הפקולטה לניהול ע"ש קולר אוניברסיטת תל אביב

Coller School of Management Tel Aviv University

The Leon Recanati Graduate School of Business Administration

MBA and M.Sc. Courses

1231.3461.01 – Networked Markets and Graph Analytics

(Updated January 14, 2024)

(Prerequisite: Marketing Management**)**

First Semester – 2023/24

Section	Day	Hour	Classroom	Exam date	Lecturer	Email	Telephone
01	Monday (Second module)	15:45-18:30	Recanati 105 + Zoom	N/A	Dr. Peter Pal Zubcsek	peterz@tauex.tau.ac.il	03-640-9564

* Some materials may be delivered asynchronously.

Teaching Assistant (TA): Dr. Rafael Hod, MBA

Office Hours: By appointment (Room 2071, Lorry Lokey Building or Zoom)

Course Units

1 course unit = 4 ECTS units

The ECTS (European Credit Transfer and Accumulation System) is a framework defined by the European Commission to allow for unified recognition of student academic achievements from different countries.

Course Description and Course Objectives

Graph Analytics is a rapidly emerging subfield of data science that stands at the confluence of network theory, statistical analysis and business intelligence. In an increasingly networked society, social linkages affect all aspects of our daily life. Businesses, too, are embedded in complex economic networks which play an important role in influencing the profitability of organizations. The past decade has witnessed a surge in availability of data from various kinds of networks. However, traditional data analysis methods are often insufficient to uncover the underlying patterns of relationships in these networks.

The objective of this course is to introduce students to the field of graph analytics through a combination of network fundamentals, hands-on experience with computational techniques and datasets, and exposure to social and business applications. Students will learn about the fundamentals of social networks and graph theory, and will learn how to leverage this knowledge to analyze real-world networks as well as business cases from a range of emerging contexts like digital marketing, fintech, or edtech. Through data-driven assignments and term projects, students will also be exposed to hands-on tools for network analysis and visualization. While prior coding experience will be an advantage, it is not a must.

By the end of this module, students will develop the following expertise/skills:

- Ability to identify high-value network problems in the student's own social and business context
- Ability to apply graph analytics to create impactful business insights for managers
- Familiarity with fundamental concepts in graph theory
- Learning how to integrate network analysis tools and packages into existing analytics pipelines

Sample Topics

- Graph theory and the fundamentals of networks
- Behavioral processes on social networks (e.g., new product adoption, social activism, etc.)
- Predictive analytics on graphs
- Designing interventions on social networks (e.g., seeding campaigns)
- Optimal design of networks
- Knowledge graphs and graph databases

Course Structure

The course will use a mix of lectures, case discussions, and guest speakers. Mini-cases and problems will also be employed to make students apply their learning to practical situations. The first two weeks of the course will establish a foundation for characterizing the patterns of relationships in networks using graph theory. The rest of the course will (a) introduce students to advanced techniques for doing predictive analytics on graphs, (b) teach a framework for designing effective interventions on networks and for optimal network design, (c) introduce students to knowledge graphs, graph databases, and the value they create in organizations, and (d) cover advanced topics such as graph embeddings and graph neural networks. We will highlight practical applications of these approaches within a variety of specific industry contexts.

Note that some lectures and/or software tutorials may be delivered asynchronously, via video recordings uploaded to the course web, and only briefly discussed at the beginning of the subsequent synchronized class ("office hours style").

Course Materials

The course will use a mixture of required and optional reading assignments in the form of book chapters, articles, and cases. I will assume that students have done the required reading for each class, have analyzed the assigned case materials, and are prepared to discuss them.

The cases, book chapters, and articles listed in the course outline will be provided on the course website prior to class. (In accordance with copyright laws, the book chapters available on Moodle will be rotated throughout the semester.) A few additional materials will be distributed in class or placed on the course website in advance of class.

The recommended textbooks for the course are

Easley, D. and Kleinberg, J. (2010): *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*. 1st edition, Cambridge University Press,

Bechberger, D. and Perryman, J. (2020): *Graph Databases in Action*. Manning Publications,

Kejriwal, M., Knoblock, C. A., and Szekely, P. (2021). *Knowledge graphs: Fundamentals, techniques, and applications*. MIT Press,

Negro, A. (2021): *Graph Powered Machine Learning*. Manning Publications, and

Stamile, C., Marzullo, A., and Deusebio, E. (2021). *Graph Machine Learning*. Packt Publishing.

Policy on Cell Phones, Other Devices, AI Usage, etc.

To be discussed during the first lecture. * Update: this discussion will take place in the "Course Overview" video recording, to be shared via the course website).

Student Groups

Students will need to form groups of 3-4 (specifics depending on overall enrollment) to work on the final project. I will communicate more details on group formation during the course overview discussion (video recording to be posted on the course website).

Evaluation (Composition of Grade)

Final grades will be determined according to the following scale:

Percentage	Assignment	Type	Due Date
40%	**Problem Sets** **(2 x 20%)**	Individual	Mar 4, 2024 (Problem Set #1) Mar 18, 2024 (Problem Set #2)
20%	**Class participation**	Individual	All sessions
40%	**Term Project:** **5% Outline** **10% Presentation** **25% Final Report**	Group	 Outline: Feb 26, 2024 Presentation: Mar 11-25, 2024 Final Report: Apr 1, 2024

The different grade components are described in detail below.

Course Assignments

Class Attendance and Contribution (Participation)

Attendance in every class and tutorial is expected and recorded. (This is in line with University regulations (Article 5).*) Please note the following conditions. First, you are responsible for any marking next to your name on the attendance sheet. **For attendance purposes, only full signatures are accepted—thus no initials, written names, or other symbols. Second, students arriving 15 minutes or more after the scheduled start of class will not be allowed in the classroom unless they sought permission beforehand.**

Critically, note that any absence, excused or otherwise, will negatively affect your score on this component of your final grade. **Three or more unexcused absences will result in an automatic score of zero on class contribution and, in all likelihood, a fail mark for the course as a whole. In line with school policy, absences can be excused only under truly extenuating circumstances.**

Class contribution is much more than simply showing up and fighting for airtime. The focus will always be on the **quality** of your involvement in class **as opposed to** its **quantity**. [Please bring name cards to classes.] Contributing implies moving the debate forward to boost the learning experience of everyone in the room, myself included. While good comments are rewarded, insightful comments are rewarded extra. Therefore, if you do only one thing to prepare, read the assigned materials and come to class on time and ready to voice your recommendations. I often cold call, so please do not put the class in a position where you are unable to help.

Generally speaking, if you read the assigned materials, actively take part in pertinent discussions, listen to others with respect, and communicate your arguments convincingly you will not have any problem. In addition, note that prior to any sessions, you may be asked to complete a 5-minute online survey. Such tasks will be announced in due time via the course website. These surveys are compulsory, and they are counted toward class contribution.

Remember that you are welcome to ask for more information on how I grade class attendance and contribution or to seek feedback on your performance at any time during the course. Simply send me an email or approach me in class.

* Students who absent themselves from classes or do not actively participate in class may be removed from the course at the discretion of the lecturer. (Students remain financially liable for the course even if they are removed.)

Problem Sets (Individual)

There will be two written individual assignments. In each of these, you will be assigned one or more mini-cases that will each contain a network dataset, and a narrative introducing a business problem pertaining to the assigned data, and some exercises for you to solve. You will be expected to solve the problems using the tools introduced in class, and write up your solution in a(n at most) three-page paper. **Remember** to observe the typical standards when preparing the document: size 12 Times New Roman font, double line spacing or less, etc. The page limit is strictly enforced and excludes tables, figures, and possible references. Where applicable, you will also be expected to submit your analysis files via Moodle. Late submission of the report is penalized at the rate of 2% of

the average class score per day, while failing to submit your solutions will result in a score of 0 on the corresponding problem set assignment.

Term Project (Group)

The term project is the most valuable and critical component of this module. The project topic will be open ended, and teams will have complete flexibility in developing a project that contributes to the development of either a new network-based business insight, a new network modeling strategy, or even a new metric. The only strict requirement here is that the project must demonstrate adequate use of network science methods and network datasets, a precise definition of what business problem the teams intend to solve, and a clear illustration of how the project results can translate into actionable business insights.

There are **three formal deliverables constituting this assignment. Two of these are to be submitted in PDF format via the course website**: a one-page outline and the report itself. **The project outline is due on February 26, 2023, by 15:45 (IST)**. This outline should list the group members, and a short description of what you plan to do. **The final report is due on April 1, 2024, by 15:45 (IDT)**. The third graded component of the assignment will be a **presentation of the group project, to be delivered via Zoom (scheduled between March 11-25, 2024, for each group)**. Late submission of the outline or report is penalized at the rate of 5% of the average class score per day, while failing to deliver the project presentation in class will result in a score of 0 on the corresponding grade component of the assignment. Failing to complete the assignment triggers an incomplete mark for the course.

A separate project handout will be circulated in the first class to provide more details on the term project requirements, evaluation strategy and recommendations.

Grading Policy

In the 2008/9 academic year, the Management faculty at Tel Aviv University instituted a grading policy for all graduate level courses that aims to maintain a certain level of the average final course grade. Accordingly, this policy will be applied to this course's final grades. Additional information regarding this policy can be found on the website of the Coller School of Management.

Evaluation of the Course by Students

Following the completion of the course, students will participate in a survey to evaluate the instructor and the course – to provide feedback for the benefit of the students, the teachers and the University.

Course Site (Moodle)

The course site will be the primary tool to communicate messages and material to students. You should check the course site regularly for information on classes, reading materials, and assignments.

All reading materials, including case studies will be available on the course website. (Copyright law note: The book chapters available on Moodle will be rotated throughout the semester.)

Tentative Course Outline and Details of Sessions*

Date	Topics	Recommended Reading	Deliverables
Online	Course overview		
Feb 12	Introduction to networks Basics of graph theory: concepts and metrics Analyzing and visualizing networked data	NCM Ch. 1 NCM Ch. 2 GPML Ch. 1	
Feb 19	Characterizing behavioral processes on networks Problem set #1 assigned	NCM Ch. 3 NCM Ch. 13 NCM Ch. 14	Submit group composition list
Feb 26	Predictive analytics using networked data	NCM Ch. 4 GPML Ch. 2 GPML Ch. 3	Submit group project outline
Mar 4	Designing interventions on networks Designing optimal networks Problem set #2 assigned	NCM Ch. 19 NCM Ch. 21	Submit Problem Set #1
Mar 11	Advanced topics: Graph embeddings Graph neural networks Knowledge graphs and graph databases	GML Ch. 2 GPML Ch. 11 GPML Ch. 12 GPML Appendix B KG Ch. 1 KG Ch. 2	
Mar 18			Submit Problem Set #2
Ad hoc (online, by group)	Project Presentations		Submit group project presentation slides
Apr 1	Term Project – Final Submission		Submit group project final report

* Subject to change.

NCM: Easley, D. and Kleinberg, J. (2010): *Networks, Crowds, and Markets: Reasoning about a Highly Connected World* (1st edition)

GML: Stamile, C., Marzullo, A., and Deusebio, E. (2021). *Graph Machine Learning*. Packt Publishing

GPML: Negro, A. (2021): *Graph Powered Machine Learning*

KG: Kejriwal, M., Knoblock, C. A., and Szekely, P. (2021). *Knowledge graphs: Fundamentals, techniques, and applications*

Relevant readings (articles / book chapters) will be uploaded to the course website before the corresponding classes.