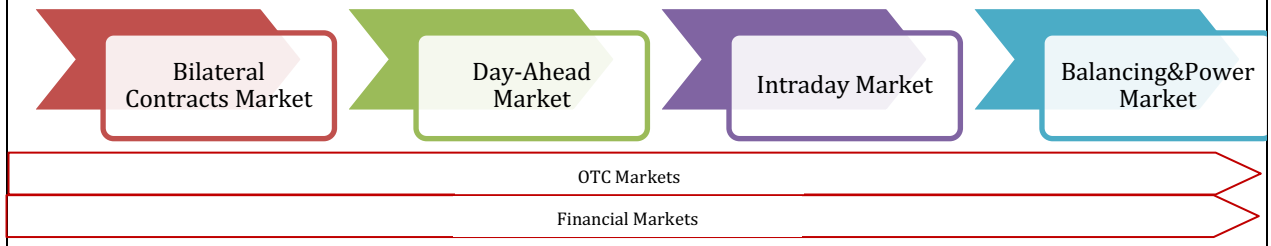
IE 492 Spring 2021 Projects

Instructor	Title
İ. Kuban Altınel	**Minimum Spanning Tree Problem with Conflicts (3-4 students)** **ASSIGNED!** A variant of the ordinary minimum spanning tree problem, the Minimum Spanning Tree Problem with Conflict Constraints (MSTC) will be considered in this project. A conflict constraint states that a certain pair of edges cannot be contained simultaneously in a feasible solution. It is convenient to represent these conflict constraints in terms of the so-called conflict graph whose vertices correspond to the edges of the original graph, and whose edges represent conflict relations. Then, every stable set of the conflict graph is a conflict-free subset of edges. Hence, MSTC becomes the determination of a stable set of the conflict graph whose elements represent a connected acyclic and spanning subgraph of the original graph with minimum total weight. The goal of this project is to develop and implement Lagrangean heuristics for MSTC.
İ. Kuban Altınel	**Assignment Problem with Conflicts (3-4 students)** A variant of the ordinary assignment problem, the Assignment Problem with Conflict Constraints (APC) will be considered in this project. A conflict constraint states that a certain pair of edges cannot be contained simultaneously in a feasible solution. It is convenient to represent these conflict constraints in terms of the so-called conflict graph whose vertices correspond to the edges of the original graph, and whose edges represent conflict relations. Then, every stable set of the conflict graph is a conflict-free subset of edges. Hence, APC becomes the determination of a stable set of the conflict graph whose elements represent a perfect matching of the original bipartite graph with minimum or maximum total weight. The goal of this project is to develope and implement Lagrangean heuristics for APC.
Necati Aras	**Determination of Trim Gas Amounts in the Glass Coating Process (3 students; students having taken IE 425 / IE 582 and IE 440 are preferred)** **ASSIGNED!** This project will be carried out with the data obtained from Şişecam A.Ş Yenişehir Plant producing glass. The focus is the coating process of the glass and trim gas is sprayed at different points to reduce the height deviation along the width of the glass. The objective is to determine the amount of gas to be sprayed at different spots so that the difference between the minimum and maximum thickness of the coated glass is as small as possible. First, a prediction problem will be solved using data analytics techniques to learn the relation between the thickness at a spot as a function of the gas sprayed at different spots. Then this function will be used as an input to minimize the thickness deviation by determining the amount of gas to be sprayed at the spots.
Necati Aras	**Contagion Blocking** **ASSIGNED!**
Yaman Barlas	**Modeling the dynamics of Covid-19 and alternative policies in Türkiye** **ASSIGNED!** There is intense modeling effort worldwide of the dynamics of Covid-19 and the potential effectiveness of alternative policies to combat the pandemic. The purpose of the project is to model the dynamics of the epidemic in Türkiye. The problem is an ideal modeling challenge for system dynamics methodology. In the first phase of the project, the basic dynamics of Covid-19 will be modeled so as to generate the fundamental epidemic wave(s). The parameters (about infectivity, mobility of different age groups, their vulnerability, delays in various stages of the epidemic, hospitalization, mortality and recovery rates…) will be estimated using both global and local Turkish data. After establishing the validity of the model in producing the main dynamics, alternative policies and scenarios will be tested in the second phase of the project. These polices will include different testing, lockdown and quarantine strategies, and alternative vaccination scenarios. The model will include not only the feedback response of policy makers to different situations, but also the behavioral response of different population groups both to the state of the epidemic and to the implemented policies. By simulation experiments, the ultimate purpose is to investigate which policies will be most effective under what conditions.

Mustafa G. Baydoğan	**Meta-learning for Algorithm Ranking in Forecasting Tasks (3 students)** As the famous no-free-lunch theorem suggests there are no algorithms or models that work best for every problem and also no algorithm perform better or worse than giving random results when all the problem domains and possible data sets are considered. Hence, it refers that when no information is available about a problem, it is not possible to make any assumption on the performance of a model. It may be the case that in particular problems, some type of algorithms works well compared to the others. Thus, with the available or extracted domain-specific knowledge, possible best-performing algorithms subset can be decreased. Distinguishing available datasets depending on the problem type or some other data-specific features and analyzing the past performances of the available algorithms on these distinguished datasets can give an idea about what type of model can be a better option in the future. Additionally, for a specific task or domain, in different parts, different algorithms can outperform the others. Apart from these, due to the size of the problems and lack of vast time, it is not possible to try all the available methods and see the best performer. There are many fields that require quick decision-making which brings along the need to obtain best possible results without spending too much resource. The vast number of available algorithms brings the problem of choosing a method or combining several methods in order to reduce the risk of selecting the wrong one. One solution is to implement ensemble learning where outputs of several different algorithms are combined. This solution has several complicacies within itself. The first one is how to combine the results since the number of possible ways is huge. The second one is that the results are not interpretable. Along with the performance, the interpretability is also a key factor on choosing a procedure because it is important to give a sense to the other people about why this method is chosen and why it performs well. On the other hand, second solution is to approach to this problem as a ranking problem which arises the meta-learning concept. Especially in dynamic problems where several conditions change over the course of the time, in which conditions which methods can be applied and can work well can be thought as a ranking problem. This project will require development of alternative prediction approaches using large number of features for a selected forecasting task. In the second phase of the project, a meta-learning approach to find out which model or models will provide the best accuracy in the forecasting period. The project group should have proficiency in dealing with large volumes of data using R/Python. Proficiency in statistical learning/modeling is required.
Mustafa G. Baydoğan	**Electricity Market Clearing Price Forecasting (3 students)** Electricity markets garner attention with their unique property of balancing requirements in both short and long term. Energy grids consist of heterogeneous interconnected systems, of an increasing number of small-scale and of dispersed energy generation and consumption devices. In these grids, electricity consumption and production should be at par at all times to prevent infrastructure damage. Therefore, over or under forecasting compared to actual consumption and production is severely penalized by the balancing market. Figure 1 illustrates the structure of the electricity markets.  **Figure 1. Structure of electricity market (PWC Turkish Electricity Market Report, 2017)** Ideally, if a distributor/supplier knows about their customer base's demand consistently with high accuracy, they might position themselves on the over the counter (OTC) (i.e. bilateral) markets via long term contracts and day-ahead market orders for fine tuning. Properly forecasting of the electricity load is the main pain point for all market participants. Increasing share of renewable energy sources (i.e. wind, solar, hydropower, geothermal) that are harder to forecast is major problem in terms of the foreseeability. In Turkey, every day until 12PM, market participants should place bid/ask orders for each of the 24 hours of the next-day according to their electricity needs or production. The result is a set of 24 market clearing prices (MCP) per hour. This is also the reference price for all other phases (i.e. imbalance). Accurate electricity demand forecasts is not the only important component of such a system. Players should also forecast MCP since they receive/pay based on the predetermined MCP. The aim of this project is to understand the dynamics of the Turkish Electricity Market and come up with predictive approaches to forecast next-day MCP. The project group should have proficiency in dealing with large volumes of data using R/Python. Proficiency in statistical learning/modeling is required

Mustafa G. Baydoğan	**Product Ranking Approaches for E-Commerce with Revenue Focus** Product ranking one of the most critical functionalities of an e-commerce site. Almost every ecommerce site provides a ranking algorithm to display its products under a category or as a result of search and etc. In other words a list of relevant items is displayed with some order. The customer then goes through these from the top one after another. She then can click one of those items and lands on its product view page. That page contains detail information about the product. The customer then can add that product to her shopping cart, can purchase it or add to her favorites. However, the ranking problem for an e-commerce search engine has several unique challenges. Most of the practitioners in this domain focus on modeling the sales probability of the items to determine the order of the products. However, this strategy is problematic since the historical data is being distorted by the proposed ranking strategy. When system promotes items that are highly likely to be sold (i.e. show in the very first ranks), there is an increased probability of the same product to be sold. Because of the ranking strategy, more profitable products which have a good chance to be sold may appear towards the end of the list. This affects the probability of selling the item as the historical data has bias towards popular products. This project is related to development of ranking strategies using the past clickstream transactions of the customers. **The project group should have proficiency in dealing with large volumes of data (i.e. gigabytes level) using R/Python. Proficiency in statistical learning/modeling is required.**
Mustafa G. Baydoğan **Könül Bayramoğlu Kavlak**	**Component Reliability Under Several System Structures** A physical system would be quite poorly designed if replacing a failed component by a functioning component caused the system to deteriorate. A coherent system is a technical structure consisting of elements with random lifetimes in which each component is relevant and replacing a failed component with a working one cannot cause a working system to fail. In this project we will consider a coherent system with redundant components. Closed-form expressions for system lifetime distributions are difficult to compute due to the computation complexity and the diversity of component lifetime distributions in real-world problems. Our aim is to evaluate and compare the performance of system reliability under several scenarios with different component sizes and system structures. This study will focus more on simulation and machine learning techniques to compute the system reliability.
Ümit Bilge Necati Aras	**Dynamic re-routing of vehicles in urban package delivery (3 students)** **ASSIGNED!** An urban package delivery company generates the minimum distance routes its vehicles will follow for each day in an off-line fashion such that its deliveries to customers and pick-up tasks from the suppliers are accomplished within the time windows chosen by the clients. However, while executing the routes during the day, several events might happen that might eventually call for revision of the routes. Different events (e.g. emergence of new pick-up calls, postponement of some delivery tasks, or failing to accomplish a task due to reasons such as traffic congestion) may give rise to problems with different nature and severity. Moreover, the decisions to recover from these situations should be taken in a short time and by causing minimum disruptions in the current routes. In this project, such dynamic issues will be analyzed, strategies to handle them will be developed and tested. Good programming skills (any programming language such as C++, C# , R or Python) will be required in this project.
Taner Bilgiç	**Pricing and Promotion Planning for Online Platforms (3/4 students)** **ASSIGNED!** In this project you are going to work with transaction data from a major Chinese online platform to answer the following questions: What is the impact of various pricing and promotion strategies on product sales? How should the platform improve its pricing and promotion strategy? In particular, among all the promotion methods (e.g., direct discounts, bundle discounts, and volume discounts), which one is more effective? The project requires good data analytics skills, statistics and machine learning.

Mahmut Ekşioğlu	**Productivity and Safety Improvement of a Work System (3 or 4 students)** **(Requirement: A basic course in ergonomics)** **ASSIGNED!** Application of ergonomics and other industrial engineering principles at the workplace enhances productivity, quality, and safety and health. This project involves application of these principles in the evaluation and redesign of a selected work system. Project consists of three main parts: (1) data gathering for identification of productivity, safety and health issues, (2) solving the identified issues, and (3) cost-benefit analysis.
Mahmut Ekşioğlu	**Evaluation and Redesign of a Human-Technology System (3 or 4 students)** **(Requirement: A basic course in ergonomics)** **ASSIGNED!** This project involves application of IE and ergonomic principles in the evaluation and redesign of a Human-Technology System. Project may involve the following: Customer/user survey, Dimensional analysis, Task analysis, Posture analysis, Force Analysis, Eye movement analysis, Usability Analysis, Benchmarking, QFD and Cost Analysis. • Examples: Evaluation and Redesign of: a medical device, a driver´s cabin of a transportation bus or agricultural machinery, a consumer product and so on.
Refik Güllü	**Design of a Robust and Diversified Asset Allocation System (3-4 students)** **ASSIGNED!** Asset allocation, or portfolio optimization is an important component of financial decision-making. It is perhaps the most fundamental decision problem for corporations, financial institutions, mutual funds, and even individual investors. A classical approach used in asset allocation is to come up with a portfolio where a financial institution aims to minimize the portfolio risk and at the same time tries to achieve an average desired return. Although this approach is fairly easy to apply, it has serious shortcomings. Due to these shortcomings, financial planners show hesitancy in applying this approach. The portfolios formed by using this approach tend to be too concentrated, that is, the method allocates funds on a few number of assets, and the resulting portfolio may change significantly as the estimates of input parameters slightly differ. In this project, we would like to come up with the design of a system where given the input parameters, a robust and well-diversified portfolio can be obtained. We would like to test the validity of our design on real data. Of course, besides generating a diversified and robust portfolio, the system should also yield a well performing portfolio with respect to common benchmarks.
Refik Güllü	**Analysis of Simultaneous Arrivals to Multiple Loss Systems (3-4 students)** **ASSIGNED!** In this project we consider a number of parallel loss systems (if the system is busy then the arriving customer is lost) with simultaneous Poisson arrivals. At an arrival instant, customers with different processing time requirements arrive to the system. Each customer is to be served by a separate loss system. In a partial order service model, customers who can start their service (that is, whose loss system is not busy) are served, and the others are lost. In a total order service model, if even one of the loss systems is busy upon the customer arrival, all customers in that arrival instance are lost. Our aim is to come up with exact or approximate expressions for the steady state probabilities of the number of customers in each system.

Wolfgang Hörmann	**Building a simulation model for disease spread in and between Turkish cities using R (2 groups of 3-4 people) (Prerequisit: Good knowledge of programming with R and of probability. Some knowledge on stochastic processes would be an advantage)** **ASSIGNED!** A general stochastic model for susceptible → infective → recovered (SIR) epidemics in non-homogeneous populations will be calibrated to several major Turkish cities. A stochastic simulation model will then be implemented in R, considering especially situations when social distancing measures create a fluctuating level of infected. The heterogeneity of the population is also a very important aspect, since it allows more realistic but also more complex models. Especially it allows to quantify the disease spread in situations where the social distancing measure are not the same in all cities. The main reference is : Islier, Hörmann, Güllü: Assessing Intervention Strategies for Non-Homogeneous Populations Using a Closed Form Formula for R0 (preliminary version available at https://arxiv.org/pdf/2008.05218.pdf)
Aybek Korugan	**Impact of Pandemic on Periodic Health Examination Workload of a Healthcare Provider** **ASSIGNED!** An internationally known private healthcare provider has a routine demand flow of periodic health examinations. In a periodic health examination sequence a patient visits n different stations. The process at each station is fairly deterministic. Most tasks are independent of each other. The final station is the starting station, thus the family practitioner. The load changes within a week and a year due to seasonality under normal conditions. Yet the pandemic disrupts the demand arrival pattern significantly due to safety regulations. The objective is to predict the future load and the variation in order to estimate the workforce required to continue the operation.
Z. Caner Taşkın **A. Tamer Ünal**	**Optimal lead time rounding in an assemble-to-order system (4 students)** Consider an assembly-type manufacturing environment where purchased materials are assembled into (possibly multiple levels of) semi-finished products, which are in turn assembled into final products. Each purchasing/manufacturing process in the bill-of-material has a lead time that is expressed on a continuous scale (such as hours or days). Assume that we are interested in performing aggregate production planning in this environment by using a linear/integer programming formulation. Since most aggregate production planning formulations work on a discretized time scale (where each period corresponds to a week, month, year, etc.), process lead times on a continuous time scale need to be converted to a discrete time scale before optimization. A straightforward rounding of all lead times up to the next multiple of period length would over-estimate total lead time while rounding down all process lead times would under-estimate total lead time. In this project the project team will design and compare various approaches to perform rounding lead times from a continuous scale to discrete scale by using optimization models and heuristics.
Z. Caner Taşkın **A. Tamer Ünal**	**Optimal Order Promising (4 students)** **ASSIGNED!** Order promising is an important business process for manufacturing companies employing make-to-order strategy. When a customer requests a quotation for an order that they are planning to place, the company needs to identify a reliable date that they can promise delivery of the order. The promised due date needs to be late enough so that sufficient capacity and materials are available for the manufacturing of the product without delaying other customer orders. On the other hand, the promised date needs to be early enough so that the customer is likely to accept the quotation instead of seeking alternative suppliers. In this project the project team will design and compare various optimization models and algorithms for optimal order promising.
Gönenç Yücel	**Designing an item allocation approach for a multi-warehouse storage operation** **ASSIGNED!** A certain company has two production facilities, and three storage locations that serve these facilities. Each of the storage locations (warehouses) are used to store a mix of raw materials, parts, semi-finished products, and final products. The company wishes to consider alternative storage/retrieval approaches (randomized, dedicated, class-based, etc.) as well as item allocation schemes in order to minimize the storage-retrieval efforts. The project aims to develop alternative

	warehouse designs (i.e. management policy and item allocations), and compare them in terms of multiple objectives based on historical operational data provided by the company.
Gönenç Yücel	**Developing a concurrent lot-sizing and job scheduling approach** **ASSIGNED!** Given a set of requirements (with due dates and quantities) for parts, a company faces the challenge of deciding on the production lot sizes for the parts, and then scheduling these lots on appropriate work centers. A delicate balance needs to be preserved between productive time lost due to unnecessary setup times resulting from smaller lot sizes, and failure to meet requirement due dates due to larger lot sizes. Therefore, these two decisions (i.e. lot sizing and scheduling) are interdependent and hence should be made concurrently for the sake of solution quality. The project aims to develop a lot-sizing and scheduling approach that generates good quality schedules that succeed in balancing the aforementioned aspects in a reasonable computational time. The project will rely on real-life data as sample instances of the aforementioned scheduling problem.
Gönenç Yücel **Yaman Barlas**	**Developing a dynamic strategy for the curtailment of the socio-economic impact of COVID-19 pandemic** **ASSIGNED!** The challenging nature of managing a pandemic as COVID-19 is apparent. Although various policy measures are discussed, it is not possible to pick one due to the various aspects of the problem (e.g. physical health, psychological health, loss of income, disruption in industrial activities and social services, interrupted education, etc). Additionally, considering the dynamic nature oda the problem, the potential benefits of different policy measures change as the dynamics of the pandemic unfold over time. In certain phases, certain measures provide the maximum benefit, but not always. Therefore, an adaptive strategy that uses a mix of policy measures depending on the phasing of the pandemic is needed. This project aims to develop such strategies, and compare their effectivenesses with the help of a simulation model. Considering the importance of the individual-level dynamics on the overall dynamics, and Agent-based Simulation model will the most likely modeling approach to be used.