Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

The sections shown on this interface are based on the templates UG OBTL+ or PG OBTL+
If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to Data Transformation Status for more information.

Expected Implementation in Academic Year	AY2024-2025
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Pui Tze Sian
Course Author Email	tspui@ntu.edu.sg
Course Title	Biomedical Instrumentation
Course Code	BG3105
Academic Units	3
Contact Hours	39
Research Experience Components	Research Defined Course (at least 50% of deliverables involve practical research activities: problem identification, hypothesis forming, data collection/analysis/interpretation, result communication)

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	
Pre-requisite to	BG4102
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

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

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Describe biomedical instrumentation system and its components. Basics of measurements error/sensitivity. Basics of Biostatistics.
ILO 2	Use computer aided design (CAD) software tool to design a 3D design prototype of bioinstruments.
ILO 3	Explain different methods of displacement, flow, temperature measurements using resistive, capacitive, piezoelectric sensor. Explain thermocouple and thermistor for temperature measurement.
ILO 4	Explain the importance of electrical safety and how to protect yourself and others from electrical shock.
ILO 5	Measure lung volumes using a spirometer and analyse its function and working principle of a spirometer.
ILO 6	Describe the functions and operations of pulse oximetry, pacemaker, and defibrillator.
ILO 7	Describe biosensors, their components, types of biosensors and their biomedical applications, and explain the working principles of these biosensors.
ILO 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).
ILO 9	Describe function, types, and applications of bioelectrodes. Explain and model the electrode-electrolyte interface.
ILO 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.

Reading and References (if applicable)

1. John G. Webster, Amit J., Medical Instrumentation: Application and Design, 5th Edition, Wiley (2020).
2. Randy H. Shih., Parametric Modeling with Creo Parametric 4.0, www.SDCpublications.com., https://static.sdcpublications.com/pdfsample/978-1-63057-105-4-1.pdf, (2022).
3. Shahriar I, Jonathan J., A review of bioelectrodes for clinical electrophysiologists, Heart Rhythm, doi: 10.1016/j.hrthm.2018.09.018. Epub 2018 Sep 25. PMID: 30261292, 16(3):460-469 (2019).
4. Nabajyoti K, Sudarshan G, Shelley D., Pranab G., Advances in Bioelectrode Design for Developing Electrochemical Biosensors, ACS Meas. Sci. Au,3,6, 404-433 (2023).
5. Lida K., Ladislau M., IIdiko P., Amplifiers in Biomedical Engineering: A review from Application Perspectives, Sensors, 23(4), 2277 (2023).

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Basic concepts of medical instrumentation	1	Reading list [1]-[2]	In-person	In-class problem solving
2	Basic concepts of medical instrumentation	1	Reading list [1]-[2]	In-person	In-class problem solving Tutorial 1, 2
3	Biomedical Instruments design using ProEngineering CAD software	2	Reading list [1]-[2]	In-person	In-class problem solving Tutorial 3
4	Basic sensors and principles	3	Reading list [1]-[2]	In-person	In-class problem solving Tutorial 4
5	Electrical safety	4	Reading list [1]-[2]	In-person	In-class problem solving Tutorial 5
6	Measurement of the respiratory system	5	Reading list [1]-[2]	In-person	In-class problem solving Tutorial 6
7	Heart-Pacemaker, Defibrillator, and oximeter	6	Reading list [1]-[2]	In-person	In-class problem solving Tutorial 7
8	Biosensors	7	Reading list [1],[3]	In-person	In-class problem solving Tutorial 8

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
9	Biosensors & Assay-based project on biomedical sensor and device	7	Reading list [1],[3]	In-person	In-class problem solving Tutorial 9
10	Biosensors & Assay-based project on biomedical sensor and device	8	Reading list [1],[3]	In-person	In-class problem solving Tutorial 10
11	Biopotentials, and Bioelectrode	8,9	Reading list [1],[3]	In-person	In-class problem solving Tutorial 11
12	Bioelectrodes	9	Reading list [1],[3]	In-person	In-class problem solving Tutorial 12
13	Amplifiers & low-noise recording	10	Reading list [1],[4]	In-person	In-class problem solving Tutorial 13

Learning and Teaching Approach

Approach	How does this approach support you 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

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Project(Continuous Assessment 1 (Project))	2	EAB SLOs a,b,c,e,i,j	30	Team	Analytic	Relational
2	Continuous Assessment (CA): Project(Continuous Assessment 2 (Project))	7,8,9,10	EAB SLOs a,b,c,d,e,f,g,h,i,j	30	Team	Analytic	Extended Abstract
3	Summative Assessment (EXAM): Final exam(Final Examination)	1-10	EAB SLOs a, b, c, d	40	Individual	Analytic	Relational

Description of Assessment Components (if applicable)

Formative Feedback

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

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Communication	Advanced
Creative Thinking	Intermediate
Curiosity	Advanced
Digital Fluency	Basic
Problem Solving	Intermediate

Course Policy

Policy (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. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

(1) General

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

Policy (Absenteeism)

(2) Absenteesim

Continuous assessments make up a significant portion of students' course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect students' overall course grade.

Policy (Others, if applicable)

Continuous assessments: Students are required to attend all continuous assessments

Last Updated Date: 27-03-2024 06:53:45

Last Updated By: Song Juha (Assoc Prof)

Appendix : Rubric/Assessment Criteria for Components listed in Assessment Table

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.

Mapping of Course ILOs to EAB Graduate Attributes

Course Code & Title	BG 3105 & Biomedical Instrumentation
Course Type	Core

Overview											
(a)	●	(b)	◐	(c)	◐	(d)	◐	(e)	◐	(f)	
(g)		(h)		(i)	◐	(j)	◐	(k)	O		

Legend:

●	Fully consistent (contributes to more than 75% of Student Learning Outcome)
◐	Partially consistent (contributes to about 50% of Student Learning Outcome)
O	Weakly consistent (contributes to about 25% of Student Learning Outcome)
Blank	Not related to Student Learning Outcome

Course ILOs		**EAB Graduate Attributes**
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, k
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,	a, b, c

	EEG, EMG, ENG, ERG, and EOG).	
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

EAB Graduate Attributes

a) **Engineering Knowledge**: Apply the knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialisation as specified in WK1 to WK4 respectively 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 with holistic considerations for sustainable development. (WK1 to WK4)

c) **Design / Development of Solutions**: Design creative solutions for complex engineering problems and design systems, components or processes that meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required. (WK5)

d) **Investigation**: Conduct investigations of complex problems using research-based knowledge (WK8) 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 problems, with an understanding of the limitations. (WK2 and WK6)

f) **The Engineer and the World**: When solving complex engineering problems, analyse and evaluate sustainable development impacts to: society, the economy, sustainability, health and safety, legal frameworks and the environment (WK1, WK5, and WK7).

g) **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (WK9).

h) **Individual and Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multidisciplinary, face-to-face, remote and distributed settings (WK9).

i) **Communication**: Communicate effectively and inclusively 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, taking into account cultural, language, and learning differences.

j) **Project Management and Finance**: Demonstrate knowledge and understanding of engineering 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.

k) **Life-long Learning**: Recognise the need for, and have the preparation and ability to (i) engage in independent and life-long learning, and (ii) adapt to new and emerging technologies, and (iii) think critically, in the broadest context of technological change (WK8).

No	Knowledge Profile
WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline
WK5	Knowledge including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts that supports engineering design and operations in a practice area
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues
WK9	Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc with mutual understanding and respect, and of inclusive attitudes

Reference: EAB Accreditation Manual