NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

COURSE CONTENT

Academic Year	2024/2025	**Semester**	1
Course Coordinator	Asst. Prof. Yin Xunyuan / Dr Alex Pui		
Course Code	BG3102		
Course Title	Control in Biosystems (Core)		
Pre-requisites	BG1117/CB1117 & MH1810		
No of AUs	3		
Contact Hours	26 hours lecture, 13 hours tutorial		
Proposal Date	Oct. 11, 2019		

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.

Intended Learning Outcomes (ILO)

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

1. Describe the principles of control systems
2. Study the performance of the existing systems and/or improving designs
3. Apply control theory to design systems with desired behaviours
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.

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 (quiz)	1, 2,4	EAB, SLO, a, b	20%	Individual	Refer to appendix 1
2. Continuous assessment 2 (quiz)	3, 4	EAB, SLO, a, b	20%	Individual	Refer to appendix 1
2. Final Examination (2hrs, Closed Book, exam paper not allowed to be removed from exam hall)	1,2,3,4	EAB, SLO, a, b, c	60%	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	●	●	◐									
Describe the principles of control systems													a
Study the performance of the existing systems and/or improving designs													a, b, c
Apply control theory to design systems with desired behaviours													a, b, c
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

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

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	TBL classroom discussion sessions on tutorial questions and related topics

Reading and References

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.

Course Policies and Student Responsibilities

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.

Continuous assessments: Students are required to attend all continuous assessments.

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.

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
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Planned Weekly Schedule

Week	Topic	Course LO	Readings/ 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
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

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