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	AY2023-2024
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Keen Mun Kelvin Yong
Course Author Email	kmyong@ntu.edu.sg
Course Title	Introduction to Data Science and Artificial Intelligence
Course Code	CB0494
Academic Units	3
Contact Hours	42
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	CE/CZ1003 Introduction to Computation Thinking BG2211 Introduction to Computational Thinking CH2107 Introduction to Computational Thinking CV1014 Introduction to Computational Thinking MS1008 Introduction to Computational Thinking MA1008 Introduction to Computational Thinking EE1005 From Computational Thinking to Programming RE1016 Engineering Computation
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	Discuss and 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 applications.
ILO 6	Discuss and explain fundamentals of state space search and reinforcement learning.

Course Content

1. Data-Analytic ThinkingWhat is Data Science? – The core problems and solutions.Extracting Intelligence from Data – formulating problems.Introduction to Python. 2. The Data PipelineTypes of Data in various practical Data Science scenarios.Data Wrangling, Cleaning and Preparation using Python 3. Data PresentationBasic concepts in Statistics and Exploratory Data Analysis.Data Exploration and Data Visualization using Python.Case Studies involving Structured and Unstructured Data 4. Data-driven InferenceBasics of Machine Learning : Prediction and Classification.Prediction and Classification techniques using Scikit-Learn. 5. Data-driven IdentificationBasics of Machine Learning : Clustering and Anomalies.Clustering and Anomaly Detection using Scikit-Learn. 6. Digital StorytellingData-driven Dashboards, Websites and Presentations.Data Presentation using Python Notebooks and Plotly. 7. Artificial IntelligenceWhat is Artificial Intelligence? – History and State-of -Art.Principles of problem solving and the State Space Search.Case Studies for State Space Search and Search Algorithms 8. Reinforcement Learning and AIIntroduction to Reinforcement Learning in context of AI.Fundamentals of Markov Processes and Q-Learning. 9. Ethics in DS&AIEthical considerations and the idea of responsible DS&AI 10. State-of-the-Art in DS&AIProgress in Big Data, Neural Networks and Deep Learning.

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	1,2	Online Video (LAMS/TEL)		
2	The Data Pipeline	1,2	Online Video (LAMS/TEL)		
3	Data Exploration	1,2	Online Video (LAMS/TEL)		
4	Data Presentation	2, 4	Online Video (LAMS/TEL)		
5	Data-driven Predictions	2, 3	Online Video (LAMS/TEL)		
6	Data-driven Classification	2, 3	Online Video (LAMS/TEL)		
7	Data-driven Identification	2,3	Online Video (LAMS/TEL)		
8	Digital Storytelling	2, 4	Online Video (LAMS/TEL)		
9	Artificial Intelligence	5, 6	Online Video (LAMS/TEL)		
10	Uninformed Search	5, 6	Online Video (LAMS/TEL)		
11	Reinforcement Learning	5, 6	Online Video (LAMS/TEL)		
12	Reinforcement Learning	5, 6	Online Video (LAMS/TEL)		
13	Ethics and State-of-the-Art	1, 5	Online Video (LAMS/TEL)		

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): Class Participation(LAMS)	1,2,3,5,6	a,b,g,k	10	Individual	Holistic	Relational
2	Continuous Assessment (CA): Test/Quiz(Theory Quiz (DS and AI))	1,2,3,5,6	a,b,g	40	Individual	Holistic	Relational
3	Continuous Assessment (CA): Test/Quiz(Lab Quiz (DS))	1,2,3,4,5,6	a,b,c,d,e,f,g,i	20	Individual	Holistic	Relational
4	Continuous Assessment (CA): Assignment(Mini Project (DS))	1,2,3,4,5,6	a,b,c,d,e,f,h,i	30	Team	Holistic	Relational

Description of Assessment Components (if applicable)

Formative Feedback

LAMS : Embedded mini quizzes within some LAMS. 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. Theory Quiz (DS and AI) and Lab Quiz (DS) : Overall performance basic statistic will be announced. Mini Project(DS) : You will be guided in choosing the topic, and the instructor will also help you in class during the course of the project as when required. Regular interactions with the instructor during class 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
Digital Fluency	Basic
Learning Agility	Basic
Problem Solving	Basic
Sense Making	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)

You are expected to complete all assigned readings, activities, assignments and assessments, attend all classes punctually and complete all scheduled assignments by due dates. You are expected to take responsibility to follow up with assignments and course related announcements. You are expected to participate in all project critiques, class discussions and activities.

Policy (Absenteeism)

Assessment activities will determine your course grade. Absence from any assessment without a valid Leave Of Absence (LOA) and without informing the instructor prior the assessment activity will be marked as "ABSENT" (0 marks) and will affect your final course grade significantly. There will be no make-up opportunities for missing the assessment activities.

Policy (Others, if applicable)

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Last Updated By: Yong Keen Mun Kelvin (Dr)

Appendix 1 : Assessment Criteria for TEL MCQs

You will complete 13 online LAMS/TEL sessions, including embedded MCQs (or similar). The maximum score is 10% of your total marks. You will take 1 online theory quiz (MCQs) based on LAMS lectures during the semester. The maximum score is 40% of your total marks.

Appendix 2 : Assessment Criteria for Exercises in Example Class

You will take 1 online Lab Quiz during the semester, based on the material covered during the Labs or the Example Classes. The maximum score for the Lab Quiz is 20% of your total marks.

Appendix 3 : Assessment Criteria for Mini-Project

You will submit the code(s) for data analysis, the visualization dashboard, and a final report to illustrate the Mini-Project – both the problem and the solution. You will need to do a presentation also for the Mini-Project. Mini-Project will be graded out of 100 points. The Mini-Project accounts for 30% of your total marks.

Criteria	Standards		
	Fail standard (0-40 %)	Pass standard (41-74 %)	High standard (75-100 %)
Identify the core definition of the problem, and plan the data-driven solution. (LO 1, 3, 5)	Identifying completely wrong definitions of the problems, and planning solutions that are somewhat related but are not the actual solutions expected for the problems.	Identifying the correct and relevant definitions of the problems in line with the course materials, planning solutions reasonably in line with solutions expected for the problems, and trying to relate the course materials to the planned solutions. Accuracy and clarity can be further improved.	Identifying the correct and relevant definitions of the problems in line with the course materials, planning technically accurate steps for the solutions that are expected for the problems, and clearly connecting the course materials to the planned solutions.
Explore the data effectively and devise required models to solve the problems. (LO 2, 3, 6)	Ad hoc analysis of the data and arbitrary steps in building the model without properly connecting the concepts with relevant concepts from the course. No or little evidence of critical evaluation of the proposed solution.	Logical exploration of the data that demonstrates a good understanding of the concepts from the course, and building models with reasonable accuracy to solve the problems. Reasonable evidence of critical thinking related to the proposed solution, and producing solutions with some degree of intuition and justification (rigorous steps for model-building or validation of	Clear logical flow of data exploration of that demonstrates a good understanding of the concepts from the course (and beyond), and building models with high accuracy to solve the problems. Extensive evidence of critical thinking related to the proposed solution, and producing solutions with clear intuition and proper justification, including

		models and results may be missing).	rigorous steps for model-building and validation of the models and results.
Overall Editorial Standard of the Solution and the Final Report. (LO 4)	Disorganised format and arrangement of the code and report, without any comment or little/no mention of references/resources.	Clear logical flow and well-formatted arrangement of the code and report, with all essential components. Reasonable comments and reasonable documentation of references /resources.	Clear logical flow and well-formatted arrangement of the code and report, with all essential components. Detailed set of technical comments to illustrate the choices made towards the solution, and to highlight the inferences. Proper documentation of references /resources.

Your Individual contribution (20 points out of 100) towards the Mini-Project will be judged based on an Oral Evaluation, as per the following rubrics.

Criteria	**Standards**		
	Fail standard (0-40 %)	**Pass standard (41-74 %)**	**High standard (75-100 %)**
Understanding of the Project and Individual Contribution. (LO 1, 2, 3)	Little understanding of problem definition, solution techniques, data exploration and machine learning tools used in the project. Individual contribution is too low compared to the team-mates.	Decent understanding of problem definition, solution techniques, data exploration and machine learning tools used in the project. Individual contribution to the project is proportional to the team size and project difficulty.	Clear understanding of problem definition, solution techniques, data exploration and machine learning tools used in the project. Individual contribution to the project is significantly high compared to team-mates.

Mapping of Course ILOs to EAB Graduate Attributes

Course Code & Title	CB0494 Introduction to Data Science and Artificial Intelligence
Course Type	Core Module

Overview											
(a)	●	(b)	●	(c)	◐	(d)	●	(e)	◐	(f)	◐
(g)	○	(h)	●	(i)	◐	(j)		(k)	○		

Legend:

●	Fully consistent (contributes to more than 75% of Student Learning Outcome)
◐	Partially consistent (contributes to about 50% of Student Learning Outcome)
○	Weakly consistent (contributes to about 25% of Student Learning Outcome)
Blank	Not related to Student Learning Outcome

Course ILOs		**EAB Graduate Attributes**
1)	Identify and define data-oriented problems and data-driven decisions in real life	(a), (b), (d), (f), (h), (i), (k)
2)	Discuss and illustrate the problems in terms of data exploration and visualization	(a), (b), (c), (d), (e), (h), (i), (k)
3)	Apply basic machine learning tools to extract inferential information from the data	(a), (b), (c), (d), (e), (h)
4)	Compose an engaging "data-story" to communicate the problem and the inference	(a), (b), (e), (f), (g), (h), (i)
5)	Outline the roles and requirements of artificial intelligence in practical applications	(a), (b), (d), (f), (g), (l)
6)	Discuss and explain fundamentals of state space search and reinforcement learning	(a), (b), (c), (d), (e), (h)

EAB Graduate Attributes

a) **Engineering Knowledge**: Apply the knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialisation as specified in WK1 to WK4 respectively 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 with holistic considerations for sustainable development. (WK1 to WK4)

c) **Design / Development of Solutions**: Design creative solutions for complex engineering problems and design systems, components or processes that meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required. (WK5)

d) **Investigation**: Conduct investigations of complex problems using research-based knowledge (WK8) 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 problems, with an understanding of the limitations. (WK2 and WK6)

f) **The Engineer and the World**: When solving complex engineering problems, analyse and evaluate sustainable development impacts to: society, the economy, sustainability, health and safety, legal frameworks and the environment (WK1, WK5, and WK7).

g) **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (WK9).

h) **Individual and Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multidisciplinary, face-to-face, remote and distributed settings (WK9).

i) **Communication**: Communicate effectively and inclusively 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, taking into account cultural, language, and learning differences.

j) **Project Management and Finance**: Demonstrate knowledge and understanding of engineering 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.

k) **Life-long Learning**: Recognise the need for, and have the preparation and ability to (i) engage in independent and life-long learning, and (ii) adapt to new and emerging technologies, and (iii) think critically, in the broadest context of technological change (WK8).

No	Knowledge Profile
WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline
WK5	Knowledge including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts that supports engineering design and operations in a practice area
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues
WK9	Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc with mutual understanding and respect, and of inclusive attitudes

Reference: EAB Accreditation Manual