COURSE SUMMARY
Prof. Stephen Graves

- Introduce optimization and simulation paradigms for the study and analysis of manufacturing systems for decision support.

- Not just formal methods and algorithms, but also *a way to think* about manufacturing systems and processes.

- Exposure to wide range of applications and implementation challenges

- Exposure to spreadsheet solvers and simulation tools: YOU CAN DO IT YOURSELF!

- Integration with Operations Management: simulation; systems dynamics (Beer Game); logistics modeling and optimization; theory of constraints

<u>Optimization</u>: Prescriptive model with decision variables; an objective or criterion function to optimize, subject to constraints due to limited resources, policy considerations, physical relationships, flow balance, etc.

Linear Programs:

- pervasive, many applications
- easy to solve via readily-available, general-purpose codes
- very robust algorithms
- concept of shadow prices, i. e., marginal value of constrained resource
- importance of sensitivity analysis and what if's
- some art required to build successful (large) application

Network Flow Problems

- pervasive, many applications for modeling flows in manufacturing, transportation, telecommunication systems etc.
- very powerful algorithms – specialization of LP

Stochastic Programs

- very important (and interesting) extension to LP to incorporate uncertainty for dynamic decision contexts
- very computationally intensive
- starting to see a few large-scale applications; should be common-place in next ten years.

Integer, Nonlinear Programs:

- pervasive, many applications
- problems of modest size are readily solvable
- algorithms quite different from that for LP
- commercial codes available for IP and NLP, but not as powerful or robust as for LP – but they keep getting better and better
- much more art needed for building successful application - both in modeling and in choice and tuning of algorithms
- IP is very useful for modeling economy of scale effects; for discrete choices, e. g., in system or network design, or investment decisions; and for scheduling and routing decisions.
- For IPs, computational time can be major concern in routine applications --- in which case, heuristic procedures are often warranted.
- Engineering design and optimization of design parameters are good application context for NLPs. Another common context is process optimization, where the control parameters are the decision variables.
- For NLPs, not able to assure global optimum is found

Simulation

- most common tool for modeling manufacturing systems
- descriptive modeling, very powerful tool for capturing uncertainty in complex systems
- a variety of software tools exist for building simulation models ranging from spreadsheet add-ins to simulation programming languages
- capability for numerical experimentation of existing and planned systems
- design of simulation entails identifying state space for system and events that result in state transitions.
- issues with simulation include appropriate level of detail; model validation; design of experiments and interpretation and analysis of output for decision support

Decision Analysis

- powerful framework for representing and structuring multi-stage decisions, subject to uncertainty
- based on underlying set of axioms for rational decision making
- most applicable for one-time decision contexts with large risks
- very useful for assessing value of information or sampling
- formalizes concept of maximizing utility