Brothers, Sheila C

From: Schroeder, Margaret <m.mohr@uky.edu>
Sent: Sunday, January 15, 2017 9:24 PM
To: Brothers, Sheila C; McCormick, Katherine
Subject: GC Engineering in Healthcare
Attachments: Engineering in Healthcare GC revised Dec2016.pdf

Proposed New Graduate Certificate: Engineering in Healthcare

This is a recommendation that the University Senate approve the establishment of a new Graduate Certificate: Engineering in Healthcare, in the F. Joseph Halcomb, III, M. D. Department of Biomedical Engineering within the College of Engineering.

Rationale:

This five-course, 15 credit hour, graduate certificate is designed for those with Bachelor's degrees in engineering, and select other fields who meet certain prerequisites, who wish to extend their education to include the quantitative aspects of medicine and biology and in so doing: a) improve their academic preparedness for medical or dental school, b) gain additional education or clinically-relevant research experience in the interval between undergraduate studies and medical or dental school, or c) explore Biomedical Engineering as a healthcare career option without formally committing to the master's degree program with an option to transfer credits earned towards this degree (following successful application to the master's or PhD degree program).

The revised proposal is attached.

Best-

Margaret

Margaret J. Mohr-Schroeder, PhD | Associate Professor of STEM Education - Mathematics | COE Faculty Council Vice Chair | SAPC University Senate Committee Chair | University Senator/Senate Council Member | Secondary Mathematics Undergraduate Program Chair | | Department of STEM Education | University of Kentucky | www.margaretmohrschroeder.com | Schedule a Meeting with Me

A graduate certificate shall have a clear and focused academic topic or competency as its subject, meet a clearly defined educational need of a constituency group, such as required continuing-education or accreditation for a particular profession, respond to a specific state mandate or provide a basic competency in an emerging (preferably interdisciplinary) topic. Certificates are minimally nine graduate credit hours but typically no more than 15. Completed forms must receive appropriate department/school approval and sent to the college for review.

Once approved at the college level, your college will send the proposal to the Graduate Council for review. Once approved at the Graduate Council, the Graduate Council will send the proposal to the Senate Council office for additional review via a committee and then to the Senate Council. Once the Senate Council has approved the proposal, it is moved to the University Senate. Once approved by that body, the University Senate will send the proposal to the Registrar to be included in the Bulletin. The contact person listed on the form will be informed throughout this process.

By default, graduate certificates shall be approved for a period of six (6) years. Re-approvals are also for six years.

1. GENERAL INFORMATION					
1a	Date of contact with Institutional Effectiveness[1]:	1/11/16			
	☒ Appended to the end of this form is a PDF of the reply from Institutional Effectiveness.				
1b	Home college: *Engineering*				
1c	Home educational unit (department, school, college[2]): *F. Joseph Halcomb III, M. D. Department of Biomedical Engineering*				
1d	Proposed certificate name: *Engineering in Healthcare*				
1e	CIP Code (provided by Institutional Effectiveness):	*14.0501, Bioengineering or Biomedical Engineering*			
1f	Requested effective date:	☐ Fall semester following approval.	OR	☐ Specific Date[3]: *Fall 2016*	
1g	Contact person name: *David Pienkowski*	Email: *pienkow@uky.edu*	Phone: *218-1667*		
2. OVERVIEW					
2a	Provide a brief description of the proposed new graduate certificate. *(300 word limit)*				
	The F. Joseph Halcomb III, M.D. Department of Biomedical Engineering at the University of Kentucky proposes a five-course (minimum 15 credit hours) graduate certificate curriculum entitled "Engineering in Healthcare". Classroom lectures, independent study, or research courses chosen un accord with the requirements and available electives of the proposed certificate from among the courses presently offered will provide students with the academic capabilities needed to apply the interdisciplinary principles inherent within biomedical engineering to solve healthcare problems. The proposed certificate is designed for those with Bachelor's degrees in				

[1] You can reach Institutional Effectiveness by phone or email (257-2873 or institutionaleffectiveness@uky.edu).
[2] Only cross-disciplinary graduate certificates may be homed at the college level.
[3] Certificates are typically made effective for the semester following approval. No program will be made effective unless all approvals, up through and including University Senate approval, are received.

	engineering, and select other fields who meet certain prerequisites, who wish to extend their education to include the quantitative aspects of medicine and biology and in so doing: a) improve their academic preparedness for medical or dental school, b) gain additional education or clinically-relevant research experience in the interval between undergraduate studies and medical or dental school, or c) explore Biomedical Engineering as a healthcare career option without formally committing to the master's degree program with an option to transfer credits earned towards this degree (following successful application to the master's or PhD degree program).
2b	This proposed graduate certificate (check all that apply):
	☒ Has a clear and focused academic competency as its subject.
	☐ Meets a clearly defined educational need of a constituency group (e.g. continuing education or licensing)
	☐ Responds to a specific state mandate.
	☒ Provides a basic competency in an emerging, preferably interdisciplinary, topic.
2c	**Affiliation.** Is the graduate certificate affiliated with a degree program? *(related to 3c)* Yes ☒ No ☐
	If "yes," include a brief statement of how it will complement the program. If "no," incorporate a statement as to how it will provide an opportunity for a student to gain knowledge or skills not already available at UK. *(300 word limit)*
	The proposed certificate complements the existing Master and Doctoral programs in the F. Joseph Halcomb III, M.D. Department of Biomedical Engineering (BME) on the educational, research, and departmental levels. Candidates for the proposed certificate will contribute to the educational mission of this department. They will likely have different academic backgrounds compared to typical BME students, and since all students (proposed certificate candidates and "regular" BME candidates) will take classes contemporaneously, it is anticipated that peer-based student learning will be enhanced due to the expected increased academic diversity. *Candidates for the proposed certificate who select a research elective will be motivated to genuinely engage in faculty-initiated research due to their desire to enhance their medical or dental school application or to explore academic medicine. The effort, enthusiasm, and perspectives contributed by candiates for the proposed certificate while engaging in a research elective will inspire regular BME MS- and PhD-candidates in their thesis or dissertation-relevant research endeavors. Participating faculty and their research programs will also benefit from the active participation of these capable and motivated proposed certificate candidates who seek meaningful engagement in biomedical engineering research endeavors.* *This department, the College of Engineering, and the University will benefit from the: a) increased enrollments due to the enhanced visibility of Biomedical Engineering as a viable healthcare career, b)improved healthcare problem solving skills of certificate graduates pursing careers in medicine and dentistry, and c) increased enrollment of under-represented groups among the student population in Biomedical Engineering.*
2d	**Duplication.** Are there similar regional or national offerings? Yes ☒ No ☐
	If "Yes," explain how the proposed certificate will or will not compete with similar regional or national offerings.
	Seven domestic institutions offer graduate certificates with titles or descriptions containing the words "bioengineering" or "biomedical engineering". Two of these (U Mass and IL Institute of Technology) are "online only". The W VA U certificate, despite self-recognition as a "biomedical engineering" graduate certificate, is titled "Information Assurance and Biometrics" and has no bearing to the presently proposed graduate certificate. Graduate certificates offered by Mississippi State, Worcester Polytechnic, Tufts, and Warnborough College do not compete with the proposed graduate certificate.
2e	**Rationale and Demand.** State the rationale for the new graduate certificate and explain the need for it (e.g. market demand, student requests, state mandate, interdisciplinary topic). *(400 word limit)*
	Admission to medical or dental school is competitive. Some applicants seek post-baccalaureate educational and

	research opportunities to improve their qualifications and differentiate their application. The proposed certificate meets this need by providing applicants an opportunity to: a) complement and extend their undergraduate education (including gain an additional Grade Point Average (GPA) metric), b) gain meaningful clinically-relevant research experience, c) obtain first-hand exposure to academic medicine/dentistry, and d) demonstrate productive use of the interval between undergraduate studies and professional school. *Second, some engineering students pursue careers in medicine or dentistry late in (or after) their undergradute educational program. For them, few(or no) remaining electives exist to help prepare them for their intended new career. The proposed certificate will aid these students by: a) providing them with some of the courses required by medical/dental programs, b) preparing them for sections of the new MCAT and DAT examinations, and c) offering an academic link between their quantitative engineering background and the healthcare-relevant basic science curriculum of medical or dental school.* *Third, medical and dental school applicants need a career alternative in the event of unsuccessful professional school admission. The proposed certificate offers a healthcare career-relevant option by obtaining a relatively quick (one or two semesters), low-cost (15 to 16 credits beyond the proposed certificate) Master's degree in Biomedical Engineering (assuming successful application to the master's program). Students electing this option may also choose to continue their education beyond the master's degree and pursue the PhD degree in BME thereby further broadening their healthcare-related career options.* *Fourth, UK's Department of BME has no undergraduate program and needs a continuous source of students. The proposed certificate partially meets this need by providing a new mechanism for high-caliber students who find biomedical engineering a more suitable profession than medicine/dentistry or who will choose BME as a healthcare career option in the event of unsuccessful professional school admission. Students entering the BME MS or PhD programs from this route will be new to UK and not cannabilized from any existing program.* *Finally, physicians and dentists are confronted with a healthcare system of increasing complexity and technological sophistication. The proposed certificate meets the need for enhanced quantitative reasoning and decision-making skills of future healthcare professionals.*
2f	**Target student population.** Check the box(es) that apply to the target student population.
	☐ Currently enrolled graduate students.
	☒ Post-baccalaureate students.
2g	Describe the demographics of the intended audience. *(150 word limit)*
	Prospective candidates for the proposed certificate include those who: *a) seek admission to medical or dental school and wish to:* • *improve the chances for successful admission by augmenting their healthcare-relevant education,* • *provide added evidence for their commitment to healthcare,* • *demonstrate academic productivity between undergraduate studies and professional school,* • *enhance preparedness for the basic science portion of the professional school curriculum,* • *obtain new quantitative problem-solving skills applicable to healthcare,* • *gain healthcare-relevant research experience,* • *establish a foundation for successful application to competitive residency programs,* • *gain a healthcare-career relevant option in the event of unsuccessful admission,* *b) wish to formally explore biomedical engineering and benefit from an:*

	• *expedited enrollment afforded to post-baccalaureate students,* • *abbreviated time to gain formal academic credentials in BME* • *option to use certificate-gained credits towards the regular MS degree.*

2h	**Projected enrollment.** What are the enrollment projections for the first three years?			
		Year 1	*Year 2 (Yr. 1 continuing + new entering)*	*Year 3 (Yrs. 1 and 2 continuing + new entering)*
	Number of Students	*5*	*10*	*15*

2i	**Distance learning (DL).** Initially, will any portion of the graduate certificate be offered via DL?	Yes ☐	No ☒

	If "Yes," please indicate below the percentage of the certificate that will be offered via DL.				
	1% - 24% ☐	25% - 49% ☐	50% - 74% ☐	75 - 99% ☐	100% ☐

	If "Yes," describe the DL course(s) in detail, including the number of required DL courses. *(300 word limit)*

3. ADMINISTRATION AND RESOURCES

3a	**Administration.** Describe how the proposed graduate certificate will be administered, including admissions, student advising, retention, etc. *(150 word limit)*
	The proposed Certificate Director will administer the proposed certificate and will obtain advice from the department (Biomedical Engineering) chair. The proposed Certificate Director will prepare advertising materials and actively market the proposed certificate. He will review applications for the certificate, and with consultation from the chair as needed, will make admission decisions. Admitted students will receive individualized advising from the proposed Certificate Director regarding course selection and healthcare career-relevant applicability. Faculty who teach students in the proposed certificate will submit mid-term grades of these students to the proposed Certificate Director for monitoring and, if needed, goal-oriented academic advising. Students who seek withdrawal from the certificate curriculum will be consulted by the proposed Certificate Director regarding cause; remediation efforts will be made if applicable. If unsuccessful, then an exit interview will be conducted.

3b	**Faculty of Record and Certificate Director.** *(related to 2c)* **T**he faculty of record consists of the graduate certificate director and other faculty who will be responsible for planning and participating in the certificate program. The director must be a member of the Graduate Faculty of the University and is appointed by the dean of the Graduate School. The faculty of record must be comprised of three or more faculty. At least three members of the graduate certificate's faculty of record must be members of the Graduate Faculty.		
	The graduate certificate is affiliated with a degree program.	Yes ☒	No ☐
	If "Yes," list the name of the affiliated degree program below. If "No," describe below the process for identifying the faculty of record and the certificate director, including selection criteria, term of service, and method for adding and removing members. *(150 word limit)*		
	Graduate Program in Biomedical Engineering		

3c	**Course utilization.** Will this graduate certificate include courses from another unit(s)?	Yes ☒	No ☐

	If "Yes," two pieces of supporting documentation are required. ☒ Check to confirm that appended to the end of this form is a letter of support from the other units' chair/director[4] from which individual courses will be used. The letter must include demonstration of true collaboration between multiple units[5] and impact on the course's use on the home educational unit. ☒ Check to confirm that appended to the end of this form is verification that the chair/director of the other unit has consent from the faculty members of the unit. This typically takes the form of meeting minutes.
3d	**Financial Resources.** What are the (non-course) resource implications for the proposed graduate certificate, including any projected budget needs? *(300 word limit)*
	No significant expenditure of funds is anticipated to implement the proposed certificate. Courses included in the proposed certificate are approved and currently offered. No new courses will be developed for the proposed certificate.
3e	**Other Resources.** Will the proposed certificate utilize resources (e.g. departmentally controlled equipment or lab space) from additional units/programs? Yes ☐ No ☒
	If "Yes," identify the other resources that will be shared. (*150 word limit*)
	If "Yes," two pieces of supporting documentation are required. ☐ Check to confirm that appended to the end of this form is a letter of support from the appropriate chair/director[4] of the unit whose "other resources" will be used. ☐ Check to confirm that appended to the end of this form is verification that the chair/director of the other unit has consent from the faculty members of the unit. This typically takes the form of meeting minutes.
4. IMPACT	
4a	**Other related programs.** Are there any related UK programs and certificates? Yes ☐ No ☒
	If "Yes," describe how the new certificate will complement these existing UK offerings. *(250 word limit)*
	If "Yes," two pieces of supporting documentation are required. ☐ Check to confirm that appended to the end of this form is a letter of support from each potentially-affected academic unit administrators. ☐ Check to confirm that appended to the end of this form is verification that the chair/director has input from the faculty members of the unit. This typically takes the form of meeting minutes.
5. ADMISSIONS CRITERIA AND CURRICULUM STRUCTURE	
5a	**Admissions criteria.** List the admissions criteria for the proposed graduate certificate. *(150 word limit)*
	Prospective students for the proposed certificate must: 1) have a bachelor's degree in engineering from an ABET-accredited post-secondary school (or equivalent) or a bachelor's degree in biology, chemistry, mathematics, or

[4] A dean may submit a letter only when there is no educational unit below the college level, i.e. there is no department/school.

[5] Show evidence of detailed collaborative consultation with such units early in the process.

	physics, 2) earn a GPA of 3.0 or greater at the institution granting the bachelor's degree, and 3) demonstrate (via official transcript) successful completion (grade B or better) in each of 2 courses (minimum 6 credit-hours total) of college mathematics (consisting of differential and integral calculus). All three criteria must be met to be eligible for admission into the proposed certificate. Applicants for admission to the proposed certificate must apply for, and be approved by, the propossed Certificate Director prior to taking classes that will be counted towards completion of the certificate. Students enrolled in the MS or PhD programs in Biomedical Engineering are ineligible for the proposed Engineering in Healthcare graduate certificate; however, exceptions can be made as noted (Section 5d).

5b **Core courses.** List the required core courses below.

Prefix & Number	Course Title	Credit Hrs	Course Status[6]
BME 530	*Biomedical Instrumentation*	*3*	No Change
BME 640	*Biomedical Engineering Ethics*	*1*	No Change
			Select one....
			Select one....
			Select one....
	Total Credit Hours of Core Courses:		

5c **Elective courses.** List the electives below.

Prefix & Number	Course Title	Credit Hrs	Course Status[7]
			Select one....
BME 579	*Neural Engineering*	*3*	No Change
BME 599	*Topics in Biomedical Engineering*	*3*	No Change
BME 605	*Biomedical Signal Processing*	*3*	No Change
BME 610	*Biomedical Control Systems*	*3*	No Change
BME 615	*Biomedical Signal Processing II*	*3*	No Change
BME 661	*Biomedical Materials Science and Engineering*	*3*	No Change
BME 662	*Tissue Implant Interface*	*3*	No Change
BME 670	*Biosolid Mechanics*	*3*	No Change

[6] Use the drop-down list to indicate if the course is a new course ("new"), an existing course that will change ("change"), or if the course is an existing course that will not change ("no change").

[7] Use the drop-down list to indicate if the course is a new course ("new"), an existing course that will change ("change"), or if the course is an existing course that will not change ("no change").

BME 672	*Musculoskeletal Biomechanics*	*3*	No Change
BME 685	*Biofluid Mechanics*	*3*	No Change
BME 781	*Special Problems in Biomedical Engineering*	*3*	No Change
BME 790	*Research in Biomedical Engineering*	*3*	No Change
PGY 412g	*Principles of Human Physiology Lectures*	*4*	No Change
PGY 502	*Principles of Systems, Cellular, and Molecular Physiology*	*5*	No Change
			Select one....
			Select one....
			Select one....
			Select one....
			Select one....

5d	Are there any other requirements for the graduate certificate? If "Yes," note below. *(150 word limit)*	Yes ☒	No ☐
	Successful completion of the certificate requires a GPA of 3.0 or greater for all courses taken in pursuit of the certificate. Students enrolled in the MS or PhD programs in Biomedical Engineering are ineligible for the proposed Engineering in Healthcare graduate certificate; however, exceptions can be made on a case-by-case basis with a majority vote of the students advisor, Director of Graduate Studies, and Certificate Director.		

5e	Is there any other narrative about the graduate certificate that should be included in the Bulletin? If "Yes," please note below. *(300 word limit)*	Yes ☒	No ☐
	The Engineering in Healthcare certificate offers quantitative graduate-level study of contemporary human healthcare problems based upon multidisciplinary scientific principles applied using engineering methods. This certificate is designed for students with a bachelor's degree in engineering, science, or mathematics who: a) desire new application of existing quantitative skills to processes and challenges attending the human body, b) wish to improve the academic competitiveness of their application to medical or dental school, c) seek academic engagement in engineeering healthcare during the interval between undergraduate studies and the beginning of medical or dental school, d) want clinically-relevant research experience with engineering and medical or dental faculty, e) contemplate a career in academic medicine or dentistry and seek preliminary experience in research-related career aspects, f) desire a healthcare-related career alternative in the event of unsuccessful admission to medical or dental school, or g) wish to explore biomedical engineering without formally committing to a master's program, yet retain the option to apply certificate-earned credits toward the Master's or PhD degree.		

6. ASSESSMENT

6a	**Student learning outcomes.** Please provide the student learning outcomes for the graduate certificate. List the knowledge, competencies, and skills (learning outcomes) students will be able to do upon completion. (Use action verbs, not simply "understand.") *(250 word limit)*
	Students who have successfully completed the certificate will obtain new knowledge regarding the anatomy, biochemistr,y and physiological processes of the human body. They will apply this new knowledge as the foundation for certificate-derived competencies regarding the identification and quantification of engineering

	parameters describing selected human anatomical, biochemical, and physiological processes. The level of these competencies will be assessed by oral and written examinations which gauge the students ability to integrate qualitative facts and processes with the appropriate mathematical relationships linking the key parameters describing these facts and processes. Certificate-conferred skills will be also be assessed by oral examinations that measure the student's ability to analyze these quantitatiave expressions and from them draw clinically relevant conclusions that students can effectively communicate to professional healthcare providers in multiple oral (one-on-one to professional conference presentations) and written (technical reports) venues. Student skill attainment will also be assesed by oral examinations evaluating the ability of the students to defend these quantitative engineering models and explanations against competing evidence and theories. Faculty administering these oral and written examinations will require minimum standards of competency that are greater than the standards required of undergraduate students pursuing a minor in biomedical engineering, but less than the standards required of graduate students pursuing a master's degree in biomedical engineering.
6b	**Student learning outcome (SLO) assessment.** How and when will student learning outcomes be assessed? Please map proposed measures to the SLOs they are intended to assess. Do not use grades or indirect measures (e.g. focus groups, surveys) as the sole method. Measures likely include artifacts such as course-embedded assessment (e.g., portfolios, research papers or oral presentations); and course-embedded test items (embedded test questions, licensure/certification testing, nationally or state-normed exams). *(300 word limit)*
	Assessment of student learning outcome will be obtained from three different sources. First: student learning progress in coursework will be assessed by in-class performance, homework assignments, and course-required projects. Second, it is anticipated that most students in the proposed certificate will choose a research elective; learning outcomes from research electives will be assessed by performance regarding: laboratory assignments, intramural oral presentations, written assignments, and contributions to scientific communications (where appropriate). The third metric of student learning outcomes will be obtained from faculty based evaluations assessing student knowledge and quantitative reasoning skills demonstrating their level of application of engineering principles to anatomical, biochemical, and physiological processes that result in clinically relevant new insights effectively communicated to healthcare professionals.
6c	**Certificate outcome assessment[8].** Describe evaluation procedures for the proposed graduate certificate. Include how the faculty of record will determine whether the program is a success or a failure. List the benchmarks, the assessment tools, and the plan of action if the program does not meet its objectives. *(250 word limit)*
	Multiple levels of certificate outcome assessment are described in Section 2.7 of the attached document.
7. OTHER INFORMATION	
7a	Is there any other information about the graduate certificate to add? *(150 word limit)*
	This is a novel certificate that offers benefits to all stakeholders, especially students, the University and the healthcare community. See Section 1.1 of the attached document. The proposed certificate augments, but does not compete with, other UK graduate or professional programs.

8. APPROVALS/REVIEWS

Information below does not supersede the requirement for individual letters of support from educational unit administrators and verification of faculty support (typically takes the form of meeting minutes).

	Reviewing Group Name	**Date Approved**	**Contact Person Name/Phone/Email**

[8] This is a plan of how the certificate will be assessed, which is different from assessing student learning outcomes.

8a	(Within College) *In addition to the information below, attach documentation of department and college approval. This typically takes the form of meeting minutes but may also be an email from the unit head reporting department- and college-level votes.*		
	Dept of Biomed. Eng.	*2 March 2015*	*David Pienkowski / 218-1667 / pienkow@uky.edu*
	College of Engineering	*21 April 2016*	*BJ Brandenburg / 257-7978 / barbara.brandenburg@uky.edu*
			/ /
			/ /
8b	(Collaborating and/or Affected Units)		
	Physiology	*24 March 2015*	*Francisco Andrade / 323-6045 / paco.andrade@uky.edu*
	Physiology	*16 February 2016*	*Allison Walters / 323-4618 / allison.walters@uky.edu*
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8c	(Senate Academic Council)	**Date Approved**	**Contact Person Name**
	Health Care Colleges Council (if applicable)		
	Graduate Council	*2 May 2016*	

			/ /
			/ /
			/ /

8c	(Senate Academic Council)	**Date Approved**	**Contact Person Name**
	Health Care Colleges Council (if applicable)		
	Graduate Council	5/12/16	Roshan Nikou

Schroeder, Margaret <mmohr2@g.uky.edu>

New Cmte Item (SAPC)_Proposed New Graduate Certificate in Engineering in Healthcare

Pienkowski, David <pienkow@uky.edu> Fri, Oct 14, 2016 at 5:31 PM
To: "Schroeder, Margaret" <m.mohr@uky.edu>
Cc: "Patwardhan, Abhijit" <abhijit.patwardhan@uky.edu>, "Pienkowski, David" <pienkow@uky.edu>

Dear Margaret:

Thank you for the comments from the committee.

In light of these comments, attached please find two revised application documents (both dated today in the file name) for the proposed “Engineering in Healthcare” certificate.

Point-by-point responses to the comments provided to me from the committee are provided in green ink.

Please advise if these responses and changes to the application documents are satisfactory.

Thank you for moving this certificate program forward. I look forward to your response.

David

From: Schroeder, Margaret [mailto:m.mohr@uky.edu]
Sent: Monday, October 03, 2016 1:45 PM
To: Pienkowski, David
Subject: Re: New Cmte Item (SAPC)_Proposed New Graduate Certificate in Engineering in Healthcare

Hi David-

The SAPC met today to review the Proposed Graduate Certificate in Engineering in Healthcare. The committee moved to table the approval of the certificate pending the following recommendations:

* Please restate 6a in SACS-COC Student Learning Outcome Language. These are the SLOs your program will be held to during periodic review, SACS review, etc. Make sure that the assessment you have for the SLOs really do assess the SLOs. Section 6a was restated according to criteria listed in Regional Accreditation and Student Learning guidelines endorsed by the Commission on Colleges of the Southern Association of Colleges and Schools.
* According to the minutes attached from the Dept of Physiology, PGY 412G and 502 are required courses. This does not match what is listed in program requirements. Please clarify for the committee the content of the minutes. The letter from the chair seems to suggest that they are OK with the inclusion and does not mention them being required. Is the latter what is true? No. Per section 5a there are no required courses. Per Section 5c, PGY 412g or PGY 502 are elective courses.
* You state the students should complete the certificate in one semester, 15-17 hours total. Over 15 hours is considered overload at the graduate school level. Please add a statement in there clarifying that if a student takes over 15 hours they will have to seek permission from the graduate to take an overload of courses. In accord with the committee’s recommendation, the following sentence was added to the third paragraph of section 2.6: “Students in the proposed certificate program who chose courses totaling 16 or 17 credit hours must either distribute such coursework over two or more semesters, or formally obtain permission for an overload from the Graduate School if they desire to complete either a 16 or 17 credit hour program in a single semester.
* STA is listed as required, but there is no indication the department was contacted and OK with the inclusion of the course. Statistics course references deleted.
* Where are the physiology courses? Listed on page 7 of the application form. Are they assumed to be elective options in the tracks you identify? Yes
* There are no minutes from your department and college indicating this program was approved. Minutes of the Biomedical Engineering Departmental Faculty Meeting showing approval of the proposed program on 2 March 2015 are attached.
* Please remove the syllabi from the program paperwork. They are not required and not necessary. Removed as requested.
* Under the evaluation form attached at the end, you state a physiology elective and stats elective has to be taken. This

does not match the program requirements in the certificate form. Same with research hours. They are stated on the evaluation form but not included in the program paperwork. Evaluation form revised – references to PGY and STA removed (see Appendix D)

* Evaluation form reads they will need to take MCAT/DAT and reapply for M/D school. The committee was curious why you thought this certificate program would increase MCAT/DAT scores? Program assessment did not include scores on such tests, but rather admissions. The committee suggests removing references to increase MCAT/DAT scores. Done as suggested – evaluation form revised (see Appendix D)

Once the revised program is received, the committee will re-review. If you have any questions, please don't hesitate to ask.

Best-
Margaret

Margaret J. Mohr-Schroeder, PhD <https://education.uky.edu/stem/faculty-and-staff/about-mohr-schroeder/> | Associate Professor of STEM Education - Mathematics | COE Faculty Council Vice Chair<http://sites.education.uky.edu/facultycouncil/> | SAPC University Senate Committee Chair <http://www.uky.edu/Faculty/Senate/committees_councils/standing_committees/academic_programs.htm> | University Senator/Senate Council Member<http://www.uky.edu/Faculty/Senate/> | Secondary Mathematics Undergraduate Program Chair<https://2b.education.uky.edu/stem/new/undergraduate-programs/> | | Department of STEM Education<http://goog_321265639/> | University of Kentucky<http://www.uky.edu/> | www.margaretmohrschroeder.com<http://www.margaretmohrschroeder.com> | Schedule a Meeting with Me<https://www.vyte.in/mohrschroeder#!>
[Quoted text hidden]
Phone (859) 257-5872<tel:%28859%29%20257-5872>
http://www.uky.edu/faculty/senate

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2 attachments

New Graduate Certificate Application Form 14 October 2016.docx
89K

Graduate Certificate in Biomedical Engineering Revised 14 October 2016.docx
59K

ENGINEERING IN HEALTHCARE

A Proposed Graduate Certificate

CIP Code: 14.0501, Bioengineering or Biomedical Engineering

1. SUMMARY

The F. Joseph Halcomb, III M.D. Department of Biomedical Engineering at the University of Kentucky proposes a five-course (minimum 15 credit hours) certificate entitled "Engineering in Healthcare". Courses taken in pursuit of this certificate will give students experience in the application of engineering principles to solve healthcare problems. It is designed for engineering graduates who seek extension of their education into healthcare related fields to permit: a) improvement in their application to and academic preparedness for medical or dental schools, b) meaningful experiences (including research) in the "gap year" between undergraduate and medical or dental studies, or c) exploration of Biomedical Engineering as a healthcare career alternative without a formal commitment to the biomedical engineering master's degree program.

Courses to be taken in pursuit of this certificate are those which are already approved and currently taught at the University. No new courses are required for implementation of this certificate.

1.1 Need

Students

Medical or dental school admission is highly competitive. Applicants to these programs endeavor to maximize their success and thus seek post-baccalaureate educational and research opportunities to differentiate their application. The proposed certificate meets this need. Specifically, it provides such students an opportunity to: a) complement and extend their undergraduate education into the healthcare field, b) gain research experience by active engagement in ongoing healthcare-related research, c) gain exposure to academic medicine or dentistry, and d) demonstrate productive use of time in the "gap" year (or two) between undergraduate studies and professional school.

The proposed certificate satisfies the unmet need of engineering and other non-life science graduates who recognize the need to compete with life science major classmates during the basic science portion of medical and dental school. Additional education offered by the proposed certificate provides students with the foundation for enduring academic success.

University of Kentucky

The proposed certificate provides three benefits to UK's F. Joseph Halcomb, III M.D. Department of Biomedical Engineering.

First, this certificate will bring new markets for UK's educational products. It promises a new supply of students for graduate courses (chiefly biomedical engineering). These students will be new admits (in post-baccalaureate status) to the University. There will be no competition with, or cannibalization of students from, other UK graduate programs.

Second, this certificate offers a new mechanism for high-quality applicants into the conventional MS and PhD Biomedical Engineering programs. Biomedical Engineering at UK has no undergraduate program and relies upon students from other majors and other institutions. The proposed certificate offers medical and dental school applicants a healthcare career alternative in the event of unsuccessful professional school admission. The potential also exists that some applicants, having experienced biomedical engineering in pursuit of enhanced medical or dental school preparedness, may change their mind and opt for a career in biomedical engineering as their primary objective. Regardless of reason, the attractiveness of this certificate

to these students is that completion of an additional 14 to 16 credits (plus satisfaction of any other prerequisites) will enable certificate recipients to obtain a master's degree in Biomedical Engineering. It is anticipated that some of these students will continue and pursue the PhD degree.

Finally, Biomedical Engineering faculty will benefit from the enthusiastic participation of certificate students exercising the option to engage in research. Although this research exposure is of only approximately one semester, strategic design of faculty research into semester-long "chewable chunks" of hands-on laboratory research is expected to yield substantial dividends from highly qualified medical and dental school hopefuls. These candidates will be highly motivated to perform given they seek: a) genuine research exposure, b) want publications, and (most of all) c) seek letters of recommendation from faculty (particularly UK MDs collaborating with UK biomedical faculty).

Healthcare Community

Physicians and dentists are confronted with a healthcare system of increasing complexity and technological sophistication. Growth in understanding of biological processes, increasingly high-level diagnostic tests and instrumentation, and expanding treatment options pose significant challenges to providers who must clinically and cost-effectively assimilate this knowledge. The proposed certificate will aid the healthcare system by enhancing the technological cognitive skills of emerging physicians and dentists. Specifically, it will: a) enhance student understanding the scientific basis of existing technologies, b) provide a foundation for objective evaluation and assimilation of new technologies, and c) encourage development of academic physicians and dentists. The proposed certificate will narrow the academic knowledge gap between engineering and life science majors while simultaneously enhancing their quantitative problem-solving skills and demonstrating application of these skills to solve contemporary healthcare challenges. Ultimately, this certificate seeks to accomplish for pre-professional healthcare education the analogue of that which STEM-based high school education seeks to accomplish for post-secondary school technological literacy.

1.2 Content

The content of the proposed certificate consists of courses in classroom instruction with options for focused independent study and laboratory research. Such laboratory research will consist of hands-on work with certificate faculty (Table 1) and related faculty in the College of Medicine, College of Dentistry, or other as determined by the specific research endeavor. All but two courses (both in Physiology) in the proposed curriculum for this certificate are in the F. Joseph Halcomb, III M.D. Department of Biomedical Engineering. Initially, all courses will be delivered by onsite instruction, but selected instruction may be delivered by distance learning at a future date. Courses included in this certificate are approved and currently being taught. No new courses will be developed for the proposed certificate.

1.3 Projected Outcomes

Projected outcomes for students include: a) new knowledge regarding the quantitative bases for human physiology, control, and reparative systems; b) enhanced acceptance rate into medical or dental school; c) and new skills enabling application of previously developed analytical capabilities to human healthcare problems.

Projected institutional and societal outcomes of the proposed certificate include: a) enhancement of the academic quality and performance of the medical and dental school classes, particularly at UK; b) quantity and quality of graduate students in UK Biomedical Engineering; c) performance improvement in next-generation physicians and dentists; and d) development of healthcare professionals better equipped to create new, or better utilize existing, healthcare technologies.

2. DETAILS

2.1 Admission Requirements

Prospective students must: 1) have a bachelor's degree in engineering from an ABET-accredited post-secondary school (or equivalent) or a bachelor's degree in biology, chemistry, mathematics, or physics, 2) demonstrate (via official transcript) successful completion (grade B or better in each) of two semesters of college mathematics (differential and integral calculus), and 3) have earned a GPA of ≥ 3.0 at the institution granting the bachelor's degree. Prospective students fulfilling these requirements will be considered for admission to the graduate school as post-baccalaureates and as candidates for the proposed certificate.

Applicants to the proposed certificate must be approved by the Certificate Director, who will then notify the Graduate School in writing. Prospective students should apply and be admitted to the curriculum prior to taking any classes to be counted towards the certificate. Students will be advised that admission to or award of the proposed certificate does not guarantee admission to the Biomedical master's or PhD degree program. Students enrolled in these MS or PhD programs are ineligible for the proposed Engineering in Healthcare graduate certificate; however, exceptions can be made on a case-by-case basis with a majority vote of the students advisor, Director of Graduate Studies, and Certificate Director.

2.2 Primary and Joint Appointment Faculty of Record

Faculty with primary appointments in Biomedical Engineering will actively participate in teaching, research, and administration of the proposed certificate as noted (Table 1). They engage in multidisciplinary research collaboration with those having primary appointments in other departments and a joint appointment in Biomedical Engineering (Table 2). Collaborative efforts also occur between biomedical engineering faculty and faculty in other departments who do not have a joint appointment in biomedical engineering. These collaborative efforts provide the basis for all certificate-relevant courses.

Table 1

Primary Appointments in Biomedical Engineering

Faculty Member	Graduate Faculty Status	Responsibilities
David Pienkowski, PhD, MBA	Full Graduate Faculty	Proposed Certificate Director, advise certificate students, convene certificate faculty meetings, teach classroom courses and offer research courses
Babak Bazrgari, PhD	Associate Graduate Faculty	teach classroom courses and offer research courses, participate in certificate faculty meetings/decisions
Abhijit Patwardhan, PhD	Full Graduate Faculty	Interim Chair & Director of Graduate Studies, teach classroom courses and offer research courses
David Puleo, PhD	Full Graduate Faculty	Department Chair, teach classroom courses, offer research courses, and participate in certificate faculty meetings and decisions.
Hainsworth Shin, PhD	Associate Graduate Faculty	teach classroom courses and offer research courses, participate in certificate faculty meetings/decisions
Sridhar Sunderam, PhD	Associate Graduate Faculty	teach classroom courses and offer research courses, participate in certificate faculty meetings/decisions
Guoqiang Yu, PhD	Full Graduate Faculty	teach classroom courses and offer research courses, participate in certificate faculty meetings/decisions

Table 2

Joint Appointments

Faculty Member	Graduate Faculty Status	Primary Appointment	Field of Research
Anders Andersen, Ph.D.	Associate Graduate Faculty	Anatomy & Neurobiology, MRISC	Analog & Digital Signal Processing
Kimberly Anderson, Ph.D.	Full Graduate Faculty	Chemical and Materials Engineering	Cellular Bioengineering
Donald T. Frazier, Ph.D.	Full Graduate Faculty	Department of Physiology	Pulmonary Function and Control
Bradley Gelfand, Ph.D.	Associate Graduate Faculty	Department of Ophthalmology and Visual Science	Fluid Mechanics and Molecular Biological Techniques
Peter A. Hardy, Ph.D.	Associate Graduate Faculty	Department of Radiology	Magnetic Resonance Imaging of cartilage
Lu-Yuan Lee, Ph.D.	Full Graduate Faculty	Department of Physiology	Chemosensitive Neurons in the Lung Airway Inflammation Bronchial Hyperreactivity
David K. Powell, Ph.D.	Associate Graduate Faculty	Department of Anatomy & Neurobiology	Magnetic Resonance Imaging of Neurodegenerative Diseases
David Randall, PhD	Full Graduate Faculty	Department of Physiology	Cardiovascular Control Systems
Keith Rouch, Ph.D.	Full Graduate Faculty	Department of Mechanical Engineering	Finite Element Analysis and Modeling
Sibu Saha, M.D.	Associate Graduate Faculty	Department of Surgery	Transmyocardial revascularization Cartotid atherosclerosis therapy for hypertension
Robert Shapiro, Ph.D.	Full Graduate Faculty	Department of Kinesiology and Health Promotion	Biomechanics and Motion Analysis
Charles Smith, M.D.	Full Graduate Faculty	Department of Neurology	Magnetic Resonance Imaging and Spectroscopy
Margaret M. Szabunio, M.D.	Full Graduate Faculty	Department of Radiology	Breast cancer screening and diagnosis, breast ultrasound
Moriel Vandsburger, Ph.D.	Associate Graduate Faculty	Department of Physiology	Magnetic resonance imaging, molecular imaging, heart failure, heart function
Janet Walker, M.D.	Full Graduate Faculty	Department of Orthopaedic Surgery	Pediatric Orthopaedics
Joseph Zwischenberger, M.D.	Full Graduate Faculty	Department of Surgery	Artificial Organs

2.3 Administration

The proposed certificate will be administered by primary faculty (Table 1) and staff in the F. Joseph Halcomb, III M.D. Department of Biomedical Engineering. Certificate-relevant decisions will be made by a majority vote (quorum assumed) of primary BME faculty attending the regular BME faculty meeting where certificate actions are on the distributed pre-meeting agenda. Student evaluations, based upon existing MS and PhD student evaluation forms (Appendix D) in current use, will be completed for each student enrolled in the certificate program at the end of each fall and spring semester. These evaluation forms will be reviewed by the Certificate Director and the Department Chair.

2.4 Division of Labor

Courses will be taught by Biomedical Engineering faculty, and as needed, by faculty in Physiology per their regular teaching schedule. Special offerings of regularly scheduled courses may be provided in response to unexpectedly larger than normal enrollments. Such special course offerings will be held at the faculty member's discretion and with the approval of the Department Chair.

2.5 Resources

No additional resources will be required to implement any courses in the proposed certificate curriculum. To augment certificate enrollment occurring from passive website recruitment, the Certificate Director will travel to area schools, e.g., Vanderbilt, Ohio State, Indiana University, etc., and actively promote the new certificate to pre-medical and pre-dental societies and related institutional advisors. Development of this approach to these schools, programs, and advisors will be assisted and beta-tested at UK's College of Medicine with the advice of their pre-medical advisor Kim Scott. Modest additional resources to offset such direct marketing costs will be allocated internally.

2.6 Curriculum Design

This certificate allows flexibility to meet the educational needs of a variety of students without constraining them to courses external to their interests. The certificate allows students the opportunity to choose courses spanning a wide breadth of subspecialty fields in biomedical engineering to those conferring depth in a specific sub-specialty field via suggested courses in areas of emphasis. These areas of emphasis consist of two or three 3-credit courses in a closely-related biomedical engineering sub-specialty field. Suggested courses for students seeking expertise in specific sub-specialty fields of biomedical engineering are provided (Appendix B).

Students enrolled in this certificate must take two required courses (BME 530 "Instrumentation", 3 credits and BME 640 "Biomedical Engineering Ethics", 1 credit) plus any non-repeated combination of the elective courses listed (Appendix A). Exceptions to this rule are that either PGY 412g or PGY 502 may be taken as an elective, but not both. Also, certificate students choosing BME 790 may not enroll for more than 3 credit hours.

The minimum number of credit hours required to for successful completion of the certificate curriculum is 15. Students may take courses in the certificate curriculum that total more than 15 credit hours; however, such students must either distribute their coursework over 2 or more semesters or formally obtain permission for an overload from the Graduate School and so notify the Certificate Director.

Descriptions of the required (core) and elective courses in the certificate curriculum are excerpted from the University of Kentucky Bulletin and shown (Appendix A) followed by a rationale for inclusion in the curriculum of the proposed certificate.

2.7 **Assessment**

	Measure	Data Source	Target
Recruitment	Number of recruitment events	Website visit log, mail log, travel log, telephone log,	• > 500 visits/yr. to Certificate links at UK Biomed. Eng., Med & Dental school, MD/PhD program websites • > 10 letters + telephone calls/yr. to pre-medical programs & advisors • > 2 personal visits/yr. to other institutions to promote this certificate
Applicants	Number of applicants to the certificate	Applicant Log maintained in Department of Biomedical Engineering	> 10 applicants to this certificate each year
Enrollment	Number of students admitted to certificate	Department of Biomedical Engineering Database	> 75% of applicants admitted to this certificate
Retention	Number of students receiving certificate	Department of Biomedical Engineering Database	> 90% of enrolled students successfully completing this certificate
Student Satisfaction	Teacher Course Evaluation Scores	Teacher Course Evaluation Forms	Students ratings for certificate courses > 3.0 on a 4-point scale
Student Performance	Student grades	UK Transcripts	Minimum GPA of certificate courses must be > 3.0
Outcomes - I	Professional and Graduate School admission rates for certificate enrollees	• Email follow-up • Telephone call check with non-UK programs	• > 50% certificate graduates successfully placed in medical or dental school • > 10% Certificate graduates successfully admitted to Master's or PhD program.
Outcomes - II	Residency of choice admission rates, specifically: • Percent of students admitted to residency specialty (but not location) of choice • Percent of students admitted to residency specialty and location of choice	• Email follow-up • Telephone call check with non-UK programs	• > 20% of med or dental school graduates secure positions in their post-grad med or dental subspecialty field of first choice • > 50% of med or dental school graduates secure positions in their chosen post-grad med or dental subspecialty program

If the proposed certificate does not meet its enrollment objectives, then:

- the proposed Certificate Director will conduct focus group interviews with prospective students for admission to UK's medical and dental schools to determine what aspects of the certificate are unattractive to students. Based upon this information, the proposed Certificate Director will meet with the chair of the F. Joseph Halcomb, III M.D. Department of Biomedical Engineering (BME), and then the entire faculty of the BME department, to discuss implementation of remedial actions.
- the proposed Certificate Director will meet with the chair of the BME department to discuss strategies for expanding the applicability of the certificate to candidates for law school who are considering a career in patent law in the field of biotechnology.

3.0 **CURRICULUM OUTLINE**

Syllabi of courses available to students in the proposed certificate were listed, but were removed per SAPC committee's comments per an email message of 3 October 2016, i.e. "…*Please remove the syllabi from the certificate paperwork. They are not required and not necessary.*"

3.1 **Potential Impact**

The proposed Certificate, "Engineering in Healthcare" offers benefits to various stakeholders including present and future students, the University, and the healthcare profession. Potential impacts to each of these stakeholders are summarized as follows:

Students

- The proposed certificate offers students the opportunity to:
  - achieve "career-extension" into the healthcare field
  - improve their academic preparedness for medical or dental school by minimizing the educational gap between their undergraduate educational curriculum and medical or dental school basic science curriculum
  - productively occupy the "gap year" between undergraduate studies and medical or dental school
  - improve the quality of formal Letters of Recommendation written by biomedical engineering and medical or dental school faculty attributable to productive certificate-enabled research
  - experience the field of biomedical engineering without formally committing to the master's program
  - enhance student transition from traditional educational backgrounds into biomedical engineering
  - obtain a healthcare-related career alternative if medical or dental school is no longer an option
  - gain meaningful real-world biomedical research experience and a deeper understanding of how new medical and dental technologies are developed and evaluated.

College of Engineering

- Improve retention of:
  - undergraduate engineering students - the proposed certificate offers a mechanism for students to redirect their education instead of abandoning it
- Improve overall graduate student quantity and quality by the infusion of high-caliber medical and dental school hopefuls into the certificate, some of whom may choose to stay for various reasons
- Enhance faculty research with the highly-motivated engagement of intelligent, zero-cost (albeit short term – one semester) research assistants that contribute to faculty research programs
- Provide the basis for future alumni contributions due to successful candidates who regard the certificate as a turning point in their professional career.

Colleges of Medicine and College of Dentistry

- Provide new opportunities for professional interactions between certificate students and UK faculty (particularly physicians, surgeons, and dentists working collaboratively with biomedical engineering faculty). These interactions will generate first-hand knowledge of applicant performance and personality by UK faculty, thereby improving the ability of admissions committees to make more informed candidate interview decisions and enhance the quality of future medical and dental classes
- Improve collective class performance by enhancing the quantitative reasoning and problem solving skills of certificate graduates who enroll in UK College of Medicine or Dentistry.

UK Colleges of Arts & Sciences and Engineering

- Enhance the attractiveness of undergraduate programs because the proposed certificate offers an established UK mechanism by which students can modify, with minimal cost and without abandoning, their educational pathway if they desire career modification towards the healthcare professions

University

- Enhance UK's reputation as a leader in developing novel approaches to pre-professional education.

Healthcare Profession

- Enhance the technological competence of future healthcare providers
- Foster the development of academic physicians and dentists, as motivated by their experiences generating new knowledge in the research opportunities offered by the proposed certificate.

APPENDIX A

Courses Available to Students pursuing the Proposed "Engineering In Healthcare" Certificate Curriculum

GRADUATE BIOMEDICAL ENGINEERING COURSES

BME 530 BIOMEDICAL INSTRUMENTATION. (3 credits)

Description: a comprehensive introduction to the major aspects of biomedical instrumentation. Topics include basic concepts of medical instrumentation, biopotentials, physiological pressure/flow/respiratory measurements, optical sensing, and clinical applications of these technologies. The fundamental mathematics underlying each instrument will be reviewed and an engineering perspective of the hardware and software needed to implement each system will be examined. Prerequisite: consent of instructor.

Rationale: this is one of the two required courses in the proposed certificate curriculum. This course presents the scientific foundations of medical and dental instrumentation and engineering principles commonly employed using these instrumentation to achieve healthcare-related diagnosis and treatment. This course is essential for aspiring healthcare practitioners who seek to understand the fundamental bases underlying the use of modern medical and dental technology.

BME 579 NEURAL ENGINEERING: MERGING ENGINEERING WITH NEUROSCIENCE. (3 credits)

Description: a multidisciplinary approach combining engineering principles for systems analysis and control, knowledge of biological control mechanisms, and computational properties of biological neural networks in the development of engineering networks for control applications. Topics include: equivalent circuit models for biological neurons and networks, non-linear differential equation representations, biological control strategies for rhythmic movements, design and development of controllers for robot function, proposal development and presentation. Prerequisite: EE 422G and engineering standing or consent of instructor.

Rationale: this course presents students with curricula designed to develop an in-depth quantitative understanding of neural systems and the basis by which artificial neural networks may be engineered to achieve clinically relevant outcomes.

BME 599 TOPICS IN BIOMEDICAL ENGINEERING. (3 credits)

Description: an interdisciplinary course devoted to detailed study of a topic of current significance in biomedical engineering, such as cellular mechanotransduction, systems biology, and tissue engineering. May be repeated once (maximum of six credits). Prerequisite: consent of instructor.

Rationale: this course provides a mechanism for instruction in topics not covered by existing biomedical engineering courses, and provides the particular needs for a student pursing a dedicated field of interest.

BME 605 BIOMEDICAL SIGNAL PROCESSING I. (3 credits)

Description: continuous and discrete signals, sampling, Fourier Transforms, LaPlace Transforms, ZTransforms, correlation and spectral analyses, digital filters. Prerequisite: concurrent enrollment or completion of PGY 412G or PGY 502.

Rationale: This course provides students with the mathematical tools needed to manipulate and analyze the variety of biomedical-related electronic information originating from various research and clinical diagnostic systems. This course provides the theoretical foundation for subsequent pursuit of BME 610 or BME 615 in which these tools are applied to develop a quantitative understanding of the means by which biological systems are governed by one or more control mechanisms.

BME 610 BIOMEDICAL CONTROL SYSTEMS I. (3 credits)
Description: homeostatic mechanisms, input-output analyses, steady state and transient responses, feedback concepts, system identification and simulation from actual operating data. Prerequisite: PGY 502 and ME 440 or equivalent.

Rationale: This course uses the tools developed in BME 605 and applies them to quantitative study of the control system(s) by which biological systems are governed. For purposes of this certificate, BME 605 satisfies the prerequisite of ME 440 or equivalent.

BME 615 BIOMEDICAL SIGNAL PROCESSING II. (3 credits)
Description: stochastic processes, Fourier-based spectral analyses and linear system identification, modern spectral estimation (AR, MA, ARMA), parametric transfer function estimation, time-frequency analyses of non-stationary signals. Prerequisite: BME 605, BME 610, and EE 640 are recommended.

Rationale: This course provides students with advanced mathematical and statistical tools needed to analyze and extract information from a variety of biomedical-related electronic signals encountered in various research and clinical diagnostic systems.

BME 640 BIOMEDICAL ENGINEERING ETHICS (1 credit).

Description: foundations of ethics, professional codes of ethics in medicine and engineering, principles of responsible conduct of research and technology development, ethics of human clinical studies, selected case studies demonstrating principles from lecture. Lecture and class discussion.

Rationale: this is one of the two required courses in the certificate curriculum. This course is required because it: a) provides students with exposure to the multidisciplinary ethical issues arising at the interface of engineering and medicine, b) provides students with an understanding of the origins of professional codes of ethics and professional oaths, c) instructs in the multidimensional aspects of responsible conduct in science, engineering, and healthcare, especially those pertaining to the ethical treatment of research animals and human study subjects, d) applies all of these principles by using case studies of engineering failures to exemplify ethical behavior in the professional engineering and healthcare workplace.

BME 661 BIOMATERIALS SCIENCE AND ENGINEERING. (3 credits)
Description: study of biological and man-made materials that perform, improve, or restore natural functions. Structure and properties of connective tissue and commonly implanted metals, ceramics, and polymers; biocompatibility of materials used in orthopedic, soft tissue, and cardiovascular applications. Prerequisite: undergraduate engineering degree or consent of instructor.

Rationale: materials selection and performance are concerns that exist at the core of every medical and dental challenge; this course provides students with exposure to the materials engineering concerns accompanying natural and prosthetic materials encountered in healthcare.

BME 662 TISSUE-IMPLANT INTERFACE. (3 credits)
Description: study of the interface between implants and host tissues from both the materials and biological perspective. Structure of the tissue-implant interface; surface characterization of biomaterials; protein adsorption; mechanisms of cell responses; and methods for controlling the tissue-implant interface. Emphasis on orthopedic and cardiovascular applications. Prerequisite: BME 661 or consent of instructor.

Rationale: high-technology medical or dental devices or prostheses are useless if they fail to attain a proper tissue-implant interface. This course is a logical successor to BME 661 and equips students to understand the interfacial behavior of prosthetic biomaterials and one of the key bases for successful clinical performance of prosthetic medical and dental devices (particularly implants).

BME 670 BIOSOLID MECHANICS. (3 credits)
Description: application of the laws of mechanics to study the behavior of human organ systems. Stress-strain analysis of soft and hard body tissues with emphasis on pulmonary and musculoskeletal systems. Viscoelasticity. Prerequisite: Undergraduate engineering degree or consent of instructor.

Rationale: this course presents the theories of deformable body mechanics and provides the foundation for advanced studies in biomechanics.

BME 672 MUSCULOSKELETAL BIOMECHANICS. (3 credits)
Description: application of laws of mechanics to study behavior of the human musculoskeletal system. Study of the materials and mechanics of tendon/ligament, muscle, cartilage and bone provide the prerequisite for quantitative study of the static, kinematic, and dynamic behavior of human body segments. Prerequisite: PGY 412g or PHY 502 and ME 330 or consent of instructor.

Rationale: this course equips students to understand the biomechanics of human posture and movement. It provides a quantitative basis for successful and efficient use of various Orthopaedic and Orthodontic procedures, therapies, and devices.

BME 685 BIOFLUID MECHANICS. (3 credits)
Description: review of the rheology of circulatory processes in the body. Special emphasis on cardiovascular dynamics, pulsatile pressure and flow, vascular impedance, wave propagation/reflection, cardiac dynamics. Special topics are also included. Three hours weekly lecture with periodic lab demonstrations. Prerequisite: undergraduate engineering degree or consent of instructor.

Rationale: this course provides students with a quantitative understanding of the fluid mechanical aspects of the human circulatory system. It establishes the engineering basis for all cardiovascular diagnoses and therapies pertaining to blood flow.

BME 781 SPECIAL PROBLEMS IN BIOMEDICAL ENGINEERING (Subtitle required). (1-3 credits)
Description: discussion of advanced and current topics in biomedical engineering. May include individual work on research problems of current interest. Lecture and laboratory hours (as needed) variable depending upon credit hours sought. Prerequisite: consent of instructor.

Rationale: this course enables certificate candidates to pursue advanced independent study in a selected field of interest with a Biomedical Engineering faculty advisor.

BME 790 RESEARCH IN BIOMEDICAL ENGINEERING. (1-6 credits)
Description: graduate research in any area of biomedical engineering, subject to approval of the Certificate Director. May be repeated to a maximum of nine hours. [N.B. the nine hour limitation applies to students formally enrolled in Master's or Doctoral Programs; a six-hour limitation applies to students in the proposed certificate]. Prerequisite: consent of the Certificate Director.

Rationale: this course offers the means by which candidates for the proposed certificate may pursue hands-on research in Biomedical Engineering with a Biomedical Engineering faculty advisor. Other faculty advisors may participate in conjunction with this course, BME faculty advisor, and student. This course will be used for studies that are primarily laboratory based. Although the Bulletin indicates that the course may be repeated for a maximum of nine hours, six hours will be the maximum number of credit hours available to certificate students.

GRADUATE COURSES IN PHYSIOLOGY

PGY 412G PRINCIPLES OF HUMAN PHYSIOLOGY LECTURES. (4 credits)
The objective of this course is to provide the basic physiological mechanisms of human body function and physiological integration of the organ systems to maintain homeostasis. Students will be learning what the different organ systems do and how they do it. With this knowledge a student should be able to form a general understanding of how the body functions in health and disease. The general purpose of the lectures is to reinforce and expand upon the material presented in the text, with a focus on concepts and problem solving skills. Lectures will be further developed with reading assignments and discussion. Prerequisite: One year biology or PGY 206.

Rationale: qualitative understanding of basic physiologic principles is an essential foundation for study of biomedical engineering. This course is intended for certificate students who recognize the need for additional education in human physiology but who have not advanced in this field beyond the required minimum undergraduate biology course.

PGY 502 PRINCIPLES OF SYSTEMS, CELLULAR AND MOLECULAR PHYSIOLOGY. (5 credits)
Description: advanced survey of major mammalian physiological systems at the systems, cellular and molecular levels; lectures, assigned readings, advanced texts or monographs, demonstrations and problem-oriented study questions. Prerequisite: one year of physics, one year of general chemistry and PGY 206 or BIO 502.

Rationale: qualitative understanding of basic physiologic principles is a necessary prerequisite to developing an advanced quantitative understanding of these principles. This course is intended for students with more two or more prior undergraduate courses in physiology who seek to develop a more advanced understanding of these physiological processes and their role in biomedical engineering.

APPENDIX B

Potential Areas of Emphasis for the Proposed "Engineering in Healthcare" Certificate Curriculum

Students admitted to the proposed certificate, especially those with defined healthcare sub-specialty career goals, may wish to obtain focused biomedical engineering expertise directly applicable to these goals. Following completion of the required courses, such students may choose particular groups of courses from among the certificate curriculum electives (Appendix A) to provide concentration (area of emphasis) in the desired field. While these groups of courses providing such areas of emphasis are not a formal component of the certificate curriculum, they are offered as suggested potential guidance to help direct student learning and meet particular student-defined educational objectives.

For example, certificate students interested in oncology, plastic surgery, restorative dentistry (among others) may be interested in a certificate curriculum having a biomaterials emphasis. Those interested in Orthopaedic surgery, orthodontics, rehabilitation medicine (among others) may find pursuit of a biomechanics emphasis attractive. Students pondering a career in cardiology, neurology, or radiology (among others) may find courses offering an emphasis in signal processing desirable. Students considering professional academic medicine or dentistry, or those considering a dual MD/PhD or DDS/PhD degree program, may wish to explore a certificate curriculum offering a research emphasis.

Examples of proposed certificate curriculum emphasis and suggested elective courses accompanying each are:

1. *Biomaterials Emphasis*
   Core Courses (BME 530 and BME 640): 4 credit hours total
   Suggested courses: BME 661, BME 662, BME 599 (Biomaterials subtitle): 9 credit hours total
   Elective course: 3 credit hours
   Total: 16 credit hours

2. *Biomechanics Emphasis*
   Core Courses (BME 530 and BME 640): 4 credit hours total
   Suggested courses: BME 670, BME 672, BME 685: 9 credit hours total
   Elective course: 3 credit hours
   Total: 16 credit hours

3. *Signal Processing Emphasis*
   Core Courses (BME 530 and BME 640): 4 credit hours total
   Suggested courses: BME 605, BME 610, BME 615: 9 credit hours total
   Elective course: 3 credit hours
   Total: 16 credit hours

4. *Research Emphasis*
   Core Courses (BME 530 and BME 640): 4 credit hours total
   Suggested courses: BME 599 and BME 790: 6 credit hours total
   BME 599 indep. study topic must be closely linked to BME 790 research topic, and a written plan for BME 599 & BME 790 must be submitted in advance and approved by the Certificate Director
   Two elective courses: minimum 6 credit hours total
   Total: 16 credit hours

APPENDIX D

F. Joseph Halcomb, III M.D. Department of Biomedical Engineering

Student (proposed "Engineering in Healthcare" Certificate) Evaluation Form

Student's name: _____ Date of Review: _____

Undergraduate institution: _____

Undergraduate GPA: _____ Graduate studies (Y or N) Graduate GPA: _____

Graduate studies institution: _____

GRE/MCAT/DAT (Y/N, circle) Dates taken/scores: _____

Date entered certificate: _____

Semester(s) certificate courses taken: _____

List certificate courses taken: _____

Total certificate credit hours earned (minimum 15):_____

Certificate courses GPA: _____

Date certificate earned: _____

Faculty research mentor(s) (Y/N) Faculty research mentor(s): _____

Date *Graduate Certificate Completion Form* sent to Graduate School: _____

Certificate Director: _____ Date: _____

Signature of Certificate Director _____ Date: _____

DEPARTMENT OF BIOMEDICAL ENGINEERING

Room 512, Robotics and Manufacturing Building

Minutes of the March 2, 2015 Faculty Meeting

Present: Babak Bazrgari, Abhijit Patwardhan, David Pienkowski, David Puleo, Hainsworth Shin, Sridhar Sunderam, Guoqiang Yu, Joyce Evans (staff), Sue Mills (staff) and Stefanie Pagano (student rep).

The meeting was called to order at 2:00 p.m. by David Puleo.

1. Approval of Minutes

   David Puleo asked Sue Mills if any additional comments/revisions were suggested for the February 2 meeting minutes that were distributed by email prior to today's meeting. He added that the minutes already include corrections/clarifications caught in the original email distribution. With no other changes in order, Puleo asked for a motion for approval of the minutes as corrected/distributed. A motion for approval was made by David Pienkowski, and seconded by Abhijit Patwardhan. With no discussion, the February 2015 meeting minutes were unanimously approved as corrected and distributed.

2. Reports

   A. DGS

      Patwardhan reported that he attended a (CoE Graduate Studies Team) meeting today in which the discussion focused on plans for a graduate student recruitment event in March. He stated that departments have been given the flexibility to extend invitations for visits to prospective students who already have/or will be extended an offer of admission. Applicants can be seeking a MS degree, although doctoral applicants are preferred, as well as be an international student if currently in the United States since the college will pay for domestic travel only. He stated that the college will pay up to $500 toward airfare, hotel, and select meals for the invitees. BME has two M.S. applicants who will be invited so we will plan to host activities with our students and mentors for Saturday morning and afternoon. He added that an optional off-campus group event will be organized by Chemical and Materials Engineering mid-day on Saturday, and Sunday morning will include a central breakfast before the students return home.

   B. Students

      Stefanie Pagano reported that BME students had their first Movie Night with refreshments last week thanks to a Student Opportunity Fund award from the College of Engineering. Pagano stated that only seven students attended, but she is hopeful that more students will be involved in future activities.

3. Other Business

A. CoE Biomedical Research Day – Mar. 25

Puleo announced that BME will participate with other College of Engineering departments to present biomedical research as part of the UK CCTS Spring Conference on March 25. He encouraged everyone to participate as this will provide needed visibility for biomedical engineering research. March 4 is the abstract deadline, and March 18 is the deadline for registration.

B. "Engineering in Healthcare" Graduate Certificate Proposal

David Pienkowski discussed the current draft of the "Engineering in Healthcare" Graduate Certificate proposal and noted that we need to determine who to admit and the criteria for admission. The certificate may be of interest to pre-professional students, many of whom will not have an engineering background. In those cases, the question arises about whether they are qualified for the certificate program. Puleo noted that historically, applicants to a BME program were expected to have an ABET-accredited B.S. degree in engineering (or the equivalent), but we receive many applications from students who do not have such a background. Puleo commented that we must remember that potential certificate candidates will be admitted as post-baccalaureate students, not students admitted to the regular MS or PhD programs in BME. Puleo stated that such students must meet the prerequisites of the particular courses comprising their planned certificate-related field of study, and there may be certain courses that some certificate students will not be qualified to take.

Lengthy discussion followed regarding admission of non-engineers and students with "hard-science", mathematics, and biology backgrounds. All agreed that bulletin-noted course prerequisites must be followed for all students regardless of the program of study. Pienkowski agreed to revise the graduate certificate proposal in accord with this discussion. The faculty approved the proposal for the new certificate given these revisions.

C. Prerequisite Courses for Admission

Discussion regarding prerequisite courses/programs of study for admission to the certificate program led to additional discussions regarding student acceptance for the MS and PhD programs. Several years ago, BME developed a list of courses mapped to some of the engineering curricula to identify the basic courses needed to prepare students for success in potential Biomedical Engineering graduate studies. Some programs, such as Chemical Engineering, admit non-engineers, e.g., chemists, and have them take the fundamental chemical engineering courses in preparation for the qualifying exam. Currently, Patwardhan in his role as DGS makes a judgement call whether to reject non-engineers and provide a list of recommended courses to applicants needing supplemental coursework. He asked if the BME faculty would prefer that he route such applications for their review or whether he should continue without change. Consensus was that the DGS should still make the initial route-the-applicant-for-faculty-approval/reject decision.

D. Student Salary Increases

Puleo referred to a handout that shows the implemented salary changes for both MS and PhD students from FY 10 through FY 14 and asked everyone to consider possible increases for the coming academic year. The sheet showed salaries for 1 to 5% escalations. He asked if anyone had any comments or suggestions for FY 15, noting that we continue to face the struggle between limited grant budgets and offering more competitive salaries. To initiate discussion, Pienkowski suggested 2% increases. Conversation then moved toward freezing both salaries. In the end, Pienkowski moved to keep the MS student salary at $18,000 (0% increase) and the PhD student salary at $21,500 (0% increase). Patwardhan seconded the motion. The motion unanimously passed.

E. Grant Effort – Academic Year vs. Summer

Due to time constraints, this item was tabled until the April 6 Meeting.

F. Review Course Descriptions – http://www.uky.edu/registrar/sites/www.uky.edu.registrar/files/BME_9.pdf

Due to time constraints, this item was tabled until the April 6 Meeting.

G. Update: New Courses and Minor

Due to time constraints, this item was tabled until the April 6 Meeting.

H. Update: Faculty Discipline Committee

Due to time constraints, this item was tabled until the April 6 Meeting.

Meeting Adjourned at 3:08 p.m.

Minutes taken and submitted by Sue Mills.

Schroeder, Margaret <mmohr2@g.uky.edu>

FW: Course and Curriculum Changes - April 11, 2016

Pienkowski, David <pienkow@uky.edu> Fri, Nov 11, 2016 at 1:33 PM
To: "Brandenburg, Barbara J" <barbara.brandenburg@uky.edu>
Cc: "Schroeder, Margaret" <m.mohr@uky.edu>

Thank you very much.

From: Brandenburg, Barbara J
Sent: Friday, November 11, 2016 1:31 PM
To: Pienkowski, David
Subject: FW: Course and Curriculum Changes - April 11, 2016
Importance: High

Dr. Pienkowski,

Below is the email where I sent the certificate to the faculty. No concerns were raised. College of Engineering approved it on April 26, 2016.

Thank you,

BJ

BJ Brandenburg

College of Engineering

Director of Student Records

373 Ralph G. Anderson Building

University of Kentucky

Lexington, KY 40506-0503

Tel: (859) 257-7978

Fax: (859) 257-5727

From: Brandenburg, Barbara J
Sent: Monday, April 11, 2016 1:27 PM
To: LIST All Engineering Faculty <Engr-Faculty@lsv.uky.edu>

Subject: Course and Curriculum Changes - April 11, 2016
Importance: High

All,

The following course is available in eCATS for your review.

CE 556

Also, please review the attached Graduate Certificate for Biomedical Engineering.

If you have any questions or concerns, please let me know by April 25, 2016.

Thanks,

BJ

F. JOSEPH HALCOMB III, M.D.
DEPARTMENT OF BIOMEDICAL ENGINEERING
Faculty Meeting

November 21, 2016
2 p.m.

AGENDA

1. Approval of Minutes
2. Reports
   A. DGS
   B. Students
3. Other Business
   A. Engineering in Healthcare Certificate (Pienkowski)
   B. Updating Information on BME Website (Patwardhan)
   C. Policy for Handling Academic Matters for Students (Patwardhan)
   D. BME 395 (Pienkowski)
   E. Holiday Party (Joyce Evans)
   F. Seminar Series – Spring 2017 [Speakers/Attendance] (Joyce Evans)

F. JOSEPH HALCOLMB III, M.D.
DEPARTMENT OF BIOMEDICAL ENGINEERING

Room 522A, Robotics and Manufacturing Building

Minutes of the November 21, 2016 Faculty Meeting

Present: Babak Bazrgari, Thomas Hedman, Abhijit Patwardhan, David Pienkowski, David Puleo, Sridhar Sunderam, Guoqiang Yu, Joyce Evans (staff), Sue Mills (staff) and Ahmed Bahrani (student rep).

The meeting was called to order at 2:00 p.m. by Abhijit Patwardhan.

1. Approval of Minutes

   Abhijit Patwardhan asked Sue Mills if any comments/revisions were suggested for the October 21 meeting minutes that were distributed by email prior to today's meeting (a hard copy was also distributed at the meeting). With no changes in order, Patwardhan asked for a motion for approval of the minutes as distributed. A motion was made by David Puleo, and seconded by Babak Bazrgari. With no discussion, the October 2016 meeting minutes were unanimously approved as distributed.

2. Reports

   A. DGS

      Abhijit Patwardhan stated that he had nothing to report.

   B. Students

      Ahmed Bahrani reported that the application for Student Opportunity Funding for the current academic year submitted in September on behalf of the UK-BMES student organization was approved, and BMES was awarded $1,800. He said that the students are still working out the details for a student group field trip to tour two or three biomedical companies in Memphis in early 2017, and would like to invite an outside speaker for a seminar during the spring semester. He reported that the BMES group met twice this month. A group meeting was held last week to acquaint students with the BMES student chapter and its activities, and attendance was poor. Also, the BMES officers met last week to discuss and plan future activities, such as an Open House. He suggested that an Open House held in conjunction with E-Day activities may attract undergraduate students. Discussion ensued with suggestions for scheduling options for the fall or spring semester as the best possible opportunity to attract a greater number of potential students to the BME program. Babak Bazrgari suggested that a video about the BME program may be an appropriate pitch. In conclusion, the group agreed that BME will commit to an Open House in spring 2017.

3. Other Business

A. Engineering in Health care Certificate

David Pienkowski reported that changes were proposed to the certificate application following the Senate Council's latest review. He stated that the comments raised and addressed that were mostly minor in nature and include the following: 1) Change of BME 530 (Instrumentation) and BME 640 (BME Ethics) from elective courses to core courses, 2) Revise the options for independent study research from a maximum of 6 credits total to 3 credits each, 3) Clarification that a GPA of 3.0 is required, and 4) Clarification of the number of credit hours required for certificate completion. The group agreed that the current "15-17 credit hours" should be revised to read "minimum of 15 credit hours." Discussion ensued, and after a vote was called, the group unanimously approved all the proposed changes. Subsequently, a motion was made by Babak Bazrgari to add a clause to the proposal that stipulates that BME students for the masters or Ph.D. degree are ineligible for the proposed certificate. Sridhar Sunderam seconded that motion. With no discussion, the motion unanimously carried. Pienkowski said that he will forward the approved changes to the SAPC.

B. Updating Information on BME Website

Guoqiang Yu commented that he feels that it critical to our recruiting efforts for the BME Chair and potential students that we update the BME website. Puleo commented that we should send website updates to the webmaster, John Hagee, or Lynn Tilley. He proposed that we have a point of contact in the department to work with Lynn and John for upkeep of BME's webpage. Patwardhan stated that the departmental point of contact will be Jennifer Hart for these purposes. Puleo remarked that faculty is responsible for their personal lab pages, and should obtain a domain name if they don't currently have one to be able to maintain the content.

C. Policy for Handling Academic Matters for Students

Patwardhan reported that a recent incident concerning a BME doctoral student and course selection prompted him to discuss the role of the doctoral advisory committee. He urged the faculty to be cognizant of the policies concerning academic matters of their students. He repeated that a doctoral student should form an advisory committee as quickly as possible, and once formed, the advisory committee should guide the student's academic progress to completion of study including course work and dissertation. He noted that the work conducted as a part of research assistantship, if the student has one, is not under the direction of the committee.

D. BME 395

Pienkowski reported that students who are interested in enrolling in BME 395 (Independent Research in Biomedical Engineering, 1-6 credits) as an elective course for a minor in biomedical engineering can come to him to discuss available opportunities for their undergraduate research. He stated that he will devise a template that will provide information about faculty and their potential research projects to interested students and send that template to all faculty to provide information about potential research projects for students who may be interested in completing BME 395 in their research group.

E. Holiday Party

Joyce Evans reported that BME is beginning to plan its Holiday Party for December. She said that the tentative date is December 16, but may change based on availability. She passed around a sign-up sheet for duties. The location for the party is currently undecided.

F. Seminar Series – Spring 2017 [Speakers/Attendance]

Joyce reported that faculty attendance at the fall seminars has been abysmal, and added that faculty should make an effort to attend all of the seminars. She remarked that students have recently improved their attention paid to the seminar speaker. She concluded by requesting suggestions for speakers for the 2017 spring seminar series.

Meeting Adjourned at 3:20 p.m.

Minutes taken and submitted by Sue Mills.

Schroeder, Margaret <mmohr2@g.uky.edu>

Revised Documents for the Proposed Graduate Certificate in Biomedical Engineering

Pienkowski, David <pienkow@uky.edu> Mon, Nov 28, 2016 at 8:14 PM
To: "Schroeder, Margaret" <m.mohr@uky.edu>
Cc: "Patwardhan, Abhijit" <abhijit.patwardhan@uky.edu>, "Mills, Belinda S" <belinda.mills@uky.edu>

Dear Margaret:

Thank you for your kind note and for your interest in moving the proposed certificate forward.

The Biomedical Engineering faculty met during their regular monthly meeting last (21 November) Monday (see Agenda, attached). Concerns raised about the proposed certificate were noted (see items #1 - #7 below). In response to all concerns raised, changes were made to the proposed certificate as noted (see items #1 - #7) and voted upon by this faculty. All changes were approved by majority vote. In addition, the BME faculty also voted to add point #8 (below) to the proposal.

While I do not yet have minutes for this meeting yet available to send you, I anticipate having these in time for the SAPC meeting on Thursday.

Thank you for placing this on the SAPC agenda so that it can hopefully make next Monday's Senate Council meeting (I'll be there) and the December Senate Meeting.

Thanks again.

David

1. The options for independent study + research were altered to a maximum of 3 credits each (maximum 6 credits total) AND require (before any courses are taken) a written plan with specific learning objectives for the combined independent study & research courses that must first be approved by the Certificate Director. This will ensure the educational quality of the research/independent study component of the certificate curriculum and simultaneously not encroach upon the master's degree research effort (6 credit hours) per the comment noted by the reviewer.

2. The status of BME 530 (Instrumentation) and BME 640 (BME Ethics) were changed from electives to required (4 credits total).

3. Text used in the application was modified to make more explicit the need for students in the proposed certificate curriculum to earn a GPA of at least 3.0 before award of the certificate can occur.

4. Text referring to the minimum credit hours required for certificate completion was clarified. It now reads "a minimum of 15". This was in response to the comment that if students take more credits of their own volition, then they will still get the certificate provided they take the core courses and have an overall certificate GPA > or = 3.0

5. Modified the application to remove the word "program" from all references to the certificate per Graduate School recommendations.

6. Added the full department name (F. Joseph Halcomb III, M.D. Department of Biomedical Engineering, where appropriate)

7. Corrected spelling of faculty members names (2 typos)

8. Added the stipulation that Students who first enter the Department of Biomedical Engineering as candidates for the masters or PhD. degree are ineligible for the proposed certificate. This was done to satisfy BME faculty requests to avoid canabalizing students from the BME masters or PhD programs.