COURSE CONTENT

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>AY2018/19</th>
<th>Semester</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Coordinator</td>
<td>Teoh Swee Hin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course Code</td>
<td>BG0491 / CH0491</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course Title</td>
<td>Engineers &amp; Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study Year (if applicable)</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-requisites</td>
<td>Nil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No of AUs</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact Hours</td>
<td>Lecture: 26 hrs; Tutorial: 13 hr; Lab: 0 hr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proposal Date</td>
<td>16 Jan 2018</td>
<td></td>
<td></td>
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</tbody>
</table>

Course Aims

This course aims to provide a general understanding of the society we live in and the engineers’ roles and responsibilities towards society’s well-being. The course is part of broadening education objective in the engineering curriculum. The course covers a wide range of topics including history, political, social and economic development, foreign policy and defence of Singapore and the issues confronting it, the history of engineering, engineering ethics and practices, international politics and globalization and contributions by engineers towards society. The students will have a holistic understanding of Singapore’s past and present situation and on the impact of industry to the society.

Intended Learning Outcomes (ILO)

By the end of this course, you would be able to:

1. Identify how Singapore transited from being a 3rd World to 1st country and lessons to be learnt
2. Illustrate the role engineers play in the development of Singapore and future challenges
3. Interpret the significance of professional ethics,
4. Interpret the significance of engineering practice in safety and sustainability, and
5. Evaluate the significance of globalization and impact of industry to the society

Course Content

<table>
<thead>
<tr>
<th>S/N</th>
<th>Topic</th>
<th>Lecture Hrs</th>
<th>Tutorial Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-independence history of Singapore</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Social and political development issues</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Economic and industrial development issues</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>National cohesion and total defence</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>History of engineering</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Engineering ethics</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Engineering practice in Singapore (WSH and sustainability)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Our neighbours and international relations</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Challenges of globalization and the new economy</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
### Contribution of engineers in the new economy

<table>
<thead>
<tr>
<th>10</th>
<th>Contribution of engineers in the new economy</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Impact of industry to the society (by external speakers)</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Total: 26 13

### Assessment (includes both continuous and summative assessment)

<table>
<thead>
<tr>
<th>Component</th>
<th>Course LO Tested</th>
<th>Related Programme LO or Graduate Attributes</th>
<th>Weightage</th>
<th>Team/Individual</th>
<th>Assessment rubrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Final Examination</td>
<td>1, 2, 3, 4, 5</td>
<td>EAB SLOs (f), (g), (h) and (l)</td>
<td>60%</td>
<td>Individual</td>
<td>Refer to Appendix 1</td>
</tr>
<tr>
<td>2 Continuous Assessment (CA): Presentation</td>
<td>1, 2, 3, 4, 5</td>
<td>EAB SLOs (f), (g), (h) and (l)</td>
<td>40%</td>
<td>Team</td>
<td>Refer to Appendix 1</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* EAB Student Learning Outcomes (12 points)


(f) The engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

(g) Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.

(h) Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

(l) Life-long Learning: Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

### Formative feedback

Upon finishing your presentation with Q&A, you will receive feedback on whether you have covered sufficiently with facts/contents, challenges faced/caused/overcome, and going forward with takeaways.

### Learning and Teaching approach

Class meets once per week over 2 hours in lecture format and 1 hour in tutorial format for classroom presentation
<table>
<thead>
<tr>
<th>outcomes?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>Formal lectures on the topics with in-class discussions</td>
</tr>
<tr>
<td>Team presentation</td>
<td>This helps you to achieve one or more of the outcomes, as you need to do self-study, research, and then make classroom presentation. (The class is split into 6 presentation teams. Two groups will make presentation with Q&amp;A in each week. You will be grouped into 3-5 students per team.)</td>
</tr>
</tbody>
</table>

### Reading and References

**References:**

5. Lee Kuan Yew: hard truths to keep Singapore going / Han Fook Kwang / et al. Singapore: Straits Times. (DS610.73.L46L478KY + 1 DVD)

### Course Policies and Student Responsibilities

1. **General**
   Students are expected to make presentations on all assigned projects and attend all tutorial classes punctually. Students are expected to participate in the Q&A sessions of all the presentations.

2. **Absenteeism**
   The course requires you to attend all tutorial classes to participate in the Q&A sessions of all the presentations. Absence from class without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU’s approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for in-class presentation activities.

### Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are
at the core of NTU’s shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

### Course Instructors

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Office Location</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Lum Kit Meng</td>
<td>N1-01b-52</td>
<td>6790 5318</td>
<td><a href="mailto:ckmlum@ntu.edu.sg">ckmlum@ntu.edu.sg</a></td>
</tr>
<tr>
<td>Dr Chew Ah Seng, David</td>
<td>N1-01b-48</td>
<td>6790 5300</td>
<td><a href="mailto:caschew@ntu.edu.sg">caschew@ntu.edu.sg</a></td>
</tr>
<tr>
<td>One invited speaker 2 hours total</td>
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<td></td>
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</tbody>
</table>

### Planned Weekly Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture</th>
<th>Course LO</th>
<th>Tutorial</th>
<th>Course LO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>History of engineering</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Pre-independence history of Singapore</td>
<td>1</td>
<td>Briefing on presentation</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Social and political development issues</td>
<td>1</td>
<td>Consultation on presentation</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Engineering ethics</td>
<td>3</td>
<td>Presentation – Series 1</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>5</td>
<td>Engineering ethics (examples)</td>
<td>3</td>
<td>Presentation – Series 1</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>6</td>
<td>Engineering practice in Singapore (WSH)</td>
<td>4</td>
<td>Presentation – Series 1</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>7</td>
<td>Engineering practice in Singapore (sustainability)</td>
<td>4</td>
<td>Presentation – Series 2</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>8</td>
<td>Economic and industrial development issues</td>
<td>5</td>
<td>Presentation – Series 2</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>9</td>
<td>National cohesion and total defence</td>
<td>1</td>
<td>Presentation – Series 2</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>10</td>
<td>Our neighbours and international relations</td>
<td>1</td>
<td>Presentation – Series 3</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>11</td>
<td>Challenges of globalization and the new economy</td>
<td>5</td>
<td>Presentation – Series 3</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>12</td>
<td>Contribution of engineers in the new economy</td>
<td>2</td>
<td>Presentation – Series 3</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>13</td>
<td>Impact of industry to the society (by external speakers)</td>
<td>5</td>
<td>Presentation – if needed</td>
<td>1, 2, 3, 4, 5</td>
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### Appendix 1: Assessment Rubric
<table>
<thead>
<tr>
<th>Performance Indicators/ Course LO Tested</th>
<th>Performance Level/Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Below expectations:</strong> 1</td>
<td><strong>Average, meet expectation:</strong> 2</td>
</tr>
<tr>
<td>Apply workplace safety measures for protection of people and property/ LO 4</td>
<td>Unable to apply concepts applicable for workplace safety measures</td>
</tr>
<tr>
<td><strong>Recognise the needs and the importance of life-long learning/ LO 1, 2, 5</strong></td>
<td>Unable to recognise the needs and importance of life-long learning</td>
</tr>
<tr>
<td><strong>Adopt systems thinking for sustainable development/LO 4</strong></td>
<td>Unable to adopt systems thinking for sustainable development</td>
</tr>
<tr>
<td><strong>Comprehend engineering codes of ethics/ LO 3</strong></td>
<td>Unable to comprehend the engineering codes of ethics</td>
</tr>
<tr>
<td><strong>Apply engineering codes of ethics to avoid conflicts/ LO 3</strong></td>
<td>Unable to apply engineering codes of ethics to working life of an engineer</td>
</tr>
</tbody>
</table>
BG1101 Introduction to Biomedical Engineering (Core)
[Lectures: 26 hours; Tutorials: 0 hours; Pre-requisites: NIL; Academic Unit: 2.0]

Objectives

This course will provide students with fundamental concept of biomedical engineering and foundational knowledge for subsequent bioengineering courses. The aims of this course are to provide adequate breath in identifying the many challenging issues in biomedical engineering, encourage team work, improve communication skills and develop compelling arguments during discussion and when examined. It also encourages creativity in presentation style.

Student Learning Outcomes

Upon successful completion of this course, students should:

Have a broad overview in the various fields of biomedical engineering.

Gain a basic understanding and build a foundation for future biomedical engineering courses.

Appreciate the interplay between the basic knowledge in mathematics, physics, chemistry, and biology and their applications to biomedical engineering.

Learn how to work in a team and to present the technical knowledge learned in class.

Course Assessment

Students will be assessed by:

- Continuous assessment (100%)
  - Quiz (30%)
  - Poster Presentation (70%)

References


Topic

1. Introduction To Biomedical Engineering. Bioethics And Regulatory Issues.
2. Anatomy And Physiology.
3. Biomechanics And Rehabilitation Engineering
4. Biomaterials And Tissue Engineering.
5. Bioinstrumentations And Biosensors
8. Bioinformatics And Computational Biology.
9. Bioimaging
10. Biomedical Optics.
BG1103 – Chemistry for Engineers (Core)

[Lectures: 26 hours; Tutorials: 13 hours; Pre-requisites: Nil; Academic Unit: 3]

Objectives

To learn general college chemistry at a fundamental level. To get introduction and reinforcement about physical chemistry, inorganic chemistry and organic chemistry. Inorganic and physical chemistry cover reaction kinetics, chemical equilibrium, ionic equilibrium, and electrochemistry, while organic chemistry covers organic compounds, their structures, properties, nomenclature, and applications.

Student Learning Outcomes

Students will learn general college chemistry at a fundamental level including physical chemistry, inorganic chemistry and organic chemistry. With that students are able to build up foundations for the future learning of Biochemistry, Biomolecular Engineering, Thermodynamics, Materials Science, Biomaterials, and Nanomaterials/technology.

Course Assessment

Students will be assessed on

(a) Continuous assessment (40%)

(b) Final examination (60%)

References


Topics

1. Basic Concepts
2. Chemical Bonding
3. Reaction Kinetics
4. Chemical Equilibrium
5. Acids And Bases, Activity
6. Electrochemistry
7. Organic Structure, Bonding And Reactions
8. Aliphatic And Aromatic Hydrocarbon
Synthetic And Natural Organic Polymers
**BG1105 – Materials Science (Core)**

[Lectures: 26 hrs; Tutorials: 13 hrs; Prerequisites: Nil; Academic Units: 3]

**Objectives**

Materials Science is an interdisciplinary field where the properties of materials are related to its structure at the atomic, microscopic and macroscopic levels. Understanding this relationship helps us achieve the required combination of properties in a given material for specific functionalities and therefore applications. This is an introductory course where basic scientific concepts are evolved, from fundamental physics and chemistry, to the roles of atomic and micro/macroscopic structures on the properties of different type of materials. Important functional properties such as metallic, semiconducting, optical, magnetic, thermal and mechanical properties are covered in greater details. This course also includes the use of materials in Bioengineering. At the end of the course, the student should be able to:

1. Know the microstructure of materials including atomic structure, crystal structure, defects, phase diagrams of alloys, etc.
2. Know different types of material properties and their general testing procedures.
3. Know different type of materials and their general properties.
4. Understand the relationship among structure, processing and properties.
5. Have a basic idea how to choose a material with required properties for a specific application especially in Chemical Engineering and Bioengineering.

**Student Learning Outcomes**

At the end of the course, the student should be able to:

1. Understand the structures of materials including atomic structure, crystal structure, defects, phase diagrams of alloys, etc.
2. Know different types of material properties and their general testing and characterizing procedures.
3. Know different type of materials and their general properties.
4. Understand the relationship among structure, processing and properties.
5. Have a basic idea how to choose a material with required properties for a specific application especially in Bioengineering.

**Course Assessment**

Students will be assessed on

(a) Continuous assessment (40%)

(b) Final examination (60%)

**References**


Topics
1. Introduction
2. Bonding Between Atom
3. Building Blocks Of Materials
4. Mechanical Properties Of Materials
5. Phases And Microstructures
6. Functional Properties Of Materials
BG1107 – Engineering Mathematics (Core)

[Lectures: 39 hrs; Tutorials: 13 hrs; Pre-requisite: MH1810 Mathematics; Academic Units: 4.0]

Objectives

To learn advanced engineering analysis in modeling, solutions of differential equations using methods involving Laplace transform and linear algebra, multiple integrals and vector calculus as well as probability and statistics. After completing this course, the student will be able to apply the analytical tools and fundamental concepts learnt in this course to various engineering disciplines in the following years of study.

Student Learning Outcomes

After completing this course, the student will be able to apply the concepts of this course to various engineering disciplines in the following years of study. At the end of this course, the student will be able to:

- Model a simple system to obtain a first order ODE.
- Solve linear and nonlinear first order ODEs as well as the second order linear homogeneous and nonhomogeneous ODE
- Solve initial value problems using the Laplace transform.
- Calculate determinant and matrix inverse of higher order matrices.
- Solve a system of linear algebraic equations using Laplace transform.
- Calculate eigenvalues and eigenvectors
- Use eigenvalues and eigenvectors to solve the 1st order linear systems
- Apply partial derivatives to evaluate directional derivatives, gradient vectors, tangent planes, etc.
- Determine the extrema of functions of multiple variables and apply it to different practical maximization/minimization problems.
- Apply multiple integral to evaluate areas, volumes, etc.
- Apply vector algebra to solve geometry problems.
- Perform line integral and surface integral over given curves and surfaces.
- Use Fourier series to represent any periodic function
- Apply the method of separation of variables to solve 1D heat equations
- Understand probability theory and basic mathematical statistics

Course Assessment

Students will be assessed by:

(a) Final examination (70%)
(b) Continuous assessment: assignment & quizzes (30%)

References

Topics

1. Modeling, Linear And Nonlinear 1st Order ODE
2. 2nd Order ODE: Linear Homogeneous And Applications
3. 2nd Order ODE: Linear Nonhomogeneous And Applications
4. Laplace Transforms, Heaviside Function
5. Linear Algebra And Eigenvalues/Eigenvectors
6. System Of The First Order Linear ODE
7. Partial Differentiation
8. Multiple Integrals
9. Vector Algebra And Calculus
10. Fourier Series And Partial Differential Equations
11. Probability And Statistics
BG1109 – Anatomy & Physiology (Core)

[Lectures: 39 hours; Tutorials: NIL; Pre-requisites: Nil; Academic Unit: 3]

Objectives

This course will provide students with the basic knowledge of human anatomy and physiology in the context of biomedical device/instrument design. Healthy and pathological tissue/organ will be compared. Demonstrations on some biomedical instruments will be included.

Student Learning Outcomes

Students are expected to be able to:

1. Identify basic human anatomical parts
2. Describe physiological processes
3. Understand the interplay between various organ systems
4. Explain the relationship between the anatomy/physiology knowledge to the design of biomedical devices

Course Assessment

Students will be assessed on

(a) Continuous assessment (40%)

(b) Final examination (60%)

References


Topics

1. Bones And Joints
2. Muscular System
3. Respiratory, Gastrointestinal, And Urinary System
4. Cardiovascular System
5. Basic Neuroanatomy
6. Structure Of The Nervous System And Sensory Organs
7. Function Of The Nervous System And Sensory Organs
Objectives

To learn advanced engineering analysis in modeling, solutions of differential equations using methods involving Laplace transform and linear algebra, multiple integrals and vector calculus as well as probability and statistics. After completing this course, the student will be able to apply the analytical tools and fundamental concepts learnt in this course to various engineering disciplines in the following years of study.

Student Learning Outcomes

After completing this course, the student will be able to apply the concepts of this course to various engineering disciplines in the following years of study. At the end of this course, the student will be able to:

- Model a simple system to obtain a first order ODE.
- Solve linear and nonlinear first order ODEs as well as the second order linear homogeneous and nonhomogeneous ODE.
- Solve initial value problems using the Laplace transform.
- Calculate determinant and matrix inverse of higher order matrices.
- Solve a system of linear algebraic equations using Laplace transform.
- Calculate eigenvalues and eigenvectors.
- Use eigenvalues and eigenvectors to solve the 1st order linear systems.
- Apply partial derivatives to evaluate directional derivatives, gradient vectors, tangent planes, etc.
- Determine the extrema of functions of multiple variables and apply it to different practical maximization/minimization problems.
- Apply multiple integral to evaluate areas, volumes, etc.
- Apply vector algebra to solve geometry problems.
- Perform line integral and surface integral over given curves and surfaces.
- Use Fourier series to represent any periodic function.
- Apply the method of separation of variables to solve 1D heat equations.
- Understand probability theory and basic mathematical statistics.

Course Assessment

Students will be assessed by:

(a) Final examination (70%)

(b) Continuous assessment: assignment & quizzes (30%)

References

Topics

1. Modeling, Linear And Nonlinear 1st Order ODE
2. 2nd Order ODE: Linear Homogeneous And Applications
3. 2nd Order ODE: Linear Nonhomogeneous And Applications
4. Laplace Transforms, Heaviside Function
5. Linear Algebra And Eigenvalues/Eigenvectors
6. System Of The First Order Linear ODE
7. Partial Differentiation
8. Multiple Integrals
9. Vector Algebra And Calculus
10. Fourier Series And Partial Differential Equations
11. Probability And Statistics
BG1131 Molecular Cell Biology for Biomedical Engineers (Core)

[Lectures: 46 hours; Tutorials: 6 hours; Pre-requisites: Nil; Academic Unit: 4]

Objectives

Molecular cell biology from molecular structure, gene regulation to protein function will be presented from a bio/biomedical engineer's perspectives. This course is designed for students with an engineering background to learn the fundamentals of molecular biology and biotechnology. The course emphasizes conceptual appreciation of the molecular interplays which are the basis of "chemical processes" in living systems. The objective of the course is to provide students with a comprehensive and concise overview of biological science with emphases on its relationship with biomedical engineering.

Student Learning Outcomes

Upon successful completion of this course, students should be able to:
1. Understand fundamental concepts on molecular cell biology, biochemistry, and genetic engineering
2. Comprehend the background, essential components, and various functions of molecular cell systems
3. Have basic knowledge on practical techniques and approaches commonly used in molecular cell biology and molecular cloning
4. Apply the knowledge of molecular cell biology to biomedical engineering and medical sciences

Course Assessment

Students will be assessed by:

a) Continuous Assessment (%) - 20% (2 Quizzes; 10% each quiz)
b) Final examination (%) - 80%

Textbooks


Reference

Topics
1. Introduction To Cells, Organelles, And Cytoskeleton
2. DNA And DNA Replication
3. Transcription And Translation
4. Control Of Gene Expression
5. Membrane Structure And Transport
6. Cell Communications
7. Cell Division, Cell Cycle Control, And Cell Death
8. Protein Structure And Function
9. Enzyme Catalysis, Kinetics, Inhibition, And Control
10. Glycolysis & Gluconeogenesis
11. Pentose Phosphate Pathway, Citric Acid Cycle, Gluconeogenesis
12. ATP Production And Electron Transport/Oxidative Phosphorylation
13. Recombinant DNA Technology And Protein Production/Purification
BG1801 – Bioengineering Laboratory 1A (Core)

[Lectures: 0 hours; Tutorials: 0 hours; Pre-requisites: Nil; Academic Unit: 1]

Objectives

This laboratory course aims to provide practical applications to reinforce theories and concepts taught in first year of bioengineering.

Student Learning Outcomes

After completing this course, the student will be able to apply the concepts learnt in bioengineering in a more practical setting.

Course Assessment

Students will be assessed on

(a) Continuous assessment (100%)

References

Nil
BG1802 – Bioengineering Laboratory 1B (Core)

[Lectures: 0 hours; Tutorials: 0 hours; Pre-requisites: Nil; Academic Unit: 1]

Objectives

This laboratory course aims to provide practical applications to reinforce theories and concepts taught in first year of bioengineering: Materials science, physics, chemistry, biomolecular engineering I.

Student Learning Outcomes

After completing this course, the student will be able to apply the concepts learnt in bioengineering in a more practical setting.

Course Assessment

Students will be assessed on

(a) Continuous assessment (100%)

References

Nil
BG2104 – Electronics for Biomedical Engineers (Core)

[Lectures: 26 hours; Tutorials: 13 hours; Pre-requisites: BG1102; Academic Unit: 3]

Objectives

To provide understanding of the characteristics of electronic components.

To provide knowledge involved in the electronic circuit design for biomedical engineers.

Student Learning Outcomes

After completing this course, the students will be able to have the knowledge of electronic devices, as well as knowledge of the analysis and design of electronic circuits

Course Assessment

Students will be assessed on

(a) Tutorial assessment (30%)

(b) A final 2-hours written examination (70%)

References


Topics

1. Introduction To Electronics
2. Diodes
3. Bipolar Junction Transistors (BJT)
4. Field Effect Transistor (FET)
5. Operational Amplifiers
BG2109 – Biomechanics (Core)
[Lectures: 27 hours; Tutorials: 12 hours; Pre-requisites: BG2141; Academic Unit: 3]

Objectives
To learn the fundamentals of cellular biomechanics and mechanotransduction with emphasis
on solid mechanics and phenomena at multiple-length scales. The students will gain a
deeper insight on biomechanics from the molecular level to advanced technologies.

Course Outline
1. General introduction (Week 1)
2. Physiological relevance (Week 1)
3. Cellular structure and tensegrity (Week 2)
4. Cytoskeleton structures (Week 3)
5. ECM and Cell adhesion (Week 4)
6. Imaging techniques for cellular structure (Week 5)
7. Techniques for mechanotransduction (Week 6)
8. Intro to biomechanics part 2, Review of important mechanics concepts (Week 7)
9. Muscles and movement: single cell models (Week 8, Week 9)
10. Part 2 Quiz
11. Muscles and movement: muscle mechanics (Week 11)
12. Skeletal biomechanics: bone physiology, fracture and failure mechanics (Week 12)
13. Skeletal biomechanics: functional adaptation and mechanobiology, soft connective
tissues (Week 13)

<table>
<thead>
<tr>
<th>Content</th>
<th>Lecture hours</th>
<th>Tutorial hours</th>
<th>Online hour (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1: General introduction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiological relevance</td>
<td>1.5</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>W2: Cellular structure and tensegrity</td>
<td>1.5</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>W3: Cytoskeleton structures</td>
<td>2.5</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>W4: ECM and Cell adhesion</td>
<td>1</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>W5: Imaging techniques for cellular structure</td>
<td>2.5</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>W6: Techniques for mechanotransduction</td>
<td>1</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>W7: Intro to biomechanics part 2, Review of important mechanics concepts</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>W8-W9: Muscles and movement: single cell models</td>
<td>4</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>W10: Part 2 Quiz</td>
<td>1.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>W11: Muscles and movement: muscle mechanics</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>W12: Skeletal biomechanics: bone physiology, fracture and failure mechanics</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>W13: Skeletal biomechanics: functional adaptation and mechanobiology, soft connective tissues</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Sub total 22.5 9 (equivalent to 4.5hr lect hr)

Total: 22.5 + 4.5 = 27 12
Student Learning Outcomes
Students will gain fundamental concepts on biomechanics with emphasis on cell behaviour, cell response, and biomechanics techniques.

Course Assessment
Students will be assessed on

(a) Continuous assessment (54%)
   (i) Part 1: TEL based Online Quiz 18% (Prof. Yansong topics: Week 1-6 and Week 11-13)
   (ii) Part 2: Class Quiz 18% (Dr Lim Jing topics: Week 7-9)
   (iii) Class Participation (18%): Students will be assessed on their participation in class discussions and showing of initiative in class activities.

(b) Final examination (46%) Restricted Open (1 A4 Sized cheat sheet) 2.5hrs

References
BG2110 – Bioelectricity (Core)
[Lectures: 31 hours; Tutorials: 8 hours; Pre-requisites: BG1131, BG2104; Academic Unit: 3]

Objectives
As many biomedical diagnosis devices (e.g. ECG) and pharmaceutical treatments (e.g. drugs targeting on ion channels for heart diseases) are based on bioelectricity, this course will be useful for student’s future study (e.g. for courses such as Bioinstrumentation) and career in biomedical industry.

Student Learning Outcomes
As many biomedical diagnosis devices (e.g. ECG) and pharmaceutical treatments (e.g. drugs targeting on ion channels for heart diseases) are based on bioelectricity, this course will be useful for student’s future study (e.g. for courses such as Bioinstrumentation) and career in biomedical industry.

Course Assessment
With effect of AY1617, Semester 2, students will be assessed on

(1) 40% CA
   - Quiz 1 (20%) (Short questions on first part of course)
   - Quiz 2 (20%) (Short questions on second part of course)
(2) 60% Final Written Examination (2.5hrs, closed book)

Course Outline:

<table>
<thead>
<tr>
<th>S/N</th>
<th>Topic</th>
<th>Lecture Hours</th>
<th>Tutorial Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction To Bioelectricity</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Ionic Current</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Cell Membrane And Membrane Potential</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Ion Channel Structures And Properties</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Single Channel Current &amp; Measurement</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Channel Gating</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Action Potential And Hodgkin-Huxley Model</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Neural Electrophysiology</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Bioelectricity In Neuromuscular Junction</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Total:</td>
<td>31</td>
<td>8</td>
</tr>
</tbody>
</table>

References
COURSE CONTENT

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>2019/20</th>
<th>Semester</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Coordinator</td>
<td>Ni Ran/Mukta Bansal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course Code</td>
<td>BG2111</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course Title</td>
<td>Introduction to Computational Thinking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-requisites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No of AUs</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact Hours</td>
<td>26 Lecture hours and 12 tutorial hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proposal Date</td>
<td>17 May 2018</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Course Aims

Computational thinking (CT) is a problem solving process with the aid of computer; i.e. formulating a problem and expressing its solution in such a way that a computer can effectively carry it out. It includes a number of characteristics, such as breaking a problem into small and repetitive ordered steps, logically ordering and analyzing data and creating solutions that can be effectively implemented as algorithms running on computer. As such, computational thinking is essential not only to the Computer Science discipline, it can also be used to support problem solving across all disciplines, including math, science, engineering, business, finance and humanities.

The aim of this course is hence to take students with no prior experience of thinking in a computational manner to a point where you can derive simple algorithms and code the programs to solve some basic problems in bioengineering domain.

Intended Learning Outcomes (ILO)

At the end of this course, you should be able to:

1. Code basic programs based on the programming language such as MATLAB.
2. Formulate a problem and express its solution in such a way that a computer can effectively carry it out. (i.e. equip you with CT skills)
3. Identify appropriate numerical methods in solving realistic problems in bioengineering using computing language (such as MATLAB).

Course Content

| 0 | Course Overview and Concepts of Computational Thinking |
|   | Solving complex problem using computer - enables the student to work out exactly what to tell the computer to do. |
| 1 | Overview of Programming Languages |
|   | Graphic programming, high level programming languages (Matlab) |
| 2 | Basic internal operation of computer |
|   | Basic computer organization and how a computer execute a program (Machine instructions) |
| 3 | Basic program structure: control constructs and data types |
|   | Concepts of data types, variables; Pseude code and flowcharts; Sequences, Selection (if/else), iteration (for/while loop); |
| 4 | CT concept – Abstraction |
|   | Problem formulation - reducing something to a set of sub problems which have existing numerical algorithms/methods such as linear/nonlinear equations, optimization, curve fitting, numerical integration/differentiation, numerical differential equations |
CT concept - Decomposition
Break a complex problem into smaller and more manageable parts/steps and find the appropriate algorithms/methods for them including the methods for linear/nonlinear equations, optimization, curve fitting, numerical integration/differentiation, numerical differential equations.

CT concept – Pattern recognition
Looking for similarities among and within problems, which also enable re-use knowledge of previous similar problems.

CT concept – Algorithm
Reformulating the problem into series of ordered steps through identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources.

Limit of computing
Analysis of Algorithm Complexity to determine how much resources (space and time) are needed to execute an Algorithm in order to achieve code optimization.

<table>
<thead>
<tr>
<th>Component</th>
<th>Course LO Tested</th>
<th>Related Programme LO or Graduate Attributes</th>
<th>Weighting</th>
<th>Team/Individual</th>
<th>Assessment rubrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Continuous Assessment 1 (CA1 and CA2): Quizzes</td>
<td>1, 2, 3</td>
<td>EAB SLO* a, b, f</td>
<td>80%</td>
<td>Individual</td>
<td></td>
</tr>
<tr>
<td>2. CA3: Assignments</td>
<td>1, 2, 3</td>
<td>EAB SLO* a, b, c, f</td>
<td>20%</td>
<td>Individual</td>
<td>Appendix 1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formative feedback
You will get back your quizzes scores and the answers;
You will receive feedback during tutorials based on your performance;
You will also receive feedback on your assignment performance.

Learning and Teaching approach

<table>
<thead>
<tr>
<th>Approach</th>
<th>How does this approach support students in achieving the learning outcomes?</th>
</tr>
</thead>
<tbody>
<tr>
<td>LECTURE</td>
<td>Course materials covering all topics</td>
</tr>
<tr>
<td>LAMS Online Lecture</td>
<td>MATLAB Implementation</td>
</tr>
<tr>
<td>TUTORIAL</td>
<td>12 classroom discussion sessions on tutorial questions and related topics</td>
</tr>
</tbody>
</table>


**Reading and References**

**TextBook**

**References**

**Course Policies and Student Responsibilities**
- Completed assignments should be submitted through box labeled BG2111. No late assignments will be accepted.
- There will be no make-up quizzes. Zero points for no show up. Exceptions will be made for leave of absence due to medical reasons (with valid proof). In this case, points will be awarded based on your performance in the final examination.
- Active note taking in the class is encouraged.

**Academic Integrity**

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU’s shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the [academic integrity website](#) for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

**Course Instructors**

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Office Location</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mukta Bansal</td>
<td>N1.2-B2-28</td>
<td>63168775</td>
<td><a href="mailto:mbansal@ntu.edu.sg">mbansal@ntu.edu.sg</a></td>
</tr>
<tr>
<td>Ni Ran</td>
<td>N1.2-B1-12</td>
<td>6790 6737</td>
<td><a href="mailto:r.ni@ntu.edu.sg">r.ni@ntu.edu.sg</a></td>
</tr>
</tbody>
</table>

**Planned Weekly Schedule**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Course LO</th>
<th>Readings/ Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Course Overview and Concepts of Computational Thinking</td>
<td>1, 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Simple Mathematical Model, Programming and Software &amp; Approximation &amp; Round-Off Errors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Overview of</td>
<td>1, 3, 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>MATLAB</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-------------------------</td>
<td>-------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>3</td>
<td>Error Propagation</td>
<td></td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>4</td>
<td><strong>Computational</strong></td>
<td><strong>Algorithms:</strong></td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bracketing Methods &amp; Open</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Methods</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><strong>Decomposition &amp;</strong></td>
<td><strong>Algorithm</strong> Open</td>
<td>1, 3, 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Methods &amp; Quiz</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><strong>Decomposition &amp;</strong></td>
<td><strong>Algorithm</strong></td>
<td>1, 3, 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>Algorithm</strong></td>
<td>LU</td>
<td>1, 3, 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decomposition and Matrix</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inversion &amp; Review</td>
<td></td>
</tr>
<tr>
<td>8 &amp; 9</td>
<td><strong>Abstraction</strong></td>
<td>Optimization</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>10</td>
<td><strong>Pattern recognition</strong></td>
<td>Curve Fitting</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>11</td>
<td><strong>Algorithm</strong></td>
<td>Numerical Integration</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>12</td>
<td><strong>Algorithm</strong></td>
<td>Differential Equation</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>13</td>
<td>Review &amp; Quiz</td>
<td></td>
<td>1, 2, 3, 4</td>
</tr>
</tbody>
</table>
## Appendix 1: Assessment criteria for the assignment

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Unsatisfactory: 1</th>
<th>Borderline: 2</th>
<th>Satisfactory: 3</th>
<th>Very good: 4</th>
<th>Exemplary: 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpretation (LO 2 and 3)</td>
<td>Interpretation of the problem is not clear</td>
<td>Interpretation of the problem and explanation of the algorithm suggests minimal understanding of the basics</td>
<td>Interpretation of the problem and explanation of the algorithm suggests that there is basic understanding</td>
<td>Interpretation of the problem and explanation of the algorithm suggests that there is clear understanding of the numerical methods.</td>
<td>Interpretation of the problem and explanation of the algorithm suggests a very clear understanding of the numerical methods that is needed for the assignment and provide recommendations</td>
</tr>
<tr>
<td>MATLAB implementation (LO 1, 2, 3)</td>
<td>Not able to implement it in MATLAB</td>
<td>Able to do it without having much idea.</td>
<td>Able to understand and implement it in MATLAB</td>
<td>Able to implement it in MATLAB and able to interpret the results.</td>
<td>The MATLAB simulation meets all the requirements and presents the results in a very user friendly/useful way.</td>
</tr>
</tbody>
</table>
Current course title, course objective(s) and content(s)

BG2111 – Computational Methods in Biomedical Engineering (Core)
[Lectures: 39 hrs; Tutorials: 12 hrs; Pre-requisite: NIL; Academic Units: 4.0]

Objectives
Use of numerical methods to solve problems in science and engineering, with emphasis on biomedical engineering.

Student Learning Outcomes
After completing this course, the student will be able to apply the numerical approaches learnt in this course to problems in biomedical engineering.

Topics
1. Introduction To Matlab
2. Numerical Solution Of Nonlinear Equations
3. Numerical Solution Of Simultaneous Linear Algebraic Equations
4. Optimization
5. Curve Fitting
6. Numerical Differentiation And Integration
7. Numerical Solution Of Ordinary Differential Equations
8. Application To Statistical Analysis: Data Interpretation
9. Applications To Design Of Experiments

<table>
<thead>
<tr>
<th>Week</th>
<th>Topics</th>
<th>Lect hrs</th>
<th>Tutorial hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Simple Mathematical Model, Programming and Software &amp; Approximation &amp; Round-Off Errors</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Taylor Series</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Error Propagation</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Bracketing Methods &amp; Open Methods</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Open Methods and Quiz</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Gauss Elimination</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>LU Decomposition and Revision</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Optimization – 1 D unconstrained optimisation</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Optimization: Multi-dimensional Unconstrained Optimization</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>Curve Fitting (regression, interpolation)</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Numerical Integration</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>Numerical solution of Ordinary Differential Equation (ODE)</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>Summary and review problems, Quiz</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Total: 39 12

Course Assessment
Students will be assessed by:
(1) 40% CA
- 2 quizzes, each having 20% weightage
(2) 60% Final Written Examination (closed book)
References
BG2112 - Cardiovascular Engineering (Core)

[Lectures: 39 hours; Tutorials: 13 hours; Pre-requisites: BG1107; Academic Unit: 4.0]

Objectives

To learn and understand the fundamentals in fluid mechanics and be able to apply this knowledge to solve problems in cardiovascular engineering. To learn and study the anatomy of the human cardiovascular system, understand blood rheology and phenomenon in blood circulation, utilize basic steady and unsteady flow models to describe flow mechanics in the cardiovascular system, and learn basic concepts in heart valve dynamics.

Student Learning Outcomes

Students will be able to:

1. Understand basic properties of fluids, the conversation laws, and fundamental concepts in fluid dynamics
2. Apply fundamental flow equations and physical relations to solve simple flow problems in hydrostatics and pipe flow.
4. Understand fluid properties and behaviors in blood rheology, and be able to perform simple viscometry calculations to determine fluid properties.
5. Understand the Bernoulli equation and be able to apply this to solve flow problems in hemodynamics.
6. Understand concepts underlying steady and unsteady flow models and be able to apply them in different cardiovascular flow problems.
7. Understand basic heart valve mechanics and be able to perform simple hemodynamic assessment of prosthetic heart valves.

Course Assessment

Students will be assessed by:

(a) Final 2.5-hour written examination (60%)
(b) Tutorial assessment (40%) - (2 Quizzes; 20% each quiz)

References

Topics

1. Hydrostatics
2. Conservation Laws
3. Friction Flow In Pipes
4. Cardiovascular Physiology
5. Blood Rheology
6. Steady And Unsteady Flow Models
7. Heart Valve Hemodynamics
BG2131 – Biomaterials (Core)

[Lectures: 26 hours; Tutorials: 12 hours; Pre-requisites: BG1105; Academic Unit: 3]

Objectives

To know and understand basic properties of biomaterials and methods in which we can manipulate them. Students should also know the basic physiological consequences in relation to biomaterial implantation, and know methods for testing biomaterial compatibility.

Student Learning Outcomes

Students will understand how basic chemical properties and constituents of a biomaterial affect their physical, mechanical, and degradation properties, know various processing and surface modifications methods in order to manipulate properties of the material. They will understand the physiological consequences during implantation, know the biological events associated to them, and learn some basic methods for in vitro and in vivo testing.

Course Assessment

Students will be assessed on

(a) Tutorial assessment and quizzes (30%)

(b) Final examination (70%)

References


Topics

1. Introduction
2. Bio-Metals
3. Bio-Ceramics, Glasses And Composites
4. Bio- Polymers
5. Applications
6. Biocompatibility
7. In-Vitro Testing
8. In-Vivo Testing
9. Degradation Of Materials In Biological Environment
BG2141 – Mechanics of Materials (Core)

[Lectures: 26 hours; Tutorials: 13 hours; Pre-requisites: FE1011; Academic Unit: 3]

Objectives

To learn the fundamentals of statics and mechanics of materials. To understand the relation between applied load and deformation, and the relation between stress and strain under different loading conditions. To build problem solving skills for practical problems in mechanics of materials.

Student Learning Outcomes

Students will build up solid foundations in mechanics of materials for subsequent courses, and be able to solve practical problems in materials design.

Course Assessment

Students will be assessed on

(a) Continuous assessment (55%)

(b) Final examination (45%)

References


Topics

1. Introduction: Concept Of Stress
2. Stress And Strain
3. Axial Loading
4. Torsional Loading
5. Bending
6. Transformation Of Stress And Strain
7. Deflection Of Beams
8. Energy Methods
9. Columns
10. Shells
BG2142 – Biological Thermodynamics (Core)

[Lectures: 26 hours; Tutorials: 12 hours; Pre-requisites: BG1103; Academic Unit: 3]

Objectives

To learn the laws of thermodynamics, the ideal gas law and kinetic theory of gases. To learn basic relationships between enthalpy, entropy and the Gibbs Free energy, and their applications in chemical and biological systems. To learn the phase equilibria and behaviours of one- and two-component systems. To learn about reaction kinetics and mechanisms.

Student Learning Outcomes

Students will know and understand ideal gas behaviours and how to apply the gas law. They will know the laws of thermodynamics and understand basic thermodynamic relationships in a given system. They will learn about Gibbs Free energy and how to calculate change in entropy in both chemical and biological systems. They will learn and understand systems in phase equilibria and be able to calculate phase points. They will learn and understand basic reaction kinetics, mechanisms and complex reactions.

Course Assessment

Students will be assessed on

(a) Tutorial assessment (40%)

(b) Final examination (60%)

References


Topics

1. Energy Transformation
2. The Laws Of Thermodynamics
3. Gibbs Free Energy
4. Statistical Thermodynamics
5. Binding Equilibria
6. Reaction Kinetics
BG2801 – Bioengineering Laboratory 2A (Core)

[Lectures: 0 hours; Tutorials: 0 hours; Pre-requisites: Nil; Academic Unit: 1]

Objectives

This laboratory course aims to provide practical applications to reinforce theories and concepts taught in second year of bioengineering.

Student Learning Outcomes

After completing this course, the student will be able to apply the concepts learnt in bioengineering in a more practical setting.

Course Assessment

Students will be assessed on

(a) Continuous assessment (100%)

References

NIL
BG2802 – Bioengineering Laboratory 2B (Core)

[Lectures: 0 hours; Tutorials: 0 hours; Pre-requisites: Nil; Academic Unit: 1]

Objectives

This laboratory course aims to provide practical applications to reinforce theories and concepts taught in second year of bioengineering.

Student Learning Outcomes

After completing this course, the student will be able to apply the concepts learnt in bioengineering in a more practical setting.

Course Assessment

Students will be assessed on

(a) Continuous assessment (100%)

References

NIL
BG3102 – Control in Biosystems (Core)

[Lectures: 26 hrs; Tutorials: 13 hrs; Prerequisites: BG1106; Academic Unit: 3]

Objectives

The objective of this subject is to provide the students with the principles and understanding of modeling and control of physiological and biomedical systems and methods for the analysis and design of these systems with applications.

Student Learning Outcomes

Upon completion of this subject, it is expected that the students have understood basic principles of biomedical control systems and gained knowledge and ability in the analysis and design of biomedical control systems.

Course Assessment

Students will be assessed on

(a) Continuous assessment (30%)

(b) Final examination (70%)

References


Topics

1. Introduction To Biomedical Control Systems
2. Biomedical Control System Models
3. Static Analysis Of Biomedical Control Systems
4. Time Domain Analysis Of Biomedical Control Systems
5. Frequency Domain Analysis Of Biomedical Control Systems
6. Stability Analysis Of Biomedical Control Systems
7. Control Of Biomedical Systems
BG3103 – Signal Processing in Biosystems (Core)

[Lectures: 26 hours; Tutorials: 13 hours; Pre-requisites: NIL; Academic Unit: 3]

Objectives

To provide knowledge for the acquisition and extract a priori desired information from biosystem. To provide knowledge for interpreting the nature of a physical process from the bio-signal

Student Learning Outcomes

Understanding the characteristics of the signal in biosystems and use of signal processing techniques for improving the signal for further analysis.

Course Assessment

Students will be assessed on

(a) Continuous assessment (30%)

(b) Final examination (70%)

References


Topics

1. Nature Of Biomedical Signals
2. Correlation
3. Impulse Response
4. Frequency Response
5. Continuous-Time Signal Modeling
6. Discrete-Time Signal Modeling
7. Noise Removal And Signal Compensation
8. Stochastic Signals Modeling
BG3104 – Biomedical Imaging (Core)

[Lectures: 26 hours; Tutorials: 13 hours; Pre-requisites: NIL; Academic Unit: 3]

Objectives

To learn fundamentals of medical image processing techniques. To cover medical imaging techniques which include, X-ray imaging, Magnetic resonance imaging, Ultrasounds and ultrasonic imaging, Nuclear Imaging and Medical Radiology.

Student Learning Outcomes

Students will learn the fundamentals of medical image processing and medical imaging methods. From this course, the students will be able to gain a strong understanding of the techniques at which current clinical medical images are acquired.

Course Assessment

Students will be assessed on

(a) Assignment assessment (30%)
(b) Final examination (70%)

References


Topics

1. Fundamentals Of Image And Signal Processing
2. Medical Image Processing Techniques
3. X-Ray Imaging
4. Magnetic Resonance Imaging (Mri)
5. Ultrasound And Ultrasonic Imaging
6. Nuclear Imaging
7. Medical Radiology
BG3105 – Biomedical Instrumentation (Core)

[Lectures: 26 hours; Tutorials: 13 hours; Pre-requisites: Nil; Academic Unit: 3]

Objectives

To introduce various biomedical instruments being used in clinical setting. To understand working principles and related human physiology at level medical doctors do. To build strong connection between what we learned in electronics/control course and the medical application.

Student Learning Outcomes

Basics about measurements and instrumentation will be learnt. Students will learn firstly about anatomy and physiology of major organs such as heart, lung, and brain, at such a level they can comfortably discuss with medical doctors, before learning details about medical instruments. A 3D CAD software skill will be acquired, such that they can comfortably draw 3-dimensional parts and assembly in their mind, for instrument prototyping.

Course Assessment

Students will be assessed on

(a) Continuous assessment (30%)

(b) A final 2-hours written examination (70%).

References

5. Kalsi, Electronic Instrumentation, Tata McGraw-Hill.

Topics

1. Introduction To Instrumentation
2. CAD Software – Pro/Engineer
3. Pressure, Displacement, Flow, Temperature
4. Electrical Safety
5. Respiratory And Cardiovascular Instruments
6. Bioelectrodes
7. Amplifier And Low-Noise Recording
8. Biomedical Sensors
9. Biopotentials
BG3801 – Bioengineering Laboratory 3 (Core)

[Lectures: 0 hours; Tutorials: 0 hours; Pre-requisites: Nil; Academic Unit: 1]

Objectives

This laboratory course aims to provide practical applications to reinforce theories and concepts taught in third year of bioengineering.

Student Learning Outcomes

After completing this course, the student will be able to apply the concepts learnt in bioengineering in a more practical setting.

Course Assessment

Students will be assessed on

(a) Continuous assessment (100%)

References

NIL
**BG3821 - Hospital Attachment (Elective)**

[Practical: 13 wks; Pre requisite: Passed Year 3; Academic Units: 3] [Lectures: 0 hours; Tutorials: 0 hours; Pre-requisites: Nil; Academic Unit: 1]

**Objectives**

The purposes of the 13 weeks medical attachment (at hospitals) training are: to gain first hand knowledge of the day-to-day operation in the medical profession, to be aware and appreciate the medical problems faced by medical professionals and patients, to apply the acquired knowledge and skills in various practices in bioengineering, and to become knowledgeable in requirements of the medical industry.

**Student Learning Outcomes**

Upon successful completion of this attachment, students should:

a) Have a broad overview of the day-to-day operation of the medical profession.

b) Understand and appreciate the medical problems and challenges faced by the clinicians and patients at the hospitals.

c) Have a better understanding of how bioengineering can contribute to the medical practices.

**Course Assessment**

Students will be assessed on

(a) Continuous assessment (100%)

**References**

NIL
BG4101 – Biomedical Project Design and Management (Core)

[Lectures: 26 hours; Tutorials: 13 hours; Pre-requisites: BG3720, Year 4 standing; Academic Unit: 3]

Objectives

This is the capstone course which utilizes the fundamentals of bioengineering in the product design.

- To know how to manage a project.
- To understand the regulations and ethics for product design.
- To provide knowledge for the acquisition and extract a priori desired information from biosystem.
- To provide knowledge for interpreting the nature of a physical process from the bio-signal.

Student Learning Outcomes

Understanding the procedure for biomedical product design and relevant regulation. The knowledge for project management and ethics.

Course Assessment

Students will be assessed on

(a) Continuous assessment (50%)

(b) Final examination (50%)

References

1. Design of Biomedical Devices and Systems (Marcel Dekker) by King and Fries.Haile JM, Molecular dynamics simulation: Elementary Methods, John Wiley & Sons 1992

Topics

1. Needs finding – Strategic focus, problem identification and need statement
2. Needs screening – disease fundamentals, treatment options,
3. Needs filtering - market analysis and stakeholders analysis
4. Brainstorming and concept screening
5. Intellectual property
6. Regulatory in biomedical
7. Prototyping
8. Reimbursement
9. Research development strategy
10. implementation
11. Business proposal planning
COURSE CONTENT

Academic Year: 2018/2019
Semester: 1
Course Coordinator: Manojit Pramanik
Course Code: BG 4102
Course Title: Medical Device Design (Core Elective)
Pre-requisites: BG3105
No of AUs: 4
Contact Hours: 2 hours lecture, 50 hours of lab work
Proposal Date: 24/05/2018

Course Aims
This course aims to provide you with the opportunity to work in teams and integrate your knowledge in bioengineering and project management courses to design and produce a medical device.

Intended Learning Outcomes (ILO)
By the end of this course, you (as a group of students) would be able to:

1. Design and produce a prototype medical device
2. Write technical report on a product prototype
3. Manage a project within given time and financial constraints
4. Showcase your prototype through demonstrations and presentations
5. Work as an effective member of a team

Course Content
There will be no specific reading materials provided in the class. Suggested materials will be dependent on the project. The module is based on hands-on design work in the lab.

Assessment (includes both continuous and summative assessment)

<table>
<thead>
<tr>
<th>Component</th>
<th>Course LO Tested</th>
<th>Related Programme LO or Graduate Attributes</th>
<th>Weighting</th>
<th>Team/Individual</th>
<th>Assessment rubrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Mid-term demo</td>
<td>1,3,4,5</td>
<td>EAB SLOs a, c,</td>
<td>20%</td>
<td>Team</td>
<td>Refer to appendix 1</td>
</tr>
<tr>
<td>(b) Mid-term project progress report</td>
<td>2, 3, 5</td>
<td>EAB SLOs a, b,</td>
<td>10%</td>
<td>Team</td>
<td>Refer to appendix 2</td>
</tr>
<tr>
<td>(c) Final product demo</td>
<td>1,3,4,5</td>
<td>EAB SLOs a, c,</td>
<td>35%</td>
<td>Team</td>
<td>Refer to appendix 1</td>
</tr>
<tr>
<td>(d) Final project report</td>
<td>2,3,5</td>
<td>EAB SLOs a, b,</td>
<td>15%</td>
<td>Team</td>
<td>Refer to appendix 2</td>
</tr>
<tr>
<td>(c) peer-evaluation</td>
<td>5</td>
<td>EAB SLOs i,</td>
<td>20%</td>
<td>Individual</td>
<td>Refer to appendix 3</td>
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<tr>
<td>Total</td>
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<td>100%</td>
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</tbody>
</table>

http://www.ntu.edu.sg/tpd/tr/obt/4/Pages/41.aspx

Formative feedback
Every week in the lab sessions the students will get feedback on the progress in the project.
Mid-term demo: after mid-term demo the students will get feedback

Learning and Teaching approach
Approach | How does this approach support students in achieving the learning outcomes?
--- | ---
Lecture | There will only one lecture class (1/2 of the first class), where the rationale and the details of the project will be discussed. Various approaches to complete the design will be discussed. Since this will be done in groups, students can form groups, discuss with their friends etc. All the other resources that will be available to the student to complete the project will also be elaborated.
Lab sessions | The project will be carried out in the lab, where you will have access to various instruments (oscilloscope, power supply, function generator, 3D printer, multimeter, electronic components etc.). During these session we will have hands-on work on design and implementation of electrical circuits and signal processing. Every week during the lab session, students can discuss, debug their problems, brainstorm their idea on the implementation of special features in their product to the instruction of the module.

Reading and References

Course Policies and Student Responsibilities
General: This module requires you to engage in self-directed learning. You are expected to complete all online activities. You are expected to learn basic electronic circuit design, matlab/labview programming. You are expected to work in a group of 8-10 students. You need to plan and distribute the workload among all the members of the group. You are expected to take responsibility to follow up with other group members to complete task. You are expected to take necessary note and course related announcements. You are expected to participate in all discussions and activities.

Lab demo (mid-term and final): You are required to attend all the lab demos and submit reports.

Absenteeism: Lab demons consists of 55% of students’ course grade. Absence from lab demos without officially approved leave will result in no marks and affect students’ overall course grade.

Academic Integrity
Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU’s shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors
<table>
<thead>
<tr>
<th>Instructor</th>
<th>Office Location</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manojit Pramanik</td>
<td>N1.3-B2-11</td>
<td>6790 5835</td>
<td><a href="mailto:manojit@ntu.edu.sg">manojit@ntu.edu.sg</a></td>
</tr>
</tbody>
</table>

Planned Weekly Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Course LO</th>
<th>Readings/ Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week</td>
<td>Activity</td>
<td>Description</td>
<td>Details</td>
</tr>
<tr>
<td>------</td>
<td>-------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Course overview,</td>
<td>To understand what you need to do in the project, what are the deliverables,</td>
<td>In class discussion on the project.</td>
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<td></td>
<td>project details discussed</td>
<td>key requirements</td>
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<tr>
<td>2-6</td>
<td>Lab sessions</td>
<td>Debug any difficulties, discuss progress, consultation</td>
<td>Hands-on lab sessions, electrical circuit design, use of instruments, 3D printing</td>
</tr>
<tr>
<td>7</td>
<td>Mid-term demo</td>
<td>To demonstrate the project progress</td>
<td>Prepare domo setup, props, tools etc. Demo your progress. Q&amp;A sessions, evaluation of project report</td>
</tr>
<tr>
<td>8-12</td>
<td>Lab sessions</td>
<td>Debug any difficulties, discuss progress, consultation</td>
<td>Hands-on lab sessions, electrical circuit design, use of instruments, programming, 3D printing</td>
</tr>
<tr>
<td>13</td>
<td>Final Demo</td>
<td>To demonstrate the final product resulted from the project</td>
<td>Prepare domo setup, props, tools etc. Demo your product. Q&amp;A sessions, evaluation of project report</td>
</tr>
</tbody>
</table>
Appendix 1: Assessment Criteria for Group Project

You will use your creativity and your knowledge about hardware and software design for prototyping shape and function of a medical device.

There will be no reading materials provided in the class. There is no lectures session. The module is based on hands-on design work in the lab.

Grouping: Each project group consists of ~8-10 students.

Division of Work: Discuss with members on how the work should be divided. Declare each group members name and what part of the work they have done in the project reports. Your mark will be largely based on the quality of your own work and your group’s performance in the mid-term and final demo.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Unsatisfactory: &lt;40%</th>
<th>Borderline: 40% to 49%</th>
<th>Satisfactory: 50% to 74%</th>
<th>Very good: 75% to 85%</th>
<th>Exemplary: &gt;85%</th>
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<tbody>
<tr>
<td><strong>Knowledge &amp; Comprehension</strong></td>
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<td>Understanding of principles of</td>
<td>Lacks understanding</td>
<td>Partial understanding</td>
<td>Good understanding</td>
<td>Good and comprehensive</td>
<td>Very good and</td>
</tr>
<tr>
<td>biomedical signal processing</td>
<td>of biomedical signal</td>
<td>of biomedical signal</td>
<td>of biomedical signal</td>
<td>understanding of the</td>
<td>comprehensive</td>
</tr>
<tr>
<td>to design biomedical device</td>
<td>processing and how</td>
<td>processing and how</td>
<td>processing and how</td>
<td>principles of biomedical</td>
<td>understanding of</td>
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<td></td>
<td>to design medical</td>
<td>to design medical</td>
<td>to design medical</td>
<td>signal processing and</td>
<td>the principles</td>
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<td></td>
<td>device for heart rate</td>
<td>device for heart rate</td>
<td>device for heart rate</td>
<td>how to design medical</td>
<td>of biomedical</td>
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<td>monitoring.</td>
<td>monitoring.</td>
<td>monitoring.</td>
<td>device for heart rate</td>
<td>signal processing</td>
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<td>and how to design</td>
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<td>medical device</td>
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<td>for heart rate</td>
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<td>monitoring.</td>
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<td><strong>Application</strong></td>
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<tr>
<td>Applying signal processing</td>
<td>Not able to design</td>
<td>Partially able to design</td>
<td>Able to design</td>
<td>Good design of the</td>
<td>Excellent design</td>
</tr>
<tr>
<td>principles to solve problems</td>
<td>filters to remove</td>
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<td>noises from the</td>
<td>to remove noises</td>
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<td>signal and amplify</td>
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<td>and amplify them.</td>
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<td><strong>Evaluation</strong></td>
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<tr>
<td>Able to evaluate which</td>
<td>Not able to choose</td>
<td>Partially able to choose</td>
<td>Able to choose</td>
<td>Good choice of software</td>
<td>Excellent choice</td>
</tr>
<tr>
<td>software and hardware options</td>
<td>software and hardware</td>
<td>software and hardware</td>
<td>software and hardware</td>
<td>and hardware to design</td>
<td>of software and</td>
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<tr>
<td>will be most appropriate for</td>
<td>to design compact</td>
<td>to design compact heart</td>
<td>to design compact heart</td>
<td>compact heart rate</td>
<td>hardware to design</td>
</tr>
<tr>
<td>designing the medical device</td>
<td>heart rate monitoring</td>
<td>rate monitoring system.</td>
<td>rate monitoring system.</td>
<td>rate monitoring system.</td>
<td>compact heart rate</td>
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<td>monitoring system.</td>
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<tr>
<td><strong>Analysis</strong></td>
<td>Unable to make</td>
<td>Can make reasonable</td>
<td>Can make reasonable</td>
<td>Can make reasonable</td>
<td>Can make correct</td>
</tr>
<tr>
<td></td>
<td>reasonable</td>
<td></td>
<td></td>
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<td>assumptions, can</td>
</tr>
<tr>
<td>Able to analyze problems, make reasonable assumptions, and choose appropriate methods.</td>
<td>assumptions and judgment according to the nature of the problems, uncertain about drawing any conclusions.</td>
<td>assumptions and judgment, but the choice of methods are not appropriate, uncertain about the accuracy of the outcome.</td>
<td>assumptions and judgment, can choose appropriate methods and predict the outcome mostly, but not necessarily the best choice.</td>
<td>assumptions and judgment, can choose appropriate methods and predict the outcome, can draw reasonable conclusions.</td>
<td>choose appropriate methods to solve the problem and draw conclusions. Can identify potential problems and tailor the process accordingly.</td>
</tr>
</tbody>
</table>
## Appendix 2: Assessment Criteria for Group Project Report

<table>
<thead>
<tr>
<th>Criteria (Team)</th>
<th>Unsatisfactory (1)</th>
<th>Satisfactory (4)</th>
<th>Good (7)</th>
<th>Exemplary (10)</th>
<th>Score (1-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of written communication</td>
<td>No scientific language, with grammatical and spelling errors; poorly constructed sentences; incorrect use of referencing; report is not properly formatted</td>
<td>Some use of scientific language, with grammatical and spelling errors; correct use of referencing in most of the report; report is properly formatted</td>
<td>Use of scientific language, with few grammatical and no spelling errors; correct use of referencing throughout; properly constructed sentences, well organized chapters and properly formatted report</td>
<td>Use of stylish scientific language, with no grammatical or spelling errors; properly formatted report; correct use of referencing throughout; report is very well written and draws you to read more</td>
<td></td>
</tr>
<tr>
<td>Language and format (10%)</td>
<td>Errors in figure legends; no formatting is done; cannot tell the different contents apart</td>
<td>No errors; standard figure format; no efforts to improve the appearance of the figures</td>
<td>Free of any errors; clear efforts to make the figures more readable and attractive</td>
<td>Free of any errors; various designs (shapes and colors) are incorporated in the figures and tables</td>
<td></td>
</tr>
<tr>
<td>Figures and tables (10%)</td>
<td>The medical device design is not described; Choices of parameters and implementation details are missing</td>
<td>The medical device design is described but without much details; Choices of parameters and implementation details are provided minimally</td>
<td>The medical device design is described in details; Choices of parameters and implementation details are provided</td>
<td>The medical device design is described in extreme details; Choices of parameters and implementation details are provided meticulously</td>
<td></td>
</tr>
<tr>
<td>Design and implementation (30%)</td>
<td>No project objectives presented; no schedule on milestones for tasks provided</td>
<td>No project objectives presented; no schedule on milestones for tasks provided</td>
<td>No project objectives presented; no schedule on milestones for tasks provided</td>
<td>Project objectives clearly stated and explaining; concise and feasible schedule on milestones for tasks provided; project completed</td>
<td></td>
</tr>
<tr>
<td>Project Management (10%)</td>
<td>No project objectives presented; no schedule on milestones for tasks provided</td>
<td>No project objectives presented; no schedule on milestones for tasks provided</td>
<td>No project objectives presented; no schedule on milestones for tasks provided</td>
<td>Project objectives clearly stated and explained; concise and feasible schedule on milestones for tasks provided; project completed</td>
<td></td>
</tr>
<tr>
<td>Experimental results and Analysis</td>
<td>Quality and relevance of results (30%)</td>
<td>Results are poor;</td>
<td>Results are good;</td>
<td>Results are excellent;</td>
<td></td>
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<tr>
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</tr>
<tr>
<td>Analysis of the results (10%)</td>
<td>no analysis</td>
<td>analysis is poorly done</td>
<td>proper analysis was done</td>
<td>in depth analysis was done</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3: Assessment Criteria for Peer Evaluation

Please rate yourself and your teammates on each of the attributes listed in the form below on a scale from 1 to 5 (1: Strongly Disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly Agree). Your own score will be calculated as the “mean of the scores” from all group members.

Return the form at the final demonstration.

Group 1

<table>
<thead>
<tr>
<th>Name</th>
<th>Contributes to workload and carries his/her fair share (1-5)</th>
<th>Participates in discussions and contributes useful ideas (1-5)</th>
<th>Willingly accepts tasks and delivers on commitments (1-5)</th>
<th>Works well with others and helps others when needed (1-5)</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

Comments to any member or the whole group (if any):
BG4210 – Advanced Biomedical Instrumentation (Core Elective)

[Lectures: 39 hours; Tutorials: 0 hours; Pre-requisites: NIL Academic Unit: 3]

Objectives

To provide broad and comprehensive knowledge of medical instruments most commonly used in hospitals. To provide measurement methods in the biomedical field. To provide knowledge involved in principles, applications and design of the medical instruments.

Student Learning Outcomes

Broad and comprehensive knowledge of medical instruments most commonly used in hospitals.

Course Assessment

Students will be assessed on

(a) Continuous assessment (30%)

(b) Final examination (70%)

References


Topics

1. Introduction To Bioinstrumentation
2. Prototyping The Shape - 3D Modeling Using Pro/E
3. Instruments In ICU
4. Prototyping The Function – Labview
5. Human Nervous System And Brain Imaging (EEG, Fmri)
BG4213 – Bioelectronics (Core Elective)

[Lectures: 39 hours; Tutorials: 0 hours; Pre-requisites: NIL Academic Unit: 3]

Objectives

Bioelectronics is concerned with the study of the interface between biological and electronic systems. The objective of this subject is to provide the students with detailed knowledge of the methods and procedures used in the design, fabrication and application of bioelectronic devices.

Student Learning Outcomes

On completion of this subject of Bioelectronics, it is expected that the students have a clear understanding of bioelectrochemistry, the principles and configurations of basic biotransducers, biosensors and bioelectronic devices. Students should be able to appreciate the performance of enzyme biosensors, immunobiosensors, cell and tissue-based biosensors and make design and selection decisions in response to measurement problems amenable to the use of such biosensors and bioelectronic devices.

Course Assessment

Students will be assessed on

(a) Continuous assessment (30%)

(b) Final examination (70%)

References


Topics

1. Introduction
2. Bioelectrochemistry
3. Biophotonics
4. Biomolecular Electronics
5. Biosensors
BG4214 – Biomedical Optics (Core Elective)
[Lectures: 39 hours; Tutorials: 0 hours; Pre-requisites: NIL Academic Unit: 3]

Objectives
To provide understanding of the interactions between light and biological matter.

Student Learning Outcomes
After completing the course, the students should have the knowledge of biophotonics, various applications involving the integration of light, photonics and biology into biophotonics.

Course Assessment
Students will be assessed on:

a) Continuous assessment (40%) – 2 homework assignments, 20% each

  Homework assignment 1 - The students are given short questions on the topics covered during first part of the course.

  Homework assignment 2 - The students are given short questions on the topics covered during second part of the course.

a) Final examination (60%) – Closed book, 2 hrs

Course Outline:

<table>
<thead>
<tr>
<th>S/N</th>
<th>Topic</th>
<th>Lecture Hours</th>
<th>Tutorial Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction of Biophotonics</td>
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</tr>
<tr>
<td>2</td>
<td>Reflection and Refraction</td>
<td>3</td>
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</tr>
<tr>
<td>3</td>
<td>Frenel Equations and Surface Plasmonic Reflection</td>
<td>6</td>
<td>0</td>
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<tr>
<td>4</td>
<td>Polarization and Applications</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Interference and Applications</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Diffraction and Applications</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Optical CW sources</td>
<td>3</td>
<td>0</td>
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<tr>
<td>8</td>
<td>Optical Pulse Sources and applications</td>
<td>6</td>
<td>0</td>
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<tr>
<td>9</td>
<td>Optical fiber characteristics</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Endoscopy and other Biophonic applications</td>
<td>3</td>
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<td>Total:</td>
<td>39</td>
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</tbody>
</table>

References
BG4215 – Biomedical Nanotechnology (Core Elective)

[Lectures: 39 hours; Tutorials: 0 hours; Pre-requisites: NIL Academic Unit: 3]

Objectives

The aim of the course is to provide an overview of the nanoparticles and other nanosystems of interest in medicine (e.g. for imaging, diagnosis, analyses of biological samples, tracking cells, drug delivery, etc.).

Student Learning Outcomes

On completion of this course, students are expected to have a clear understanding of the various nanosystems of interest in medicine.

Course Assessment

Students will be assessed on

(a) Continuous assessment (20%)
(b) Final examination (80%)

References


Topics

1. Introduction To The Course, Organization Of Mini-Teams
2. Nanofabrication (Basics Of Microfabrication, Methods Of Nanofabrications: Soft Lithography And Printing Technologies)
3. Molecular Manufacturing And Bioconjugation
4. Nanomedicine; Facts & Myths About Nanoparticles
5. Nano-Particles; Properties, Characterization, Materials Used For Different Nano-Particle Types.
6. Functionalization Of Nanoparticles Including Carbon Nanotubes
7. Nanosystems For Imaging And Photodynamic Therapy. Qds (Quantum Dots As Optical Contrast Agents For Imaging)
8. Natural Biological Nano-Systems
9. Nano-Delivery Systems For Genes And Vaccines
10. Nano-Delivery Systems For Drugs
11. Biochips And Applications
12. Nanoanalytics (Surface Biology Analysis, AFM, SEM, Confocal Spectroscopy, Raman Spectroscopy, Nanoparticle Labels, And Bioconjugated Bionanoparticle For Bioanalysis)
13. Review And Discussion
BG4231 – Advanced Biomaterials (Core Elective)

[Lectures: 39 hrs; Prerequisites: Nil; Academic Unit: 3 AU]

Objectives

Introduction of various applications of materials and engineering techniques to solve basic and clinical problems. Neural engineering based on advanced materials and science will be discussed to achieve a better understanding on the neural system.

Student Learning Outcomes

Students will learn about the chemical synthesis and characterization of materials with advanced nanostructure and properties, understand various classes of advanced biomaterials used in medicine and dentistry and distinguish materials suitable for specific applications. Students should be able to critically read and review the literature in the field of biomaterials and have developed their abilities to digest, organize, and effectively present technical material to a group of their peers.

Course Assessment

Students will be assessed on

(a) Continuous assessment (40%)

(b) Final examination (60%)

References


Topics

1. Bioceramics: Structure And Properties
2. Processing
3. Applications
4. Polymers
5. Biodegradable Polymers
6. Natural Polymers
BG4234 – Stem Cell Fundamentals (Core Elective)
[Lectures: 39 hours; Tutorials: 0 hours; Pre-requisites: Nil; Academic Unit: 3.0]

Objectives
The course aims to teach students about fundamental knowledge and technology of stem cells. Stem cells related research, development, and application have become more and more popular and important in biomedical areas, no matter for basic research, industrial R&D, clinical practice, or academic education. This course is developed to deliver the fundamental knowledge about stem cell biology and the mainstream applications of stem cell technology. This course is designed for bioengineering students on undergraduate level, therefore it won’t go too much depth in stem cell biology, but emphasize on basic concepts and focus on the application of them - how to translate the biological sciences into practical technology.

Course Outline

<table>
<thead>
<tr>
<th>S/N</th>
<th>Topic</th>
<th>Lecture Hours</th>
<th>Tutorial Hours</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction to Stem Cells</td>
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<tr>
<td>2</td>
<td>Embryonic Stem Cells</td>
<td>12</td>
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<tr>
<td></td>
<td>Introduction to embryonic stem cells. Basic biology &amp; mechanisms of pluripotency. Embryo early development and embryo cell biology: embryonic stem cells, embryonic germ cells, embryonal carcinoma cells, embryoid body, and trophoblast stem cells.</td>
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<td>3</td>
<td>Fetal/Adult Stem Cells</td>
<td>15</td>
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<tr>
<td></td>
<td>Introduction to fetal/adult stem cells. Basic biology &amp; mechanisms of multipotency. Fetal/Adult development and fetal/adult cell biology. Ectodermal: neurogenesis, epidermal stem cells, and dental stem cells; Mesodermal: multipotent adult progenitor cells, hematopoietic stem cells, mesenchymal stem cells, hemangioblasts, and cardiac progenitor cells; Endodermal: liver stem cells, pancreatic stem cells, GI stem cells, and lung stem cells.</td>
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<td>4</td>
<td>Clinical Applications of Stem Cells</td>
<td>6</td>
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<td></td>
<td>Therapeutic stem cells for regenerative medicine: cardia</td>
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</table>

Total: 39

Student Learning Outcomes
Upon successful completion of the course, students will be able to grasp the fundamental concepts and applications of stem cells in the areas of biological sciences, biomedical research, and clinical practice.
Course Assessment
Students will be assessed on:

(1) CA (40%)
      i. Topics: Stem cells, Embryonic stem cells, Fetal/Adult stem cells,
         Clinical Application of stem cells
   b. Class Participation: 10% (involvement in class discussion and spontaneous
      Q&As)

(2) Final exams: 60% (closed book), 2 hours written examination.

References
2. R. Lanza, J. Gearhart, B. Hogan, et. al., Editors. Essentials of Stem Cell Biology, Elsevier
BG4237 – Gene Therapy Fundamentals (Core Elective)

[Lectures: 39 hours; Tutorials: 0 hours; Pre-requisites: Nil; Academic Unit: 3.0]

Objectives

The course aims to teach students about fundamental knowledge and technology of gene therapy and genetic therapeutics. Gene therapy related research and applications have become more and more popular and important in medical and biomedical areas. This course is developed to deliver the fundamental knowledge about gene therapeutics and the typical applications in clinical practice. This course is designed for bioengineering students on undergraduate level, therefore it won’t go too much depth in specific disciplines, but emphasize on basic concepts and focus on the application of them - how to translate the biological sciences into practical technology.

Student Learning Outcomes

Upon successful completion of the course, students will be able to grasp the fundamental concepts and applications of gene therapy in the areas of biomedical research and clinical practice.

Course Assessment

Students will be assessed on

(a) Continuous assessment (30%)

(b) Final examination (70%)

References


Topics

1. Introduction To Gene Therapy
2. Gene Delivery
3. Antisense Delivery And Therapeutics
4. Applications And Perspectives
BG4240 – Special Topics in Bioengineering (Core Elective)
[Lectures: 39 hours; Tutorials: 0 hours; Pre-requisites: NIL Academic Unit: 3]

Objectives
The course serves as an introduction to mixed microbial consortia, biofilms, and their biomedical and environmental applications, with the following broad objectives:

- Introduction to bacterial interactions in mixed microbial communities, in both planktonic and biofilms mode of growth.
- Understanding biomedical applications of biofilms and biofilm control
- Understanding electromicrobiology and how redox bioprocesses are applied in emerging environmental biotechnologies.
- Applications of environmental biotechnologies, e.g., detoxification and bioremediation.

Student Learning Outcomes
- Understanding of microstructure and activity of mixed microbial consortia
- Role of biofilms in modern biomedical applications.
- Up-to-date knowledge in detoxification and bioremediation technologies
- Understanding of industrial implementation of environmental biotechnologies.
- Principles of design of detoxification and bioremediation treatments
- Review of case study from industry and applied research

Course Assessment
Students will be assessed on:
Continuous assessment (40%):
- Mid-term test (Week 5) – 20% (essays and quantitative questions)
- End-of-term test (Week 10) – 20% (essays and quantitative questions)
Final exam (60%): 2-hour final exam comprises both short essays and quantitative questions, Restricted Open book, where students can bring in 1 Page (2-sided) A4 cheat sheet.

Course Outline

<table>
<thead>
<tr>
<th>S/N</th>
<th>Topic</th>
<th>Lecture hours</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Kinetics of Microbial Processes</td>
<td>4</td>
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<tr>
<td>2</td>
<td>Biofilms microstructure and charact</td>
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<td>3</td>
<td>Biofilm kinetics</td>
<td>4</td>
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<tr>
<td>4</td>
<td>Biofilm characterization methods</td>
<td>3</td>
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<tr>
<td>5</td>
<td>Biofilm control in biomedical appl</td>
<td>4</td>
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<tr>
<td>6</td>
<td>Detoxification of hazardous chemi</td>
<td>3</td>
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<tr>
<td>7</td>
<td>Bioremediation</td>
<td>3</td>
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<td></td>
<td>Bioprocess involving redox reactions</td>
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<td>9</td>
<td>Electromicrobiology</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>Full-scale application of detoxification and bioremediation</td>
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<tr>
<td>11</td>
<td>Microbial Electrotechnology for Biosynthesis and wastewater treatment</td>
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</tr>
<tr>
<td>Total:</td>
<td></td>
<td>39</td>
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</tbody>
</table>

**References**


BG4240 – Special Topics in Bioengineering (Core Elective)
[Lectures: 39 hours; Tutorials: 0 hours; Pre-requisites: NIL Academic Unit: 3]

Objectives
The course serves as an introduction to mixed microbial consortia, biofilms, and their biomedical and environmental applications, with the following broad objectives:

- Introduction to bacterial interactions in mixed microbial communities, in both planktonic and biofilms mode of growth.
- Understanding biomedical applications of biofilms and biofilm control
- Understanding electromicrobiology and how redox bioprocesses are applied in emerging environmental biotechnologies.
- Applications of environmental biotechnologies, e.g., detoxification and bioremediation.

Student Learning Outcomes
- Understanding of microstructure and activity of mixed microbial consortia
- Role of biofilms in modern biomedical applications.
- Up-to-date knowledge in detoxification and bioremediation technologies
- Understanding of industrial implementation of environmental biotechnologies.
- Principles of design of detoxification and bioremediation treatments
- Review of case study from industry and applied research

Course Assessment
Students will be assessed on:
Continuous assessment (40%):
- Mid-term test (Week 5) – 20% (essays and quantitative questions)
- End-of-term test (Week 10) – 20% (essays and quantitative questions)
Final exam (60%): 2-hour final exam comprises both short essays and quantitative questions, Restricted Open book, where students can bring in 1 Page (2-sided) A4 cheat sheet.

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<tr>
<th>S/N</th>
<th>Topic</th>
<th>Lecture hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kinetics of Microbial Processes</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Biofilms microstructure and characterization</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Biofilm kinetics</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Biofilm characterization methods</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Biofilm control in biomedical applications</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Detoxification of hazardous chemicals</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Bioremediation</td>
<td>3</td>
</tr>
</tbody>
</table>
8  Bioprocess involving redox reactions  3
9  Electromicrobiology  3
10  Full-scale application of detoxification and bioremediation  4
11  Microbial Electrotechnology for Biosynthesis and wastewater treatment  4
Total:  39

References
BG4308 – Therapeutic Engineering (Core Elective)

[Lectures: 39 hours; Tutorials: 0 hours; Pre-requisites: Nil; Academic Unit: 3]

Objectives


Student Learning Outcomes

Students will learn fundamentals of biological therapeutics and translations from biomedical engineering based therapeutic strategies to clinical practices.

Course Assessment

Students will be assessed on

(a) Continuous assessment (30%)
(b) Final examination (70%)

References


Topics

1. Basic Cell And Structural Biology
2. Basic Histology
3. Tissues And Organs
4. Cell Culture
5. Transport Phenomenon
6. Biomaterials
7. Tissue Engineering Scaffolds
8. Cell-Biomaterials Interactions
9. Tissue Engineering Case Studies
BG4309 Tissue Engineering and Gene Therapy

Aims and objectives

The course aims to teach students the fundamental knowledge and technology of tissue engineering and gene therapy.

Content

Tissue Engineering Part:

Definitions of Tissue Engineering, Engineered Tissue, Engineered Therapeutics and Regenerative Medicine; Therapeutic Cells Delivery and Settlement for Tissue Engineering; Tissue Engineering Scaffolding with Functional Biomaterials; Tissue Engineering Strategy with Developmental Biology; Engineered/Native Tissue Integration; and Model/Clinical Applications and Evaluations of Engineered Tissues.

Gene Therapy Part:

Definitions of Gene Therapy and Genetic Therapeutics; Related Criteria, Standards, R&D Regulations and Ethics; Gene Delivery: Viral and Non-Viral Vectors; Therapeutic and Regenerative Remedies by Transfer of Genes and Antisense; and Applications and Application Perspectives of Gene Therapy.

Course Outline

[Lectures: 39 hrs; Tutorials: 0 hrs; Prerequisites: General Biology; Academic Unit: 3]

<table>
<thead>
<tr>
<th>S/N</th>
<th>Topic</th>
<th>Lecture Hours</th>
<th>Tutorial Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td><strong>Introduction to Tissue Engineering</strong></td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>This lecture will cover the basic concepts and components of a tissue engineering system and general strategies applied to tissue engineering.</td>
<td></td>
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<tr>
<td>1-2</td>
<td><strong>Tissue Engineering Scaffolding</strong></td>
<td>6</td>
<td>0</td>
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<tr>
<td></td>
<td>This lecture will cover classic scaffolds and their characteristics: biocompatibility, biodegradation / bio-responses / bio-absorptions, bio-functionalities; and also typically with hydrogels as a scaffold material. Ionic, covalent, and physical crosslinking systems for hydrogel formation. Examples of synthetic and natural hydrogels in tissue engineering.</td>
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<tr>
<td>Time</td>
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<td>Credits</td>
<td>Notes</td>
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<tr>
<td>1-3</td>
<td>Tissue Engineering Strategy &amp; Developmental Biology</td>
<td>6</td>
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<tr>
<td></td>
<td>This lecture will cover the related developmental biology fundamentals based on which the corresponding tissue engineering strategy is made in pursuit of targeted <em>in situ</em> regeneration. This answers “how engineered tissue grows out”.</td>
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<tr>
<td>1-4</td>
<td>Engineered/Native Tissue Integration</td>
<td>3</td>
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<tr>
<td></td>
<td>This lecture will cover the related technology of post-operational settlement of engineered tissues integrating with surrounding native tissues, which includes two levels of integration: physical immobilization and developmental fuse. This answers “how engineered tissue grows into ‘real’ tissue”.</td>
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<tr>
<td>1-5</td>
<td>Applications and Perspectives of Tissue Engineering</td>
<td>3</td>
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<tr>
<td></td>
<td>This lecture will cover relevant successful trials, setbacks, challenges and prospects.</td>
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<tr>
<td>2-1</td>
<td>Introduction to Gene Therapy</td>
<td>3</td>
<td>0</td>
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<tr>
<td></td>
<td>This lecture will cover the fundamental concepts and definitions of gene therapy, including identification of a disease that is likely to respond to gene therapy, isolation a functional copy of the gene, incorporation of the gene into a carrier for gene delivery, and determination of whether the gene product is made.</td>
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<tr>
<td>2-2</td>
<td>Gene Delivery</td>
<td>6</td>
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<td></td>
<td>This lecture will cover the fundamental principles and strategies of gene delivery, including non-viral system using chemical methods (CaP, peptide, etc.) and physical methods (microinjection, particle bombardment, etc.), and emphasize on viral vectors (adenovirus, Herpes simplex virus, baculovirus, lentivirus, etc.)</td>
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<tr>
<td>2-3</td>
<td>Antisense Delivery and Therapeutics</td>
<td>6</td>
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<tr>
<td></td>
<td>This lecture will cover antisense strategies and related delivery systems, including ribozyme, antisense oligonucleotides, RNA interference (RNAi), etc.; and also specifically, antisense in regenerative medicine, including antisense in anti-apoptosis, antisense in regulating cell functionalities, and antisense in shaping optimal microenvironments.</td>
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<tr>
<td>2-4</td>
<td>Applications and Perspectives of Gene Therapy</td>
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<tr>
<td></td>
<td>This lecture will cover relevant successful trials, setbacks, challenges and prospects.</td>
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</tbody>
</table>
Learning Outcome

Upon successful completion of the course, students will be able to grasp the fundamental concepts and applications of tissue engineering and gene therapy.

Student Assessment

<table>
<thead>
<tr>
<th>Continuous Assessment (%)</th>
<th>40%</th>
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</thead>
<tbody>
<tr>
<td>Final examination (%)</td>
<td>60%</td>
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<tr>
<td>Open/Closed Exam</td>
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<tr>
<td>Duration of Exam Paper (hrs)</td>
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</table>

Textbooks/References


BG4313 – Global Medical Device Regulatory Overview

[Lectures: 25 hrs; E-Learning: 14hrs; Pre-requisite: NIL; Academic Units: 3.0]

Objectives
Knowledge of medical device regulatory affairs (MDRA) is critical for the development, commercialisation and distribution of safe and effective healthcare products. This course aims to provide students with an overview of medical device regulatory systems globally.

Student Learning Outcomes
After completing this course, the student will be able to
- Define and understand the term “Medical Devices” in a country-specific context
- Understand the general principles of regulatory frameworks
- Understand the role of risk mitigation in regulatory decisions
- Recognise role-specific differences in MDRA

Course Outline:

<table>
<thead>
<tr>
<th>Week</th>
<th>Content</th>
<th>Lecture hours</th>
<th>E-learning</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
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<tr>
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<td>Topic 1 – Course Objectives &amp; Administrative Details (ILT)</td>
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<td>Topic 2 – Why Study Regulatory Systems? (ILT)</td>
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<td>Topic 3 – The Need for Regulatory Systems (ILT)</td>
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<tr>
<td>2</td>
<td>Medical Device Fundamentals: The Science Behind Regulatory Decisions</td>
<td>2</td>
<td>1</td>
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<tr>
<td></td>
<td>Topic 1 – Introduce Medical Devices (Online)</td>
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<td>Topic 2 – Tackling regulatory issues in developing new devices (Online)</td>
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<td></td>
<td>Topic 3 – Addressing Blood Compatibility Issues (ILT)</td>
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<tr>
<td></td>
<td>Topic 4 – Why do you need to understand regulatory concerns as a device developer? (ILT)</td>
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<tr>
<td>3</td>
<td>Medical Device Fundamentals</td>
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<td></td>
<td>Topic 1 – What is a Medical Device? (Online)</td>
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<td>Topic 2 – Classification of Medical Devices (Online)</td>
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<td>Topic 3 – Quality Management Systems (ILT)</td>
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<td>Topic 4 – Regulation of Medical Devices (ILT)</td>
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<td>Overview of Singapore’s Medical Device Regulatory Framework</td>
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<td>Topic 3 – Principles of Regulation (Online)</td>
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<td>Topic 4 – Risks (ILT)</td>
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<td>Topic 5 – Overview of I (Online)</td>
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<td>Topic 6 – Regulatory Framework and Approach (ILT)</td>
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<td>Regulatory Requirements for Medical Device Registration</td>
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<td>Topic 1 – Introduction (ILT)</td>
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<td>ISO 10993: Bio-compatibility Testing</td>
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<td>Conclusion (Online)</td>
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<td>Debrief</td>
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Course Assessment:
Students will be assessed on:
CA (50%)
   a) Group position papers* (20%):
   b) Participation in online discussion (10%): students will be assessed on their participation in online discussions and showing of initiative in online activities.
   c) Group project and presentation on Regulatory Strategy (20%)
Exams (50%): open-book. 2 hours

* Group position papers elaboration:
As part of the course, students engage in a blended role-playing game to analyze and discuss emerging topics in the regulatory field of medical devices (changes every year). Students are assigned to adopt diverse persona, and undergo a conditioning period of shadowing / interviewing real-life professionals (doctors, regulatory agents, industry professionals). This is followed by the preparation of an essay to represent the position of their group on the topic discussed. Students then debate on their stands online, followed by revisions to their positions.

The “Group Position Paper (20%)” thus refers to the essay submitted. It is a team project, in which students are graded on (i) quality of presentation (ii) depth of discussion (iii) effort shown in this exercise.

References:
Handbook of Medical Device Regulatory Affairs in Asia Paperback by Jack Wong (Editor), Raymond Tong Kaiyu (Editor)