線上課程學分採計課程大綱

一、課程基本資料

課程名稱	Operations Research: Models and Algorithms 作業研究：模型與演算法		
課號/課程識別碼	Online0014 / N0101300		
課程教師	資管系孔令傑	課程影片及作業時數	約 30 小時
學分數	2 學分	通識課程領域別	A6 數學與資訊科學領域
課程概述	Operations Research (OR) is a field in which people use mathematical and engineering methods to study optimization problems in Business and Management, Economics, Computer Science, Civil Engineering, Industrial Engineering, etc. This course introduces frameworks and ideas about various types of optimization problems in the business world. In particular, we focus on how to formulate real business problems into mathematical models that can be solved by computers. As the second part of the series, we study some efficient algorithms for solving linear programs, integer programs, and nonlinear programs. We also introduce the basic computer implementation of solving different programs, integer programs, and nonlinear programs and thus an example of algorithm application will be discussed.		
教學目標	• Students will learn how to formulate different types of mathematical models to tackle optimization problems with business applications. Technically, the concepts and applications of Linear Programming, Integer Programming, and Nonlinear Programming will be delivered. Moreover, students will also learn how to solve an optimization problem with one of the most accessible software: Microsoft Excel. • Students can learn how to use algorithms to solve different types of optimization programs and use Gurobi solver with Python to solve these problems efficiently.		

授課對象	學士班學生
課程難易度	適合沒有分析經驗的初學者 本課程以英語授課

二、課程內容

第一部分：Operations Research (1): Models and Applications

模組	課程內容設計
1	**W1: Course Overview** This lecture gives students an overview of what they may expect from this course, including the fundamental concept and brief history of Operations Research. We will also talk about how mathematical programming can be used to solve real-world business problem. • Video: Prelude • Video: 1-1: Motivation • Video: 1-2: Business analytics • Video: 1-3: Mathematical programming • Video: 1-4: History • Video: 1-5: Preview for this course • Quiz: Quiz for Week 1
2	**W2: Linear Programming** Linear programming (LP) is one of the most important method to achieve the outcome of optimization problems. We can use LP models for various decisions, including production, inventory, personnel scheduling, etc. • Video: 2-0: Opening • Video: 2-1: Introduction • Video: 2-2: Elements of a mathematical program (1) • Video: 2-3: Elements of a mathematical program (2) • Video: 2-4: Linear programming • Video: 2-5: Graphical approach • Video: 2-6: Three types of LPs • Video: 2-7: Simple LP formulation - Product mix • Video: 2-8: Simple LP formulation - Production and inventory • Video: 2-9: Simple LP formulation - Personnel scheduling • Video: 2-10: Compact LP formulation - Production and Inventory • Video: 2-11: Compact LP formulation – Product mix • Video: 2-12: Computers – The Solver add-in and Example 1 – producing desks and tables. (TA) • Video: 2-13: Computers – Example 2: personnel scheduling. (TA)

	• Video: 2-14: Closing remarks • Quiz: Quiz for Week 2
3	**W3: Integer Programming** In many practical areas, some of the optimization problems occur with integrality constraints imposed on some of the variables. Facility location, machine scheduling, and vehicle routing are some examples. Integer Programming (IP) provides a mathematical way to solve these problems. • Video: 3-0: Opening • Video: 3-1: Introduction • Video: 3-2: IP formulation (1) • Video: 3-3: IP formulation (2) • Video: 3-4: Facility location – Overview • Video: 3-5: Facility location – Covering • Video: 3-6: Facility location - UFL • Video: 3-7: Machine scheduling - Overview • Video: 3-8: Machine scheduling - Completion time minimization • Video: 3-9: Machine scheduling - Makespan minimization • Video: 3-10: Traveling salesperson problem - Basics • Video: 3-11: Traveling salesperson problem - Subtour elimination • Video: 3-12: Computers – Example 1 – personnel scheduling. (TA) • Video: 3-13: Computers – Example 2 – facility location. (TA) • Video: 3-14: Closing remarks • Quiz: Quiz for Week 3
4	**W4: Nonlinear programming** In the real life, many problems involve nonlinearities. Examples include pricing, inventory, and portfolio optimization. For such problems, we may use Nonlinear Programming (NLP) to formulate them into models and solve them. • Video: 4-0: Opening • Video: 4-1: Introduction • Video: 4-2: The EOQ problem • Video: 4-3: Formulating the EOQ model • Video: 4-4: The portfolio optimization problem • Video: 4-5: Portfolio optimization • Video: 4-6: Linearizing an absolute value function • Video: 4-7: Linearizing max_min functions • Video: 4-8: Linearizing products 1A • Video: 4-9: Linearizing products 1B 1C and 1D

	• Video: 4-10: Linearizing products 2A • Video: 4-11: Linearizing products 2B, 2C, and 2D • Video: 4-12: Remarks - why linearization • Video: 4-13: Computers – Portfolio optimization problem. (TA) • Video: 4-14: Closing remarks • Quiz: Quiz for Week 4
5	**W5: Case Study: Personnel Scheduling** In this lecture, we introduce a real business case that has been solved with Operations Research by the instructor. The problem is for a company to schedule its customer service representatives to minimize the total amount of staff shortage. We will demonstrate the problem, process of conducting an OR study, integer programming formulation, and result. • Video: 5-0: Opening • Video: 5-1: Background and motivation • Video: 5-2: Research objective • Video: 5-3: Problem description - objective • Video: 5-4: Problem description - constraints • Video: 5-5: Model formulation - objective • Video: 5-6: Model formulation - constraints • Video: 5-7: Results • Video: 5-8: Closing remarks • Quiz: Quiz for Week 5
6	**W6: Course Summary and Future Directions** In the final lecture of this course, we will summarize what we have learned. We will also preview what we may learn in future courses. • Video: 6-1: Review for this course • Video: 6-2: Preview of the next course • Video: A story that never ends • Quiz: Quiz for Week 6

第二部分：Operations Research (2): Optimization Algorithms

模組	課程內容設計
7	**W7: Course Overview** In the first lecture, we briefly introduce the course and give a quick review about some basic knowledge of linear algebra, including Gaussian elimination, Gauss-Jordan elimination, and definition of linear independence. • Video: Prelude

	• Video: 7-1: Overview • Video: 7-2: The row and column views for a linear system – A two-dimensional example • Video: 7-3: The row and column views for a linear system – A three-dimensional example • Video: 7-4: Using Gaussian elimination to solve Ax=b – Nonsingular • Video: 7-5: Using Gauss-Jordan elimination to solve A^(-1) – Singular • Video: 7-6: Linear dependence and independence • Quiz: Quiz for Week 7
8	**W8: The Simplex Method** Complicated linear programs were difficult to solve until Dr. George Dantzig developed the simplex method. In this week, we first introduce the standard form and the basic solutions of a linear program. With the above ideas, we focus on the simplex method and study how it efficiently solves a linear program. Finally, we discuss some properties of unbounded and infeasible problems, which can help us identify whether a problem has optimal solution. • Video: 8-0: Opening • Video: 8-1: Introduction • Video: 8-2: Standard form – Extreme points • Video: 8-3: Standard form – Standard form LPs • Video: 8-4: Standard form – Standard form LPs in matrices • Video: 8-5: Basic solutions – Independence among rows • Video: 8-6: Basic solutions – Basic solutions • Video: 8-7: Basic solutions – An example for listing basic solutions • Video: 8-8: Basic solutions – Basic feasible solutions • Video: 8-9: Basic solutions – Adjacent basic feasible solutions • Video: 8-10: The simplex method – The idea • Video: 8-11: The simplex method – The first move • Video: 8-12: The simplex method – The second move • Video: 8-13: The simplex method – Updating the system through elementary row operations • Video: 8-14: The simplex method – The last attempt with no more improvement • Video: 8-15: The simplex method – Visualization and summary for the simplex method • Video: 8-16: The tableau representation – An example • Video: 8-17: The tableau representation – Another example

	• Video: 8-18: Solving unbounded LPs • Video: 8-19: Infeasible LPs – The two-phase implementation • Video: 8-20: Infeasible LPs – An example • Video: 8-21: Computers – Gurobi and Python for LPs. (TA) • Video: 8-22: Computers – An example. (TA) • Video: 8-23: Computers – Model-data decoupling. (TA) • Video: 8-24: Closing remarks • Quiz: Quiz for Week 8
9	**W9: The Branch-and-Bound Algorithm** Integer programming is a special case of linear programming, with some of the variables must only take integer values. In this week, we introduce the concept of linear relaxation and the Branch-and-Bound algorithm for solving integer programs. • Video: 9-0: Opening • Video: 9-1: Introduction • Video: 9-2: Linear relaxation • Video: 9-3: Properties of linear relaxation • Video: 9-4: Idea of branch and bound • Video: 9-5: Example 1 for branch and bound (1) • Video: 9-6: Example 1 for branch and bound (2) • Video: 9-7: Example 2 for branch and bound • Video: 9-8: Remarks for branch and bound • Video: 9-9: Solving the continuous knapsack problem • Video: 9-10: Solving the knapsack problem with branch and bound • Video: 9-11: Heuristic algorithms • Video: 9-12: Performance evaluation • Video: 9-13: Remarks for performance evaluation • Video: 9-14: Computers – Gurobi and Python for IPs. (TA) • Video: 9-15: Closing remarks • Quiz: Quiz for Week 9
10	**W10: Gradient Descent and Newton's Method** In the past two weeks, we discuss the algorithms of solving linear and integer programs, while now we focus on nonlinear programs. In this week, we first review some necessary knowledge such as gradients and Hessians. Second, we introduce gradient descent and Newton's method to solve nonlinear programs. We also compare these two methods in the end of the lesson. • Video: 10-0: Opening

	• Video: 10-1: Introduction • Video: 10-2: Gradient descent – Gradient and Hessians • Video: 10-3: Gradient descent – A gradient is an increasing direction • Video: 10-4: Gradient descent – The gradient descent algorithm • Video: 10-5: Gradient descent – Example 1 • Video: 10-6: Gradient descent – Example 2 • Video: 10-7: Newton's method – Newton's method for a nonlinear equation • Video: 10-8: Newton's method – Newton's method for a single-variate NLPs • Video: 10-9: Newton's method – An example for single-variate Newton's method • Video: 10-10: Newton's method – Newton's method for multi-variate NLPs • Video: 10-11: Computers – Gurobi and Python for NLPs. (TA) • Video: 10-12: Closing remarks • Quiz: Quiz for Week 10
11	**W11: Design and Evaluation of Heuristic Algorithms** As the last lesson of this course, we introduce a case of NEC Taiwan, which provides IT and network solutions including cloud computing, AI, IoT etc. Since maintaining all its service hubs is too costly, they plan to rearrange the locations of the hubs and reallocate the number of employees in each hub. An algorithm is included to solve the facility location problem faced by NEC Taiwan. • Video: 11-0: Opening • Video: 11-1: Background • Video: 11-2: Motivation and objective • Video: 11-3: Three levels of modeling • Video: 11-4: Conceptual modeling • Video: 11-5: Mathematical modeling (1) • Video: 11-6: Mathematical modeling (2) • Video: 11-7: Results • Video: 11-8: A heuristic algorithm • Video: 11-9: Pseudocode • Video: 11-10: Performance evaluation • Video: 11-11: Closing remarks • Quiz: Quiz for Week 11

12	**W12: Course Summary and Future Learning Directions** In the final week, we review the topics that we have learned and give students a summary. Besides, we briefly preview the advanced course to provide future direction of studying. • Video: 12-1: Summary and discussions • Video: 12-2: Preview of the next course • Video: A story that never ends • Quiz: Quiz for Week 12

三、成績評量方式

本課程的成績評量方式
除完成線上練習題外，需參與實體考核