible actual recordings from biomedical applications will be used to demonstrate the methods

**BME Medical Physics Courses:**

**BME 6505 - Advanced Diagnostic Radiological Physics** (3) *Prereq: ENU 6657.* Applying advanced physical principles, image acquisition, and processing techniques to clinical imaging physics. Methods and principles of MRI and ultrasound imaging. Digital image archiving, transmission and processing standards, and networks.

**BME 6533 – Radiological Anatomy and Physiology** (3) *Prereq:None.* Provides a fundamental knowledge of human anatomy and physiology as illustrated and interpreted through radiological imaging techniques and conventions of relevance to the medical physicist.

**BME 6535 – Radiological Physics, Measurements and Dosimetry** *Prereq: Upper level college physics.* Interactions and measurement techniques for x-rays, gamma rays, neutrons and charged particles with matter; radioactive decay processes ion chamber measurements, scintillation detectors, and dosimetry techniques. Applications of cavity theory and dosimetry measurement in medical physics.

**BME 6590 – Medical Physics** *Prereq/Co-req: BME 6535 (Radiological Physics).* Introduces students to the physical basis and clinical practice of medical physics. Fundamentals of imaging physics and techniques including radiographic, CT, ultrasound, MRI and nuclear medicine procedures. Image quality metrics are introduced and the fundamental strategies of radiation therapy, treatment planning and components of professional development are studied.

**BME 6591 – Therapeutic Radiological Physics I** *Prereq: BME 6535 (Radiological Physics).* Introduces students to the principles of therapeutic radiological physics including the measurement and calculation of absorbed dose and dosimetric calculations. External beam radiation therapy is studied including dose distributions within patients and the treatment planning techniques used to produce desired isodose distributions.

**BME 6592 – Therapeutic Radiological Physics II** *Prereq: BME 6591 (Therapy Radiological Physics I).* Builds upon the basic principles of radiation therapy to study more advanced radiation treatment planning, electron beam and brachytherapy techniques. Topics of clinical and regulatory significance including radiation shielding and quality assurance.

**BME 6593 - Therapeutic Radiological Physics III** *Prereq: BME 6592 (Therapy Radiological Physics II).* Explores state-of-the-art radiation therapy techniques in clinical practice. Examines the physical principles and clinical implementation of three-dimensional conformal therapy, Intensity modulated radiation therapy, stereotactic radiosurgery, high dose rate brachytherapy, image guided radiation therapy, proton beam therapy, and other techniques as they become integrated into clinical practice.

**ENU 5626 - Radiation Biology** (3) *Prereq: one year each of college biology, chemistry, and physics; permission of instructor.* Effects of radiation on biological molecules, cells, and man including cancer and mutagenesis; use of radiation in

treatment of disease.
**ENU 5658 - Image Analysis with Medical Physics Applications** (3) Description and processing of images obtained using X-ray/neutron fields. Filtering, enhancement, reconstruction of CT and coded aperture images. Digital and optical methods.
**ENU 6051 - Radiation Interaction Basics and Applications I** (3) Interaction of X-rays, gamma rays, neutrons, and charged particles with matter; radioactive decay, nuclear moments, and nuclear transitions. Application to basic problems in nuclear engineering sciences.
**ENU 6061- Survey of Medical Radiological Physics** (1) *Prereq: undergraduate classical and modern physics, and differential equations.* An overview of the areas of medical radiological physics including diagnostic radiography, nuclear medicine, and radiation therapy. Basic radiation physics, biology, and safety.
**ENU 6623 - Radiation Dosimetry** (3) Concepts, dosimetry quantities and units, calculations for external gamma, beta, and neutron radiation, calculation of dose from internal radioactivity, dose measurements concepts, gamma and beta dose measurements, dose assessment from survey and personnel monitoring.
**ENU 6636 – Medical Radiation Shielding & Protection** (3) *Prereq: BME or ENU 6051.* Shielding design fundamentals. Methods of calculating gamma-ray attenuation, fast neutron penetration, effects of ducts and voids in shields, problems of heat generation and deposition in reactor components.
**ENU 6651 - Clinical Rotation in Radiation Therapy** (3) *Prereq: working knowledge of therapeutic radiological physics.* Experience in clinical therapeutic radiological procedures, patient dosimetry, and treatment planning.
**ENU 6652 - Clinical Rotation in Diagnostic Radiology** (3) *Prereq: working knowledge of diagnostic radiological physics.* Experience in clinical diagnostic radiological procedures. Application of physical principles to imaging and the quality assurance of the imaging chain.
**ENU 6655 - Advanced Diagnostic Radiological Physics** (3) Applying advanced physical principles, image acquisition, and processing techniques to clinical imaging physics. Methods and principles of MRI and ultrasound imaging. Digital image archiving, transmission and processing standards, and networks.
**ENU 6657 - Diagnostic Radiological Physics** (3) *Prereq: ENU 5615, 6051, 6053.* X- and gamma-ray production and spectra. Radiopharmaceuticals. Medical imaging concepts and hardware. Clinical overview of diagnostic x-ray and nuclear medicine. Application of radiation protection principles.
**ENU 6659 - Nuclear Medicine Instrumentation and Procedure** (3) *Prereq: ENU 5615 or equivalent.* Theory, evaluation, applications of detecting and imaging systems in nuclear medicine including collimators, scintillation probes, cameras, dataprocessing devices; uses of radionuclides in medicine for radiopharmaceutical preparation.

**BME Research:**

**BME 6910 - Supervised Research** (1-5; max: 5) S/U
**BME 6940 - Supervised Teaching** (1-5; max: 5) S/U
**BME 6971 - Research for Master's Thesis** (1-15) S/U
**BME 7979 - Advanced Research** (1-12) Research for doctoral students before admission to candidacy. Designed for students with a Master's degree in the field of study or for students who have been accepted for a doctoral program. Not open to students who have been admitted to candidacy. S/U.
**BME 7980 - Research for Doctoral Dissertation** (1-15) S/U