NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

COURSE CONTENT

Academic Year	2023/2024	**Semester**	1
Course Coordinator	Prof. Chen Peng / Dr. Pui Tze Sian		
Course Code	BG3105		
Course Title	Biomedical Instrumentation (Core)		
Pre-requisites	Nil		
No of AUs	3		
Contact Hours	26 hours lecture, 13 hours tutorial		
Proposal Date	Please indicate the day when this course outline was completed		

Course Aims

The course aims to support you in learning various principles, applications and designs of conventional as well as state-of-the-art medical instruments, devices, and techniques. Concepts of measurements, sensors, biopotentials, bioelectrodes, noises and interferences, flow, temperature, pressure, displacement etc. will be covered.

Intended Learning Outcomes (ILO)

By the end of this course, you (as a student) would be able to:

1. Describe biomedical instrumentation system and its components. Basics of measurements error/sensitivity. Basics of Biostatistics.
2. Use computer aided design (CAD) software tool to design a 3D design prototype of bioinstruments.
3. Explain different methods of displacement, flow, temperature measurements using resistive, capacitive, piezoelectric sensor. Explain thermocouple and thermistor for temperature measurement.
4. Explain the importance of electrical safety and how to protect yourself and others from electrical shock.
5. Measure lung volumes using a spirometer and analyse its function and working principle of a spirometer.
6. Describe the functions and operations of pulse oximetry, pacemaker, and defibrillator.
7. Describe biosensors, their components, types of biosensors and their biomedical applications, and explain the working principles of these biosensors.
8. Explain why biopotentials can be measured extracellularly. Describe the origin, recording, and applications of different types of biopotentials (ECG, EEG, EMG, ENG, ERG, and EOG).
9. Describe function, types, and applications of bioelectrodes. Explain and model the electrode-electrolyte interface.
10. Describe amplifiers and filters. Identify strategies to reduce noises and interferences in biopotential recording.

Course Content

Basic concepts of medical instrumentation. Sensors and principles. Temperature, flow, distance, pressure measurement. Electrical safety. Lung volume measurement. Biopotentials. Bioelectrodes for recording and stimulation. Amplifiers and low-noise recording.

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team /Individual	Assessment rubrics
1. Continuous Assessment 1 (project)	2	EAB SLOs e, i, j, l	30%	Team	Refer to appendix 1
2. Continuous Assessment 2 (project)	7,8,9,10	EAB SLOs a,b,c,d,e,f,g,h ,i,j	30%	Team	Refer to appendix 1
2. Final Examination (2hrs, Closed Book, exam paper not allowed to be removed from exam hall)	1-10	EAB SLOs a, b, c, d	40%	Individual	Refer to appendix 3
Total			100%		

Mapping of Course ILOs to EAB Graduate Attributes

Course Intended Learning Outcomes	Cat	EAB's 12 Graduate Attributes*											
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
	Core	●	◐	◐	◐	◐				◐	◐		š
1. Describe biomedical instrumentation system and its components. Basics of measurements error/sensitivity. Basics of Biostatistics.													a, j
2. Use computer aided design (CAD) software tool to design a 3D design prototype of bioinstruments.													e, i, j, l
3. Explain different methods of displacement, flow, temperature measurements using resistive, capacitive, piezoelectric sensor. Explain thermocouple and thermistor for temperature measurement.													a, b, c
4. Explain the importance of electrical safety and how to protect yourself and others from electrical shock.													a, b, c, d
5. Measure lung volumes using a spirometer and analyse its function and working principle of a spirometer.													a, b, c
6. Describe the functions and operations of pulse oximetry, pacemaker, and defibrillator.													a, b, c,
7. Describe biosensors, their components, types of biosensors and their biomedical applications, and explain the working principles of these biosensors.													a, b, c, d
8. Explain why biopotentials can be measured extracellularly. Describe the origin, recording, and applications of different types of biopotentials (ECG, EEG, EMG, ENG, ERG, and EOG).													a, b,c
9. Describe function, types, and applications of bioelectrodes. Explain and model the electrode-electrolyte interface.													a, b,c
10. Describe amplifiers and filters. Identify strategies to reduce noises and interferences in biopotential recording.													a, b,c

Legend:
- ● Fully consistent (contributes to more than 75% of Intended Learning Outcomes)
- ◐ Partially consistent (contributes to about 50% of Intended Learning Outcomes)
- š Weakly consistent (contributes to about 25% of Intended Learning Outcomes)
- Blank Not related to Student Learning Outcomes

Formative feedback

Examination results;
Regular meet with the students to discuss about their project and feedback will be provided.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lecture	Demonstrate how to carry out a procedure such as working through a problem, use incomplete handouts which enabling students participating in class.
Tutorial	In the tutorial session we will solve numerical problems and discuss about other problem statement relevant to the materials covered in the class during lectures

Reading and References

1. John G. Webster, Medical Instrumentation: Application and Design, 4rd ed., Wiley, 2010
2. Carr, Joseph J and Brown John M, Introduction to Biomedical Equipment Technology, 4th Edition, Prentice Hall 2001
3. John G. Webster, Bioinstrumentation, Wiley, 2004.

Course Policies and Student Responsibilities

General: You are expected to complete all online activities and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments and course related announcements. You are expected to participate in all tutorial discussions and activities.

Continuous assessments: You are required to attend all continuous assessments.
Absenteeism: Continuous assessments make up a significant portion of your course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect your 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

Instructor	Office Location	Phone	Email
Chen Peng	N1.3-B3-08	6514 1086	chenpeng@ntu.edu.sg
Alex Pui	N1.3 B2-12	6790 4485	tspui@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1, 2	Basic concepts of medical instrumentation	1	Face to face lecture
3	Biomedical Instruments design using Pro Engineering CAD software	2	Tutorial 1 Tutorial 2 Tutorial 3
4	Basic sensors and principles	3	Face to face lecture Tutorial 4
5	Electrical Safety	4	Face to face lecture Tutorial 5
6	Measurement of the respiratory system	5	Face to face lecture Tutorial 6
7	Heart – Pacemaker, Defibrillator, and oximeter	6	Face to face lecture Tutorial 7
8	Biosensors	7	Face to face lecture Tutorial 8
9	Biosensors & Assay-based project on biomedical sensor and device	7	Face to face lecture Tutorial 9
10	Biopotentials & Assay-based project on biomedical sensor and device	8	Face to face lecture Tutorial 10
11	Biopotentials, and Bioelectrode	8, 9	Face to face lecture Tutorial 11
12	Bioelectrodes	9	Face to face lecture Tutorial 12
13	Amplifiers & Low-noise recording	10	Face to face lecture Tutorial 13

Appendix 1: Assessment Criteria for CA

Group mark (30)

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Knowledge & Comprehension Understanding of a biomedical instrument and its function	• Lacks understanding of the principles of the instrument and its function.	• Partial understanding of the principles of the instrument and its function.	• Good understanding of the principles of the instrument and its function.	• Good and comprehensive understanding of the principles of the instrument and its function.	• Very good and comprehensive understanding of the principles of the instrument and its function.
Application Applying different design principles to model the instrument	• Unable to understand different design concept and implement them using CAD software tool.	• Can partially understand different design concept and implement them using CAD software tool.	• Can understand different design concept and implement them using CAD software tool.	• Can understand very well different design concept and implement them using CAD software tool.	• Can understand exceptionally well different design concept and implement them using CAD software tool.
Communication skill Written report and presenting the instrument	• Unable to communicate properly through written reports and present the designed instrument.	• Able to communicate through written reports and present the designed instrument.	• Able to communicate properly through written reports and present the designed instrument.	• Able to communicate properly through written reports and present the designed instrument. Include various views of the instrument, labelling, dimensions etc.	• Able to communicate properly through written reports and present the designed instrument. Include various views of the instrument, labelling, dimensions etc. Brochure design is professional and appealing to the buyer.

Assessment Criteria for Peer Evaluation:

If you are working as a group with other students for the homework submission, then, each student in the group is required to rate the contribution of other group members. All evaluations are held in confidence so no student will know how other group members rate his/her contribution. You are to evaluate other group members fairly and objectively, bearing in mind the implications for the other members' grades (explained below). It is absolutely essential for you to submit your peer evaluation form to get marks. To factor peer evaluations into the marks for your homework assignment, the following computation will be used:

- If, on average, a student receives a rating of 9 or more, that student receives 100% of the group's grade.
- If, on average, a student receives a rating of less than 9, that student receives a specific percentage of the group's grade to be determined by the formulae below:

An average rating of 8 to < 9 = 90% + (average rating obtained - 8)*10
An average rating of 7 to < 8 = 80% + (average rating obtained - 7)*10
An average rating of 6 to < 7 = 70% + (average rating obtained - 6)*10
An average rating of 5 to < 6 = 60% + (average rating obtained - 5)*10
An average rating of 4 to < 5 = 50% + (average rating obtained - 4)*10
An average rating of 3 to < 4 = 40% + (average rating obtained - 3)*10
An average rating of < 3 will be investigated by your instructor and the student may receive 0% of group grades.

Example 1:
Assume the overall group assignment is 30 marks, and out of 30 your group got 30 marks. A student with an average rating of 9.10 gets 100% of 30 marks, i.e., 30 marks. An average rating of 6.29 means that a student gets 72.9% (or 70%+(6.29-6)*10) of 30 marks, i.e., 21.87 marks.

Example 2:
Assume the overall group assignment is 30 marks, and out of 30 your group got 20 marks. A student with an average rating of 9.10 gets 100% of 20 marks, i.e., 20 marks. An average rating of 6.29 means that a student gets 72.9% (or 70%+(6.29-6)*10) of 20 marks, i.e., 14.58 marks.

Your instructor reserves the right to review the student ratings for questionable circumstances, which include, but are not limited to, acts of discrimination or malice.

Criteria	Yourself	Member 1	Member 2	Member 3	Member 4	Member 5
Contributed the fair share of work (Score: 0 to 10)						
TOTAL						
Comments, if any						

Appendix 2: Assessment Criterial for Final exam

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Knowledge & Comprehension Understanding of principles of biomedical instruments and sensors	• Lacks understanding of the principles of instruments and sensors.	• Partial understanding of the principles of instruments and sensors.	• Good understanding of the principles of instruments and sensors.	• Good and comprehensive understanding of the principles of instruments and sensors.	• Very good and comprehensive understanding of the principles of instruments and sensors.
Application Applying different principles to solve problems	• Unable to understand theoretical concepts of how instruments work and apply the knowledge to design and optimize biomedical instruments and sensors	• Can read and partially understand theoretical concepts of how instruments work and apply the knowledge to design and optimize biomedical instruments and sensors	• Can read and understand theoretical concepts of how instruments work and apply the knowledge to design and optimize biomedical instruments and sensors	• Can read and understand theoretical concepts of how instruments work and apply the knowledge to design and optimize biomedical instruments and sensors	• Can read and understand theoretical concepts of how instruments work and apply the knowledge to design and optimize biomedical instruments and sensors
Evaluation Able to solve numerical problems in designing instruments and sensors	• Calculations are attempted but are both unsuccessful and are not comprehensive.	• Calculations are attempted but represent only a portion of the calculations required with some comprehensive to solve the problem.	• Calculations attempted are mostly successful and sufficiently comprehensive to solve the problem.	• Calculations attempted are all successful and sufficiently comprehensive to solve the problem.	• Calculations attempted are all successful and fully comprehensive to solve the problem; calculations are also presented elegantly
Analysis Able to analyze problems, make reasonable assumptions, and choose appropriate methods.	• Unable to make reasonable assumptions and judgment according to the nature of the problems, uncertain about drawing any conclusions.	• Can make reasonable assumptions and judgment, but the choice of methods are not appropriate, uncertain about the accuracy of the outcome.	• Can make reasonable assumptions and judgment, can choose appropriate methods and predict the outcome mostly, but not necessarily the best choice.	• Can make reasonable assumptions and judgment, can choose appropriate methods and predict the outcome, can draw reasonable conclusions.	• Can make correct assumptions, can choose appropriate methods to solve the problem and draw conclusions. Can identify potential problems and tailor the process accordingly.

Appendix 3: The EAB (Engineering Accreditation Board) Accreditation SLOs (Student Learning Outcomes)

a) **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems
b) **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
d) **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
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.
i) **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
j) **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
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