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	AY2021-2022
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	Control in Biosystems
Course Code	BG3102
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	BG1117/CB1117 & MH1810
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

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

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Describe the principles of control systems
ILO 2	Study the performance of the existing systems and/or improving designs
ILO 3	Apply control theory to design systems with desired behaviours
ILO 4	Analyse a given system in terms of key specifications from different perspectives, for example, in the time domain, by transfer function or state space representation.

Course Content

Laplace transform, mathematical modelling, time-domain analysis, state-space analysis, PID controller design and applications, pole placement method, frequency response analysis, bode plot, Nyquist plot and Nyquist stability criterion, stability analysis.

Reading and References (if applicable)

1. Khoo, Michael C.K., Physiological Control Systems - Analysis, Simulation, and Estimation, IEEE Press, 2000.
2. Ogata, Katsuhiko, Modern Control Engineering (5th Edition), Prentice Hall, 2009.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Introduction to control systems and Laplace transform	1			Face to face lecture
2	Mathematical modelling	1,2			Face to face lecture, Tutorial 1
3	Time domain analysis of control systems I	2, 3,			Face to face lecture, Tutorial 2
4	Time domain analysis of control systems II	3, 4			Face to face lecture, Tutorial 3
5	State space analysis of control systems II	2, 3			Face to face lecture, Tutorial 4
6	State space analysis of control systems II	3, 4			Face to face lecture, Tutorial 5
7	PID controller design and applications	4			Face to face lecture, Tutorial 6
8	Pole placement methods	3, 4			Face to face lecture, Tutorial 7
9	Identification of physiological control systems	1, 2			Face to face lecture, Tutorial 8
10	Frequency response analysis	2			Face to face lecture, Tutorial 9

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
11	Bode plot	2, 4			Face to face lecture, Tutorial 10
12	Nyquist and Nyquist stability criterion	3, 4			Face to face lecture, Tutorial 11
13	Stability analysis	3 , 4			Face to face lecture, Tutorial 12

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	TBL classroom discussion sessions on tutorial questions and related topics

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	Summative Assessment (EXAM): Final exam(Final Examination (2.5hrs, Closed Book, exam paper not allowed to be removed from exam hall))	1,2,3,4	EAB, SLO, a, b, c	60	Individual	Analytic	Relational
2	Continuous Assessment (CA): Test/Quiz(Continuous assessment 2 (quiz))	3, 4	EAB, SLO, a, b	20	Individual	Analytic	Relational
3	Continuous Assessment (CA): Test/Quiz(Continuous assessment 1 (quiz))	1, 2,4	EAB, SLO, a, b	20	Individual	Analytic	Relational

Description of Assessment Components (if applicable)

Formative Feedback

Examination results;
Marker's report on overall examination performance will be uploaded to NTUlearn;
Quiz answers will be discussed in class

NTU Graduate Attributes/Competency Mapping

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

Attributes/Competency	Level
Creative Thinking	Intermediate
Curiosity	Intermediate
Problem Solving	Basic
Transdisciplinarity	Basic

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)

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)

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.

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Last Updated By: Koh Yi Jing

Appendix 1: Assessment Criteria

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Comprehension The ability to studying the performance of the existing system and/or improving designs.	Unable to understand the components and functionality of the control system from any given description.	Some understanding of the components and functionality of the control system but no linkage among them.	Understands the components and functionality of the control system, and the linkage in terms of functionality.	Understands the components and functionality of the control system very well and most likely can predict the behavior of the system in given conditions.	A thorough understanding of the components and functionality of control system and can accurately predict behavioral changes in given conditions.
Application Applying control theory to design systems with desired behaviors	Unable to understand theoretical concepts of control systems and apply the knowledge to design and optimize control engineering system.	Can read and partially understand theoretical concepts of control systems but unable to apply the knowledge to design and optimize control engineering system	Can read and understand theoretical concepts of control systems and apply the knowledge to design and optimize simple control engineering system.	Can read and understand theoretical concepts of control systems and apply the knowledge to design and optimize medium level control engineering system	Can read and understand theoretical concepts of control systems and apply the knowledge to design and optimize complex level control engineering system.

Appendix 2: Assessment Criteria

Criteria	Unsatisfactory: 1	Borderline: 2	Satisfactory: 3	Very good: 4	Exemplary: 5
Knowledge Understanding of principles of control systems	• Lacks understanding of the principles of control systems. • Unable to apply the principles of control systems to solve engineering problems.	• Partial understanding of the principles of control systems. • Can apply the principles of control systems to solve simple engineering problems.	• Good understanding of the principles of control systems. • Can apply the principles of control systems to solve medium level engineering problems	• Good and comprehensive understanding of the principles of control systems. • Can apply the principles of control systems to solve complex engineering problems	• Very good and comprehensive understanding of the principles of control systems. • Can apply the principles of control systems to solve all engineering problems.
Comprehension The ability to studying the performance of the existing system and/or improving designs.	• Unable to understand the components and functionality of the control system from any given description.	• Some understanding of the components and functionality of the control system but no linkage among them.	• Understands the components and functionality of the control system, and the linkage in terms of functionality.	• Understands the components and functionality of the control system very well and most likely can predict the behavior of the system in given conditions.	• A thorough understanding of the components and functionality of control system and can accurately predict behavioral changes in given conditions.
Application Applying control theory to design systems with desired behaviors	• Unable to understand theoretical concepts of control systems and apply the knowledge to design and optimize control engineering system.	• Can read and partially understand theoretical concepts of control systems but unable to apply the knowledge to design and optimize control engineering system	• Can read and understand theoretical concepts of control systems and apply the knowledge to design and optimize simple control engineering system.	• Can read and understand theoretical concepts of control systems and apply the knowledge to design and optimize medium level control engineering system	• Can read and understand theoretical concepts of control systems and apply the knowledge to design and optimize complex level control engineering system.
Analysis The ability to analyze a given system in terms of key specifications from different perspectives, for example, in the time domain, by transfer function or state space representation.	• Unable to make reasonable assumptions according to the nature of the problems.	• Can make reasonable assumptions, but the choice of methods are not appropriate.	• Can analyze a simple system given in the form of diagram, transfer function or state space representation	• Can analyze a medium level system given in the form of diagram, transfer function or state space representation	• Can analyze a complex system given in the form of diagram, transfer function or state space representation

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

Mapping of Course ILOs to EAB Graduate Attributes

Course Code & Title	BG 3102 & Control in Biosystems
Course Type	Core

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

Legend:

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

Course ILOs		**EAB Graduate Attributes**
1)	Describe the principles of control systems	a
2)	Study the performance of the existing systems and/or improving designs	a, b, c
3)	Apply control theory to design systems with desired behaviours	a, b, c
4)	Analyse a given system in terms of key specifications from different perspectives, for example, in the time domain, by transfer function or state space representation.	a, b, c
5)		
6)		
7)		
8)		
9)		
10)		

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