BME 2000: Introduction to Biomedical Engineering in the Clinical Environment

Instructor Contact Information:
Professor Christy Holland
Department of Internal Medicine,
Division of Cardiovascular Health and Disease
and Biomedical Engineering Program
513 558 5675
Christy.Holland@uc.edu
Cardiovascular Research Center 3935

Professor Kevin Haworth
Department of Internal Medicine
Division of Cardiovascular Health and Disease
and Biomedical Engineering Program
513 558 3536
Kevin.Haworth@uc.edu
Cardiovascular Research Center 3939

Teachers’ Assistants
Teckla Akinyi, Cardiovascular Research Center 3960, akinyitg@mail.uc.edu, 513.558.5135
David Drake, Medical Sciences Building E681, drakedm@mail.uc.edu, 513.439.0177

Course Description: In this course, you will have an opportunity to explore some of the exciting medical devices developed by biomedical engineers. In the process, you will develop considerable insight into biomedical principles and engineering balances used in biomedical engineering. The best way to learn about applications of biomedical engineering is to spend time with clinicians and scientists who work in a clinical and biomedical research environment. These guest instructors are interested in working with biomedical engineering students in their research programs. It would be a good idea to contact these individuals directly to help you find volunteer shadowing, co-op or research assistant positions. You will tour clinical and research environments that rely heavily on bioinstrumentation, biomedical imaging, and/or the use of biomaterials. You may choose to pursue an industrial position after graduation, or to attend graduate, medical, or law school. This course will help you make a decision regarding your pathway wisely. By the end of the course you should achieve the learning outcomes listed on the syllabus in the rightmost column.

Reading, Writing, and Thinking: To take charge of our own education, you must be willing to read. We will provide you with reading assignments that you will read, analyze, and think about between each class.

E-copies available through UC Library: http://site.ebrary.com/lib/cincinnati/docDetail.action?docID=10333219&p00
Mark Saltzman’s lectures on this material are available at http://www.virtualprofessors.com/frontiers-of-biomedical-engineering

Homework Assignments: As noted on the syllabus, reading and homework assignments should be completed by the start of the class on the date listed on the syllabus. For example, you should read Chapter 1 of the course text before you arrive at class on 8/25/14. Similarly, homework set #1 (See Bb) is due at the start of class on 8/27/14. The course text breaks up the homework into "questions" and "problems" at the end of each chapter. Please take note of the exact assignments. In general, "questions" tend to require a more qualitative response, while "problems" tend to require a more quantitative answer. When you arrive at class, please put your homework assignment in the designated location at the front of class.

You will note that some homework questions and problems are also listed as "Group Exercises" on the
For these questions and problems, we will set aside some time during class to work through them together. This time is meant to help assimilate the ideas learned earlier in the class. The instructors will provide some direction for the questions and problems and then allow each group to begin working toward a solution. The instructors and TA will be available to answer questions. Please note even if we complete a problem during class, you must still write-up your own solution and submit it with the proper homework assignment. In general, we encourage you to work collaboratively on the problems together. The emphasis is on collaborative work. You may not directly copy another student's work, as it will be considered academic dishonesty. You must work through and understand the solution you provide for all of the homework questions and problems. Any students caught copying solutions from another student or providing answers verbatim to another student will receive a 0 for that assignment. The TA will run homework help sessions in CVC 3936 on Thursdays from 5:30pm to 7:00 pm.

Write your name, email address, and date in the upper right hand corner of each sheet. Write or type your solutions legibly so that you can communicate effectively with the grader.

Each problem is worth 2 points. To get full credit all of the following items must be included as part of your solution.

1) A list of any assumptions that you must make to solve the problem. For each assumption, provide some rational for why the assumption is appropriate. (0.50 pt)
2) References for values not given in the problem. (0.25 pt)
3) Units! For every step of the problem, all numbers should include their corresponding units. (0.25 pt)
4) Derivation of the solution (show your steps). (0.50 pt)
5) The solution with a box around it. (0.25 pt)
6) If the solution is a number, please include a sentence indicating if it has the appropriate units (i.e. perform dimensional analysis). Also include a sentence or two stating whether the solution is appropriate (e.g. is it the magnitude for what was expected). (0.25 pt)
7) If the solution requires a graph, please use a computer program (such as Excel) or graphing paper to accurately produce the graph.

The reason for each of these steps will be discussed in further detail during the "Solving BME Problems" class on 9/08/14. Example problems will be completed to provide a template.

Blackboard: In this class, we will use Blackboard – a web-based course management system with password-protected access at https://canopy.uc.edu - to distribute course materials, to communicate and collaborate online, and to post grades. You can find support for using Blackboard at http://www.uc.edu/canopy/tools/blackboard/Resources-Training/Students.html, or by sending an email to HelpDesk@uc.edu, or by calling the Help Desk at 513 556-4357.

Use of Technology During Class: You are encouraged to use electronic devices (including e-readers, laptops, and tablets) in this course. However, if you use a digital device for anything other than class activities (including, but not limited to, instant messaging on a computer, text messaging on cell phones, Facebooking, etc.) you will be dismissed from class and considered absent. These activities are distracting not just to yourself, but also the students sitting around you.

Academic Integrity Policy: The University of Cincinnati Rules, including the Student Code of Conduct (http://www.uc.edu/conduct/Code_of_Conduct.html), and other documented policies of the school, college, and university related to academic integrity will be enforced. Any violation of these regulations, including acts of plagiarism or cheating, will be dealt with on an individual basis according to the severity of the misconduct.

Special Needs Policy: If you have any special need related to your participation in the course, including identified visual impairment, hearing impairment, physical impairment, communication disorder, and/or specific learning disability that may influence your performance in this course, you should meet with the instructors to arrange for reasonable provisions to ensure an equitable opportunity to meet all the requirements of this course. At the discretion of the instructors, some accommodations may require prior approval by Disability Services (http://www.uc.edu/aess/disability.html).
**Group Project:** In the introductory session (8/25/14), students will divide into teams consisting of approximately 6-7 students each. Each team will be responsible for identifying a specific medical device that they will research the device from concept through development to its clinical application. The device may be one you encounter during tours or one that is of special interest to your group. Each team will be responsible for a single written paper and a single presentation to the other teams at the end of the semester. All members of the team will be expected to participate in writing the paper and giving the presentation. The writing of the paper will help you refine your thinking and understanding of the clinical need for the device, the parameters affecting the design of the device, the associated patent that grants exclusive rights to the inventor, and the process of its development from concept to final production. You will learn how to utilize the talents of each team member and how to utilize editing to your advantage to communicate effectively about a medical device. If you do not learn to communicate in words, you cannot formulate fully developed thoughts and will, instead, live by the vague impressions and emotions that often substitute for ideas. Visual aids used during the presentation, your ability to convey the information in your report to the group, and the ability to answer appropriate questions will be used to grade your oral presentation. The oral presentations will be given during class on November 26, and December 3, 5 and 10, 2013. Check the syllabus to determine the specific date your group will present. Attendance is mandatory for everyone during all presentations.

**Grading Policy:** Your grade for this course will be based on the following criteria:

I. **Participation** – 10% Participation in group exercises during class is mandatory. Attendance will be taken. Scheduling conflicts (such as a meeting or interview during class) will not be considered excused. Only illness and unexpected emergencies will be counted as excused absences. Email Christy.Holland@uc.edu and cc Kevin.Haworth@uc.edu, akinyitg@mail.uc.edu, and drakedm@mail.uc.edu for excused absences.

II. **Homework Assignments** are due at the beginning of class on designated dates found in the 2013 syllabus. They will count 40% of the final grade.

III. **Exam Scores** – 20% Keep up with your homework and reading assignments, which will help you perform well on these exams.

IV. The **written paper** produced for the group project will contribute to 15% of your final grade.

V. The **oral presentations** given for the group project will contribute to 15% of your final grade.
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<tr>
<th>LEARNING DATE</th>
<th>TITLE OF LECTURE</th>
<th>INSTRUCTOR(S)</th>
<th>READING/HOMEWORK</th>
<th>LEARNING OUTCOMES</th>
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<tbody>
<tr>
<td>25-Aug-14</td>
<td>Intro To BME</td>
<td>Prof. Christy Holland</td>
<td>Read Chapter 1</td>
<td>Students will be able to:</td>
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<tr>
<td>Monday, MSB 3351</td>
<td>Introduction to BME 2000</td>
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<td>Read the Syllabus in Detail</td>
<td>Outline what will be accomplished in this course</td>
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<tr>
<td>Wednesday, MSB 5051</td>
<td>Working in Groups: An Exercise</td>
<td>Prof. Christy Holland</td>
<td>HW#1: NIH Human Participant Protections</td>
<td>Know how to prepare for clinical tours, understand tours as networking opportunities</td>
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<td>Education for Research Teams Certificates Due</td>
<td>Develop a definition for biomedical engineering and understand the subdisciplines in BME</td>
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<td>Be familiar with proper communication etiquette, including email</td>
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<td>03-Sep-14</td>
<td>Ethics in Biomedical Engineering: Debates</td>
<td>Prof. Kevin Haworth</td>
<td>Prepare for Ethics Debate (see Blackboard)</td>
<td>Define ethics vs. morals</td>
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<td>Wednesday, MSB 5051</td>
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<td>HW#2: Turn in summary and opening statement for ethics debate</td>
<td>Communicate convincing arguments during a debate</td>
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<td>HW#1: NIH Human Participant Protections</td>
<td>Appreciate the difference in patient, family, and physician perspectives</td>
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<td>Education for Research Teams Certificates Due</td>
<td>Defend the responsible conduct of research</td>
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<td>08-Sep-14</td>
<td>Solving BME Problems</td>
<td>Prof. Kevin Haworth</td>
<td>Read Box 2.1</td>
<td>Know the ‘Problem-System-Roadmap’ approach to BME problem solving</td>
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<td>Monday, MSB 5051</td>
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<td>Understand the role of assumptions in solving BME problems</td>
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<td>Describe ways to check whether an answer is correct</td>
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<td>Know the format for how all BME 2000 homework problems should be completed</td>
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<td>10-Sep-14</td>
<td>The Cardiovascular System: An Engineer's Perspective</td>
<td>Prof. Christy Holland</td>
<td>Read Chapter 8</td>
<td>List the components of the human circulatory system</td>
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<td>Wednesday, MSB 5051</td>
<td>Group Exercises (Chapter 8: Problems 1, 7 and 10)</td>
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<td>Apply the relationship between vessel radius, resistance to flow, and pressure drop</td>
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<td>Understand the events in the cardiac cycle</td>
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<td>15-Sep-14</td>
<td>Cardiology Tour</td>
<td>Jack Rubinstein, M.D.</td>
<td>HW#3: Chapter 8: Problems 1, 2, 3, 4, 7, 8, 10 &amp; 14</td>
<td>Describe the training required to be a cardiologist</td>
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<td>Monday, MSB 3351</td>
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<td>Be familiar with medical devices and imaging modalities used in cardiology</td>
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<td>17-Sep-14</td>
<td>Engineering Balances: Respiration</td>
<td>Prof. Kevin Haworth</td>
<td>Groups A1 and B1 Prepare 60 s Seminar</td>
<td>Understand and apply the engineering concept of ‘mass balances’</td>
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<td>Wednesday, MSB 5051</td>
<td>Group Exercises (Chapter 7: Question 2 and Problems 8 &amp; 9)</td>
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<td>Read Chapter 2.4 and 2.5, 7.1 through 7.3</td>
<td>Be familiar with the roles of ventilation and diffusion in respiration</td>
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<td>Define and apply first-order kinetics to the concept of mass balances</td>
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<td>22-Sep-14</td>
<td>Introduction to UC Emergency Room</td>
<td>George Shaw, M.D., Ph.D.</td>
<td>HW#4: Chapter 7: Question 2</td>
<td>Describe the training required to be an emergency physician</td>
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<td>Monday, MSB 3351</td>
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<td>Ope Adeoye, M.D.</td>
<td>Chapter 7: Problems 8, 9, 11, 12, &amp; 14</td>
<td>Be familiar with measurement systems used in the emergency department</td>
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<td>Identify the parameters affecting the design of tools used in the emergency department</td>
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<td>24-Sep-14</td>
<td>60 s Seminar: Groups A2 and B2</td>
<td>Prof. Kevin Haworth</td>
<td>Groups A2 and B2 Prepare 60 s Seminar</td>
<td>Understand and apply the engineering concept of stress and strain</td>
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<td>Wednesday, MSB 5051</td>
<td>Group Exercises (Chapter 10: Questions 6 &amp; 8, Problem 5)</td>
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<td>Read Chapter 10</td>
<td>Understand the engineering concept of elasticity</td>
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<td>Understand how structure affects material properties and function in human cells and tissue</td>
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<td>Apply the problem-system roadmap to understanding the mechanics of respiration</td>
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### Biomedical Principles
- **29-Sep-14**
  - UC Library
  - Group Written Report Outline due
  - Ted Baldwin
  - HW#1: Chapter 10: Questions 2, 4, 6 & 8
  - Employ library resources and patent search engines
  - Choose a medical device to research for the group project
  - Understand how to properly cite a reference

- **01-Oct-14**
  - Instruments in Medical Practice
  - Prof. Kevin Haworth
  - HW#6: Chapter 11: Problems 1, 3 & 8
  - Understand what a patent protects
  - Describe the parts of a patent
  - Define intellectual property

- **06-Oct-14**
  - Intellectual Property Development: Patenting Your Idea
  - Geoffrey Pinski, J.D.
  - UC IP Office Director
  - HW#16: Chapter 11: Problems 1, 3 & 8
  - Understand what a patent protects
  - Describe the parts of a patent
  - Define intellectual property

- **08-Oct-14**
  - The FDA Approval Process
  - Prof. Christy Holland
  - HW#16: Chapter 12: Questions 1 & 2
  - Understand how medical products are classified by the FDA
  - Describe the FDA approval Process for Drugs, Biologics, and Medical Devices

- **13-Oct-14**
  - Academic Research vs. Industrial Research Co-op Opportunities
  - Prof. Christy Holland
  - HW#7: Chapter 12: Questions 1 & 2
  - Appreciate the difference between an academic research co-op and an industrial co-op
  - Utilize online tools to find a funded position

- **15-Oct-14**
  - EXAM #1 OVER READING Chapters 1, 7, 8, 10, 11 AND HW#1 - 6
  - Wednesday, MSB 5051
  - Apply and demonstrate the knowledge gained by reading Chapters 1, 2, 7, 8, 11 and problem solving examples in homework #1 - 5

### Biomedical Imaging
- **20-Oct-14**
  - Biomedical Imaging with Ionizing Radiation
  - Prof. Christy Holland
  - Read Chapter 12.1, 12.2 and 12.4
  - Be familiar with the radiological imaging systems which utilize ionizing radiation
  - Understand the principles behind x-ray and nuclear medicine imaging systems

- **22-Oct-14**
  - Biomedical Imaging without Ionizing Radiation
  - Prof. Christy Holland
  - Draft of Medical Device Written Report Due
  - Be familiar with the current technology used in ultrasound and magnetic resonance imaging
  - Understand the principles behind ultrasound, magnetic resonance, and optical imaging

- **27-Oct-14**
  - Medical Imaging Tour
  - Charles Damasolin, Ph.D.
  - Wen-Jang Chu, Ph.D.
  - Ann Choe, M.D.
  - Work on Group Presentation
  - Describe the training required to be a radiologist or an imaging researcher
  - Be familiar with the imaging systems used in the UC Center for Imaging Research

- **29-Oct-14**
  - 60 s Seminar: Groups A3 and B3
  - Todd Abruzzo, M.D.
  - Maneet Patel, M.D.
  - John Racadio, M.D.
  - Groups A3 and B3 Prepare for 60 s Seminar
  - Work on Group Presentation
  - Describe the training required to be a radiologist and interventional radiologist
  - Be familiar with the imaging systems used in a radiology department
  - Be familiar with the image archiving and analysis systems used in a radiology department

- **03-Nov-14**
  - 60 s Seminar: Groups A4 and B4
  - David Caster, IACUC
  - Joanne Tetens-Woodring, DVM
  - Laboratory Animal Medicine
  - Groups A4 and B4 Prepare 60 s Seminar
  - HW#17: Chapter 12: Questions 1 & 2
  - Name the government and national organizations regulating laboratory animal research
  - Be familiar with the animal models of human disease

### Biomaterials
- **05-Nov-14**
  - Biomaterials in Surgical Applications
  - Prof. Kevin Haworth
  - HW#15: Chapter 15: Problem 4 Expanded on Handout
  - Understand coagulation response and foreign body response to biomaterials
  - Compare and contrast the requirements for extracorporeal and implantable devices
  - Be able to apply mass balance principles to understanding heart-lung and hemodialysis machines

- **10-Nov-14**
  - Surgical Environment Tour
  - George Meier, M.D.
  - Chief of Vascular Surgery
  - HW#18: Chapter 15: Problem 4 Expanded on Handout
  - Describe the training required to be a surgeon and vascular surgeon
  - Be familiar with surgical tools and measurement systems used in the operating room

- **12-Nov-14**
  - 60 s Seminar: Groups A6 and B6
  - Michael Archdeacon, M.D.
  - Chair, Department of Orthopaedic Surgery
  - Groups A6 and B6 Prepare for 60 s Seminar
  - Be familiar with the medical devices used to treat bone fractures and joint pathologies
<table>
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<tr>
<th>Date</th>
<th>Time</th>
<th>Location</th>
<th>Event Details</th>
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| 17-Nov-14  |       | Monday, MSB 3351 | Scientific Communication: How to give a Technical Presentation  
Prof. Kevin Haworth  
Describe why technical presentations are important  
List the basic structure for technical presentations  
Understand the concepts associated with effective slides |
| 19-Nov-14  |       | Wednesday, MSB 5051 | EXAM  
EXAM #2 OVER READING Chapters 12, 15, 16 AND HW#7 - 9  
Profs. Christy Holland and Kevin Haworth  
Apply and demonstrate the knowledge gained by reading Chapters 12, 15, and 16 and problem solving examples in homework #6 - 8 |
| 24-Nov-14  |       | Monday, MSB 3351 | Group Presentations  
Small Group Presentations  
Group Project Papers Due: A6, A5, B6 |
| 26-Nov-14  |       |           | No Class |
| 01-Dec-14  |       | Monday, MSB 3351 | Group Presentations  
Small Group Presentations  
Group Project Papers Due: A5, A2, B3  
Communicate effectively about the development of a medical device |
| 03-Dec-14  |       | Wednesday, MSB 5051 | Group Presentations  
Student Group Presentations  
Group Project Papers Due: A1, B2, B1  
Communicate effectively about the development of a medical device |
| 08-Dec-14  |       | Monday, MSB 3351 | Group Presentations  
Small Group Presentations  
Group Project Papers Due: B5, B4, A4  
Communicate effectively about the development of a medical device |