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

Course Overview

Expected Implementation in Academic Year	AY2023-2024
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Liew Chi Hin Timothy
Course Author Email	timothyliew@ntu.edu.sg
Course Title	Biomechanics and Exercise Physiology
Course Code	PH3303
Academic Units	3
Contact Hours	42
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	BG2119 Anatomy & Physiology
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

This module introduces students to the physics of human and animal movement. The Lagrangian approach will be used to describe the macroscopic motion of humans in terms of bones connected by joints with applied torques and forces. A simple neural network model will then be employed to define an appropriate mechanism of control needed to achieve movements such as walking. Basic principles for the description of elastic solids and fluids will also be studied, where the fluid equations of motion will be used to describe the physics of flight and blood flow in arteries.

The Exercise Physiology component will focus on the theme of "where physics meet physiology" in health, physical performance and ageing. Students will be taught the key concepts and mechanisms that regulate physiological functions in health, performance and ageing. Special emphasis will be given the appreciation of the physical laws underlying physiological functions e.g., gas pressures, diffusion and transport in pulmonary physiology, the Frank-Starling mechanism in cardiac output, the Laplace law in blood flow and distribution, concept of physical work and calorimetry in metabolism, and force production in muscle contraction.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Body Mechanics: Derive from first principles the equations of motion of multiple bones connected by joints using the Lagrangian approach. Derive the double pendulum model for arm swing.
ILO 2	Describe a model of a standing (inverted pendulum) and walking human. Use a neural network model to determine appropriate control of forces, torques, and step length.
ILO 3	Mechanical Properties of fluids and materials: describe and derive the origin of the equations of motion describing fluids (Navier-Stokes equation) and Hookean solids (Navier's equation)
ILO 4	Physics of flight: Describe and derive from first principles the equations that explain the flow around a fixed wing and the lift force.
ILO 5	Blood Flow in arteries: Derive and explain the velocity profile of steady state flow in a tube and describe a model of pulsatile flow.
ILO 6	Describe and explain the fundamental concepts of physiological regulation and physical performance.
ILO 7	Describe and explain the physiological functions and regulations in health, performance, and ageing – where physics meet physiology – in the following systems: a) Cardiovascular system b) Pulmonary system c) Human metabolism d) Muscular system

Course Content

Topic	Details
Biomechanics of human skeleton	Lagrangian approach for description of connected bones from energy arguments. Double pendulum model of the arm and inverted pendulum model of standing. Model of human walking using step length control and feedback via a neural network.
Mechanical Properties of Biological Tissues	Equations of motion for fluids (Navier-Stokes equation) and elastic solids (Navier's equation). Lagrangian and Eulerian descriptions. Continuity equation and mass conservation. Stress tensor.
Liquid flow	Blood flow in arteries, including laminar flow of blood in a tube and pulsatile Flow. Air flow around a wing and physics of flight.
Fundamental concepts of physiological regulation and physical performance	Homeostasis, stress adaptation, physiological reserve, physiological and performance plasticity, compensation and supercompensation, Definition of fitness, physical activity and exercise, fitness and health, healthspan, Entropy from the perspective of human body design and movement.
Cardiovascular system	Theoretical foundation: Introduction and anatomy of the cardiovascular system; blood flow within the heart; definitions and functions of arteries, veins, and capillaries; blood circulation and distribution; cardiac functions (venous return, systole, diastole, ejection fraction, stroke volume, and cardiac output), Frank-Starling law, blood pressure regulation; vasoconstriction and vasodilation. Application: Acute and chronic adaptations to physical work, effects of ageing on the cardiovascular system and common age-related chronic disease in the cardiovascular system. Laboratory: Measurement of blood pressure (systolic, diastolic and pulse pressure), heart rate measurement, demonstration on measurement of pulse wave velocity and augmentation index.
Pulmonary system	Theoretical foundation: Introduction and anatomy of the pulmonary system; gas composition and partial pressure in the atmosphere (sea level and altitude); O2 transport in the body and the effects of hemoglobin concentration, blood pH and temperature on the O2 dissociation curve; gas partial pressure and diffusion, lung volume and capacities, Fick's law.

	Application: Acute and chronic adaptations to physical work, effects of ageing on the pulmonary system and common age-related chronic disease in the pulmonary system. Laboratory: Measurement of lung volumes and capacities (Spirometry)
Human metabolism	Theoretical foundation: Laws of thermodynamics, principle of work (W = L X D), chemical energy storage (ATP) and release, dietary energy and storage, metabolic pathway (creatine phosphate, glycolysis, Kreb cycle, electron transport chain). Calorimetry (direct and indirect), physiological basis of VO2max, Fick equation, measurement, interpretation and applications of VO2max in health, performance and disease. Anaerobic threshold: physiological basis, concepts, measurements and applications. Application: Acute adaptation during physical performance, chronic adaptation to physical training. Concept of metabolic disease and syndrome. Laboratory session: Demonstration of VO2max
Muscle physiology	Theoretical Foundation: Anatomy of the muscle and muscle cell; neural stimulation and muscle contraction; cross-bridge mechanism of muscle contraction; force production, muscle typing and classification; types of muscle contraction and performance; golgi tendon organ and control of maximum force production; muscle spindles and control of muscle length; soft tissue injury and repair. Application: Acute and chronic adaptations to physical work, effects of ageing on the muscle and sarcopenia Laboratory: Measurement of muscle functions – isometric strength, hand grip strength, endurance, motor skills, balance, walk-speed, muscular power

Reading and References (if applicable)

Lecture notes will be provided to students.

Planned Schedule

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
1	Lagrangian Approach	1			Lecture notes
2	Walking	2			Lecture notes
3	Feedback with a neural network	2			Lecture notes
4	Continuum Approach	3			Lecture notes
5	Flying	4		Presentations and Vivas.	Lecture Notes
6	Blood flow in arteries	5		Presentations and Vivas.	Lecture Notes
7	Fundamental concepts of physiological regulation and physical performance	6		Mid-term Test 1	Reference (5) and lecture notes
8	Cardiovascular system	7			Reference (5) and lecture notes
9	Pulmonary system	7			Reference (5) and lecture notes
10	Human metabolism	7			Reference (5) and lecture notes
11	Lab 1: Blood pressure, spirometry, VO2max	7			Reference (5) and lecture notes
12	Muscular system	7			Reference (5) and lecture notes
13	Overview and application in health and performance	7		Mid-term Test 2	Reference (5) and lecture notes

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures and discussions	Content and derivations, examples of problem solving and discussion of conceptual understanding. You will have the opportunity to engage in discussions during lectures to practise explaining, deriving, problem solving and applying the concepts covered in the lectures. Through this, you will also receive feedback on your conceptual understanding.
Tutorials	Review and discussion of key concepts from lectures with TAs, by working through problems. The TAs will monitor and provide timely feedback.
Lab Demonstration	Laboratory sessions will be conducted at Exercise Physiology Lab in LKCMedicine Novena campus
Assignments	Develop a computational model of a walking human. Students would be tasked with coding an algorithm for solving the system of coupled nonlinear differential equations describing a walking human and use a machine learning method based on an artificial neural network to handle the required feedback control. In this way students will become familiar with the mechanical equations of motion and understand how they can be used to describe and explain real biomechanical systems.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Report/Case study(Lab reports)	All		25		Individual	Analytic	Relational
2	Continuous Assessment (CA): Presentation(Presentation & Viva)	All		25		Individual	Analytic	Relational
3	Continuous Assessment (CA): Test/Quiz(Mid-term Test 1)	1-6		25		Individual	Analytic	Relational
4	Continuous Assessment (CA): Test/Quiz(Mid-term Test 2)	7		25		Individual	Analytic	Relational

Description of Assessment Components (if applicable)

Formative Feedback

You will receive formative feedback through discussion within tutorial lessons.

You will receive both written and/or oral feedback on your report and presentation.

Feedback is also given after each term test on the common mistakes and level of difficulty of the problems.

NTU Graduate Attributes/Competency Mapping

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

Attributes/Competency	Level
Adaptability	Basic
Creative Thinking	Intermediate
Digital Fluency	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)

Policy (Absenteeism)

Absence Due to Medical or Other Reasons

If you are sick and unable to attend your class (particularly the mid-terms), you must:

1. Send an email to the instructor regarding the absence.
2. Submit the original Medical Certificate* to administrator.

* The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

Policy (Others, if applicable)

Diversity and inclusion policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:

- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;
- If you feel like your performance in the class is being impacted by your experiences outside of class;
- If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;

Please speak to your teaching team, our school pastoral officer or a peer or senior (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.

The assessment of the lab component will be done through lab report, viva and presentation in the class.

Appendix 1: Assessment Rubrics for Lab Report (25%)

Criteria Description	**Assessment**				**Score**
	Poor (0)	**Adequate (1)**	**Good (2)**	**Excellent (3)**	
REPORT STRUCTURE & ORGANISATION Consider the layout of the report - a clear and concise abstract followed by logical sequences on the written chapters, and good finishing in conclusion and suggestion of prospective development in the topic surveyed.	Report is poorly organised	Report is adequately organised	Report is well organised	Report is excellently organised	Max 3
QUALITY OF REPORT CONTENT Consider the level of work presented in the report, particularly the quality of the technical content in the abstract and written chapters. Write-up is in good English with minimal grammatical errors and spellings.	Quality of work presented is poor	Quality of work presented is marginally acceptable	Good quality of work presented	Excellent quality of work presented	Max 3
INFORMATION GATHERING & LITERATURE REVIEW Consider the degree of preparation on the information gathering related to the work. Literature review with extensive use of relevant references.	Poor information gathering	Only minimal effort of information gathering is shown	Good effort of information gathering is shown	Excellent information gathering is presented	Max 3
RESULTS & DISCUSSIONS Consider if interpretation and discussion of results are put into context, main points picked for discussion, understanding of underlying assumptions and limitation while being rationale to various approaches.	Poor or no discussion	Only minimal discussion is presented	Good discussion and in-depth analysis in presented	Excellent discussion and new ideas are presented	Max 3
				Total	Max 12

Appendix 2: Assessment Rubrics for Presentation & Viva (25%)

Criteria Description	**Assessment**				**Score**
	Poor (0)	**Adequate (1)**	**Good (2)**	**Excellent (3)**	
FUNDAMENTAL UNDERSTANDING Consider the student's ability to explain the technical knowledge learnt, specifically from physics viewpoint. Also consider the coherence between the presentation and the contents of the report submitted.	Fails to demonstrate the relevant technical understanding.	Able to demonstrate the relevant technical understanding.	Demonstrate good understanding of the technical knowledge	Demonstrate excellent understanding and strong command of the technical knowledge	Max 3
PRESENTATION, ORGANISATION AND MATERIALS Consider the degree of preparation of the presentation materials – informative, and appropriateness on the topics discussed; consider the clarity and context of the slides.	Ideas were poorly presented and visuals were not helpful to audience.	Ideas were vaguely presented and visuals were marginally helpful to audience.	Ideas were presented clearly and visuals were helpful to audience.	Exceptional presentation skills with highly informative materials.	Max 3
CLARITY, LANGUAGE USE AND ACCURACY Consider the student's ability to give a clear and concise presentation – appropriate choice of words, understandable, minimal stoppage, proper pace and good timing.	Poor verbal and communication skills	Able to communicate ideas and relates to others.	Communicates and explains ideas clearly and concisely.	Communicates in a highly convincing and persuasive manner.	Max 3
QUESTIONS AND ANSWERS Consider the student's ability to explain his/her work in the Q&A session – able to provide unambiguous and logical answers confidently.	Unable to answer any questions asked.	Limited capability in answering questions	Able to answer most queries raised.	Confidently respond to all queries raised and able to provide new ideas	Max 3
				Total	Max 12