Bachelor of Engineering

Biomedical Engineering

SPRINGFIELD RESEARCH UNIVERSITY

Bachelor of Engineering: Biomedical Engineering

MISSION STATEMENT

*The **SRU Bachelor of Engineering in Biomedical Engineering** is dedicated to advancing the frontiers of science, engineering, and medicine. Our program integrates fundamental knowledge and skills to solve biological and medical challenges, improve quality of life, and shape the future of healthcare. Through rigorous education, interdisciplinary collaboration, and ethical leadership, we empower students to become biomedical engineering innovators and compassionate global contributors.*

At Springfield Research University, our **Bachelor of Engineering in Biomedical Engineering** program prepares students for dynamic careers in the biomedical engineering. Our mission is built upon three fundamental pillars:

1. **Academic Excellence**:
    - We maintain rigorous standards, fostering critical thinking and intellectual growth.
    - Through engaging coursework, practical training, and evidence-based practice, we empower students to excel in the dynamic field of biomedical engineering.
    - Students gain a solid foundation in science, engineering, medicine, and biology, preparing them for the challenges of this interdisciplinary domain.
2. **Cutting-Edge Research**:
    - Our faculty and students actively contribute to advancing biomedical technology.
    - By addressing real-world health challenges, exploring innovative medical device concepts, and shaping industry practices, we drive positive change within the field.
    - Students engage in research projects, simulations, and analysis, enhancing their ability to provide innovative solutions for healthcare.
3. **Societal Impact**:
    - We recognize our responsibility to society and human well-being.
    - Our graduates are not only skilled engineers but also ethical leaders who advocate for patient safety, sustainability, and improved health outcomes.
    - We empower them to make meaningful contributions to medical research, healthcare delivery, and community well-being.

The mission of our Bachelor of Engineering in Biomedical Engineering program is to provide an academically rigorous experience that seamlessly integrates engineering principles with biomedical sciences. Over the course of the four-year curriculum, we empower students to explore innovative solutions at the intersection of technology and healthcare. By fostering critical thinking, interdisciplinary collaboration, and ethical responsibility, we prepare graduates to drive advancements in medical devices, diagnostics, and healthcare systems.

The program features eight semesters of engineering design and problem solving focused on challenges at the interface of biology, medicine and engineering, as well as traditional classroom and laboratory learning. The design sequence culminates with the senior year Capstone design project, where students partner with an industry or clinic professional to design a solution to a real-world problem.

Integrating Knowledge Seamlessly

Our Bachelor of Engineering in Biomedical Engineering program seamlessly integrates knowledge acquisition throughout the curriculum. Here's how we achieve this:

1. **Foundational Sciences**:
    - Students delve into core subjects such as structural mechanics, building physics, and construction materials.
    - These foundational sciences provide the essential groundwork for understanding biomedical systems, medical devices, and sustainable design principles.
2. **Applied Correlations**:
    - Lectures and practical sessions correlate theoretical knowledge with real-world biomedical scenarios.
    - For instance, students learn about medical imaging techniques and immediately apply this knowledge in designing diagnostic tools.
3. **Case-Based Learning**:
    - Real-world biomedical cases serve as powerful teaching tools.
    - Students analyze patient data, clinical outcomes, and safety considerations.
    - This approach bridges theory and practice, reinforcing biomedical concepts.
4. **Simulated Design Experiences**:
    - Simulation labs replicate actual biomedical design conditions.
    - Students practice modeling medical devices, conducting simulations, and analyzing health-related data, honing their skills before working on real projects.
5. **Industry Collaborations and Internships**:
    - During industry placements and internships, students work directly with healthcare professionals.
    - They apply theoretical knowledge in designing, evaluating, and improving medical technologies.
6. **Cutting-Edge Research and Innovation**:
    - Students critically evaluate research articles, explore emerging medical technologies, and contribute to advancements in biomedical engineering.
    - Evidence-based practices ensure that knowledge acquisition aligns with current best practices in the field.

By seamlessly weaving theory, practical experiences, and evidence-based approaches, our program prepares graduates to contribute effectively to the dynamic field of biomedical engineering

Rationale for the Bachelor of Engineering in Biomedical Engineering

At Springfield Research University, our Bachelor of Engineering in Biomedical Engineering program is purposefully designed to prepare students for impactful careers in the healthcare and medical technology fields. Rooted in academic excellence, this program equips students with essential knowledge, practical skills, and hands-on experience. By emphasizing evidence-based practices and innovation, our graduates emerge as competent professionals poised to make a positive impact on the future of biomedical design, healthcare delivery, and patient well-being.

National Needs (Eswatini):

1. **Quantitative Expertise**:

    - Eswatini requires skilled biomedical professionals who can navigate complex scenarios in medical device design, diagnostics, and safety.
    - The program equips students with mathematical proficiency and critical thinking abilities to assess biomedical conditions effectively.
2. **Cutting-Edge Practices**:
    - Graduates advocate for evidence-based decision-making, ensuring safety, efficiency, and equitable treatment in healthcare.
    - By enhancing their understanding of medical materials, imaging systems, and sustainable healthcare design, they contribute to better biomedical outcomes.
3. **Policy and Innovation**:
    - The program fosters critical thinking, enabling graduates to engage in research, policy formulation, and informed decision-making at the national level.

Regional Needs (SADC):

1. **Harmonization of Practices**:
    - SADC member states share biomedical challenges related to healthcare infrastructure, medical technology, and public health.
    - The program aligns with SADC's goal of harmonizing biomedical frameworks, promoting cooperation, and advancing sustainable healthcare practices.
2. **Human Capital Development**:
    - Biomedical professionals play a pivotal role in regional development and community well-being.
    - The program contributes to building a skilled workforce capable of addressing cross-border biomedical complexities.
3. **Technological Advancements**:
    - SADC's prosperity relies on informed biomedical practices that balance medical efficacy, accessibility, and environmental impact.
    - Our graduates contribute to maintaining biomedical integrity, resolving healthcare challenges, and fostering regional well-being.

Purpose of the Program:

1. **Technical Leadership**:
    - The program educates ethical leaders who champion evidence-based practices, fairness, and patient safety in biomedical engineering.
    - Graduates not only assess technical data but also shape policies, regulations, and protocols that impact healthcare delivery.
2. **Innovative Research**:
    - Students engage in specialized biomedical research, addressing contemporary challenges such as medical device innovation, personalized medicine, and healthcare infrastructure enhancement.

PROGRAMME LEARNING OBJECTIVES

1. **Core Skills**: Students will recall, explain, and deploy core skills in mathematics, programming, electrical engineering, and mechanical engineering within various bioengineering contexts.

2. **Problem Solving**: They will apply engineering skills to analyze and solve problems specific to biomedical engineering.

3. **Research Competence**: Students will engage in planning, designing, and implementing collaborative, multidisciplinary original research in biomedical engineering.

4. **Foundational Knowledge**: They will appreciate the core physical science and engineering principles underpinning healthcare and biomedicine.

5. **Information Literacy**: Students will access, analyze, and critically evaluate scientific and engineering information sources, preparing both oral and written reports.

6. **Laboratory Proficiency**: They will plan and develop laboratory investigations in biomedical engineering, adhering to health, safety, and ethical considerations.

7. **Mathematical and Computational Skills**: Students will use appropriate mathematical and computational approaches to address clinical and biomedical challenges.

8. **Critical Thinking**: They will demonstrate problem-solving abilities through critical thinking, evaluative skills, and analytical reasoning.

9. **Effective Communication**: Students will communicate technical and non-technical information using various methods and tailored to diverse audiences.

PROGRAMME LEARNING OUTCOMES

The following are the program learning outcomes of the Bachelor of Engineering in Biomedical Engineering at Springfield Research University (SRU). Our program equips students with the skills, knowledge, and ethical awareness needed to address complex biomedical challenges. From designing life-saving medical devices to advancing healthcare systems, our graduates emerge as innovative problem solvers and compassionate leaders.

1. **Problem Solving and Critical Thinking**: Graduates will adeptly identify, formulate, and solve intricate engineering challenges by skillfully applying principles from engineering, science, and mathematics.
2. **Innovative Design and Social Responsibility**: They will creatively design solutions that address specified needs, while considering public health, safety, welfare, and global, cultural, social, environmental, and economic factors.
3. **Effective Communication**: Graduates will communicate proficiently with diverse audiences, bridging technical and non-technical domains.
4. **Ethical and Global Awareness**: They will recognize their ethical and professional responsibilities within engineering contexts, making informed judgments that account for the broader impact of solutions on a global scale.
5. **Collaboration and Leadership**: Graduates will function effectively within interdisciplinary teams, providing leadership, fostering collaboration, and achieving shared goals.
6. **Experimental Proficiency and Data Interpretation**: They will skillfully design and conduct experiments, analyze and interpret data, and apply engineering judgment to draw meaningful conclusions.
7. **Lifelong Learning and Adaptability**: Graduates will continuously acquire and apply new knowledge, employing appropriate learning strategies to stay current in this dynamic field.

CAREER OPPORTUNITIES

Senior Clinical Research Associate

Responsibilities: Clinical research associates provide advanced technical support during the clinical research process, including testing, handling equipment, and presenting findings. Due to the private nature of this work, these individuals are often held to high ethical standards and must strictly follow established processes to prevent unwanted contamination of collected data or patient records.

Biomedical Scientist

Responsibilities: Biomedical scientists at this level can design and implement experiments in a research environment. They may work independently or under the supervision of PhD-level scientists, and are often required to publish articles in academic journals on their findings.

Senior Medical Writer

Responsibilities: Medical writers create manuals and other training or educational materials for readers both with and without medical backgrounds. They often conduct the research needed to develop these materials and thus require a robust understanding of the biomedical science field as a whole. Their writing must translate between audiences, speaking to medical professionals, patients, and even, at times, commercial audiences.

Senior Medicinal Chemist

Responsibilities: Medical chemists create the chemicals and compounds that are used to develop helpful medicinal drugs. This often includes making calculated adjustments to chemical compounds while studying each chemical's reaction to each other and its environment and leveraging that information to understand how a drug will behave in the human body.

ENTRY REQUIREMENTS

The student must have 6 credits and/or passes in SGCSE/GCE/IGCSE O' level including a pass with Grade C or better in English Language and at least four other subjects. Special: Mathematics and any other two from Chemistry, Combined Science, Physics, Physical Science. Faculty may set mature entry requirements subject to approval by Senate.

The Bachelor's Degree shall:

The Bachelor's degree program in Biomedical Engineering at Springfield Research University is designed to equip students with the skills and knowledge necessary for a successful career in this dynamic field. Here are the key features of our program:

1. **Duration**:
    - The program spans **four years** for full-time students or **six years** for part-time students, including an industrial attachment or internship period.
2. **Semester Structure**:
    - Each academic year consists of **two semesters**.
    - **Semester Duration**: Each semester runs for **20 weeks**.
        - **Orientation Week**: One week dedicated to orientation.
        - **Teaching Weeks**: A minimum of **14 weeks** for instruction.
        - **Mid-Semester Break**: A one-week break for students.
        - **Examination Period**: Two weeks for final exams.
        - **Results Processing**: Two weeks allocated for marking and result processing.

Our program ensures a rigorous academic experience while allowing flexibility for part-time students. Students engage in hands-on learning, theoretical coursework, and practical projects, preparing them for the exciting challenges of the Biomedical industry.

Special Departmental Regulations

1. **Course Completion Requirements**:
    - All **Core**, **Prerequisite**, **Required**, **General**, and **Elective** courses within the degree program are compulsory. Students must pass these courses with a minimum grade of **50%** to graduate.
    - However, during the third and fourth years, all courses must be passed with a minimum grade of **60%** (equivalent to a CGPA of **3.00**) to qualify for graduation.
2. **Optional Courses**:
    - Optional courses do not contribute to the final grade. Their marks are excluded from the computation of the overall grade.
3. **Externalization of Courses**:
    - All courses within the degree programs must be completed internally. Externalization is not permitted.
4. **Quality Control and Evaluation**:
    - Regular academic audits and reviews occur every four years, overseen by external moderators. Internal program evaluation is ongoing.
5. **Competence and Preparation**:
    - The courses offered in the Bachelor of Engineering in Biomedical Engineering program provide adequate competences, preparing students for professional practice at the required academic level.
6. **Core and Prerequisite Courses**:

- Students must pass all Core and Prerequisite courses with a minimum grade of **50%** before progressing to the next level or enrolling in additional courses.

Degree Award and Classification

- Upon successful completion of all **Core**, **Required**, and **Education** courses, as well as meeting the program requirements, a student will be awarded the degree of **Bachelor of Engineering in Biomedical Engineering** at the end of the final year.
- The **normal classification** of a Bachelor's Degree is determined based on the academic performance during the third and fourth years of study.

Rationale to Course Numbering

At Springfield Research University, we meticulously design our Biomedical Engineering curriculum to empower students with the knowledge and skills needed to thrive in this dynamic field. Our course numbering system serves as a roadmap, guiding students through their academic journey - ****100-level courses**** introduce foundational concepts. - ****200-level courses**** build on those foundations. - ****300-level courses**** explore more specialized topics. - ****400-level courses**** are advanced and often include research or project components. Let's delve into the reasons behind our thoughtful approach:

1. **Logical Progression**: Our course numbers reflect a logical progression. Foundational concepts begin with the "100" series, followed by deeper explorations in the "200" and "300" levels. Advanced topics and research opportunities reside in the "400" series.
2. **Prerequisites and Coherence**: Clear numbering helps students understand prerequisites and co-requisites. For instance, a 200-level course assumes knowledge from related 100-level courses, ensuring a coherent learning experience.
3. **Specialization and Depth**: As students advance, higher-level courses delve into specialized areas such as control systems, machine learning, and autonomous Biomedical. The numbering system communicates this depth of study.
4. **Alignment with Program Goals**: Each course number aligns with our program's learning outcomes. Whether it's mastering kinematics or diving into image processing, students can track their progress.
5. **Transferability**: Consistent numbering facilitates credit transfer between institutions, supporting seamless academic mobility.

In summary, our course numbering isn't just a sequence—it's a deliberate framework that enhances learning, fosters curiosity, and prepares our students for impactful careers in Biomedical engineering. Biomedical Engineering courses simplifies the course numbering system.

1. **100-Level Courses:**
   - **BME 101:** Introduction to Biomedical Engineering
   - **BME 110:** Linear Algebra for Biomedical Engineering
   - **BME 120:** Mechanics and Dynamics in Biomedical Systems

2. **200-Level Courses:**
    - **BME 201:** Biomechanics and Biomaterials
    - **BME 210:** Digital Signal Processing for Biomedical Applications
    - **BME 220:** Anatomy and Physiology for Engineers
3. **300-Level Courses:**
    - **BME 301:** Medical Imaging and Instrumentation
    - **BME 310:** Biomedical Control Systems
    - **BME 320:** Bioinformatics and Computational Modeling
4. **400-Level Courses:**
    - **BME 401:** Biomedical Device Design and Innovation
    - **BME 410:** Rehabilitation Engineering
    - **BME 420**: Advanced Topics in Biomedical Engineering

The Bachelor of Engineering is a four (4) program. The student is expected to accumulate 576 credit points to be considered to have met the requirements of the Bachelor of Engineering in Biomedical Engineering and must pass each module by at least 50%.

- Level 1 = minimum of credits 144 (1440 notional hours of study)
- Level 2 = minimum of credits 144 (1440 notional hours of study)
- Level 3 = minimum of credits 144 (1440 notional hours of study)
- Level 4 = minimum of credits 144 (1440 notional hours of study)

TOTAL credit points 576 (5760 notional hours of study)

Credit Transfer and Accumulation

1. Credits are derived from engagement of students in learning activities during lectures, seminars, tutorials, micro or macro field trips, directed and self-directed learning and writing examination tests and assignments.
2. Modules from the engineering faculty are worth 12 credit. Lecture attendance is compulsory. Students who attend less than 80% of lessons will not be allowed to sit for their sessional examinations.

Weighting

The degree class shall be based on weighting the results from part 1, 2, 3, and 4, the Degree weighting shall be as follows:

Level 1	20%
Level 2	20%
Level 3	30%
Level 4	30%

Distribution of Notional Hours

Module	Lecture Hrs	Tutorials/ Seminars	Self-Directed Study	Assignment Tests/Exams	Notional Hrs	Credits
BME000	36	24	30	30	120	12
PROJECT	0	0	60	60	120	12

ASSESSMENT METHODS

1. **Formative Assessment (30%)**:
   - **Class Participation**: Actively engage in discussions, seminars, and practical activities related to biomedical engineering.
   - **Quizzes and Short Tests**: Regular assessments on specific biomedical engineering topics.
   - **Draft Assignments**: Receive feedback on early assignment drafts related to biomedical engineering principles.
   - **Peer Review**: Collaborate with peers to review and improve each other's engineering project work.
2. **Summative Assessment (60%)**:
   - **Final Examinations**: Comprehensive exams covering course content specific to biomedical engineering disciplines.
   - **End-of-Semester Projects**: Assess students' knowledge and problem-solving skills related to biomedical engineering challenges.
   - **Oral Presentations**: Evaluate communication abilities within the context of biomedical engineering solutions.
   - **Engineering Design Competitions**: Simulate real-world biomedical engineering scenarios.
3. **Continuous Assessment (10%)**:
   - **Internships or Work Placements**: Engage in supervised biomedical engineering placements, applying theoretical knowledge to practical projects.
   - **Assignments and Projects**: Regular tasks contribute to the overall grade, emphasizing practical skills in biomedical engineering design and analysis.
   - **Research Papers**: Demonstrate research abilities related to biomedical engineering innovations and advancements.
   - **Attendance and Active Participation**: Engage in lectures, workshops, and industry events specific to biomedical engineering practices.

These adapted assessment methods align with Springfield Research University's commitment to academic excellence and the development of competent engineers.

Teaching Methods

At Springfield Research University (SRU), we are committed to employing a diverse array of teaching methods to ensure a comprehensive and engaging learning experience for our students. Our teaching methods are carefully selected to align with the programme's objectives and to meet the needs of our diverse student body. The following are the key teaching methods utilized across all SRU programmes:

1. Lectures:

- Lectures are used to introduce and explain key concepts, theories, and principles. They provide a structured and systematic approach to delivering content, allowing students to gain a solid foundation in their respective fields. Lectures are often supplemented with visual aids, multimedia presentations, and interactive elements to enhance understanding and engagement.

2. Seminars:

- Seminars are interactive sessions that promote critical thinking and in-depth discussion on specific topics. Students are encouraged to actively participate, share their perspectives, and engage in debates. Seminars provide an opportunity for students to develop their analytical and communication skills.

3. Workshops:

- Workshops are hands-on sessions that focus on practical skills and applications. These sessions allow students to engage in experiential learning, apply theoretical knowledge to real-world scenarios, and collaborate with peers on projects and activities. Workshops are designed to foster creativity, problem-solving, and teamwork.

4. Problem-Based Learning (PBL):

- Problem-Based Learning is a student-centered approach that involves presenting students with complex, real-world problems to solve. Students work in small groups to research, discuss, and propose solutions, developing critical thinking and collaborative skills in the process. PBL encourages independent learning and active engagement.

5. Case Studies:

- Case studies are used to analyze real-life situations and decision-making processes. Students examine and discuss case studies to understand the context, identify key issues, and evaluate possible solutions. This method helps students develop their analytical and problem-solving abilities while relating theoretical concepts to practical situations.

6. Clinical Practice:

- For programmes that include a clinical component, such as Health and Medical Sciences, clinical practice is an integral part of the curriculum. Students gain hands-on experience in clinical settings, working under the supervision of qualified professionals. This method provides valuable opportunities for students to apply their knowledge, develop clinical skills, and gain insights into professional practice.

7. Research Projects:

- Research projects are designed to cultivate a culture of inquiry and innovation. Students engage in independent or group research projects, exploring topics of interest and contributing to the body of knowledge in their field. Research projects develop students' research skills, critical thinking, and ability to communicate findings effectively.

8. Online Learning:

- Online learning is incorporated to provide flexible and accessible education. SRU utilizes online platforms to deliver lectures, conduct discussions, and facilitate collaborative projects. Online learning allows students to access course materials, participate in virtual classrooms, and engage with peers and instructors remotely.

9. Continuous Assessment:

- Continuous assessment methods, such as quizzes, assignments, and presentations, are used to monitor students' progress and provide ongoing feedback. These assessments help identify areas for improvement and ensure that students are meeting learning objectives throughout the course.

10. Peer Learning:

- Peer learning encourages students to collaborate and learn from each other. Group projects, study groups, and peer review sessions provide opportunities for students to share knowledge, offer feedback, and support each other's learning journey.

At SRU, our commitment to employing diverse and effective teaching methods ensures that our students receive a well-rounded education that prepares them for success in their chosen fields. We continuously review and enhance our teaching practices to provide the best possible learning experience for our students.

Delivery Methods

At Springfield Research University (SRU), we utilize a variety of delivery methods to ensure that our educational programmes are accessible, engaging, and effective. Our delivery methods are designed to cater to the diverse needs of our students and to provide flexible learning opportunities. The following are the key delivery methods employed across all SRU programmes:

1. In-Person Delivery:

- **Classroom Lectures:** Traditional classroom lectures provide a structured and interactive environment where students can engage with instructors and peers. These sessions often include discussions, presentations, and multimedia resources to enhance learning.
- **Laboratory Sessions:** For programmes that require practical and experimental learning, laboratory sessions are conducted in specialized labs equipped with the necessary tools and equipment. These hands-on sessions allow students to apply theoretical knowledge in a controlled environment.
- **Clinical Placements:** Health and Medical Sciences programmes include clinical placements in hospitals, clinics, and healthcare facilities. These placements provide students with real-world experience under the supervision of qualified professionals.

2. Online Delivery:

- **Virtual Classrooms:** Online platforms are used to deliver lectures, conduct discussions, and facilitate collaborative projects. Virtual classrooms enable students to access course materials, participate in live sessions, and engage with peers and instructors from remote locations.
- **Recorded Lectures:** Recorded lectures are made available for students to access at their convenience. This flexible approach allows students to review and revisit course content as needed.
- **Online Assessments:** Online assessments, including quizzes, assignments, and exams, are conducted through secure online platforms. These assessments provide timely feedback and help monitor students' progress.

3. Blended Learning:

- **Hybrid Courses:** Blended learning combines in-person and online delivery methods to provide a flexible and comprehensive learning experience. Hybrid courses may involve alternating between classroom sessions and online activities.
- **Flipped Classroom:** In the flipped classroom model, students access instructional content online before class and use in-person sessions for interactive, application-based activities. This approach encourages active learning and deeper engagement with the material.

4. Independent Study:

- **Self-Paced Learning:** Self-paced learning allows students to progress through course materials at their own speed. This method is ideal for students who prefer to learn independently and manage their own schedules.
- **Research Projects:** Independent research projects provide students with the opportunity to explore topics of interest, develop research skills, and contribute to the body of knowledge in their field. Faculty advisors provide guidance and support throughout the research process.

5. Collaborative Learning:

- **Group Projects:** Group projects foster teamwork and collaboration among students. These projects often involve problem-solving, research, and presentations, allowing students to learn from each other and develop interpersonal skills.
- **Peer Review:** Peer review sessions encourage students to provide and receive constructive feedback on each other's work. This method promotes critical thinking, reflection, and improvement.

6. Experiential Learning:

- **Internships and Work Placements:** Internships and work placements provide students with practical experience in their chosen field. These opportunities allow students to apply their knowledge in real-world settings, develop professional skills, and build industry connections.
- **Field Trips and Excursions:** Field trips and excursions offer experiential learning opportunities outside the classroom. These activities provide students with firsthand exposure to relevant sites, industries, and practices.

7. Continuous Assessment:

- **Formative Assessments:** Formative assessments, such as quizzes, assignments, and in-class activities, provide ongoing feedback to students and help track their progress. These assessments are designed to support learning and identify areas for improvement.
- **Summative Assessments:** Summative assessments, including final exams, projects, and presentations, evaluate students' overall performance and mastery of course content.

At SRU, our diverse delivery methods ensure that students receive a well-rounded and flexible education that caters to their individual learning preferences. We are committed to continuously enhancing our delivery methods to provide the best possible learning experience for our students.

Curriculum

Biomedical Engineering, ESQF Level 8 BE-BME degree, typical course sequence

YEAR 1: SEMESTER 1

Code	Course	Lectures	Practicals	Credits
BME100	Calculus I	**120**	**0**	**12**
BME101	General Chemistry I and Lab	**100**	**20**	**12**
BME102	General Physics I and Lab	**100**	**20**	**12**
BME103	Computing for Engineers and Scientists	**100**	**20**	**12**
BME104	Introduction to Electronics	**100**	**20**	**12**
BME105	Design I	**100**	**20**	**12**
TOTAL				**72**

YEAR 1: SEMESTER 2

Code	Course	Lectures	Practicals	Credits
BME106	Calculus II	**120**	**0**	**12**
BME107	Engineering Science	**100**	**20**	**12**
BME108	Introduction to Programming & Computation	**100**	**20**	**12**
BME109	Material Science and Lab	**100**	**20**	**12**
BME110	Communication for Academic Purposes	**120**	**0**	**12**
BME111	Physics for Engineers II and Lab	**100**	**20**	**12**
TOTAL				**72**

YEAR 2: SEMESTER 3

Code	Course	Lectures	Practicals	Credits
BME212	Calculus III	**120**	**0**	**12**
BME213	Probability and Statistics	**120**	**0**	**12**
BME214	Basic Life Mechanics and Lab	**100**	**20**	**12**
BME215	Statics	**120**	**0**	**12**
BME216	Communication for Professional Purposes	**120**	**0**	**12**
BME217	Genomic Data Science	**100**	**20**	**12**
TOTAL				**72**

YEAR 2: SEMESTER 4

Code	Course	Lectures	Practicals	Credits
BME218	Anatomy and Physiology for Engineers	**100**	**20**	**12**

BME219	Engineering Graphics	**100**	**20**	**12**
BME220	Differential Equations and Matrix Algebra	**100**	**20**	**12**
BME221	Mechanics of Materials	**100**	**20**	**12**
BME222	Circuits and Electronics	**100**	**20**	**12**
BME223	Fundamentals of Robotics	**100**	**20**	**12**
TOTAL				**72**

YEAR 3: SEMESTER 5

Code	Course	Lectures	Practicals	Credits
BME324	Signal and Systems	**100**	**20**	**12**
BME325	Transport Phenomena I	**100**	**20**	**12**
BME326	Bioinformatics	**100**	**20**	**12**
BME327	Computational Neuroscience	**100**	**20**	**12**
BME328	Neurobiology, Medicine and Society	**100**	**20**	**12**
BME329	Experimental Methods in System Biology	**100**	**20**	**12**
TOTAL				**72**

YEAR 3: SEMESTER 6

Code	Course	Lectures	Practicals	Credits
BME330	Engineering Physiology and Lab	**100**	**20**	**12**
BME331	Introduction to Biomedical Imaging	**100**	**20**	**12**
BME332	Principles of Magnetic Resonance Imaging	**100**	**20**	**12**
BME333	Imaging Probes for Nuclear & Optical Imaging	**100**	**20**	**12**
BME334	Principles of Diagnostic and Therapeutic Ultrasound	**100**	**20**	**12**
BME335	Neurological Imaging	**100**	**20**	**12**
TOTAL				**72**

YEAR 4: SEMESTER 7

Code	Course	Lectures	Practicals	Credits
BME436	Bioengineering	**100**	**20**	**12**
BME437	Cell and Tissue Engineering	**100**	**20**	**12**
BME438	Bioinspired Surfaces	**100**	**20**	**12**
BME439	Structure and Function of Biomaterials	**100**	**20**	**12**
BME440	Internship I	**0**	**120**	**12**
BME441	Work based Learning I	**0**	**120**	**12**
TOTAL				**72**

YEAR 4: SEMESTER 8

Code	Course	Lectures	Practicals	Credits
BME442	Introduction to Human Biomechanics	**100**	**20**	**12**
BME443	Sports Injury Biomechanics	**100**	**20**	**12**
BME444	Rehabilitation Biomechanics (Physioplus)	**100**	**20**	**12**
BME445	Orthopedic Biomechanics	**100**	**20**	**12**
BME446	Internship II	**0**	**120**	**12**
BME447	Work based Learning II	**0**	**120**	**12**
TOTAL				**72**

COURSE DESCRIPTIONS

EXPERIMENTAL METHODS IN SYSTEM BIOLOGY

Learn about the technologies underlying experimentation used in systems biology, with particular focus on RNA sequencing, mass spec-based proteomics, flow/mass cytometry and live-cell imaging.

A key driver of the systems biology field is the technology allowing us to delve deeper and wider into how cells respond to experimental perturbations. This in turns allows us to build more detailed quantitative models of cellular function, which can give important insight into applications ranging from biotechnology to human disease. This course gives a broad overview of a variety of current experimental techniques used in modern systems biology, with focus on obtaining the quantitative data needed for computational modeling purposes in downstream analyses. We dive deeply into four technologies in particular, mRNA sequencing, mass spectrometry-based proteomics, flow/mass cytometry, and live-cell imaging. These techniques are often used in systems biology and range from genome-wide coverage to single molecule coverage, millions of cells to single cells, and single time points to frequently sampled time courses. We present not only the theoretical background upon which these technologies work, but also enter real wet lab environments to provide instruction on how these techniques are performed in practice, and how resultant data are analyzed for quality and content.

NEUROBIOLOGY, MEDICINE AND SOCIETY

The objective of this course is to give students the most up-to-date information on the biological, personal, and societal relevance of sleep. Personal relevance is emphasized by the fact that the single best predictor of daytime performance is the quality of the previous night's sleep. The brain actively generates sleep, and the first section of the course is an overview of the neurobiological basis of sleep control. The course provides cellular-level understanding of how sleep deprivation, jet lag, and substances such as alcohol, ,caffeine, and nicotine alter sleep and wakefulness. The second section of the course covers sleep-dependent changes in physiology and sleep disorders medicine. Particular emphasis will be placed on disorders of excessive sleepiness, insomnia, and sleep-dependent changes in autonomic control. Chronic sleep deprivation impairs immune function and may promote obesity. Deaths due to all causes are most frequent between 4:00 and 6:00 a.m., and this second section of the class highlights the relevance of sleep for preventive medicine. The societal relevance of sleep will be considered in the final section of the class. In an increasingly complex and technologically oriented society, operator-error by one individual can have a disastrous negative impact on public health and safety. Fatigue-related performance decrements are known to have contributed as causal factors to nuclear power plant failures, transportation disasters, and medical errors.

COMPUTATIONAL NEUROSCIENCE

This course provides an introduction to basic computational methods for understanding what nervous systems do and for determining how they function. We will explore the computational principles governing various aspects of vision, sensory-motor control, learning, and memory. Specific topics that will be covered include representation of information by spiking neurons, processing of information in neural networks, and algorithms for adaptation and learning. We will make use of Matlab/Octave/Python demonstrations and exercises to gain a deeper understanding of concepts and methods introduced in the course. The course is primarily aimed at third- or fourth-year undergraduates and beginning graduate students, as well as professionals and distance learners interested in learning how the brain processes information.

PATHWAYS IN BIOMEDICAL ENGINEERING

Overview of biomedical engineering and the biomedical engineering industry, including specialties, degree requirements and scholastic programs in the Department of Biomedical Engineering.

COMPUTING FOR BIOMEDICAL ENGINEERING

Introduction to the principles of computer programming for biomedical applications including program design and development, programming techniques and documentation; introduction to and programming in the Python and LabVIEW environments.

BIOMEDICAL APPLICATIONS OF SIGNALS AND SYSTEMS

Quantitative analysis of biomedical and physiological signals; Fourier and Laplace transforms; filtering of biomedical signals; electrical circuits an analog representations of physiological systems as model systems; A/D conversion and sampling.

MEDICAL DEVICE DESIGN I

FDA design controls for medical device development in a regulated environment; small-scale team biomedical engineering design project.

BIOINSTRUMENTATION

Introduction to biomedical instrumentation design; hands on acquisition of biomedical signals; design, building and testing of bioinstrumentation circuits including analog signal amplifiers and analog filter circuits.

BIOMEDICAL ELECTRONICS

Introduction to biomedical signals; basic circuit analysis for biomedical signals; design of bioamplifier circuits; characteristics of linear and nonlinear circuit elements; design of basic electronic circuits, principles and practice of bioelectronic measurements.

BIOSIGNAL ANALYSIS

Design and application of analog and digital signal analysis in biomedical engineering; characteristics of biomedical signals; design considerations for analog-to-digital and digital-to-analog circuitry; biosignal transformation methods; analog and digital filter design for biomedical signals.

BIOFLUID MECHANICS

Introduction into the mechanics of fluids in biomechanics, including blood, synovial fluid and physiological solutions, with an emphasis on the importance of mechanobiology and the formation of biological problems within the context of 1) kinematics, 2) the concept of stress, 3) linear momentum balance, 4) constitutive relations, and 5) boundary conditions.

INTRODUCTION TO BIOMATERIALS

Properties of natural and man-made materials commonly encountered in biomedicine and biomedical engineering; an integrated approach in the presentation of material structures, characteristics and properties; the basics of material structures, including crystalline and chemical structure, and microstructure; and bulk properties and characteristics of the materials developed from the microscopic origins.

BIOLOGICAL RESPONSES TO MEDICAL DEVICES

Selection and characterization of materials in implantable and tissue contacting medical devices; biodegradation, biocompatibility, hemocompatibility and cell-material interactions of biomaterials.

BIOMATERIALS LAB

Experimental methods used to prepare and characterize polymeric biomaterials used in biomedical engineering; related fundamental aspects of forming a hypothesis, experimental design, empirical observation, data collection, interpretation and presentation of data.

STATISTICS FOR BIOMEDICAL ENGINEERING

Evaluation of the efficacy of clinical research; quantitative methods used in clinical trials in biomedical engineering; ethical and regulatory issues that must be considered during the design and implementation of any clinical trial, or pre-clinical study.

MEDICAL DEVICE DESIGN II

Identification of needs for biomedical engineering design solutions, development of design proposals, analysis of design project requirements and constraints.

BIOSOLID MECHANICS

Introduction to the mechanics of deformable media in biomedical engineering, including medical devices, biomaterials, and soft and hard biological tissues: emphasis on biomechanics and mechanobiology and formulation of problems within the context of basic continuum biomechanics; problems include analytical solutions for stress-strain analysis of extension, distension, bending, buckling, and torsion of biosolids.

ENGINEERING PROFESSIONAL DEVELOPMENT

Participation in an approved high-impact learning practice; reflection on professional outcomes from engineering body of knowledge; documentation and self-assessment of learning experience at mid-curriculum point.

HISTORY OF HUMAN AND VETERINARY MEDICINE

Addresses the major developments in human and veterinary medicine from the Middle Ages to the present; explores key events and figures in medical history and analyzes issues of current biomedical concern in a historical context; for example, animal rights, ethics of humane experimentation, euthanasia.

PRINCIPLES AND ANALYSIS OF BIOLOGICAL CONTROL SYSTEMS

Techniques for generating quantitative mathematical models of physiological control systems and devices; the behavior of physiological control systems using both time and frequency domain methods.

BIOMEDICAL OPTICS LABORATORY

Biomedical optics technology; basic engineering principles used in developing therapeutic and diagnostic devices; hands-on labs including optical monitoring, diagnostic and therapeutic experiments.

GOOD LABORATORY AND CLINICAL PRACTICES

Implementation of Good Laboratory Practices (GLP) for the submission of preclinical studies and use of Good Clinical Practices (GCP) in clinical trials in accordance with Food and Drug Administration (FDA) regulations; includes similarities and differences in GLP and GCP critical for the introduction of new drugs and medical devices.

MEDICAL DEVICE PATH TO MARKET

Path to market for a medical device with specific attention to the regulatory affairs to enable the development of an appropriate regulatory strategy due to the highly regulated global environment.

MEDICAL IMAGING

The principles of the major imaging modalities including x-ray radiography, x-ray computed tomography (CT), ultrasonography and magnetic resonance imaging; including a brief discussion on other emerging imaging technologies such as nuclear imaging (PET and SPECT).

BIOELECTROMAGNETISM

Electric, magnetic and electromagnetic phenomena associated with biological tissues; source modeling based on physiological current including line and volume conductor models as well as electromagnetic-based stimulation, sensing and imaging.

BIOPHOTONICS

Theory and application of optical instrumentation, including light sources, lasers, detectors, and optical fibers; instrumentation and engineering in biomedical applications of optics in therapeutics, diagnostics, and biosensing. **Prerequisites:** Admitted into the major degree sequence in biomedical engineering; junior or senior classification.

MAGNETIC RESONANCE ENGINEERING

Design, construction and application of instrumentation for MR imaging; fundamentals of the architecture of an MR spectrometer and the gradient subsystem used for image localization; emphasis on the radiofrequency sensors and systems used for signal generation and reception.

EMBEDDED SYSTEMS FOR MEDICAL APPLICATIONS

Principles of embedded system architecture and programming; fundamentals and theoretical foundations of wireless communication systems; hands-on experiences of how an embedded system could be used to solve problems in biomedical engineering; projects on wireless sensors and imaging for medical devices.

BIOMOLECULAR ENGINEERING

Foundations for understanding and experimental approaches for measuring and manipulating biomolecules; proteins, nucleic acids and carbohydrates; thermodynamics and kinetics of biomolecular reactions.

MOLECULAR AND CELLULAR BIOMECHANICS

Introduces biomolecules and their assemblies that play structural and dynamical roles in subcellular to cellular level mechanics; emphasis on quantitative/theoretical descriptions; discussions of the relevant experiment approaches to probe these nano to micro-scale phenomena; includes topics in self-assembly of cytoskeleton and biomembranes, molecular motors, cell motility, and mechanotransduction.

BIOMOLECULAR AND CELLULAR ENGINEERING LABORATORY

Laboratory biosafety and biohazard awareness; cell culture protocols and standards for biocompatibility testing; setting protocols for cellular and biomolecular projects; bioimaging, bioassays and biomolecule activity testing.

HEALTHCARE TECHNOLOGY IN THE DEVELOPING WORLD

Principles of operation for major types of medical equipment; physiology underlying the measurement; major functional (system) pieces for each instrument; typical problems/applications of each instrument.

MASS AND ENERGY TRANSFER IN BIOSYSTEMS

Transport phenomena associated with physiological systems and their interaction with medical devices; exchange processes in artificial life support systems and diagnostic equipment.

ANALYSIS AND DESIGN PROJECT I

Group or team biomedical engineering analysis and design project involving statement, alternative approaches for solution, specific system analysis and design.

ORTHOPEDIC BIOMECHANICS

Development of competencies in biomechanical principles using practical examples and clinical case studies; application of biomechanical knowledge to the evaluation of musculoskeletal tissues and structures, and treatment options for musculoskeletal dysfunction.

MOTION BIOMECHANICS

Skeletal anatomy and mechanics; muscle anatomy and mechanics; theory and application of electromyography; motion and force measuring equipment and techniques; inverse dynamics modeling of the human body; current topics in musculoskeletal biomechanics research.

CARDIAC MECHANICS

Application of continuum mechanics and computational solid mechanics to the study of the mammalian heart; utilization of continuum mechanics and finite element analysis in solving non-linear boundary value problems in biomechanics.

SOFT TISSUE MECHANICS AND FINITE ELEMENT METHODS

Application of continuum mechanics and finite element methods to the study of the mechanical behavior of soft tissues and associative applications in biomedicine.

BIOMECHANICS EXPERIENTIAL LEARNING LAB

Applications in biomechanics (solid and fluid); includes experimental methods used to investigate biomechanical factors in the assessment of therapeutic interventions; mechanical testing load frames; motion capture systems, high speed imaging and flow systems; hypothesis forming, experimental design, empirical observation, data collection and interpretation, and presentation of results.

ADVANCED BIOMECHANICS

Application of fluid and solid mechanics to problems in biomedical engineering ranging from molecular-level to organ-level, including the mechanics of the cell cytoskeleton, whole cells, blood, arteries and the heart.

ENTREPRENEURIAL PATHWAYS IN MEDICAL DEVICES

Overview of fundamental elements and development steps for an effective strategy pathway including regulatory pathway for commercialization of medical product/medical device innovations; application of the basic regulations and associated requirements and enforcements for product market approval; exploration of product quality test method design requirements; understanding of the applicable regulations and standards pertaining to the design, testing, approval and marketing of medical devices.

NUMERICAL METHODS IN BIOMEDICAL ENGINEERING

Application of numerical analysis to analyze molecular, cellular and physiological systems, using general techniques including programming in MATLAB to analyze steady and dynamic systems.

BIOMEDICAL ENGINEERING OF TISSUES

Introduction to aspects of tissue engineering with and emphasis placed on tissue level topics including tissue organization and biological processes, with insights from recent literature (state-of-the-art).

POLYMERIC BIOMATERIALS

Preparation, properties, and biomedical applications of polymers including polymerization; structure-property relationships; molecular weight and measurement; morphology; thermal transitions; network formation; mechanical behavior; polymetric surface modification; polymer biocompatibility and bioadhesion; polymers in medicine, dentistry, and surgery; polymers for drug delivery; polymeric hydrogels; and biodegradable polymers.

POLYMERIC BIOMATERIAL SYNTHESIS

Overview of polymer synthetic routes and key structure-property relationships with emphasis on the design of polymeric systems to achieve specific properties; tissue engineering and drug delivery applications will be used as model systems to explore the process of biomaterial design from synthesis to device evaluation.

BIOMEDICAL NANOTECHNOLOGY

Nanotechnology applications in biomedicine; concepts of scale; unique properties at the nanoscale; biological interaction, transport, and biocompatibility of nanomaterials; current research and development of nanotechnology for medical applications, including sensors, diagnostic tools, drug delivery systems, therapeutic devices, and interactions of cells and biomolecules with nanostructured surfaces.

DRUG DELIVERY

Mechanisms for controlled release of pharmaceutically active agents and the development of useful drug delivery systems; controlled release mechanisms including diffusive, convective, and erosive driving forces by using case studies related to oral, topical and parenteral release in a frontier interdisciplinary scientific research format.

COURSE OUTLINES

Calculus I

Course Description

Calculus I introduces fundamental concepts in differential and integral calculus. The course emphasizes understanding mathematical principles and their applications in engineering and science. Topics covered include limits, derivatives, integration, and techniques for solving engineering problems.

Learning Objectives

By the end of this course, students should be able to:

- Understand the concept of limits and continuity.
- Compute derivatives using differentiation rules.

- Apply derivatives to solve real-world problems.
- Evaluate definite and indefinite integrals.
- Utilize integration techniques for practical applications.

Topics Covered

1. **Functions and Properties:**
    - Types of functions (polynomial, exponential, trigonometric).
    - Properties of functions (domain, range, symmetry).
2. **Limits and Continuity:**
    - Evaluating limits algebraically and graphically.
    - Determining continuity of functions.
3. **Derivatives:**
    - Definition of derivatives.
    - Rules for differentiation (product rule, chain rule).
    - Applications of derivatives (rates of change, optimization).
4. **Integrals:**
    - Definite and indefinite integrals.
    - Techniques of integration (substitution, integration by parts).
    - Applications in physics, engineering, and biology.
5. **Mathematical Modeling:**
    - Using calculus to model real-world phenomena.
    - Solving engineering problems involving rates of change and accumulation.

Assessment

- Homework assignments and problem-solving exercises.
- Quizzes and midterms.
- Final exam assessing understanding of concepts and problem-solving skills.

Recommended Reading

- Stewart, J. (or other calculus textbooks).
- Supplementary materials available online.

Design I

Course Description

Design I focuses on fundamental principles of engineering design, emphasizing creativity, problem-solving, and interdisciplinary collaboration. Students learn to apply design thinking to real-world challenges, with a specific focus on biomedical applications. The course integrates theoretical knowledge with practical skills, preparing students to create innovative solutions that enhance human healthcare.

Learning Objectives

By the end of this course, students should be able to:

- Understand the design process, including problem identification, ideation, and prototyping.

- Apply engineering principles to develop solutions for medical devices and instruments.
- Collaborate effectively in multidisciplinary teams.
- Communicate design concepts through sketches, models, and presentations.

Topics Covered

1. **Introduction to Design Thinking:**
    - Overview of the design process.
    - Identifying user needs and constraints.
    - Brainstorming and concept generation.
2. **Biomedical Design Challenges:**
    - Analyzing healthcare problems.
    - Ethical considerations in medical design.
    - Case studies of successful biomedical innovations.
3. **Sketching and Visualization:**
    - Techniques for expressing design ideas visually.
    - Creating concept sketches and storyboards.
4. **Prototyping and Iteration:**
    - Building physical prototypes.
    - Testing and refining designs.
    - Iterative design cycles.
5. **Collaboration and Communication:**
    - Working in interdisciplinary teams.
    - Effective communication of design concepts.
    - Presenting design proposals.

Assessment

- Design projects (individual and group).
- Design journals documenting the design process.
- Presentations and critiques.

Recommended Reading

- Ulrich, K. T., & Eppinger, S. D. (2012). *Product Design and Development*. McGraw-Hill Education.

General Chemistry I for Engineers & Lab

Course Description

General Chemistry I is an introductory chemistry course designed specifically for engineering students. It covers fundamental chemical principles, including reactivity, bonding, structure, energetics, and electrochemistry. The course also emphasizes applications relevant to health, energy, the environment, and materials.

Learning Objectives

By the end of this course, students will be able to:

- Discuss chemical concepts, theories, and examples of fundamental chemistry.

- Apply chemistry to real-world scenarios within engineering themes.
- Develop problem-solving skills specific to chemical questions.
- Engage in experimental investigations related to chemistry.

Topics Covered

1. **Introduction to Chemical Principles:**
    - Overview of chemical reactivity and bonding.
    - Atomic structure and periodic trends.
    - Chemical equations and stoichiometry.
2. **Energetics and Thermodynamics:**
    - Heat, work, and the first law of thermodynamics.
    - Enthalpy, entropy, and Gibbs free energy.
    - Chemical equilibrium and reaction spontaneity.
3. **Electrochemistry:**
    - Redox reactions and electrochemical cells.
    - Nernst equation and cell potential.
    - Corrosion and batteries.
4. **Applications in Engineering:**
    - Environmental chemistry (pollution, climate change).
    - Materials science (polymers, ceramics, metals).
    - Health-related chemistry (pharmaceuticals, biomolecules).

Lab Component

- One lab session every other week (two and a half hours).
- Experimental investigations related to course topics.
- Hands-on experience with chemical techniques and instrumentation.

Assessment

- Homework assignments and problem-solving exercises.
- Quizzes and midterms.
- Lab reports and practical assessments.

Recommended Textbook

- General Chemistry: Principles and Modern Applications; Custom 11th Edition for University of Waterloo,

General Physics I

Course Description

General Physics I introduces fundamental principles of mechanics, covering topics related to motion, forces, and energy. The course provides a solid foundation for understanding physical phenomena and their applications in various fields.

Learning Objectives

By the end of this course, students should be able to:

- Apply Newton's Laws of Motion to analyze real-world scenarios.
- Understand concepts related to energy, work, and momentum.
- Solve problems involving rotational dynamics and torque.
- Explore fluid mechanics, simple harmonic motion, and thermodynamics.

Topics Covered

1. **Introduction to Mechanics:**
   - Measurement and estimation.
   - One-dimensional motion: velocity, acceleration, and vectors.
   - Projectile motion.
2. **Newtonian Mechanics:**
   - Newton's Laws of Motion.
   - Vector force diagrams.
   - Friction and circular motion.
3. **Gravitation:**
   - Kepler's Laws.
   - Universal gravitation.
4. **Work, Energy, and Momentum:**
   - Work-energy theorem.
   - Conservation of mechanical energy.
   - Impulse and momentum.
5. **Rotational Dynamics and Torque:**
   - Angular motion.
   - Moment of inertia.
   - Torque and equilibrium.
6. **Fluid Mechanics and Thermodynamics:**
   - Properties of fluids.
   - Simple harmonic motion.
   - Basic concepts in heat and thermodynamics.

Assessment

- Homework assignments and problem-solving exercises.
- Quizzes and midterms.
- Final exam covering all course topics.

Introduction to Computing for Engineers and Scientists

Course Description

This interdisciplinary course provides an introduction to computer science concepts relevant to engineering and scientific applications. It covers computational thinking, algorithmic problem-solving, and Python programming. Emphasis is placed on practical use cases in physics, statistics, electrical engineering, biology, and other related fields.

Learning Objectives

By the end of this course, students will be able to:

- Understand computational principles and their application.
- Develop algorithms for solving engineering and scientific problems.
- Write Python programs for data analysis and modeling.

Topics Covered

1. **Foundations of Computing:**
    - Introduction to programming languages and data representation.
    - Problem-solving techniques.
    - Spreadsheet-based data analysis and visualization.
2. **Python Programming:**
    - Basics of Python syntax and control structures.
    - Functions, loops, and conditional statements.
    - Scientific libraries (NumPy, SciPy) for numerical computing.
3. **Computer Architecture and Emerging Technologies:**
    - Overview of computer architecture.
    - Security considerations.
    - Trends in networking and emerging technologies.

Assessment

- Homework assignments and coding exercises.
- Quizzes and practical programming tasks.
- Final project applying computational concepts to an engineering or scientific problem.

Calculus II

Course Description

Calculus II builds upon the concepts introduced in Calculus I. This course delves deeper into integration techniques, differential equations, and applications of integrals. Students will explore parametric equations, polar coordinates, and infinite series.

Learning Objectives

By the end of this course, students should be able to:

- Apply integration techniques, including u-substitution, trigonometric substitution, and integration by parts.
- Solve differential equations and understand their applications.
- Compute volumes, areas, and arc lengths using integrals.
- Work with parametric equations and polar coordinates.

- Analyze infinite series and power series.

Topics Covered

1. **Integrals Review:**
   - Accumulations of change.
   - Riemann sums and definite integrals.
   - Properties of definite integrals.
2. **Integration Techniques:**
   - u-substitution.
   - Trigonometric identities.
   - Integration by parts.
   - Linear partial fractions.
3. **Differential Equations:**
   - Verifying solutions for differential equations.
   - Sketching slope fields.
   - Approximation with Euler's method.
4. **Applications of Integrals:**
   - Average value of a function.
   - Area between curves.
   - Volume of solids of revolution.
5. **Parametric Equations, Polar Coordinates, and Vector-Valued Functions:**
   - Second derivatives of parametric equations.
   - Arc length for parametric curves.
   - Area in polar regions.
6. **Infinite Series:**
   - Convergent and divergent series.
   - Geometric series, nth-term test, and integral test.
   - Taylor and Maclaurin polynomials.

Engineering Science

Course Description:

Engineering Science provides a foundational understanding of the principles and techniques that underpin modern engineering practice. Students will develop analytical, design, and computing skills necessary for successful engineering careers. The course covers a broad range of topics, including mechanics, thermodynamics, fluid dynamics, and materials science.

Learning Objectives:

- Understand fundamental engineering concepts and theories.
- Apply mathematical and computational tools to solve engineering problems.
- Develop critical thinking and problem-solving skills.
- Gain practical knowledge through hands-on experiments and projects.

Topics Covered:

1. **Engineering Mechanics:**
   - Statics and dynamics
   - Forces, moments, and equilibrium
   - Kinematics and kinetics

2. **Thermodynamics and Heat Transfer:**
    - Laws of thermodynamics
    - Heat transfer mechanisms (conduction, convection, radiation)
    - Energy conversion processes
3. **Fluid Mechanics:**
    - Fluid properties
    - Fluid statics and dynamics
    - Bernoulli's equation
4. **Materials Science and Machine Element Design:**
    - Material properties and behavior
    - Stress and strain analysis
    - Design of machine components (gears, bearings, shafts)
5. **Measurement and Control:**
    - Sensors and instrumentation
    - Feedback control systems
    - Data acquisition and analysis
6. **Engineering Design:**
    - Design methodologies
    - CAD (Computer-Aided Design) tools
    - Prototyping and testing

Assessment and Grading:

- Regular quizzes and assignments: 30%
- Midterm examinations: 20%
- Final project or design challenge: 25%

Recommended Reading:

1. Hibbeler, R. C. (2016). *Engineering Mechanics: Statics & Dynamics* (14th ed.). Pearson.
2. Cengel, Y. A., & Boles, M. A. (2014). *Thermodynamics: An Engineering Approach* (8th ed.). McGraw-Hill.
3. Munson, B. R., Young, D. F., & Okiishi, T. H. (2013). *Fundamentals of Fluid Mechanics* (7th ed.). Wiley.

Introduction to Programming and Computation

Course Description

This course serves as an introduction to fundamental programming concepts and computational thinking. Students will learn problem-solving techniques, algorithm design, and gain practical experience in writing code. The course emphasizes clarity, efficiency, and creativity in programming.

Learning Objectives

By the end of this course, students should be able to:

- Understand basic programming constructs (variables, loops, conditionals).
- Design and implement algorithms to solve problems.

- Apply computational thinking to real-world scenarios.
- Write clear and efficient code.

Topics Covered

1. **Programming Fundamentals**:
    - Variables, data types, and control structures.
    - Functions and modular programming.
    - Debugging techniques.
2. **Algorithmic Thinking**:
    - Problem-solving strategies.
    - Flowcharts and pseudocode.
    - Efficiency analysis (time and space complexity).
3. **Python Programming**:
    - Syntax, loops, and conditional statements.
    - Lists, dictionaries, and file I/O.
    - Object-oriented programming basics.

Assessment

- Homework assignments and coding exercises.
- Quizzes and practical programming tasks.
- Final project demonstrating understanding of programming concepts.

Recommended Reading

- Zelle, J. M. (2016). *Python Programming: An Introduction to Computer Science*. Franklin, Beedle & Associates.

Materials Science

Course Description

Materials Science for Biomedical Engineering explores the fundamental principles of materials used in medical devices, implants, and tissue engineering. Students will gain insights into the properties, processing, and interactions of materials relevant to healthcare applications. The course emphasizes the synergy between materials science and biomedical engineering.

Learning Objectives

By the end of this course, students should be able to:

- Understand the structure-property relationships of biomaterials.
- Evaluate the biocompatibility and mechanical behavior of materials.
- Apply materials science principles to solve biomedical engineering challenges.
- Explore emerging materials technologies in healthcare.

Topics Covered

1. **Introduction to Biomaterials**:
    - Types of biomaterials (metals, ceramics, polymers, composites).

- Biocompatibility assessment.
- Surface modification techniques.

2. **Mechanical Behavior of Biomaterials**:
   - Stress-strain relationships.
   - Elasticity, plasticity, and fracture mechanics.
   - Fatigue and wear in biomedical materials.
3. **Tissue Engineering Materials**:
   - Scaffolds and tissue regeneration.
   - Hydrogels and cell-material interactions.
   - Biodegradable polymers.
4. **Materials for Medical Devices**:
   - Implants (orthopedic, dental, cardiovascular).
   - Drug delivery systems.
   - Wear-resistant coatings.
5. **Emerging Trends in Biomedical Materials**:
   - Nanomaterials and drug delivery.
   - 3D printing and personalized implants.
   - Smart materials for diagnostics.

Assessment

- Assignments, lab reports, and case studies.
- Quizzes and exams assessing understanding of materials science concepts.
- Group projects related to biomaterials design.

Recommended Reading

- Ratner, B. D., Hoffman, A. S., Schoen, F. J., & Lemons, J. E. (Eds.). (2013). *Biomaterials Science: An Introduction to Materials in Medicine*. Academic Press.

Materials Science Laboratory

Course Description

The Materials Science Laboratory provides hands-on experience in characterizing and analyzing materials. Students learn practical techniques for examining material properties, microstructures, and behavior. The lab reinforces theoretical concepts from materials science courses and fosters critical thinking skills.

Learning Objectives

By the end of this course, students should be able to:

- Operate laboratory equipment for material testing.
- Analyze material samples using microscopy and spectroscopy.
- Interpret experimental results and relate them to material properties.
- Document and communicate findings effectively.

Topics Covered

1. **Sample Preparation and Handling**:

    - Cutting, mounting, and polishing specimens.
    - Safety protocols in the lab.
2. **Microstructural Analysis**:
    - Optical microscopy.
    - Scanning electron microscopy (SEM).
    - Grain size determination.
3. **Mechanical Testing**:
    - Tensile testing.
    - Hardness testing.
    - Impact testing.
4. **Thermal Analysis**:
    - Differential scanning calorimetry (DSC).
    - Thermogravimetric analysis (TGA).
5. **Materials Characterization**:
    - X-ray diffraction (XRD).
    - Fourier-transform infrared spectroscopy (FTIR).
    - Energy-dispersive X-ray spectroscopy (EDS).

Assessment

- Lab reports documenting experiments and results.
- Practical assessments during lab sessions.
- Final project related to material analysis.

Recommended Reading

- Callister, W. D., & Rethwisch, D. G. (2018). *Materials Science and Engineering: An Introduction*. Wiley.

Basic Engineering III: Probability and Statistics

Course Description

This course introduces fundamental concepts of probability theory and statistical methods relevant to engineering applications. Students will learn how to analyze data, make informed decisions, and draw meaningful conclusions. The course emphasizes practical problem-solving skills and their application in engineering contexts.

Learning Objectives

By the end of this course, students should be able to:

- Interpret graphs and descriptive statistics for one and two variables, drawing meaningful insights from the data.
- Understand and apply basic probability rules, as well as concepts of expected value and variance for both discrete and continuous variables.
- Apply the Central Limit Theorem effectively for inference, providing a foundation for statistical reasoning.
- Formulate mathematical models and arguments, utilizing statistical models to address real-world situations and provide effective solutions.

Topics Covered

1. **Descriptive Statistics**:
   - Measures of central tendency (mean, median, mode).
   - Measures of dispersion (variance, standard deviation).
   - Data visualization techniques (histograms, scatter plots).
2. **Probability Concepts**:
   - Sample spaces and events.
   - Probability rules (addition, multiplication).
   - Conditional probability and independence.
3. **Random Variables and Distributions**:
   - Discrete and continuous random variables.
   - Probability mass functions (PMFs) and probability density functions (PDFs).
   - Expected value and variance.
4. **Statistical Inference**:
   - Confidence intervals for population parameters.
   - Hypothesis testing (null and alternative hypotheses).
   - One-sample and two-sample tests.
5. **Regression Analysis**:
   - Simple linear regression.
   - Correlation coefficient.
   - Prediction intervals.

Assessment

- Homework assignments and problem-solving exercises.
- Quizzes and exams assessing understanding of probability and statistical concepts.
- Practical applications of statistical methods in engineering scenarios.

Recommended Textbook

- *Probability & Statistics for Engineers & Scientists* by Walpole, Myers, Myers, and Ye (9th edition).

Calculus III

Course Description

Calculus III extends the study of calculus to functions of several variables. Topics include vectors, partial derivatives, multiple integrals, and vector calculus. The course prepares students for applications in physics, engineering, and other fields.

Learning Objectives

By the end of this course, students should be able to:

- Understand vectors and vector operations.
- Compute partial derivatives and gradients.
- Evaluate multiple integrals over regions and volumes.
- Apply vector calculus concepts (line integrals, surface integrals, Green’s theorem, Stokes’ theorem, and the divergence theorem).

Topics Covered

1. **Vectors and 3D Coordinate Systems**:
    - Vector operations (addition, scalar multiplication, dot product, cross product).
    - Lines and planes in three-dimensional space.
    - Cylindrical and spherical coordinates.
2. **Partial Differentiation**:
    - Partial derivatives and tangent planes.
    - Chain rule for multivariable functions.
    - Directional derivatives and gradients.
3. **Multiple Integrals**:
    - Double integrals over rectangular and non-rectangular regions.
    - Triple integrals in Cartesian, cylindrical, and spherical coordinates.
    - Applications (volume, mass, center of mass).
4. **Vector Calculus**:
    - Line integrals and work.
    - Green's theorem and circulation.
    - Surface integrals and flux.
    - Divergence and curl.

Assessment

- Homework assignments and problem-solving exercises.
- Quizzes and exams assessing understanding of multivariable calculus concepts.
- Applications of calculus to real-world scenarios.

Recommended Textbook

- Stewart, J. (or other calculus textbooks).

Basic Life Mechanics with Lab

Course Description

Basic Life Mechanics explores fundamental principles of mechanics as they apply to biological systems. Students will learn how mechanical forces influence living organisms, from cells to whole-body movement. The course integrates theoretical concepts with practical laboratory experiments to enhance understanding.

Learning Objectives

By the end of this course, students should be able to:

- Understand the biomechanics of human movement.
- Analyze forces acting on biological structures.
- Apply mechanical principles to physiological processes.
- Conduct laboratory experiments related to life mechanics.

Topics Covered

1. **Introduction to Biomechanics**:

- Overview of biomechanics and its applications.
    - Kinematics and kinetics of human movement.
2. **Forces in Biological Systems**:
    - Internal and external forces.
    - Stress and strain in tissues.
    - Bone mechanics and fracture risk.
3. **Muscle Mechanics**:
    - Muscle contraction and force generation.
    - Muscle-tendon interactions.
    - Joint stability and range of motion.
4. **Gait Analysis**:
    - Walking and running mechanics.
    - Measurement techniques (motion capture, force plates).
5. **Laboratory Experiments**:
    - Hands-on activities related to biomechanical concepts.
    - Data collection and analysis.

Assessment

- Lab reports documenting experimental procedures and findings.
- Quizzes and exams assessing theoretical knowledge.
- Practical assessments during lab sessions.

Recommended Reading

- Nordin, M., & Frankel, V. H. (2001). *Basic Biomechanics of the Musculoskeletal System*. Lippincott Williams & Wilkins.

Statics

Course Description

Statics is the study of methods for quantifying the forces between bodies. It focuses on maintaining balance and understanding motion of bodies or changes in their shape. This course is essential for various branches of engineering, including mechanical, civil, aeronautical, and bioengineering. Topics covered include forces, equilibrium, trusses, friction, and moments of inertia.

Learning Objectives

By the end of this course, students should be able to:

- Understand the principles of equilibrium.
- Analyze forces acting on structures.
- Solve problems related to truss systems and friction.
- Calculate moments of inertia for rotating bodies.

Topics Covered

1. **Introduction to Statics**:
    - Overview of statics and units.

    - Problem-solving techniques.
2. **Forces and Vectors**:
    - Vector operations (addition, scalar multiplication).
    - Resultant forces.
    - Free body diagrams.
3. **Equilibrium of Particles and Rigid Bodies**:
    - Equilibrium conditions.
    - 2D and 3D force systems.
    - Moments and couples.
4. **Structural Analysis**:
    - Truss analysis.
    - Frictional forces.
    - Center of gravity and centroids.
5. **Moments of Inertia**:
    - Calculating moments of inertia.
    - Parallel-axis theorem.
    - Rotational equilibrium.

Assessment

- Homework assignments and problem-solving exercises.
- Quizzes and exams assessing understanding of statics concepts.
- Practical applications of statics principles.

Recommended Textbook

- Hibbeler, R. C. (or other statics textbooks).

BME Design Lab III

Course Description

BME Design Lab III is an advanced project-based course where students apply their knowledge of biomedical engineering to solve real-world problems. Working in interdisciplinary teams, students design, prototype, and test innovative solutions. The course emphasizes creativity, project management, and effective communication.

Learning Objectives

By the end of this course, students should be able to:

- Apply engineering principles to design and develop biomedical devices or systems.
- Collaborate effectively in multidisciplinary teams.
- Conduct feasibility studies, risk assessments, and project planning.
- Communicate design concepts through reports and presentations.

Topics Covered

1. **Project Selection and Definition**:
    - Identifying project needs and constraints.
    - Defining project scope and objectives.

    - Conducting literature reviews.
2. **Concept Generation and Evaluation**:
    - Brainstorming and ideation.
    - Concept selection using decision matrices.
    - Prototyping and proof-of-concept development.
3. **Design Implementation and Testing**:
    - Detailed design and engineering analysis.
    - Building and refining prototypes.
    - Conducting usability and safety testing.
4. **Project Management and Documentation**:
    - Project planning and scheduling.
    - Risk management and mitigation.
    - Design documentation and regulatory considerations.

Assessment

- Design project deliverables (concept sketches, CAD models, prototypes).
- Design reports and presentations.
- Peer evaluations and teamwork assessments.

Recommended Resources

- Biomedical Device Design: Innovation from Concept to Market by Andrew P. King and John Enderle.

Anatomy and Physiology for Engineers

Course Description

Anatomy and Physiology for Engineers provides an essential understanding of the human body's structure and function, tailored for engineering students. The course explores how anatomical systems relate to engineering design, biomechanics, and medical technologies. Students will gain insights into physiological processes and their relevance to engineering applications.

Learning Objectives

By the end of this course, students should be able to:

- Describe the major anatomical systems (skeletal, muscular, cardiovascular, nervous, etc.).
- Understand physiological processes (respiration, circulation, digestion, etc.) and their interactions.
- Relate anatomical knowledge to engineering challenges (biomechanics, medical devices, ergonomics).
- Apply principles of anatomy and physiology in interdisciplinary projects.

Topics Covered

1. **Introduction to Human Anatomy and Physiology**:
    - Overview of body organization and terminology.

    - Homeostasis and feedback mechanisms.
2. **Skeletal System and Biomechanics**:
    - Bone structure, joints, and mechanics.
    - Role of bones in load-bearing and movement.
3. **Muscular System and Ergonomics**:
    - Muscle types, contraction, and force generation.
    - Ergonomic design considerations for workplace safety.
4. **Cardiovascular and Respiratory Systems**:
    - Heart anatomy, blood vessels, and circulation.
    - Gas exchange in the lungs.
5. **Nervous System and Biomedical Devices**:
    - Neurons, synapses, and nerve impulses.
    - Neuroprosthetics and brain-computer interfaces.

Assessment

- Quizzes and exams assessing understanding of anatomical structures and physiological processes.
- Project-based assignments linking anatomy to engineering applications.
- Lab sessions (if applicable) for hands-on exploration of anatomical models.

Recommended Textbook

- Marieb, E. N., & Hoehn, K. (or other anatomy and physiology textbooks).

BME Design Lab IV

Course Description

BME Design Lab IV is an advanced project-based course where students apply their knowledge of biomedical engineering to solve real-world problems. Working in interdisciplinary teams, students design, prototype, and test innovative solutions. The course emphasizes creativity, project management, and effective communication.

Learning Objectives

By the end of this course, students should be able to:

- Apply engineering principles to design and develop complex biomedical devices or systems.
- Collaborate effectively in multidisciplinary teams, integrating diverse expertise.
- Conduct feasibility studies, risk assessments, and project planning for advanced designs.
- Communicate design concepts through comprehensive reports and presentations.

Topics Covered

1. **Project Selection and Definition**:
    - Identifying challenging biomedical engineering problems.
    - Defining project scope, objectives, and constraints.
    - Conducting thorough needs assessments.

2. **Concept Generation and Evaluation**:
   - Iterative brainstorming and ideation.
   - Rigorous concept selection using decision matrices.
   - Prototyping and proof-of-concept development.
3. **Advanced Design Implementation and Testing**:
   - Detailed engineering analysis and optimization.
   - Building and refining complex prototypes.
   - Rigorous usability and safety testing.
4. **Project Management and Documentation**:
   - Comprehensive project planning, resource allocation, and scheduling.
   - Risk management strategies for ambitious designs.
   - Regulatory considerations and intellectual property protection.

Assessment

- Comprehensive design project deliverables (concept sketches, CAD models, prototypes, technical documentation).
- Final design reports and professional presentations.
- Peer evaluations and teamwork assessments.

Recommended Resources

- Biomedical Device Design: Innovation from Concept to Market by Andrew P. King and John Enderle.
- FDA Design Control Guidance for Medical Device Manufacturers (available online).

Physics for Engineers II

Course Description

Physics for Engineers II builds upon the principles introduced in Physics for Engineers I. This course focuses on more advanced topics relevant to engineering applications. Students will explore electromagnetism, waves, optics, and modern physics concepts.

Learning Objectives

By the end of this course, students should be able to:

- Understand electromagnetic theory and its applications.
- Analyze wave phenomena and interference.
- Apply optics principles to imaging and communication systems.
- Explore modern physics topics such as quantum mechanics and relativity.

Topics Covered

1. **Electromagnetism**:
   - Electric fields and Gauss's law.
   - Magnetic fields and Ampère's law.
   - Electromagnetic induction and Faraday's law.
2. **Waves and Optics**:
   - Wave properties (frequency, wavelength, speed).

    - Interference and diffraction.
    - Geometric optics (reflection, refraction, lenses).
3. **Modern Physics**:
    - Quantum mechanics (wave-particle duality, Schrödinger equation).
    - Special relativity (time dilation, length contraction).

Assessment

- Homework assignments and problem-solving exercises.
- Quizzes and exams assessing understanding of advanced physics concepts.
- Laboratory experiments related to electromagnetism and optics.

Recommended Textbook

- Serway, R. A., & Jewett, J. W. (or other physics textbooks).

Differential Equations and Matrix Algebra

Course Description

Differential Equations and Matrix Algebra is a foundational course that combines two essential mathematical topics. Students will explore differential equations, which describe rates of change and dynamic systems, and matrix algebra, which plays a crucial role in various engineering and scientific applications.

Learning Objectives

By the end of this course, students should be able to:

- Understand the fundamental concepts of differential equations.
- Solve ordinary differential equations (ODEs) using various techniques.
- Manipulate matrices and perform matrix operations.
- Apply matrix algebra to solve systems of linear equations.

Topics Covered

1. **Differential Equations**:
    - First-order ODEs (separable, linear, exact).
    - Second-order ODEs (homogeneous, nonhomogeneous).
    - Laplace transforms and their applications.
2. **Matrix Algebra**:
    - Matrix operations (addition, multiplication, inverse).
    - Determinants and eigenvalues.
    - Systems of linear equations and Gaussian elimination.
3. **Applications**:
    - Modeling physical systems using differential equations.
    - Solving engineering problems with matrix algebra.

Assessment

- Homework assignments and problem-solving exercises.

- Quizzes and exams assessing understanding of differential equations and matrix algebra concepts.
- Practical applications of mathematical techniques.

Recommended Textbooks

- Boyce, W. E., & DiPrima, R. C. (or other differential equations textbooks).
- Strang, G. (or other linear algebra textbooks).

Mechanics of Materials

Course Description

Mechanics of Materials explores the behavior of solid materials under various loads and stresses. Students will learn how to analyze and design structures, machines, and components to ensure their safety and reliability. The course emphasizes both theoretical concepts and practical applications.

Learning Objectives

By the end of this course, students should be able to:

- Understand stress, strain, and deformation in materials.
- Analyze axial loads, torsion, bending, and shear.
- Calculate deflections and stresses in beams and columns.
- Apply material properties to engineering design.

Topics Covered

1. **Introduction to Mechanics of Materials**:
    - Overview of stress, strain, and material behavior.
    - Hooke's law and elastic deformation.
2. **Axial Loading and Torsion**:
    - Normal stress and strain.
    - Shear stress and strain.
    - Torsional deformation and stress distribution.
3. **Bending and Shear in Beams**:
    - Bending moment and shear force diagrams.
    - Flexural stress and deflection.
    - Shear stress in beams.
4. **Stress Transformation and Mohr's Circle**:
    - Principal stresses and maximum shear stress.
    - Mohr's circle for stress analysis.
5. **Columns and Buckling**:
    - Euler's formula for column buckling.
    - Slenderness ratio and critical loads.

Assessment

- Homework assignments and problem-solving exercises.
- Quizzes and exams assessing understanding of mechanics of materials concepts.

- Design projects related to structural analysis.

Recommended Textbook

- Beer, F. P., Johnston, E. R., DeWolf, J. T., & Mazurek, D. F. (or other mechanics of materials textbooks).

Biomedical Signals and Systems

Course Description:

This course applies mathematical analysis tools to biological signals and systems. Students will learn how to represent and analyze continuous and discrete-time biosignals using frequency analysis, Fourier and Laplace transforms, and state equations. The course also covers classic feedback analysis tools applied to biological systems that rely on negative feedback for control and homeostasis.

Learning Objectives:

Upon completion of the course, students should be able to:

1. Understand how electrical signals arise in the body and explain their physiological function at a systems level.
2. Quantify the frequency content of bioelectrical signals using both continuous and discrete Fourier and Z transforms, distinguishing physiological function from noise.
3. Apply state transition matrices to linear dynamic systems for studying the natural response of biological systems.
4. Define homeostasis and describe mechanisms of feedback that maintain it in physiological systems.
5. Determine conditions for system stability and study convergence of signals (continuous- and discrete-time).
6. Apply appropriate methods to study transient responses and stability after analyzing signal and system nature.
7. Describe the typical impulse response of a neuron.
8. Design continuous and discrete-time filters for neural, cardiac, and other biosignals and determine their outputs.
9. Analyze stability and dynamic responses of biological systems using various methods (e.g., Laplace transform, continuous and discrete-time).

Topics Covered:

1. Introduction to biological systems relying on negative feedback for control and stability.
2. Feedback system analysis using root locus, Bode diagrams, and Nyquist criterion.
3. MATLAB-based computational assignments for signal processing and LabVIEW-based laboratory exercises.

Textbook:

- “Signal Processing First” by McClellan, Schafer, and Yoder (Prentice Hall, ISBN: 0-13-090999-8).

Transport Phenomena I

Course Description:

This course provides an introduction to the field of transport phenomena, covering the molecular mechanisms of momentum transport (viscous flow), energy transport (heat conduction), and mass transport (diffusion). Students will explore isothermal equations of change (continuity, motion, and energy), the development of the Navier-Stokes equation, and non-isothermal and multicomponent equations of change for heat and mass transfer. Exact solutions to steady-state, isothermal unidirectional flow problems and steady-state heat and mass transfer problems will also be discussed.

Learning Objectives:

Upon completion of the course, students should be able to:

1. Understand the fundamental principles of momentum, energy, and mass transport.
2. Apply mathematical tools to describe transport phenomena.
3. Develop and solve equations for heat and mass transfer in various contexts.
4. Analyze steady-state flow problems and heat/mass transfer scenarios.

Topics Covered:

1. Molecular mechanisms of momentum transport (viscous flow).
2. Energy transport through heat conduction.
3. Mass transport via diffusion.
4. Isothermal equations of change (continuity, motion, and energy).
5. Development of the Navier-Stokes equation.
6. Non-isothermal and multicomponent equations of change for heat and mass transfer.
7. Exact solutions for steady-state, isothermal unidirectional flow problems.
8. Steady-state heat and mass transfer problems.

Introduction to Electrical Circuits

Course Description:

This foundational course introduces the fundamental concepts of electric circuits. Students will learn about electrical quantities, circuit elements, and basic analysis techniques. The course covers both direct current (DC) and alternating current (AC) circuits.

Learning Objectives:

Upon completion of the course, students should be able to:

1. Describe the behavior of basic circuit elements: resistance, inductance, capacitance, voltage sources, and current sources.
2. Apply principles encapsulated in laws and theorems: Ohm’s law, Kirchhoff’s laws, superposition theorem, Thevenin’s and Norton’s theorems.
3. Analyze circuits using formal methods such as node analysis, mesh analysis, and loop analysis.

4. Simplify and transform circuits: series and parallel components, Thevenin and Norton equivalents, and two-port networks.
5. Understand specialized techniques for solving differential equations and analyzing circuits with sinusoidal excitation.
6. Design and analyze circuits involving operational amplifiers (op-amps).

Course Content:

1. **Introduction to Electrical Quantities:**
    - Atomic structure
    - Electric current
    - Voltage
2. **Conductors, Insulators, and Semiconductors**
3. **DC Electric Circuit Analysis:**
    - Kirchhoff's voltage law (KVL) and Kirchhoff's current law (KCL)
    - Voltage division and current division
    - Nodal analysis and loop analysis
    - Equivalent circuits
4. **Advanced DC Circuit Analysis:**
    - Superposition theorem
    - Thevenin's theorem
    - Norton's theorem
5. **Energy-Storing Devices:**
    - Capacitors and inductors
    - Energy storage principles
    - Simplification techniques
6. **Transient Analysis:**
    - First-order circuits during transients

BME Design Lab V

Course Description:

BME Design Lab V is a capstone course in biomedical engineering that focuses on practical design, project management, and hands-on implementation. Students work on real-world projects, applying their knowledge to create innovative solutions. The course emphasizes teamwork, communication, and ethical considerations.

Learning Objectives:

By the end of this course, students will be able to:

1. **Engineering Decision-Making:**
    - Develop the ability to make informed decisions in engineering designs, considering uncertainty and imprecise information.
    - Predict user needs, define design parameters, and identify constraints for Engineering Design Projects (EDPs).
2. **Project Selection and Optimization:**
    - Select optimal design choices based on known constraints.
    - Work effectively as a team player and contribute to positive team dynamics.
3. **Effective Communication:**

- Demonstrate written and oral communication skills in discussing design choices, using technical vocabulary, and presenting information clearly and concisely.

Course Content:

1. **Lectures (Seminar Series):**
    - Design advice
    - Project management
    - Reliability
    - Software tools
    - Circuit components
    - Documentation
2. **Laboratory Component:**
    - Students select a project to be completed in the subsequent Winter semester (BME 800 Design Project).
    - Consult with faculty lab coordinators to search for information, design, and source components.
    - Bioethics seminars are also arranged.

Technical Communication I

Course Description:

This course offers a practical introduction to essential skills and strategies needed for effective communication in the technical workplace. Whether you're writing reports, proposals, or giving presentations, this course equips you with the tools to succeed.

Learning Objectives:

By the end of this course, students will be able to:

1. **Problem-Solving Approach:**
    - Identify purpose, audience, and appropriate production and delivery plans for communication tasks.
    - Apply research and critical thinking to determine design feasibility.
2. **Effective Writing:**
    - Draft and revise various documents used by technical professionals (e.g., correspondence, proposals, reports).
    - Edit and proofread for clarity, organization, and Standard English usage.
3. **Team Collaboration:**
    - Understand team roles, constructive communication, and self-evaluation.
    - Encourage productive, accountable collaboration.
4. **Professional Presentations:**
    - Prepare and deliver oral presentations using appropriate visual aids.

BME Design Lab VI

Course Description:

BME Design Lab VI serves as a capstone experience in biomedical engineering, emphasizing practical design, project management, and hands-on implementation. Students work collaboratively on real-world projects, applying their knowledge to create innovative solutions. The course focuses on teamwork, communication, and ethical considerations.

Learning Objectives:

By the end of this course, students will be able to:

1. **Creative Problem-Solving:**
    - Develop creative thinking skills and conduct research to interconnect various engineering knowledge for realistic designs.
    - Make informed decisions in engineering designs, considering uncertainty and imprecise information.
2. **Foundational Elements of Engineering Design:**
    - Understand the principles of natural and engineering sciences, mathematics, and iterative design processes.
    - Apply feedback to arrive at effective design solutions.
3. **Experimental Data Collection and Analysis:**
    - Collect experimental data using appropriate sensing and measurement techniques.
    - Analyze data critically, employing statistical principles.

Course Content:

1. **Lectures (Seminar Series):**
    - Design process guidance
    - Project management strategies
    - Reliability considerations
    - System components overview
    - Documentation practices
    - Safety protocols
2. **Laboratory Component:**
    - Student groups select project topics assigned by faculty lab coordinators.
    - Plan, design, source components, build, test, debug, and analyze their projects.
    - Submit a comprehensive final design project report.

Engineering Physiology Lab

Course Description:

The Engineering Physiology Lab provides hands-on experience in applying engineering principles to physiological systems. Students learn to design, conduct experiments, and analyze data related to cellular and systems physiology. The course emphasizes practical skills, teamwork, and ethical considerations.

Learning Objectives:

By the end of this course, students will be able to:

1. **Experimental Design and Execution:**
   - Plan and execute experiments related to physiological phenomena.
   - Use appropriate techniques and tools for data collection.
2. **Data Analysis and Interpretation:**
   - Analyze experimental data using quantitative methods.
   - Interpret physiological responses and draw engineering conclusions.
3. **Professional Responsibility:**
   - Understand ethical considerations in biomedical device development and treatment.

Topics Covered:

1. **Nervous System:**
   - Neurons, synapses, and neural signaling.
2. **Muscle Physiology:**
   - Striated (skeletal) muscle, smooth muscle, and cardiac muscle.
3. **Cardiovascular System:**
   - Blood flow, heart function, and vascular dynamics.
4. **Respiratory System:**
   - Gas exchange, lung mechanics, and ventilation.

Fundamentals of Materials Science

Course Description:

This course focuses on the fundamentals of structure, energetics, and bonding that underpin materials science. It serves as the introductory lecture class for sophomore students in Materials Science and Engineering, taken alongside other related courses to create a unified introduction to the subject.

Learning Objectives:

By the end of this course, students will be able to:

1. **Thermodynamic Functions and Equilibrium Properties:**
   - Understand the laws governing equilibrium properties.
   - Relate macroscopic behavior to atomistic and molecular models of materials.
2. **Electronic Bonding and Material Stability:**
   - Explore the role of electronic bonding in determining energy, structure, and stability.
   - Study quantum mechanical descriptions of interacting electrons and atoms.
3. **Materials Phenomena and Symmetry:**
   - Investigate heat capacities, phase transformations, multiphase equilibria, and magnetism.
   - Understand symmetry properties of molecules and solids.
4. **Structure Determination:**
   - Learn about complex, disordered, and amorphous materials.

- Explore tensors and constraints on physical properties imposed by symmetry.
- Determine material structure through diffraction.

Real-World Applications:

Applications include engineered alloys, electronic and magnetic materials, ionic and network solids, polymers, and biomaterials.

Technical Communications II: Presentation

Course Description:

In this course, students build upon the skills developed in Technical Communication I. The focus is on defining a document's audience and purpose to present information optimally. Students improve their technical writing style and technique while creating writing samples for both print and online presentation. Additionally, the course covers technical communication tools, technology, and current web content and formatting languages.

Learning Objectives:

By the end of this course, students will be able to:

1. **Audience-Centric Communication:**
   - Define the target audience for technical documents.
   - Tailor content to meet audience needs.
2. **Effective Presentation Techniques:**
   - Develop confidence in delivering technical presentations.
   - Use visual aids effectively.
3. **Writing for Print and Online Platforms:**
   - Create writing samples suitable for both traditional print and digital formats.
   - Understand web content creation and formatting.

Topics Covered:

1. **Audience Analysis:**
   - Identifying audience characteristics and expectations.
2. **Presentation Skills:**
   - Structuring presentations.
   - Effective slide design.
   - Delivery techniques.
3. **Web Content Creation:**
   - HTML basics.
   - Web accessibility.
   - Writing for online platforms.

BME Capstone Design I

Course Description:

BME Capstone Design I provides guidance for choosing a capstone design topic and advisor. Students learn about the definition of design, intellectual property, bioethics, safety, and professional societies. The course covers library research, time and cost planning, oral and written reports, and constructing a working prototype.

Learning Outcomes:

By the end of the course, students will be able to:

1. **Project Implementation:**
    - Define the development of a biomedical engineering technology-based project.
    - Develop engineering documentation for the selected project.
2. **Research and Critical Thinking:**
    - Use effective research skills.
    - Understand ethical issues in research and design.
3. **Teamwork and Communication:**
    - Perform multi-disciplinary teamwork.
    - Monitor project progress using planning and milestone management.

Topics Covered:

- Design specifications development and traceability
- Design reviews
- Industrial design, ergonomics, performance, aesthetics
- Reliability and performance testing
- FDA and regulatory issues
- Ethics in biomedical engineering

BME Senior Capstone Design II

Course Description:

Capstone Design II continues the design process initiated in Capstone I. In this course, you will build upon the work started earlier by developing detailed design specifications, creating a test plan, constructing and testing the product, and demonstrating its alignment with customer needs. Successful completion of the program requires meeting course requirements and satisfying your customer.

Learning Outcomes:

By the end of the course, you will be able to:

1. **Project Implementation:**
    - Complete the development and testing of a biomedical engineering technology-based project.
    - Develop comprehensive engineering documentation for the selected project.
    - Successfully demonstrate the project’s functionality.

2. **Research and Critical Thinking:**
    - Utilize effective research skills.
    - Understand ethical considerations related to research and design.
3. **Teamwork and Communication:**
    - Engage in multi-disciplinary teamwork.
    - Communicate effectively through written and verbal means.
    - Monitor project progress using planning and milestone management.

Topics Covered:

1. **Design Specifications Development and Traceability:**
    - Detailed requirements for the project.
    - Ensuring alignment with customer needs.
2. **Industrial Design, Ergonomics, and Aesthetics:**
    - Enhancing the product's usability and visual appeal.
3. **Test Plans and Performance Testing:**
    - Creating comprehensive test plans.
    - Evaluating reliability and performance.
4. **Regulatory Issues and FDA Considerations:**
    - Understanding regulatory requirements for biomedical devices.

Research Project

Course Description:

The research project is a significant component of academic study, allowing students to delve into a specific topic in-depth. It involves independent research, critical thinking, and the production of a substantial piece of work. The project can take various forms, such as a research report, dissertation, or creative work.

Learning Objectives:

By the end of this course, students will be able to:

1. **Research Planning and Proposal:**
    - Develop a research proposal that outlines the project's scope, objectives, and methodology.
    - Understand the ethical considerations related to their work.
2. **Independent Research and Analysis:**
    - Conduct original research or synthesize existing materials relevant to significant conversations within the discipline.
    - Select appropriate research methods and collect data.
3. **Scholarly Writing and Communication:**
    - Present findings in a clear, cohesive, and evidence-based manner.
    - Reflect on the strengths and weaknesses of their research.

Course Components:

1. **Introduction to Research:**
    - Understanding the purpose and significance of research projects.
    - Identifying research questions and hypotheses.

2. **Literature Review:**
    - Evaluating existing knowledge on the chosen topic.
    - Identifying gaps and areas for further exploration.
3. **Methodology:**
    - Selecting research methods (qualitative, quantitative, or mixed).
    - Data collection and analysis techniques.
4. **Findings and Results:**
    - Presenting research data and drawing conclusions.
    - Relating findings to existing scholarly literature.
5. **Final Report or Dissertation:**
    - Assembling all components into a cohesive document.
    - Reflecting on the research process and future improvements.

Introduction to Human Biomechanics

Course Description:

This course provides an overview of biomechanics as it relates to the human body. Students will explore fundamental mechanical principles and their application to human movement. Topics covered include statics, dynamics, kinematics, and the biomechanics of muscles and joints.

Learning Objectives:

By the end of this course, students will be able to:

1. **Basic Mechanics:**
    - Understand statics and dynamics.
    - Apply principles of equilibrium and force analysis.
2. **Human Biomechanics:**
    - Explore joint kinematics and muscle function.
    - Analyze forces and stresses in musculoskeletal structures.
3. **Clinical Relevance:**
    - Relate biomechanical concepts to clinical practice (e.g., physiotherapy).

Topics:

1. Introduction to biomechanics terminology.
2. Kinematics of muscles and joints.
3. Forces and stresses in joints.

Sports Injury and Biomechanics

Course Description:

This course integrates principles of biomechanics with the study of sports injuries. Students will explore the mechanics of human movement, injury risk factors, and techniques for enhancing sports performance. The course emphasizes the application of biomechanical knowledge to prevent injuries and optimize athletic abilities.

Learning Objectives:

By the end of this course, students will be able to:

1. **Understand Biomechanical Principles**:
    - Describe the fundamental concepts of biomechanics, including kinematics and kinetics.
    - Explain how forces and torques influence human movement.
2. **Analyze Sports Movements**:
    - Apply biomechanical analysis to sports techniques.
    - Identify optimal movement patterns for enhancing performance.
3. **Evaluate Injury Risk Factors**:
    - Recognize factors contributing to sports injuries.
    - Assess loading on body structures during sports activities.
4. **Implement Injury Prevention Strategies**:
    - Propose methods to reduce injury risk.
    - Develop safe movement habits for athletes.

Topics Covered:

1. **Introduction to Biomechanics**:
    - Kinematics (displacement, velocity, acceleration).
    - Kinetics (forces, torques).
2. **Sports Injury Mechanisms**:
    - Properties of biological materials.
    - Mechanisms of injury occurrence.
    - Risk reduction strategies.
3. **Muscle Recruitment and Loading**:
    - Assessment of muscle activation.
    - Estimation of forces in biological structures.
4. **Equipment Analysis**:
    - Evaluation of sports equipment (e.g., shoes, surfaces, rackets).

Assessment:

- Regular quizzes and assignments on biomechanical principles.
- Practical analysis of sports movements.
- Research project on injury prevention strategies.

Recommended Reading:

1. Bartlett, R., & Bussey, M. (2011). *Sports Biomechanics: Reducing Injury Risk and Improving Sports Performance*. Routledge
2. Knudson, D. (2019). *Fundamentals of Biomechanics*. Springer

Rehabilitation of Biomechanics (Physioplus)

Course Description:

Running injuries often have multifactorial origins, including personal, training, and health-related factors. Developing a comprehensive plan of care for runners requires systematic examination of all contributing factors. This course introduces the basics of creating an individualized plan for runners with injuries. It covers understanding training and injury history, identifying mobility and motor control deficits related to running form, and creating a comprehensive care plan.

Learning Objectives:

By the end of this course, participants will be able to:

1. **Assess Running Biomechanics**:
    - Understand the impact of biomechanics on running injuries.
    - Evaluate running form using treadmill and 2-D video analysis.
2. **Develop Comprehensive Plans**:
    - Address both symptoms and underlying causes.
    - Tailor rehabilitation approaches to individual needs.

Topics Covered:

1. **Understanding Running Injuries**:
    - Multifactorial origins.
    - Personal, training, and health-related factors.
2. **Biomechanical Assessment**:
    - Treadmill and 2-D video analysis.
    - Identifying mobility and motor control deficits.
3. **Creating Individualized Plans**:
    - Incorporating training and injury history.
    - Addressing specific biomechanical issues.

Orthopedic Biomechanics

Course Description:

Orthopedic Biomechanics is a specialized field that focuses on the mechanical behavior of musculoskeletal tissues, joints, and orthopedic implants. This course provides an in-depth understanding of the engineering principles applied to orthopedic problems. Topics include bone structure, joint kinematics, implant design, and failure modes.

Learning Objectives:

By the end of this course, students will be able to:

1. **Analyze Musculoskeletal Mechanics**:
    - Understand the structure and function of bones, joints, and soft tissues.
    - Evaluate forces and moments acting on human joints.
2. **Orthopedic Implant Design**:
    - Study the materials used in orthopedic prostheses.
    - Analyze design objectives for hip, knee, and spinal implants.
3. **Modes of Implant Failure**:
    - Identify common failure mechanisms in replaced joints.
    - Explore preventive measures based on clinical experience and materials selection.

Topics Covered:

1. **Bone Structure and Properties**:
   - Microscale to full construct level.
   - Bone tissue mechanics and kinematics.
2. **Orthopedic Implants**:
   - Design principles and materials.
   - Hip, knee, and spine prostheses.
3. **Failure Modes and Prevention**:
   - Modes of joint implant failure.
   - Surgical and engineering approaches.

Assessment:

- Regular quizzes and assignments.
- Project on implant design or failure analysis.

Recommended Textbook:

- Bartel DL, Davy DT, and Keaveny TM: “Orthopaedic Biomechanics: Mechanics and Design in Musculoskeletal Systems” (Pearson Prentice Hall, New Jersey, 2006).

Bioengineering

Course Description:

Bioengineering is an interdisciplinary field that applies engineering principles to solve problems in healthcare, medicine, and biological systems. This course provides a solid foundation in both engineering and life sciences, preparing students to address complex challenges at the intersection of biology and technology.

Learning Objectives:

By the end of this course, students will be able to:

1. **Understand Biological Systems**:
   - Explore the structure and function of biological tissues, cells, and organs.
   - Learn about physiological processes and their engineering implications.
2. **Apply Engineering Principles**:
   - Integrate engineering concepts (mechanics, materials, electronics) with biological systems.
   - Design and analyze medical devices, implants, and diagnostic tools.
3. **Explore Specializations**:
   - Gain exposure to various bioengineering subfields (biomechanics, biomaterials, tissue engineering, medical imaging).
   - Understand how bioengineering impacts healthcare and research.

Topics Covered:

1. **Introduction to Bioengineering**:
   - Historical context and current trends.
   - Ethical considerations in bioengineering.
2. **Biomechanics and Biomaterials**:
   - Mechanics of biological tissues.
   - Properties and applications of biomaterials.
3. **Medical Imaging and Diagnostics**:
   - Principles of medical imaging techniques (MRI, CT, ultrasound).
   - Diagnostic tools and their engineering design.
4. **Tissue Engineering and Regenerative Medicine**:
   - Strategies for tissue repair and regeneration.
   - Scaffold design and cell-based therapies.

Assessment:

- Regular quizzes and assignments.
- Design projects related to medical devices or tissue engineering.

Recommended Textbook:

- Gray, D., & Lee, J. (Eds.). (2019). *Introduction to Bioengineering*. Cambridge University Press.

Cell and Tissue Engineering

Course Description:

Cell and Tissue Engineering is an interdisciplinary field that combines principles from biology, engineering, and medicine to develop solutions for repairing, replacing, or regenerating damaged or diseased tissues. This course provides a comprehensive understanding of cellular and tissue-level processes, biomaterials, and engineering techniques used in tissue engineering applications.

Learning Objectives:

By the end of this course, students will be able to:

1. **Understand Cellular Processes**:
   - Explore cell biology, including cell signaling, differentiation, and proliferation.
   - Learn about stem cells and their potential applications in tissue engineering.
2. **Biomaterials and Scaffold Design**:
   - Study different biomaterials (natural and synthetic) used as scaffolds.
   - Understand scaffold fabrication methods and their impact on tissue regeneration.
3. **Tissue Engineering Strategies**:
   - Explore in vitro and in vivo tissue engineering approaches.
   - Learn about bioreactors, growth factors, and tissue-specific considerations.

Topics Covered:

1. **Cell Biology Fundamentals**:

    - Cell structure, function, and signaling pathways.
    - Stem cells and their role in tissue regeneration.
2. **Biomaterials and Scaffold Design**:
    - Properties of biomaterials (polymers, ceramics, metals).
    - Scaffold fabrication techniques (3D printing, electrospinning, etc.).
3. **Tissue Engineering Applications**:
    - Case studies of tissue-specific engineering (bone, cartilage, skin, etc.).
    - Challenges and ethical considerations.

Assessment:

- Regular quizzes and exams.
- Group projects on scaffold design or tissue-specific engineering.

Recommended Textbook:

- Langer, R., & Vacanti, J. P. (Eds.). (1999). *Principles of Tissue Engineering*. Academic Press.

Materials Engineering

Course Description:

Materials Engineering is an interdisciplinary field that explores the properties, behavior, and applications of various materials. This course provides a solid foundation in the science and engineering principles underlying the development, processing, and utilization of materials. Students will learn about different material classes, their structures, and how they impact real-world applications.

Learning Objectives:

By the end of this course, students will be able to:

1. **Understand Material Properties**:
    - Explore the fundamental properties of materials, including mechanical, thermal, electrical, and optical characteristics.
    - Learn how material properties influence material selection for specific applications.
2. **Materials Processing Techniques**:
    - Study various methods for shaping, modifying, and treating materials (e.g., casting, forming, heat treatment).
    - Understand the impact of processing on material properties.
3. **Materials Selection and Design**:
    - Apply engineering principles to select appropriate materials for specific engineering applications.
    - Consider factors such as cost, performance, and sustainability.

Topics Covered:

1. **Introduction to Materials Science and Engineering**:
    - Historical context and significance of materials engineering.

- Classification of materials (metals, ceramics, polymers, composites).

2. **Atomic Structure and Bonding**:
    - Basics of crystal structures and defects.
    - Types of chemical bonding (ionic, covalent, metallic).
3. **Mechanical Behavior of Materials**:
    - Stress, strain, and mechanical properties (strength, hardness, toughness).
    - Deformation mechanisms (elasticity, plasticity).
4. **Materials Processing and Characterization**:
    - Techniques for shaping and modifying materials.
    - Material characterization methods (microscopy, spectroscopy).
5. **Materials Selection and Design Considerations**:
    - Material selection criteria (performance, cost, environmental impact).
    - Case studies of material applications (e.g., aerospace, biomedical, automotive).

Assessment:

- Regular quizzes and exams.
- Design projects related to material selection and processing.

Recommended Textbook:

- Callister, W. D., & Rethwisch, D. G. (2018). *Materials Science and Engineering: An Introduction*. Wiley.

Bio-Inspired Surfaces

Course Description:

Bio-Inspired Surfaces is an interdisciplinary field that draws inspiration from nature to design functional surfaces with unique properties. This course explores the principles behind natural surfaces found in plants, animals, and insects. Students will learn how to apply these concepts to create innovative materials for various applications, including anti-corrosion coatings, self-cleaning surfaces, and medical devices.

Learning Objectives:

By the end of this course, students will be able to:

1. **Understand Natural Surface Functionalities**:
    - Explore the remarkable properties of biological surfaces (e.g., lotus leaves, gecko feet, shark skin).
    - Analyze the underlying mechanisms behind their functionality.
2. **Design Bio-Inspired Surfaces**:
    - Apply micro-nano structures and surface coatings to achieve specific properties (e.g., superhydrophobicity, self-healing).
    - Consider adaptability and fabrication methods.
3. **Applications and Validation**:
    - Evaluate the performance of bio-inspired surfaces in real-world scenarios (e.g., medical devices, anti-corrosion coatings).
    - Understand the impact on precision medicine and human health.

Topics Covered:

1. **Introduction to Bio-Inspired Surfaces**:
   - Historical context and significance.
   - Examples of natural surfaces and their functionalities.
2. **Mechanisms and Micro-Nano Structures**:
   - Coupling effects in bio-inspired surfaces.
   - Design principles for ultra-slipperiness and strong wet attachment.
3. **Fabrication Techniques**:
   - Adaptable designs for medical devices and wearable technology.
   - Validation methods for enhanced contact properties.

Assessment:

- Regular quizzes and exams.
- Design projects related to bio-inspired surface functionality.

Recommended Reading:

- No specific textbook required. Lecture materials and relevant research papers will be provided.

Structure and Function of Biomaterials

Course Description:

The course explores the fundamental principles underlying biomaterials, focusing on their structure, properties, and interactions with biological systems. Students will learn about the various classes of biomaterials, their mechanical behavior, surface properties, and applications in medical devices and tissue engineering. The course emphasizes the relationship between material structure and biological function.

Learning Objectives:

By the end of this course, students will be able to:

1. **Differentiate Biomaterial Classes**:
   - Understand the chemical composition and properties of biomaterials (polymers, metals, ceramics, composites).
   - Evaluate the suitability of different materials for specific applications.
2. **Characterize Biomaterials**:
   - Explore analytical methods for assessing bulk and surface properties.
   - Consider biocompatibility, mechanical behavior, and degradation.
3. **Cell-Biomaterial Interactions**:
   - Study how biomaterials interact with cells and tissues.
   - Examine host responses and biocompatibility.

Topics Covered:

1. **Introduction to Biomaterials**:
   - Historical context and significance.

    - Natural vs. synthetic biomaterials.
2. **Mechanical Behavior of Biomaterials**:
    - Elastic deformation, viscoelasticity, and time-dependent behavior.
    - Multiaxial loading and complex stress states.
3. **Surface Properties and Interactions**:
    - Surface energy, adsorption, and reconstruction.
    - Protein-surface interactions and cell adhesion.
4. **Biodegradation and Biocompatibility**:
    - Understanding material breakdown and tissue response.
    - FDA testing and regulatory considerations.
5. **Applications of Biomaterials**:
    - Implants (orthopedic, cardiovascular, dental).
    - Tissue engineering scaffolds.
    - Controlled drug release systems.

Assessment:

- Regular quizzes and exams.
- Case studies on biomaterial selection and design.

Introduction to Biomedical Imaging

Course Description:

Biomedical imaging technologies play a crucial role in modern healthcare. This course provides an overview of the physics, engineering, and clinical applications of various imaging modalities. Students will gain insights into X-ray, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, nuclear medicine, and optical-based methods.

Learning Objectives:

By the end of this course, students will be able to:

1. **Understand Imaging Modalities**:
    - Recognize the need for different imaging techniques.
    - Grasp the basic principles of each modality.
    - Learn the terminology specific to biomedical imaging.
2. **Explore Clinical Applications**:
    - Understand patient experiences during imaging procedures.
    - Select the most suitable modality for specific clinical cases.
3. **Stay Updated on Advancements**:
    - Explore recent developments in imaging technology.
    - Discuss the role of artificial intelligence in biomedical imaging.

Topics Covered:

1. **X-ray and Computed Tomography (CT)**:
    - Principles, instrumentation, and clinical applications.
2. **Nuclear Medicine**:
    - Radiotracers, attenuation correction, and contrast-to-noise.
3. **Ultrasound Imaging**:

    - Energy loss mechanisms, transducer arrays, and signal-to-noise.
4. **Magnetic Resonance Imaging (MRI)**:
    - Tissue-dependent relaxation times, imaging sequences, and techniques.
5. **Optical Imaging**:
    - Direct imaging with visible light and optical coherence tomography.

Assessment:

- Regular quizzes and exams.
- Case studies on selecting appropriate imaging modalities.

Principles of Magnetic Resonance Imaging

Course Description:

This course provides an in-depth understanding of the fundamental principles underlying magnetic resonance imaging (MRI). Students will explore the physics, engineering, and clinical applications of MRI. Topics covered include nuclear spin, relaxation times, pulse sequences, image contrast, spatial encoding, and k-space analysis.

Learning Objectives:

By the end of this course, students will be able to:

1. **Understand MRI Basics**:
    - Describe the principles of nuclear magnetization and tissue relaxation.
    - Explain the role of protons in MRI signal generation.
2. **Explore Pulse Sequences**:
    - Study various MRI pulse sequences (e.g., spin echo, gradient echo, inversion recovery).
    - Understand how different sequences affect image contrast and resolution.
3. **Image Formation and Interpretation**:
    - Learn about k-space, Fourier transform, and image reconstruction.
    - Interpret MRI images and recognize common artifacts.

Topics Covered:

1. **Introduction to MRI Physics**:
    - Nuclear spin, Larmor equation, bulk magnetization, and precession.
    - RF excitation and signal detection.
2. **Tissue Relaxation and Contrast**:
    - T1, T2, and T1ρ relaxation times.
    - Coherence pathways and relaxation mechanisms.
3. **Spatial Encoding and k-Space**:
    - Gradient fields, k-space properties, and imaging equation.
    - Sampling and image reconstruction.

Assessment:

- Regular quizzes and exams.
- Image interpretation exercises.

Recommended Reading:

- While there is no specific textbook required, you may find the following references useful (optional):
  - D. Nishimura, *Principles of Magnetic Resonance Imaging* (available online).
  - Z. Liang and P.C. Lauterbur, *Principles of Magnetic Resonance Imaging: A Signal Processing Perspective*.

Imaging Probes for Nuclear and Optical Imaging

Course Description:

This course explores the principles, design, and applications of imaging probes used in nuclear and optical imaging. Students will learn about the underlying physics, chemistry, and engineering behind these probes. The course covers both preclinical and clinical imaging, emphasizing the development of targeted probes for disease detection and monitoring.

Learning Objectives:

By the end of this course, students will be able to:

1. **Understand Imaging Modalities**:
   - Compare and evaluate nuclear and optical imaging techniques.
   - Recognize the strengths and limitations of each modality.
2. **Probe Design and Chemistry**:
   - Explore the chemical structures of imaging probes.
   - Learn about labeling techniques and radionuclides.
3. **Applications and Case Studies**:
   - Study specific imaging probes for cancer, cardiovascular diseases, and neuroimaging.
   - Understand the role of multimodal imaging.

Topics Covered:

1. **Introduction to Imaging Probes**:
   - Overview of nuclear and optical imaging.
   - Types of imaging agents (small molecules, nanoparticles, antibodies).
2. **Radionuclide Labeling**:
   - Radiolabeling techniques (PET, SPECT).
   - Bifunctional chelators and radiometals.
3. **Fluorescent Probes**:
   - Organic dyes, quantum dots, and fluorescent proteins.
   - NIR-II imaging for deep tissue penetration.
4. **Clinical Applications**:
   - Case studies on cancer imaging, inflammation, and molecular targeting.

Assessment:

- Regular quizzes and exams.
- Design projects related to imaging probe development.

Principles of Diagnostic and Therapeutic Ultrasound

Course Description:

This course provides a comprehensive understanding of the principles underlying diagnostic and therapeutic ultrasound. Students will explore the physics, instrumentation, safety considerations, and clinical applications of ultrasound. The course covers both diagnostic imaging and therapeutic uses, emphasizing evidence-based practice and safe implementation.

Learning Objectives:

By the end of this course, students will be able to:

1. **Understand Ultrasound Physics**:
    - Describe the production, propagation, and interaction of ultrasound waves.
    - Explain the principles of transducer operation and image formation.
2. **Diagnostic Ultrasound Imaging**:
    - Study the use of ultrasound for diagnostic purposes.
    - Learn about image quality, artifacts, and interpretation.
3. **Therapeutic Ultrasound Applications**:
    - Explore therapeutic uses of ultrasound (e.g., physiotherapy, pain management).
    - Understand safety guidelines and biological effects.

Topics Covered:

1. **Physics of Ultrasound**:
    - Ultrasound waves, frequency, wavelength, and velocity.
    - Reflection, refraction, and attenuation.
2. **Diagnostic Ultrasound Imaging**:
    - Transducers, pulse-echo technique, and B-mode imaging.
    - Doppler ultrasound and color flow imaging.
3. **Therapeutic Ultrasound Techniques**:
    - Continuous wave vs. pulsed ultrasound.
    - Clinical applications (e.g., tissue heating, cavitation).

Assessment:

- Regular quizzes and exams.

Advanced Neurological Imaging

Course Description:

Advanced Neurological Imaging is a specialized course that delves into the multifaceted sphere of brain imaging. It explores various imaging modalities, their specific applications in neurology, and the challenges they present. The course emphasizes both structural and functional aspects of brain imaging, providing insights into normal brain function and pathology alterations in various neurological disorders.

Learning Objectives:

By the end of this course, students will be able to:

1. **Differentiate Imaging Modalities**:
    - Understand the differences between various advanced imaging techniques (e.g., magnetoencephalography, event-related potentials, functional near-infrared spectroscopy, magnetic resonance imaging).
    - Recognize the strengths and limitations of each modality.
2. **Explore Brain Structural and Functional Architectures**:
    - Study brain anatomy and connectivity using advanced imaging methods.
    - Investigate underlying principles of brain function and dysfunction.
3. **Clinical Applications and Challenges**:
    - Apply advanced imaging techniques to diagnose and monitor neurological disorders.
    - Address challenges related to image acquisition, interpretation, and clinical translation.

Topics Covered:

1. **Functional Neuroimaging Techniques**:
    - Magnetoencephalography (MEG), event-related potentials (ERPs), and functional near-infrared spectroscopy (fNIRS).
    - Insights into brain function and connectivity.
2. **Structural Imaging Modalities**:
    - Magnetic resonance imaging (MRI) and its applications.
    - Computed tomography (CT) for structural assessment.
3. **Pathology Alterations in Brain Disorders**:
    - Investigate brain abnormalities in various neurological conditions.
    - Understand the impact of imaging findings on diagnosis and treatment.

Assessment:

- Regular quizzes and exams.
- Case studies on advanced imaging applications in neurological disorders.

Genomic Data Science

Course Description:

Genomic Data Science is an interdisciplinary field that applies statistical and computational methods to analyze and interpret data from next-generation sequencing experiments. This course provides foundational knowledge and practical skills for working with genomic data. Students will learn how to process, analyze, and derive insights from large-scale genomic datasets.

Learning Objectives:

By the end of this course, students will be able to:

1. **Understand Genomic Data**:

    - Explore the structure and organization of genomic data (DNA sequences, variants, expression profiles).
    - Learn about common file formats (FASTQ, BAM, VCF).
2. **Data Preprocessing and Quality Control**:
    - Clean and preprocess raw sequencing data.
    - Perform quality assessment and filtering.
3. **Statistical Analysis and Visualization**:
    - Apply statistical methods to identify genetic variants, differential expression, and associations.
    - Visualize genomic data using appropriate tools.

Topics Covered:

1. **Introduction to Genomic Data Science**:
    - Overview of genomics and its applications.
    - Ethical considerations and privacy issues.
2. **Sequence Alignment and Variant Calling**:
    - Mapping reads to a reference genome.
    - Identifying single nucleotide variants (SNVs) and structural variants.
3. **Gene Expression Analysis**:
    - RNA-seq data processing.
    - Differential expression analysis.
4. **Genome-Wide Association Studies (GWAS)**:
    - Identifying genetic variants associated with traits or diseases.
    - Population genetics and allele frequencies.

Assessment:

- Regular quizzes and assignments.
- Practical exercises using real genomic datasets.

Bioinformatics for Biomedical Engineering

Course Description:

This course introduces students to the field of bioinformatics, emphasizing its applications in biomedical engineering. Students will learn fundamental concepts, tools, and techniques for analyzing biological data, including DNA, RNA, and protein sequences. The course covers sequence alignment, genome annotation, structural bioinformatics, and network analysis. Practical skills in data analysis and machine learning for biological problems will be developed.

Learning Objectives:

By the end of this course, students should be able to:

- Understand the basics of biological data (DNA, RNA, proteins) and relevant databases.
- Perform pairwise and multiple sequence alignments using tools like BLAST.
- Annotate genomes and compare genomic elements across species.
- Predict protein structures and analyze protein-ligand interactions.
- Apply network-based approaches to understand cellular processes.

- Utilize machine learning algorithms for biological data analysis.
- Explore biomedical applications of bioinformatics.

Topics Covered:

1. **Introduction to Bioinformatics**
    - Overview of bioinformatics and its significance
    - Biological databases and data formats
2. **Sequence Analysis**
    - Pairwise sequence alignment (BLAST, Needleman-Wunsch)
    - Multiple sequence alignment (ClustalW, MUSCLE)
    - Hidden Markov Models (HMMs)
3. **Genome Annotation and Comparative Genomics**
    - Gene prediction and functional annotation
    - Comparative analysis of genomes
    - Evolutionary insights
4. **Structural Bioinformatics**
    - Protein structure prediction methods (homology modeling, ab initio)
    - Visualization tools (PyMOL, Chimera)
    - Docking and ligand binding sites
5. **Systems Biology and Network Analysis**
    - Biological networks (protein-protein interactions, metabolic pathways)
    - Network visualization and analysis
    - Integration of omics data
6. **Next-Generation Sequencing (NGS) Technologies**
    - High-throughput sequencing platforms (Illumina, PacBio)
    - NGS data analysis pipelines
    - Variant calling and functional annotation
7. **Machine Learning in Bioinformatics**
    - Classification algorithms (Random Forest, SVM)
    - Feature selection and dimensionality reduction
    - Applications in genomics and proteomics

Assessment:

- Quizzes and assignments
- Practical exercises (sequence alignment, structure prediction)
- Midterm and final exams
- Group projects (applying bioinformatics tools to real-world data)

Recommended Resources:

- **Textbooks:**
    - "Bioinformatics Algorithms: An Active Learning Approach" by Phillip Compeau and Pavel Pevzner
    - "Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids" by Richard Durbin et al.
- **Online Platforms:**
    - NCBI BLAST for sequence alignment
    - UniProt for protein information
    - Rosalind for bioinformatics practice

Computational Neuroscience

Course Description:

This course introduces quantitative approaches to understanding brain and cognitive functions. Students will explore mathematical descriptions of neurons, neural responses to sensory stimuli, simple neuronal networks, statistical inference, and decision-making.

Learning Objectives:

By the end of this course, students should be able to:

- Understand basic neuroscience concepts.
- Model neurons mathematically.
- Analyze neural encoding and decoding.
- Apply information theory to neural systems.
- Explore network models and plasticity/learning.

Topics Covered:

1. **Introduction to Basic Neuroscience Concepts**
    - Overview of nervous system function
    - Neuronal structure and communication
2. **Models of Neurons**
    - Mathematical representations of individual neurons
    - Hodgkin-Huxley model, integrate-and-fire model
3. **Neural Encoding**
    - How neurons encode sensory information
    - Spike trains and rate coding
4. **Neural Decoding**
    - Inference from neural activity
    - Decoding sensory stimuli
5. **Information Theory in Neuroscience**
    - Measures of information content
    - Entropy, mutual information
6. **Network Models**
    - Simple neuronal networks (feedforward, recurrent)
    - Emergent properties in network dynamics
7. **Plasticity and Learning**
    - Synaptic plasticity (Hebbian learning, long-term potentiation)
    - Learning rules in neural networks

Neurobiology, Medicine, and Society

Course Description:

This interdisciplinary course explores the intersection of neurobiology, medicine, and societal implications. Students will delve into the neurobiological basis of mental illnesses and their impact on public health. The course emphasizes critical thinking and understanding the broader context of mental health.

Learning Objectives:

By the end of this course, students should be able to:

- Understand the neurobiological mechanisms underlying mental illnesses.
- Analyze the societal implications of mental health disorders.
- Evaluate current concepts and controversies in the field.

Topics Covered:

1. **Introduction to Neurobiology and Mental Illness**
   - Overview of brain structure and function
   - Common mental health disorders (e.g., depression, anxiety, schizophrenia)
2. **Neurotransmitters and Brain Circuits**
   - Role of neurotransmitters (serotonin, dopamine, etc.)
   - Neural circuits implicated in mental illnesses
3. **Genetics and Epigenetics**
   - Genetic factors in mental health
   - Epigenetic modifications and susceptibility
4. **Neuroinflammation and Immune System**
   - Inflammatory processes in mental disorders
   - Immune-brain interactions
5. **Psychopharmacology and Treatment**
   - Medications for mental illnesses
   - Challenges in drug development
6. **Social Stigma and Mental Health Advocacy**
   - Impact of stigma on individuals and society
   - Advocacy efforts and reducing stigma
7. **Ethical Considerations**
   - Balancing individual rights and public safety
   - Ethical dilemmas in mental health care

Assessment:

- Participation in class discussions
- Research-based essays on specific mental health topics
- Case studies and critical analysis

Experimental Methods in Systems Biology

Course Description:

This course provides an overview of the technologies used in modern systems biology. We focus on obtaining quantitative data needed for computational modeling. Key topics include RNA sequencing, mass spectrometry-based proteomics, flow/mass cytometry, and live-cell imaging.

Learning Objectives:

By the end of this course, students will be able to:

- Understand the underlying technologies for experimentation in systems biology.
- Analyze how cells respond to experimental perturbations.

Topics Covered:

1. **Introduction to Systems Biology**
    - Scope and overview
    - Biological model systems
    - Experimental perturbations
2. **RNA Sequencing (mRNA Sequencing)**
    - Principles and applications
    - Data analysis techniques
3. **Mass Spectrometry-Based Proteomics**
    - Protein identification and quantification
    - Sample preparation and instrumentation
4. **Flow/Mass Cytometry**
    - Cell analysis and sorting
    - Fluorescence-based techniques
5. **Live-Cell Imaging**
    - Visualization of cellular processes
    - Time-lapse microscopy

Alternating and Direct Current Circuits

Course Description:

This course explores the fundamental concepts related to alternating current (AC) and direct current (DC) circuits. Students will gain insights into the differences between AC and DC, their applications, and practical circuit analysis techniques.

Learning Objectives:

By the end of this course, students should be able to:

- Understand the characteristics of AC and DC currents.
- Analyze simple AC and DC circuits.
- Apply circuit laws (Ohm's law, Kirchhoff's laws) to solve problems.
- Explore diode and transistor circuits as switches.

Topics Covered:

1. **Introduction to AC and DC**
    - Definitions and historical context
    - AC vs. DC: Differences and applications
2. **AC Circuits**
    - Generating AC using alternators
    - Waveforms (sine, square, triangle)
    - AC circuit analysis techniques
3. **DC Circuits**
    - Voltage, current, and resistance in DC circuits
    - Series and parallel circuits

- Diode and transistor circuits

4. **Digital Signals and Logic Gates**
   - Representing information using digital signals
   - Designing logic gates with diodes and transistors

Digital Signal Processing

Course Description:

This course introduces fundamental concepts and techniques related to digital signal processing. Students will learn how to analyze and manipulate discrete-time signals, apply filters, and convert analog signals to digital format. Practical implementation and real-time algorithms will also be covered.

Learning Objectives:

By the end of this course, students should be able to:

- Understand the differences between analog and digital signals.
- Analyze data using the Fourier transform.
- Design and implement digital filters.
- Convert analog signals to digital representation.

Topics Covered:

1. **Introduction to DSP**
   - Analog vs. digital signals
   - Sampling and quantization
2. **Discrete-Time Signals and Systems**
   - Signal representation
   - Linear time-invariant systems
3. **Frequency Domain Analysis**
   - Fourier transform
   - Spectral analysis
4. **Digital Filters**
   - FIR (finite impulse response) filters
   - IIR (infinite impulse response) filters
5. **Analog-to-Digital Conversion**
   - ADC basics
   - Quantization error
6. **Real-Time DSP Algorithms**
   - Implementing DSP on microcontrollers
   - Practical applications

Fundamentals of Robotics

Course Description:

This course provides a comprehensive understanding of essential concepts and practical skills necessary for excelling in the field of collaborative robotics. Participants will explore the intricacies of sensors, transducers in machine tools and robots, servo systems, and interfacing and simulation techniques.

Learning Objectives:

By the end of this course, participants should be able to:

- Understand the interdisciplinary nature of robotics engineering.
- Design robotic grippers.
- Apply PLC (Programmable Logic Controller) concepts.
- Develop mechatronics system designs.

Unit:

1. **Introduction to Robotics**
    - Historical context and significance
    - Basics of industrial manufacturing
2. **Sensors and Transducers**
    - Types of sensors (proximity, vision, force)
    - Signal conditioning and interfacing
3. **Servo Systems and Motion Control**
    - Principles of servo motors
    - Trajectory planning and control
4. **Gripper Designs and Manipulation**
    - End-effector design considerations
    - Gripper kinematics and dynamics
5. **PLC Programming and Automation**
    - Programmable Logic Controllers (PLCs)
    - Logic programming for automation tasks
6. **Simulation Techniques**
    - Modeling and simulating robotic systems
    - Virtual prototyping and testing

Computer-Aided Drafting

Course Description:

This course focuses on the application of computer-aided design (CAD) principles in the field of biomedical engineering. Students will learn how to create accurate and precise technical drawings related to medical devices, implants, and prosthetics. The course emphasizes both 2D and 3D representations, adhering to industry standards.

Learning Objectives:

By the end of this course, students should be able to:

- Understand the role of CAD in biomedical engineering.
- Create 2D orthographic projections of medical components.
- Develop 3D models for visualization and prototyping.
- Apply relevant standards and conventions in biomedical drafting.

Topics Covered:

1. **Introduction to Biomedical CAD**
    - Overview of CAD applications in medical device design
    - Importance of precision and accuracy
2. **2D Orthographic Projections**
    - Creating technical drawings (top view, front view, side view)
    - Dimensioning and annotation
3. **3D Modeling Techniques**
    - Solid modeling (extrusion, revolve, loft)
    - Surface modeling for complex shapes
4. **Biomedical Components and Assemblies**
    - Implants (joint replacements, dental implants)
    - Prosthetics (limb, craniofacial)
    - Medical instruments (surgical tools, diagnostic devices)
5. **Standards and Conventions**
    - ANSI standards for medical drawings
    - ISO symbols for biomedical components
6. **Prototyping and Visualization**
    - Rapid prototyping techniques (3D printing, CNC machining)
    - Rendering and animation for presentations

Trigonometry

Course Description:

This course introduces fundamental trigonometric concepts and their applications in biomedical engineering. Students will learn how trigonometry plays a crucial role in analyzing biological signals, medical imaging, and biomechanics. The course emphasizes practical problem-solving and real-world scenarios.

Learning Objectives:

By the end of this course, students should be able to:

- Understand the properties of trigonometric functions (sine, cosine, tangent, etc.).
- Apply trigonometry to analyze physiological waveforms (e.g., ECG, PPG).
- Solve problems related to medical imaging geometry.
- Model biomechanical systems using trigonometric principles.

Topics Covered:

1. **Trigonometric Basics**
    - Definitions of sine, cosine, tangent, and their reciprocal functions
    - Unit circle and radian measure
2. **Trigonometric Identities and Equations**

    - Pythagorean identities
    - Solving trigonometric equations
3. **Periodic Functions in Biomedical Signals**
    - Modeling physiological waveforms (ECG, PPG) using trigonometric functions
    - Frequency analysis and Fourier series
4. **Medical Imaging Geometry**
    - Trigonometry in X-ray, MRI, and ultrasound imaging
    - Determining angles and distances in imaging systems
5. **Biomechanics Applications**
    - Joint angles and range of motion
    - Forces and torques in musculoskeletal systems

Assessment:

- Quizzes and problem-solving exercises
- Application of trigonometry to real-world biomedical scenarios
- Group projects related to medical imaging or biomechanics

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