# 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 | AY2019-2020 |
| Semester/Trimester/Others (specify approx. Start/End date) | Semester 1 |
| Course Author<br>* Faculty proposing/revising the course | Lee-Chua Lee Hong |
| Course Author Email | clhlee@ntu.edu.sg |
| Course Title | Introduction to Data Science and Artificial Intelligence |
| Course Code | CV0003 |
| Academic Units | 3 |
| Contact Hours | 39 |
| Research Experience Components | Not Applicable |

## Course Requisites (if applicable)

| | |
|---|---|
| Pre-requisites | CV1014 Introduction to Computation Thinking |
| Co-requisites | |
| Pre-requisite to | |
| Mutually exclusive to | |
| Replacement course to | |
| Remarks (if any) | |

## Course Aims

In today's era of Information, 'Data' is the new driving force, provided we know how to extract relevant 'Intelligence'. This course will start with the core principles of Data Science, and will equip you with the basic tool and techniques of data handling, exploratory data analysis, data visualization, data-based inference, and data-focussed communication. The course will also introduce you to the fundamentals of Artificial Intelligence – state space representation, uninformed search, and reinforcement learning.
The course will motivate you to work closely with data and make data-driven decisions in your field of study. The course will also touch upon ethical issues in Data Science and Artificial Intelligence, and motivate you to explore the cutting-edge applications related to Big Data, Neural Networks and Deep Learning. Python will be the language of choice to introduce hands-on computational techniques.

## Course's Intended Learning Outcomes (ILOs)

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

| | |
|---|---|
| ILO 1 | Identify and define data-oriented problems and data-driven decisions in real life |
| ILO 2 | Illustrate the problems in terms of data exploration and visualization |
| ILO 3 | Apply basic machine learning tools to extract inferential information from the data |
| ILO 4 | Compose an engaging “data-story” to communicate the problem and the inference |
| ILO 5 | Outline the roles and requirements of artificial intelligence in practical application |
| ILO 6 | Explain and discuss fundamentals of state space search and reinforcement learning |

## Course Content

| | **Topics** | LAMS/TEL (Hours) | Example Classes (2-Hour Sessions) |
|---|---|---|---|
| 1 | **Data-Analytic Thinking**<br>What is Data Science? – The core problems and solutions.<br>Extracting Intelligence from Data – formulating problems. | 1 | Problem Formulation, Data Wrangling, Cleaning and Preparation<br>(2 weeks) |
| 2 | **The Data Pipeline**<br>Types of Data in various practical Data Science scenarios.<br>Data Wrangling, Cleaning and Preparation using Python. | 1 | |
| 3 | **Data Presentation**<br>Basic concepts in Statistics and Exploratory Data Analysis.<br>Data Exploration and Data Visualization using Python.<br>Case Studies involving Structured and Unstructured Data | 2 | Basic Statistics, Data Exploration and Visualization<br>(2 weeks) |
| 4 | **Data-driven Inference**<br>Basics of Machine Learning : Prediction and Classification.<br>Prediction and Classification techniques using Scikit-Learn. | 2 | Prediction and Classification<br>(2 weeks) |

| | | | |
|---|---|---|---|
| 5 | **Data-driven Identification**<br>Basics of Machine Learning : Clustering and Anomalies.<br>Clustering and Anomaly Detection using Scikit-Learn. | 1 | Clustering and Anomaly Detection<br>(1 week) |
| 6 | **Digital Storytelling**<br>Data-driven Dashboards, Websites and Presentations.<br>Data Presentation using Python Notebooks and Plotly. | 1 | Data Presentation and Dashboards<br>(1 week) |
| 7 | **Artificial Intelligence**<br>What is Artificial Intelligence? – History and State-of-Art.<br>Principles of problem solving and the State Space Search.<br>Case Studies for State Space Search and Search Algorithms | 2 | State Space Search and misc. Search Algorithms<br>(2 weeks) |
| 8 | **Reinforcement Learning and AI**<br>Introduction to Reinforcement Learning in context of AI.<br>Fundamentals of Markov Processes and Q-Learning. | 2 | Markov Processes and Q-Learning<br>(2 weeks) |
| 9 | **Ethics in DS&AI**<br>Ethical considerations and the idea of responsible DS&AI. | 0.5 | Ethical Data Science and AI<br>(1 week) |
| 10 | **State-of-the-Art in DS&AI**<br>Progress in Big Data, Neural Networks and Deep Learning. | 0.5 | |
| | Check for Hours | = 13 | = 26 |

## Reading and

## References (if applicable)

There is no single textbook for the course. The following books and resources will be used as references.

1. Python Data Science Handbook : Jake VanderPlas : O'Reilly (1st edition)
2. An Introduction to Statistical Learning : James, Witten, Hastie, Tibshirani
3. Artificial Intelligence: A Modern Approach : Russell and Norvig (3rd edition)

Additional resources, if required, will be shared with you in the LAMS/TEL videos and Example Classes.

## Planned Schedule

| Week or Session | Topics or Themes | ILO | Readings | Delivery Mode | Activities |
|---|---|---|---|---|---|
| 1 | Data-Analytic Thinking What is Data Science? – The core problems and solutions. Extracting Intelligence – formulating problems. | 1, 2 | Online Video (LAMS/TEL) | In-person | Defining a Data Science Problem in real-life. Familiarization with Python tools for DS. |
| 2 | The Data Pipeline Types of Data in various practical Data Science scenarios. Data Wrangling, Cleaning, Preparation. | 1, 2 | Online Video (LAMS/TEL) | In-person | Extraction, Wrangling, Cleaning, Preparation of Data using Pandas. |
| 3 | Data Exploration Basic concepts in Statistics and Exploratory Data Analysis. | 1, 2 | Online Video (LAMS/TEL) | In-person | EDA using Case Studies involving Structured and Unstructured Data |
| 4 | Data Presentation Data Exploration and Data Visualization using Python. | 2, 4 | Online Video (LAMS/TEL) | In-person | Visualization tools in Python and the basics of Data Visualization |
| 5 | Data-driven Predictions Prediction using techniques of Regression and Time Series | 2, 3 | Online Video (LAMS/TEL) | In-person | Using Prediction tools from Scikit-Learn. |

| Week or Session | Topics or Themes | ILO | Readings | Delivery Mode | Activities |
|---|---|---|---|---|---|
| 6 | Data-driven Classification Classification using techniques of Decision Trees and Support Vectors | 2, 3 | Online Video (LAMS/TEL) | In-person | Using Classification tools from Scikit-Learn. |
| 7 | Data-driven Identification Clustering and Anomaly Detection. | 2, 3 | Online Video (LAMS/TEL) | In-person | Using Clustering tools from Scikit-Learn. |
| 8 | Digital Storytelling Data-driven Dashboards, Websites and Presentations. | 2, 4 | Online Video (LAMS/TEL) | In-person | Data Presentation using Notebooks and Plotly. |
| 9 | Artificial Intelligence What is Artificial Intelligence? – History and State-of-Art. Principles of problem solving and State Space. | 5, 6 | Online Video (LAMS/TEL) | In-person | Case Studies for State Space Search and Search Algorithms |
| 10 | Uninformed Search Search Algorithms : breadth-first, depth-first, IDA, uniform-cost. | 5, 6 | Online Video (LAMS/TEL) | In-person | Case Studies for State Space Search and Search Algorithms |

| Week or Session | Topics or Themes | ILO | Readings | Delivery Mode | Activities |
|---|---|---|---|---|---|
| 11 | Reinforcement Learning Introduction to Reinforcement Learning in context of AI. Basics of Markov Processes and Q-Learning. | 5, 6 | Online Video (LAMS/TEL) | In-person | Case Studies for Reinforcement Learning |
| 12 | Reinforcement Learning Introduction to Reinforcement Learning in context of AI. Basics of Markov Processes and Q-Learning. | 5, 6 | Online Video (LAMS/TEL) | In-person | Case Studies for Reinforcement Learning |
| 13 | Ethics and State-of-the-Art Ethical considerations and the idea of responsible DS&AI. Progress in Big Data, Neural Net, Deep Learning. | 1, 5 | Online Video (LAMS/TEL) | In-person | Ethical considerations and the idea of responsible DS&AI. |

## Learning and Teaching Approach

| Approach | How does this approach support you in achieving the learning outcomes? |
|---|---|
| LAMS/ TEL (Online Video) | Topics will be delivered as a series of online videos lectures, and you will also be provided reference materials for self-study to achieve the ILOs. |
| Example Class (Face-to-Face) | Example Classes will be used for seminar sessions for students to discuss, debate and clarify the contents of the online LAMS/TEL contents, as well as hands-on sessions to equip students with practical knowledge on data science, machine learning and artificial intelligence, and to guide in terms of the design and implementation of a mini project, to achieve the ILOs. |

# 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 | Continuous Assessment (CA): Others([class participation] TEL participation and TEL MCQs) | 1,5,6 | a,b,h,l | 10 | Team | Analytic | Multistructural |
| 2 | Continuous Assessment (CA): Others([quiz/test] Online Quizzes based on MCQs) | 2,5,6 | a,b,h | 40 | Team | Analytic | Relational |
| 3 | Continuous Assessment (CA): Others([assignments (e.g. term paper, essay)] Exercises in Example Class) | 3,4,6 | a,b,c,d,e,h | 20 | Team | Analytic | Multistructural |
| 4 | Continuous Assessment (CA): Others([group or individual projects/evaluations] Mini Project in Example Class) | 1,2,3,4,5,6 | a,b,c,d,e,f,i,j | 30 | Team | Analytic | Relational |

Description of Assessment Components (if applicable)

(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 analyze 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: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Formative Feedback

TEL participation and TEL MCQs : This is an online exercise. You will see you scores, your answers, the correct answers, feedback on your incorrect answers, and explanations for the correct answers, immediately after you have submitted your answers online.

Online Quizzes based on MCQs : These are online exercises too. You will see you scores, your answers, the correct answers, feedback on your incorrect answers, and explanations for the correct answers, immediately after you have submitted your answers online.

Exercises in Example Class : These are partially based on online exercises based on MCQs, and partially on classwork submissions. For the MCQs, you will see you scores, your answers, the correct answers, feedback on your incorrect answers, and explanations for the correct answers, immediately after you have submitted your answers online. For the classwork submissions, Individual feedback will be provided to you after proper evaluation of your submissions. The answers will be discussed in the class, and you will also get to know the basic score statistics of the other students in the same cohort.

Mini Project in Example Class : You will be guided in choosing the topic, and the instructor will also help you during the course of the project, as and when required. Regular interactions with the instructor will be arranged to monitor your progress, and to provide you with constructive criticism.

## NTU Graduate Attributes/Competency Mapping

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

| Attributes/Competency | Level |
|---|---|
| Problem Solving | Advanced |
| Critical Thinking | Advanced |
| Embrace Challenge | Advanced |

## 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)

Policy (Others, if applicable)

As a student of the course, you are required to abide by both the University Code of Conduct and the Student Code of Conduct. The Codes provide information on the responsibilities of all NTU students, as well as examples of misconduct and details about how students can report suspected misconduct. The University also has the Student Mental Health Policy. The Policy states the University's commitment to providing a supportive environment for the holistic development of students, including the improvement of mental health and wellbeing. These policies and codes concerning students can be found in the following link: http://www.ntu.edu.sg/SAO/Pages/Policies-concerning-students.aspx

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