The Hong Kong Polytechnic University

Subject Description Form

Subject Code	ABCT1D18
Subject Title	Modern Day Material Sciences
Credit Value	3.0
Level	1
Pre-requisite/ Co-requisite/ Exclusion	NIL
Objectives	This course aims to introduce modern material sciences, with a particular focus on novel materials developed by experienced scientists. ABCT scientists will share their research journey, achievements, and commercialization strategies with students. Additionally, we will explore how chemists and biologists collaborate in the design of functional materials for modern applications.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. understand the scientific background, fundamentals and development of modern materials; b. identify the features and applications of different materials; c. understand the design and characterization of the materials based on their nature; investigate their working principles and mechanism of operation; d. demonstrate analytical and critical thinking for various types of modern materials and their impact to human; e. appreciate the technological aspect of modern materials; f. appreciate the importance of lifelong learning, teamwork, and communication skills.
Subject Synopsis/ Indicative Syllabus	Basic principles and fundamentals of modern materials and their applications will be covered. The design and characterization of the materials based on their nature will be discussed. The working principles, operation mechanism as well as impact to human life will be introduced in this course. In addition, we will invite ABCT scientists, who are working in modern materials to share their journey Details of Indicative Syllabus: **(a) Materials for biomedical application, labelling, and other possible usage for industry**

	1.) The design, working principle and nature of various imaging techniques, such as MRI, CT, and optical imaging, will be introduced. The mechanism of how imaging agents enhance the results by providing more information about biological systems. 2.) Nano-materials have been developed and can be used as non-erasable labels/barcodes for official/legal documents and manufacturing industries to prevent fraud and counterfeiting. They also prevent fading and ensure information remains intact. These materials can also be applied in the manufacturing industry. 3.) Nano size core-shell antimicrobial particles have been developed and can be used in medicine, food packaging, and water treatment to improve public health and safety. **(b) Materials for renewable energy** The principles of catalysis and how they are applied in renewable energy sources, including solar, biomass, and geothermal energy harvest. Different types of catalysts, such as photocatalysts, homogenous and heterogeneous electrocatalysts, and biocatalysts, as well as strategies for performance optimization will be discussed. The design and nature of the materials will be covered. We will also discuss the applications of catalysis in the production of energy carriers, starting at a basic level, and include sections on adsorption and surface science, catalytic kinetics, and studying key characteristics of emerging nanomaterials that are effective catalysts in renewable energy applications. **(c) Organic light-emitting devices (OLEDs)** The rapid developments of cutting-edge research on photofunctional organic semiconductor materials are greatly promoting the progress of science and technology in optoelectronic devices. As one of the most important applications of organic semiconductor materials, organic light-emitting devices (OLEDs) are promising candidates for solid-state lighting and full color displays in future owing to their appealing advantages (e.g., high luminance, high contrast, wide viewing angle, ultrathin, large-area, lightweight, flexibility, low-cost, and low-power consumption, etc.). In this topic, the basic science of advanced functional materials involved in OLEDs and the device working mechanisms will be covered in details. The design and nature of the materials will also be covered. **(d) Wearable materials** Many new developments in recent years include the use of flexible and stretchable materials that can be integrated into clothing and other wearable items. The materials include conductive polymers, nano carbon and other advanced materials that can be used to create high-performance batteries, supercapacitors and other energy storage devices. Other recent developments in wearable materials include the use of smart fabrics and textiles that can help to monitor various health

	parameters. The advancements in wearable materials have the potential to greatly improve the functionality, durability and comfort of wearable devices, opening up new possibilities for their use in various applications. The design and nature of the materials will also be covered. **(e) Soft Robotic** Movement is one of the vital features in living systems to allow various functions related to survival and reproduction. Some of the naturally existing protein motors, *e.g.*, myosin in muscle tissue, are employed to produce motility by amplification of collective molecular motions from nanoscale up to macroscopic dimensions. Advancements in manufacturing processes and materials science have enabled various state-of-the-art technological developments. For instance, conversional hard robotics, which are produced from rigid structural materials, enable energy conversion to mechanical motions for animal-like functions, *e.g.*, expansion, contraction, and stiffness change. Soft robotics are recently considered as the complementary counterpart to hard robotics. Although soft robotics remain their technological infancy, they could potentially create the next generations of biocompatible and safe actuating robotic systems, to provide a link between living systems and artificial systems at multiple levels. The design and nature of the potential materials will also be covered.
Teaching/Learning Methodology	**Lectures:** Science fundamentals of different types of modern materials will be introduced and discussed. The design and nature of the materials will also be covered. The development, technological principle, operation mechanism as well as impact to human will be examined. Examples will be used to demonstrate the scientific principles. **Tutorials:** Students are required to search for information and discussion is encouraged for selected topics and their project work. In-class tutorial questions will be used to draw students' interest, understanding and discussion. Group poster/oral presentation or project preparation may be arranged. Finally, logical thinking will be developed using the tutorial questions. **Group activities**: (1) students are required to work in groups for learning activities in-class or out-of-class; (2) students will be required to prepare a mini project and deliver an oral/poster presentation on selected topics. Through presentation, their higher order thinking, such as problem analysis and solving skills, critical and creative thinking, can be evaluated. Their group effort such as preparation of group presentation and discussion, their critical and creative thinking mind can be solicited and consolidated. During the project preparation, students will have chance to apply their lifelong learning skills, analytical skills as well as critical thinking for problem identification, data collection, analysis and interpretation as well as drawing conclusion and recommendation for further action. In this subject, students are required to do extensive reading (on literatures, reference books and government reports/websites and internet) and analyze information for possible

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<tr><td></td><td>action formulation via self-study and group discussion. Students will also be required to write an individual report on their findings for learning consolidation, idea elaboration as well as developing scientific thinking for their future study.</td></tr>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>
<table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="6">Intended subject learning outcomes to be assessed (Please tick as appropriate)</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td><td>f</td></tr>
<tr><td>1.Test and Assignment</td><td>30%</td><td>✓</td><td>✓</td><td></td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>2.In-clas/out-of-class Tutorials</td><td>20%</td><td></td><td>✓</td><td>✓</td><td></td><td>✓</td><td>✓</td></tr>
<tr><td>3.Group activities</td><td>50%</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Total</td><td>100 %</td><td colspan="6"></td></tr>
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Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:
Test and Assignment:
Assess the students' understanding of the basic scientific aspects related to modern day materials. The students' higher order thinking, such as analytical and problem-solving skills, critical thinking and creative thinking, will be evaluated. [Outcomes 1, 2, 3 and 5]

Tutorials:
Student assessments and group effort during tutorial classes, such as discussion topics, mind-map construction after information consolidation, will be assessed and graded. The students' higher order thinking, such as the analytical mind, data collection as well as report writing skill will be assessed and evaluated. Students will develop their teamwork skill during practical classes. [Outcomes 1- 6]

Group learning activities, project work and presentation:
Students will be assessed based on their individual performance in group learning activities, presentation skills and prepared content, as well as response to questions raised by subject lecturer(s), peers. The team spirit and individual contribution to the presentation will also be evaluated. [Outcomes 1-6]
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<tr><td>Student Study Effort Expected</td><td>
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<tr><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lecture</td><td>24Hrs.</td></tr>
<tr><td>▪ Tutorial</td><td>12Hrs.</td></tr>
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	Other student study effort:	
	▪ Preparation of presentation; preparation of project reports	40 Hrs.
	▪ Self study (reading on literatures, reference books, textbooks and reports)	50 Hrs.
	Total student study effort	126 Hrs.

Reading List and References

1. Lecture notes and supplementary materials (for some special topics) will be given.

2. Biomaterials for Tissue Engineering Applications: A review of the fast and future trends by Jason A. Burdick, Robert L. Mauck (2011)

3. Magdalena Aflori (2021). Smart nanomaterials for biomedical applications – a review. Nanomaterials, 11(2), 396.

4. A volume "Wearable bioelectronics" (2020) by Parlak, Alberto Salleo and Anthony Turner in Materials Today. Elsevier Ltd.

5. Colourful 3D anti-counterfeiting label using nanoscale additive manufacturing (2023) by S. Peng, S. Sun, Y. Zhu, J. Qiu and H. Yang, Virtual and Physical Prototyping. 18 (1) e2179929-2179938.

6. Soft robotics: Technologies and systems pushing the boundaries of robot abilities (2016) by C. Laschi, B. Mazzolai and M. Cianchetti. 1(1) 1-10.

Additional Reading List:

1. Machine Learning in Materials Science; American Chemical Society, 2022. DOI: 10.1021/acsinfocus.7e5033.

2. Phosphorescent Materials; American Chemical Society, 2023. DOI: 10.1021/acsinfocus.7e7004.

3. Carbon-Free Fuels; American Chemical Society, 2023. DOI: 10.1021/acsinfocus.7e7013.

4. Advanced Materials for Biomedical Applications; Edited By Ashwani Kumar, Yatika Gori, Avinash Kumar, Chandan Swaroop Meena, Nitesh Dutt, Copyright 2023, SBN 9781032356068, 292 Pages, Published December 13, 2022 by CRC Press, https://www.routledge.com/Advanced-Materials-for-Biomedical-Applications/Kumar-Gori-Kumar-Meena-Dutt/p/book/9781032356068.

5. National Academies of Sciences, Engineering, and Medicine. 2017. Sustainable Materials and Manufacturing for Renewable Energy Technology Development to 2030: Proceedings of a Workshop–in Brief. Washington, DC: The National Academies Press. https://doi.org/10.17226/24876.

	6. Organic Light-Emitting Materials and Devices; Edited By Zhigang Rick Li, 2nd Edition, Copyright 2015, ISBN 9781138749696, 816 Pages, Published July 27, 2017 by CRC Press, https://www.routledge.com/Organic-Light-Emitting-Materials-and-Devices/Li/p/book/9781138749696. 7. Flexible and Wearable Sensors Materials, Technologies, and Challenges; Edited By Ram K. Gupta, 1st Edition, Copyright 2023, ISBN 9781032288178, 380 Pages, Published March 21, 2023 by CRC Press, https://www.routledge.com/Flexible-and-Wearable-Sensors-Materials-Technologies-and-Challenges/Gupta/p/book/9781032288178. 8. The Science of Soft Robots; Edited By Koichi Suzumori, Kenjiro Fukuda, Ryuma Niiyama, Kohei Nakajima, eBook ISBN 978-981-19-5174-9, Published: 12 September 2023 by Springer Singapore, https://doi.org/10.1007/978-981-19-5174-9.