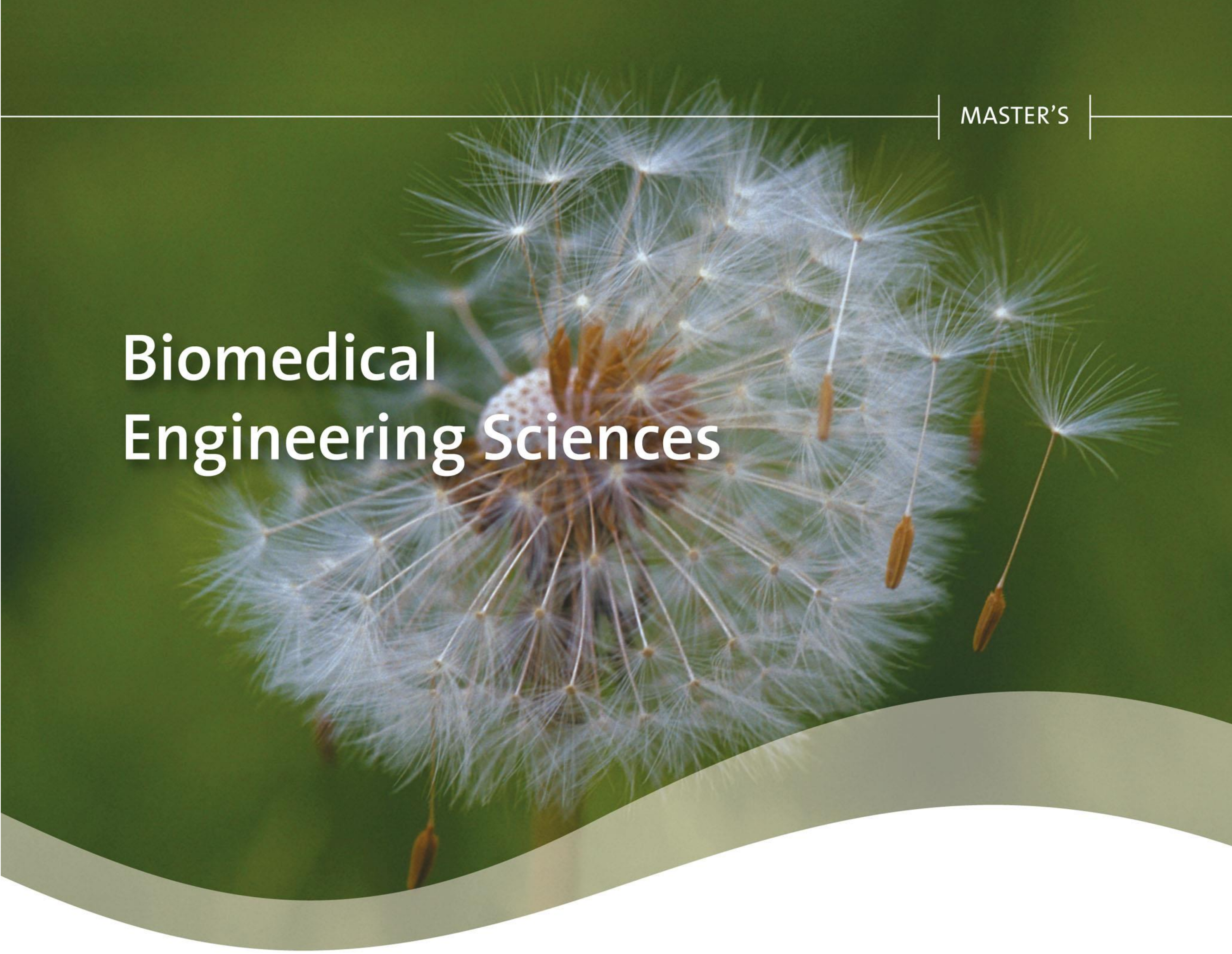

MASTER'S

Biomedical Engineering Sciences

Warming up for MBE

Knowledge we are building on.
Hints on how to acquire it for students entering the program.

2013 Edition

> Technology is biological.

FACHHOCHSCHULE
TECHNIKUM WIEN

How to prepare for an easy start

Biomedical Engineering is multicultural and multidisciplinary

Looking at the many and very diverse biomedical engineering projects and activities out there we usually find that they have one thing in common: Teams and co-operations of experts from many backgrounds work together to meet the requirements of medicine. Those who contribute in this field are therefore fluently discussing and communicating with representatives from “elsewhere”, on top of their special knowledge in medicine and engineering. We are therefore happy to welcome newcomers from “elsewhere” into the field of biomedical engineering and into the “Biomedical Engineering Sciences” (MBE) master’s study program at University of Applied Sciences Technikum Wien.

Individuals bring in individual strengths, we all face individual challenges

Some of the students from “elsewhere” are not too familiar with some of the prerequisites that are necessary to follow the courses right from the start. As an example: It is natural that graduates from medical study programs have so far not needed knowledge about the basics of electronic circuits. On the other hand graduated engineers might not have encountered physiology in their careers so far. And even those who are not new to the field may need a bit of brushing up here and there. Generally, the entry phase into the program is sometimes challenging. You deal with a new city, new people, a foreign language and maybe other obstacles that take your time and energy. Here is how we provide help to you, so that you find your way into the program smoothly.

Preparing for a smooth start – self organized learning in selected fields

The interview you had with the program director, the entry exam or your own experience may have exposed individual areas that you wish to improve. You start your individual preparation using this document as a guide. It lists the knowledge that we have found to be necessary and provides hints on how you can individually acquire it: literature, web pages, software that you can download, etc. You will prepare yourself as best as you can, identify problem areas and prepare dedicated questions that you cannot solve yourself. Additionally it makes sense to extend and test your knowledge by working on the tasks as described below. Depending on need and available resources the MBE program will provide support for example in the form of meetings, either in person or over the internet, and by helping you individually on specific questions and problems. We are well aware that a few weeks of work cannot replace years of study. The intention therefore is to provide beginners with exactly those very defined and limited pieces of knowledge that are necessary to study successfully in our MBE program.

Warm-up tasks for rounding things off

As an opportunity for assuring the core points we provide specific “warm-up” tasks. A zip file that contains the necessary information is available from the program homepage, “Toolbox”. The program takes it for granted that all students entering the program are able to solve the tasks to a high degree.

Experience from the first years of “warm-up” has shown us that what you need is not always identical to what we offer to you. We had courses on our campus in late August and monthly virtual meetings, with some success. We now accepted the fact that “warm-up” needs to be individually tailored. Therefore please stay in contact with the program management and make sure that you get what you need. We will support you as far as our resources reach. What do we offer:

- Meetings, on campus or virtual (Skype, …), in groups or individually
- Specific feedback on documents you send
- Contact to other individuals who also work on the tasks, so that you can discuss and cooperate
- Specific tutorials in late August to address gaps that may have appeared

Do not hesitate to ask for help! We are happy to provide it!

Grow, and help the program to grow

We especially want to encourage self-organized learning. The “warm-up” started with on-site courses in 2009. Based on feedback and experience we have now extended the warm-up period to start immediately after the first placement test, so that students have more time to get familiar with the new contents. We will continue to learn and improve.

Learning will go on even more intensively as the program starts in September. We want to hear about your experiences and needs. The “student’s jour fixe” is a way for students to communicate any observations to the program management in a structured way. Please use this to give us feedback, discuss with us and to optimize our mutual cooperation and your learning experience.

Good luck to you, and a really warm welcome here at the University of Applied Sciences Technikum Wien

We are looking forward to meeting you here at our university and wish you good luck and a successful time to graduation and beyond. It is a very positive and rewarding experience to work with groups of motivated individuals in a productive environment. We find that both, lecturers as well as students, do have good reasons to meet exactly here. They actively chose this place with a clear vision. This is a great opportunity for all of us to learn and to develop.

The management team, the lecturers and all staff members will do their best to support you as our students. Welcome in Vienna, welcome to our university!

Table of Contents

Mandatory: Electronics

Electronics know how is necessary in many areas in biomedical engineering, especially in the design and evaluation of medical devices. The basic principles and are also applied as calculation models in many areas. The behavior of human organs in cardiovascular engineering, for example, is often described in analogy to electrical circuits.

The main points we need in the area of electronics are:

- Basic passive circuit elements, R, L, C, Diodes, Transistors, operational amplifiers, properties, behavior, typical use, circuit examples.
- Analysis of linear circuits, using nodal and mesh equations
- Application of complex numbers (real part / imaginary part) for alternating current (AC) circuits, polar and Cartesian form, graphical representations
- Typical basic linear circuits: voltage dividers, equivalent voltage and current sources, etc
- Simple filters, (e.g. RC high / lowpass) and their characteristics
- Operational amplifier circuits, some typical examples
- Manually estimating the behavior of basic circuits
- Numerical computer simulation in the time and frequency domain

References, guidance

The following book is a good introductory guide into the basics of electrical circuits (Take care, it covers additional areas that are not listed above):

- Maxfield, C., Bird J., Laughton M.A. et al: Electrical Engineering – Know it all. Elsevier, Amsterdam, Netherlands, August 2008, 1128 pages, ISBN 978-1-85617-528-9
  Other books with similar content will also do.
  Based on the knowledge in there it also makes sense to download a free circuit simulation program, for example LTspice IV (Linear Technologies, Milpitas, CA, USA).
- http://www.linear.com/designtools/software/
  Using the software you can simulate the circuits described in the book, test if your calculations match the simulation results and get a general feeling of signals in the time and frequency domain.
- The Massachusetts Institute of Technology maintains a useful site "Open Course Ware":
  http://ocw.mit.edu/OcwWeb/web/courses/courses/index.htm
  A possible selection (among very many relevant others) might be 6.002 "Circuits and Electronics": http://ocw.mit.edu/OcwWeb/Electrical-Engineering-and-Computer-Science/6-002Spring-2007/CourseHome/index.htm
  MIT occasionally uses MatLab. See MATLAB chapters for an open source alternative: Octave.

Mandatory: Informatics / C# Basics

Software is a general element in all biomedical engineering environments. Graduates of the program therefore need a clear idea on how software developers think and work. Some courses extend the programming skills, especially the more IT oriented electives. Some courses in the program build on basic C# software development know how and add methods for object oriented architecture work and management ideas. Programming skills/experiences are therefore useful.

Skills in software development are also useful for all students to solve major problems that you will encounter in many places with relatively minor effort. The C# programming language is a frequent tool of choice to generate software on personal computers with graphical “Windows” like look and feel. C# runs on other platforms as well. It is especially useful as a fast entry point for beginners.

Some main points are:

- Typical computer language elements: Loops, branches, variables, functions etc.
- Object oriented programming, inheritance, polymorphism, constructors, namespaces
- Programming skills and first experience in C#

References

- Ewan McEachran: C# tutorial. Website hosted by Softsteel Solutions Ltd, Sheffield, UK. Available online (31.5.2010) http://li153-236.members.linode.com/tutorials/csharp/index.php
- Joe Mayo: C# Tutorial. http://csharp-station.com, online (4.7.2013) http://csharp-station.com/Tutorial/CSharp/SmartConsoleSetup.aspx
- A free C# development environment is available at the Microsoft Corporation (Redmond, WA, USA) Homepage: http://www.microsoft.com/express/Downloads/
  Using this you can develop console applications and also programs with graphical user interfaces, and acquire the necessary hands on experience.
- The Massachusetts Institute of Technology maintains a useful site “Open Course Ware”: http://ocw.mit.edu/OcwWeb/web/courses/courses/index.htm
- You might try (among very many relevant others) the course 6.00SC “Introduction to Computer Science and Programming (Spring 2011)” (Beware, this uses the Python programming language): http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-00sc-introduction-to-computer-science-and-programming-spring-2011

Mandatory: Microcontroller basics, binary numbers

Embedded Systems are omnipresent in today's electronic devices and specifically in the biomedical engineering sciences. Microcontrollers or systems-on-chips provide useful interfaces for measuring sensor data or controlling actuators, and can be freely programmed to work in various applications ranging from active electronic implants to industrial devices. Basic knowledge of microcontrollers, their varieties and their application is essential for a biomedical engineer and for research in this area.

The MBE study program offers courses and project based learning involving embedded systems and microcontrollers. The prerequisites for these courses do build on basic electronics and informatics skills. The following additional details are of special importance for all who enter the MBE program:

- Application of number systems (especially the binary number system and the hexadecimal system)
- Bit operations (AND, OR, NOT, XOR, SHIFT, INVERT)

References

- Binary System. Basic Electronics Tutorials Site by Wayne Storr, www.electronics-tutorials.ws, online (3.7.2013) http://www.electronics-tutorials.ws/binary/bin_1.html
- Boolean Algebra. Basic Electronics Tutorials Site by Wayne Storr, www.electronics-tutorials.ws, online (3.7.2013) http://www.electronics-tutorials.ws/boolean/bool_1.html
- The Binary System. A pretty damn clear guide to a quite confusing concept by Christine R. Wright with some help from Samuel A. Rebelsky, Department of Mathematics & Statistics, Grinnell College, Grinell, Iowa, USA, online (3.7.2013) http://www.math.grin.edu/~rebelsky/Courses/152/97F/Readings/student-binary
- The Hexadecimal Number System. Interactive Tutorial. Winfried Just, Department of Mathematics, Ohio University, Athens, OH, USA. Online (4.7.2013) http://www.ohio.edu/people/just/hex.htm
- Bitwise Operators in C and C++: A Tutorial. Alex Allain, Cprogramming.com, online (3.7.2013) http://www.cprogramming.com/tutorial/bitwise_operators.html

Mandatory: MATLAB Basics

MATLAB is a very general purpose tool for the typical numerical problem. It is for example useful for statistics, graphing, data manipulation. This is frequently necessary in many situations and definitely in more situations than we usually believe.
The areas of “Mathematical Applications with MATLAB” and “Simulink” also use this knowledge.
Some main points are:

- Data manipulation, vector & matrix calculations (sum, product, inverse, transpose…)
- simple basic commands (sin, cos, log, exp, sqrt…)
- Programming .m files
- .mat, text, excel data formats (import/export)
- syntax of functions and simple commands (for, if, while, …, load, save …)
- signal generation & manipulation (sin, square, saw, chirp, noise…)
- Graphics, various kind of plots (line, bar, scatter, …, semi-logarithmic plots…), formatting

References

- The open source Octave software project provides functionality very similar to MATLAB. It can be **downloaded here for free**, and used for practicing: John W. Eaton, University of Wisconsin, WI, USA (4.7.2013): http://www.gnu.org/software/octave

From the producer: The MathWorks, Inc: The MathWorks, Inc., Natick, MA, USA. Available online (31.5.2010):

- MATLAB® 7 Getting Started Guide. http://www.mathworks.com/access/helpdesk/help/pdf_doc/matlab/getstart.pdf
- MATLAB tutorial webpage: http://www.mathworks.com/academia/student_center/tutorials/launchpad.html
- The short video “Getting Started with MATLAB” explains you the basic features of this programming language (watch also the other videos for more examples).
- For a detailed guide see: http://www.mathworks.com/moler/chapters.html

The university-authored MATLAB tutorials present well explained examples:

- WF Sharpe: MATLAB. Stanford University. Stanford, California, USA. Available online (31.5.2010) http://www.stanford.edu/~wfsharpe/mia/mat/mia_mat3.htm
- Control Tutorials for MATLAB and Simulink (CTMS). Prof. Bill Messner, Department of Mechanical Engineering at Carnegie Mellon University and Prof. Dawn Tilbury of the Department of Mechanical Engineering and Applied Mechanics at the University of Michigan. Available online (4.7.2013): http://ctms.engin.umich.edu/CTMS/index.php?aux=About_Tutorials
- The “MATLAB help” (F1 key) !!!

For heroes: Programming embedded systems

Embedded Systems extend the basics of microprocessor programming for use in real world systems. The MBE program includes courses and projects that involve embedded systems and microcontrollers. Students will receive specific training in the program. However those who already want to get a first glimpse can enter early into the following topics:

- Basic understanding of computer architecture and the processes in a CPU
- Knowledge about the HW/SW interface, for example register access
- using C as a low-level programming language
- Working with C-Development tools (Compiler / Linker) from shell/command line, GCC

References

Designing Embedded Hardware (O'Reilly, 2005)
Programming Embedded Systems (O'Reilly, 2006)
An Introduction to GCC (Brian J.Gough, Richard M. Stallman)

WinAVR (tm) is a suite of executable, open source **software development tools** for the Atmel AVR series of RISC microprocessors hosted on the Windows platform. Includes the GNU GCC compiler for C and C++. The package WinAVR-20100110-install.exe (28.8 MB) together with AVR Studio 4 enables you to develop code and simulate. They are available here:
http://sourceforge.net/projects/winavr/files/WinAVR/
http://www.atmel.com/tools/STUDIOARCHIVE.aspx (Use AVR Studio 4.18, build 684)
A tutorial is available from us on request (ChrisVeigl_Getting_Started.pdf).

Those who really want to test code on real hardware can even purchase a microcontroller circuit (or borrow it from us):
http://www.watterott.com/de/Arduino-Uno?x40f5c=4ac5af828f759b73855297c620a57008

General background, optional, good to have: Physiology

Basic knowledge in physiology is necessary for all biomedical engineers, independent of their area of specialization. Especially students who did not have any exposure to medical content in their previous career will do good to have a look into this. Be assured that you will acquire much more detailed knowledge as you engage in the courses and then work in projects together with medical experts. In successful teamwork both biomedical engineers as well as medical experts learn a lot from each other. This is one of the experiences that motivate us most to initially enter and then to stay in the field and contribute to its further development.
The following topics are typically encountered first by biomedical engineers:

Neurophysiology

- Physiology of nerve and muscle cells: membrane potential, synaptic transmission, action potential, autonomous nervous system
- Function of skeletal muscle, smooth muscle, cardiac muscle, reflexes, central control of posture and movement
- Physiology of sensory organs: visual system, hearing and equilibrium, somatosensory system, smell and taste
- Integrative functions of the nervous system: structure of the brain, information flow from primary to secondary and tertiary cortical regions (association cortices: examples and pathopysiology), learning and memory (incl. selected pathophysiology), circadian rhythm, emotion, motivation and addiction

Autonomic functions / organ physiology

- General physiology, Homeostasis, control systems
- Physiology of the blood, functions of blood cells, hemoglobin, coagulation, fibrinolysis
- Physiology of the heart and circulatory system, biophysics, rheology, autonomous control, regulation of blood pressure, electrocardiography
- Endocrine system, control of plasma glucose, electrolytes, physiology of the adrenal, pituitary and thyroid gland
- Renal function, regulation of body fluids and blood pressure
- Physiology of the lung, respiration, ventilation, perfusion
- Gastrointestinal system, digestion, metabolism

References

- John E. Hall: Pocket Companion to Guyton & Hall Textbook of Medical Physiology (Paperback). Elsevier B.V., Amsterdam, Netherlands, 11th edition (March 2006), 736 pages, ISBN-13: 978-1-4160-0213-0.
- Stuart Ira Fox: Human Physiology (Hardcover). McGraw-Hill Higher Education - Science and Mathematics, NY, USA, 11th edition (2009), 832 pages, ISBN-13: 9780077265878

Silbernagl S, Despopoulos A.: Color Atlas of Physiology. 6th edition, 2008, Thieme, Stuttgart, Germany. 456 pages; ISBN 978-3-13-545006-3