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	AY2024-2025
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Tang Qinshen
Course Author Email	qinshen.tang@ntu.edu.sg
Course Title	Prescriptive Analytics with Generative AI
Course Code	BC2410
Academic Units	4
Contact Hours	52
Research Experience Components	Research Defined Course (at least 50% of deliverables involve practical research activities: problem identification, hypothesis forming, data collection/analysis/interpretation, result communication)

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

In the recent era, numerous corporations and public entities are directing substantial resources towards a diverse array of analytical methodologies. Prescriptive Analytics emerges as a critical frontier that transcends the scope of deciphering past occurrences (Descriptive Analytics) and forecasting future events (Predictive Analytics). It delves into the realm of actionable insights, elucidating the optimal sequence of actions for companies and public organizations to bolster their decision-making process. This course will leverage Generative AI to help you comprehensively approach prescriptive analytics, bridging the gap between raw data and informed decision-making strategies. The curriculum seamlessly integrates the two pivotal facets below.

1. Data-driven Optimization Theories and Techniques:
Central to this module is an exploration of a spectrum of optimization theories and techniques that are underpinned by data-driven methodologies. You will have exposure to optimization paradigms, including linear optimization, discrete optimization, network optimization, quadratic optimization, and stochastic optimization. Incorporating Generative AI within this framework enhances the capacity to generate and refine complex models, providing a more intuitive and automated approach to understanding data patterns and decision processes. You are equipped with the analytical prowess and prompt engineering skills to harness these optimization techniques in diverse scenarios.

2. Important Business Applications in Finance, Investments and Operations Management:
This course segment will unfurl the tangible impact of prescriptive analytics across domains such as finance, investment, and operations management. The materials will indicate how the methodologies are applied and how the applications are visualized or implemented in real industry, including but not limited to portfolio selection, asset allocation, revenue optimization, pricing strategies, appointment scheduling, retail operations, and project management. The examples will be diversified from close to your life such as course selection, and study loans to more complex such as portfolio management or monetized arbitrage.

By enrolling in this course, you will embark on a transformative journey where you traverse the intersection of cutting-edge analytics and pragmatic decision-making. Through a blend of comprehensive theoretical exposition and real-world case studies, learners emerge as adept navigators of the intricate landscape of data-driven optimization and its tangible applications, poised to drive innovation and foster informed choices in an increasingly data-driven world. The group project will also act as an additional important part to give you hands-on experience and problem-solving skills on a realistic problem.

The course will also place a specific focus on analyzing real data and solving optimization models relying on Generative AI using Python with commercial solver Gurobi*, further enhanced by the adaptive and innovative capabilities of Generative AI.

* Academic version is free.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Explain the principles of prescriptive analytics and identify real-world business problems that can be addressed by prescriptive analytics techniques.
ILO 2	Utilize Generative AI to analyse varying kinds of data and find underlying patterns.
ILO 3	Identify problems for business cases based on the analysed data.
ILO 4	Model the problems with data-driven optimization tools.
ILO 5	Solve optimization problems using Generative AI to program, e.g., Python, with commercial solver Gurobi.
ILO 6	Formulate a strategy to apply analytical tools to make real-world decisions.
ILO 7	Make a case for the role and importance of prescriptive analytics.

Course Content

This course unfolds over five engaging modules, each accompanied by real-world examples and/or datasets for hands-on experience. We'll kick off with an introduction to prescriptive analytics. Weeks two to four delve into linear optimization, highlighting its role in areas like asset cash flow matching and production planning. Module two introduces integer programming, optimizing dilemmas like Sudoku and course selection. In the third module, we'll navigate network optimization, applying it to practical challenges such as Hawker centre inspections and project management. Module four centers on quadratic optimization, guiding you through savvy portfolio decisions. We'll conclude with the fifth module, venturing into decision-making amidst uncertainty. Here, we'll explore the realms of stochastic optimization, elucidating their roles in scenarios like inventory management.

Reading and References (if applicable)

Recommended books:

[CR] Gerard Cornuejols and Reha Tütüncü. Optimization Methods in Finance. Vol. 5. Cambridge University Press, 2006.

[H] Frederick S. Hillier. Introduction to Operations Research. Tata McGraw-Hill Education, 2012.

[AW] Christian Albrightand Wayne L.Winston. Business Analytics: Data Analysis and Decision Making. Cangage Learning, 2015.

[BOP] Dimitris Bertsimas, Allison O'Hair and Bill Pulleyblank.The Analytics Edge, Dynamic Ideas, 2016. ISBN: 978-0989910897.

[G] GilbertStrang. Introduction to Linear Algebra. 5th ed. Wellesley, MA: Wellesley-Cambridge Press, February 2016. ISBN: 9780980232776

Other Materials: Lectures slides, exercises, assignments, and other course materials will be made available on the course website (NTULearn) in due time.You shall be notified via university email whenever new materials are available. The course website will also be used for announcements and otherc ourse communication purposes. You are therefore encouraged to regularly check the course website and your university email account for any updates.

NOTE: The above listing comprises the foundational readings for the course and more up-to-date relevant readings will be provided when they become available.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Introduction to Prescriptive Analytics	1,5,7	Lecture slides BOP, Chapter 1. G, Chapter 1 & 2	In-person	Icebreaker
2	Linear Optimization 1	1,2,3,4,6	Lecture slides CR, Chapter 3	In-person	Case study
3	Linear Optimization 2	1,2,3,4,6	Lecture slides CR, Chapter 3	In-person	Case study
4	Hands-on with GenAI 1	2,5	Lecture slides	In-person	AI-powered coding
5	Geometry of Linear Optimization	2,3,4,5,6	Lecture slides H, Chapter 3	In-person	Visualization
6	Sensitivity Analysis and Duality	2,3,4,5,6	Lecture slides CR, Chapter 4 H, Chapter 6	In-person	Sensitivity analysis
7	Tutorial	2,5	Lecture slides	Online	Q&A
8	Discrete Optimization	1,2,3,4,6	Lecture slides H, Chapter 12 CR, Chapter 12	In-person	Sudoku
9	Network Optimization	1,2,3,4,6	Lecture slides H, Chapter 10	In-person	Case study
10	Hands-on with GenAI 2	2,5	Lecture slides	In-person	AI-powered coding
11	Quadratic Optimization	1,2,3,4,6	Lecture slides CR, Chapter 7 & 8	In-person	Case study
12	Stochastic Optimization	1,2,3,4,6	Lecture slides CR, Chapter 16	In-person	Case study
13	Group/Individual project presentations	2,3,4,5,6,7		In-person	Project showcase

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures and classroom discussions	Most of the classes will be conducted via the "Lectures and Classroom Discussions" approach. Lectures will facilitate me to articulate the key concepts and methodologies in prescriptive analytics; Classroom discussions will demonstrate your learning progress, allowing you to share your intuitions, to express your difficulties in understanding the content, and it also provides me opportunities to assess your ability to think critically and articulate clearly.
Case Studies	Case studies will focus on the applications of the analytics tools and methodologies of mathematical formulation. The roles of the instructors are to facilitate discussion and to guide you to apply the concepts and theories. You are expected to adopt, adapt and synthesize the acquired concepts and theories into real business problems
Group Project	Each group has approximately four students. You are required to choose a business problem to address that is of particular interest to you. The project should be careful modeling and optimization of a real application. This project will comprehensively demonstrate your ability to identify and define business problems, make assumptions clearly, and formulate optimization models properly. Through the group project, you will have a deep understanding of the role and importance of prescriptive analytics.
Exercises	Exercises, both in-class and off-class, not only help build the fundamental technical knowledge required for this course, but also help develop your individual learning abilities and attitudes toward active learning. Answers for in-class exercises will be provided after the discussion, but answers for off-class exercises will not be offered.

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()	ILO1 - 7	Oral Communication; Critical Thinking	15	Individual	Analytic	Multistructural
2	Continuous Assessment (CA): Assignment(Group Assignment)	ILO2 - 5	Teamwork & Interpersonal Skills; Problem Solving; Acquisition of Knowledge	25	Team	Analytic	Extended Abstract
3	Continuous Assessment (CA): Project(Group Project)	ILO2- 7	Teamwork & Interpersonal Skills; Problem-solving & Decision making; Oral Communication	40	Team	Analytic	Extended Abstract
4	Continuous Assessment (CA): Test/Quiz(Mid-term Quiz)	ILO2, ILO4, ILO5, ILO6	Problem-solving; Acquisition of Knowledge	20	Individual	Analytic	Extended Abstract

Description of Assessment Components (if applicable)

*Students are to do a group project presentation during week 13. Every team member is required to present.

+Peer evaluation will be incorporated. Peer evaluation will adopt the use of Annex B4 to assess individual team members' contributions to be submitted through NTULearn. It will be a mandatory submission for all students. Each student is required to fill in the contribution of all team members in the same group. Should the contribution be significantly unequal, the assignment/project marks of individual students will be weighted according to peer evaluation input from group members according to the instruction on page 13 of this document.

^The mid-term quiz could be purely open-ended questions or a combination of MCQs and open-ended questions.

Description of Assessment Components:
Group Assignments: There will be 3-5 group assignments for this class. You are required to solve 2-5 problems as a team for each assignment. The group assignments are designed to prepare you well for analyzing data and modeling real-world problems.

GroupProject: The project for this class is to do careful modeling and optimization of a real application. Choose a problem to address that is of particular interest to your group. Your project should include a clearly defined business problem, assumptions, model setting, optimization formulation, and computational results. Each group would have to present and submit the report, including the code after the presentation but within the same week.

All parts of the project will be primarily evaluated in the following aspects:
a.Innovation: is the problem interesting and new?
b.Relevance: are the problem and model practical?
c.Rigor: is the model formulation correct?

Formative Feedback

You are required to participate in classroom discussions and will be accessed based on your participation and the quality of your inputs. You will receive verbal feedback during and after the in-class discussion. Assignments will be graded, answer keys will not be provided, but common mistakes and weaknesses will be reviewed in class. You will receive feedback on your group project in one week after the in-class presentation. Group peer evaluation is mandatory at the end of the semester.

NTU Graduate Attributes/Competency Mapping

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

Attributes/Competency	Level
Collaboration	Intermediate
Digital Fluency	Intermediate
Learning Agility	Advanced
Critical Thinking	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)

You are expected to complete all assigned pre-class readings and activities, attend all seminar classes punctually,and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments,and course-related announcements for seminar sessions they have missed. You are expected to participate in all seminar discussions and activities.

Policy (Absenteeism)

Absence from class without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies.

If you miss a lecture, you must inform the course instructor via email prior to the start of the class.

Policy (Others, if applicable)

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Last Updated By: Nursyaza Liyana Binte Zulkifli