Nanyang Technological University
Division of Physics and Applied Physics

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| **Academic Year** | 1718 | **Semester** | 2 |
| **Course Coordinator** | Assoc Prof Lew Wen Siang / Dr Leek Meng Lee | | |
| **Course Code** | PH4418 | | |
| **Course Title** | Physics in the Industry | | |
| **Pre-requisites** | PH3101 - Quantum Mechanics II<br>PH3102 – Condensed Matter I | | |
| **No of AUs** | 4 | | |
| **Contact Hours** | 52 hours | | |
| **Proposal Date** | 20/8/2017 | | |

**Course Aims**

This course aims to introduce you to a broad range of physics-related industries. On completion of the course, you will appreciate how physics is being applied to a wide range of industries and can make a more informed decision on the industries that better suit your career interests.

**Intended Learning Outcomes (ILO)**

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

1. Describe key physics principles used in specific industries.
2. Conduct an investigation into how physics is applied to a chosen industry.
3. Present the findings from the investigation in the form of a report and a presentation.

Examples of industries include the Electronics industry, the Optics industry, the Food, Pharmaceutical & Oil industry, the Biomedical industry and the Financial industry. These are subjected to changes.

**Course Content**

Topics include

- *Industry 1*: Physics in the Electronics Industry
- *Industry 2*: Physics in the Optics Industry
- *Industry 3*: Soft Condensed Matter Physics in the Industry
- *Industry 4*: Physics in the Biomedical Industry
- *Industry 5*: Physics Modelling in the Financial Industry

**Course Outline**

| S/N | Topic | Lecture Hours | Tutorial Hours |
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| 1 | **Physics in the Semiconductor Industry:**<br>This topic has two main sections:<br>1. Semiconductor integrated circuits devices<br>2. Semiconductor processing technology | 8 | 0 |

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| | **<u>Semiconductor integrated circuits devices</u>**<br>• CMOS transistor<br>• Memory devices – SRAM, DRAM, Non-volatile memory devices<br>• Scaling of integrated circuit<br><br>**<u>Semiconductor processing technology</u>**<br>• Growth of silicon wafer<br>• Physical vapour deposition – sputtering growth<br>• Chemical vapour deposition<br>• Lithography – immersion scanner<br>• Pattern transfer – etching<br>• Doping<br>• Metallisation<br>• Packaging | | |
| 2 | **Physics in the Photonics industry:**<br>Working using light spectral property:<br>• Light spectrum and related concepts<br>• Spectrometers and its applications<br>• Hyperspectral Imaging and its applications<br>• New emerging spectral related industries<br><br>Working using light coherence property:<br>• Light coherence and related concepts<br>• Different classes of lasers<br>• Diode pumped solid state lasers and its applications<br>• Nonlinear optical devices and its applications | 8 | 0 |
| 3 | **Physics in the Food, Pharmaceutical & Oil Industry:**<br><br>An overview of soft condensed matter physic will be covered to familiarize students to broad aspects of various industries. Physical systems easily deformable by thermal or mechanical stresses of order of magnitude similar to thermal fluctuations. Attention will | 8 | 0 |

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| | be focused on industrial applications rather than academic theoretical research.<br>Topics covered will include<br>• Forces & Energy, Intermolecular forces<br>• Colloids as model systems for soft matter<br>  ○ Colloidal interactions<br>  ○ Phase diagrams<br>  ○ Packing<br>  ○ Self assembly<br>• Complex fluids<br>  ○ Force, pressure & stress<br>  ○ Newtonian & non-Newtonian liquids<br>  ○ Reynolds number<br>  ○ Navier- Stokes<br>• Structure of soft materials<br>  ○ Equilibrium & non-equilibrium<br>  ○ Linear rheology<br>  ○ Flexible polymer<br>  ○ Viscoelasticities | | |
| 4 | **Physics in the Biomedical Industry:**<br>**1) Speech, Acoustics and Audiology**<br>Overview of voice generation, vocal tract, acoustic modelling of voice and acoustic transmission. Acoustic transmission includes pinna, outer, middle & inner ear acoustics. Further on, the basics of mechanical to electrical nerve stimulation and acoustic path up to the auditory cortex will be introduced. Human speech recognition, e.g. represented by Speech Intelligibility Index (SII), is highly linked to audiology and acoustic perception. Introduction of basic acoustic physics like pressure wave, wave equation, acoustic impedance, sound pressure levels<br>**2) Physics of Middle & Inner Ear**<br>Definition of Hearing Threshold, Measurement of Hearing Threshold. Frequency shaping of acoustic path, middle ear impedance matching, inner ear mechanics and nerve stimulation, optoacoustic emissions – modeling concepts and measurement | 8 | 0 |

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| | Introduction to basics of time series analysis, data measurement, filtering, FFT & Spectrogram and applications<br>**3) Hearing Aids**<br>Basics of hearing aid technology, requirements, technical concepts, advanced signal processing, directional microphones. Manufacturing requirements and challenges.<br>Introduction to basic signal processing techniques, algorithms and tools.<br>**4) Measurement Methods and Hearing Aids**<br>Introduction of various measurement techniques for transducers, noise and spatial hearing. Impact of hearing aids on noise, noise perception and spatial hearing.<br>Overview hearing aid industry: Manufacturer, Suppliers, Clinics and Audiologists. | | |
| 5 | **Physics in the Financial Industry:**<br><br>1. Random walk and Brownian motion<br>a. What is a random walk? Simulating a random walk<br>b. The diffusion equation<br>c. Theoretical return distribution<br>d. Empirical return distribution<br>e. Levy flight and its simulation<br>2. Black-Scholes equation<br>a. Stochastic differential equation of stock price<br>b. Risk-neutral valuation and derivation of Black-Scholes equation<br>c. Black-Scholes equation and the diffusion equation<br>d. Green function of Black-Scholes equation<br>e. Interpretation of Green-function solution<br>3. Pricing exotic derivatives<br>a. Barrier options = option to exercise when barrier exceeded<br>b. First passage problem in random walk – theoretical results<br>c. Simulating first passage | 8 | 0 |

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| | d. Using Monte Carlo simulations to price barrier options<br>4. Order-Book Models<br>a. The Dealer model<br>b. Reserve prices and mid-price<br>c. Random walk<br>d. Price trending<br>e. Volatility clustering<br>f. Simulation<br>5. Balance-Sheet Models<br>a. Interbank and credit network models<br>b. Equity, assets, and liabilities<br>c. Random shocks<br>d. Bassel Accords<br>e. DebtRank measure of systemic risk | | |

**Assessment (includes both continuous and summative assessment)**

| Component | Course LO Tested | Related Programme LO or Graduate Attributes | Weighting | Team/Individual | Assessment Rubrics |
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| 1. Periodical Tests | LO 1 | Competence | 60% | Individual | No assessment rubric for this component. These are 45 mins closed book tests with formula sheet allowed. Structured questions |
| 2. Continuous Assessment (CA): Report | LO 2-3 | Communication & creativity | 40% | Individual | Please see appendix 1 for assessment rubric. Report |

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| & Presentation | | | | | (20%) and presentation (20%) on the 13th week. |
| Total | | | 100% | | |

**Formative feedback**

The periodical tests allow students to test their competency in their knowledge and understanding at suitably-spaced intervals during the semester. These questions will feedback to the students about their competency and the students' answers will feedback to the instructors about their understanding of lectures.

The CA which involves the student reading deeper into certain applications and industries will allow the student to explore his/her interest more deeply and ascertain if his/her interest is indeed in the said industry.

**Learning and Teaching approach**

| **Approach** | **How does this approach support students in achieving the learning outcomes?** |
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| Lectures | The lectures will help communicate the applications as stated in the learning outcomes. |
| Midterms | Midterm tests will reinforce what is taught in the lectures by testing the students on what they have learnt in the lectures. |
| Presentation | Students can choose a topic they have interest in and learn deeper about it and then demonstrate the knowledge acquired by writing up a report and giving a presentation. |

**Reading and References**

1. Semiconductor Manufacturing Technology by Michael Quirk and Julian Serda (2000) ISBN-13: 978-0130815200
2. Optoelectronics & Photonics: Principles & Practices (2nd Edition) by Safa O. Kasap (2012) ISBN-13: 978-0132151498
3. Soft Condensed Matter (Oxford Master Series in Condensed Matter Physics, Vol. 6 by Richard A. L. Jones (2002) ISBN-13: 978-0198505891
4. Audiology: Science to Practice, Second Edition by Steven Kramer (2013) ISBN-13: 978-1597565233
5. Econophysics and Physical Economics by Peter Richmond and Jurgen Mimkes (2013) ISBN-13: 978-0199674701

**Course Policies and Student Responsibilities**

**(1) General**

Students are expected to complete all assigned pre-class and post-class readings, attend all classes punctually 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 for classes they have missed. Students are expected to participate in all class discussions and activities.

**(2) Compulsory Assignments**

Students are required to submit compulsory assignments on their specified due dates. Late assignments will field a deduction of 10% per day without exceptions. Assignments are meant to be a reflection of individual work, and plagiarism is taken very seriously. In the event of detection, plagiarized assignments will be given a mark of zero.

**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.

**Appendix 1: Assessment Criteria for Continuous Assessment**

By mark range

| **Marks** | **Criteria** |
|---|---|
| > 90% | Demonstrates understanding and very deep skills in carrying out experimental work and has the ability to carry out detailed data analysis of the experimental results. |
| 75% to 89% | Demonstrates understanding and deep skills in carrying out experimental work and has the ability to carry out most of the data analysis of the experimental results. |
| 65% to 74% | Demonstrates some understanding and reasonable skills in carrying out experimental work and has the ability to carry out some data analysis of the experimental results. |
| 50% to 64% | Demonstrates some understanding and shallow skills in carrying out experimental work and requires assistance to carry out data analysis of the experimental results. |
| < 50% | Shows no understanding and lack of skills in carrying out experimental work and unable to carry out data analysis of the experimental results. |

**Appendix 2: Assessment Criteria for Final Examination**

By mark range

| Marks | Criteria |
|---|---|
| > 90% | Demonstrates understanding and very deep skills in carrying out experimental work and has the ability to carry out detailed data analysis of the experimental results. |
| 75% to 89% | Demonstrates understanding and deep skills in carrying out experimental work and has the ability to carry out most of the data analysis of the experimental results. |
| 65% to 74% | Demonstrates some understanding and reasonable skills in carrying out experimental work and has the ability to carry out some data analysis of the experimental results. |
| 50% to 64% | Demonstrates some understanding and shallow skills in carrying out experimental work and requires assistance to carry out data analysis of the experimental results. |
| < 50% | Shows no understanding and lack of skills in carrying out experimental work and unable to carry out data analysis of the experimental results. |