Subject 2.854.1x – **Introduction to Manufacturing Systems**

Syllabus

Summary

As part of the Principles of Manufacturing MicroMasters program, this course will provide ways to analyze manufacturing systems in terms of material flow, information flow, capacities, and times and durations of events. We will cover the following topics:

- Overview of Issues in Manufacturing Systems
- Basic Probability
- Stochastic Processes
- Queuing Theory
- Inventory Management
- Toyota Production System
- Single Part Type Manufacturing Systems

Instructors

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Pre-requisites:

- Engineering Undergraduate preparation
- Some knowledge of basic manufacturing systems: helpful but not necessary
- 6.041.1x or equivalent. Knowledge and comfortability with undergraduate-level calculus, probability and statistics.

Time Commitment

- *Length: 8 Weeks*
- *Weekly Effort: 10-hours*
    - including lectures, readings, exercises and 7 weekly assignments.

Deadlines

- Modules launched weekly starting on August 28, 2018 @ 15:00 UTC
- Assignments due 2 weeks later @ 15:00 UTC
- Course will end October 23, 2018 3PM UTC and a timed exam will be released on that date, which must be completed by October 30, 2018 by 15:00 UTC.

Grading

- Grading is based on assignments (30%) and the exam (70%).
- The overall grading scheme is

  - A (90-100)
  - B (75-89)
  - C (60-74)
  - F (<60)

- A passing grade (A, B, C) is required for the certificate.

Class Schedule

Please note:

- Material for each week will be released on Tuesdays at 15:00 UTC.
- Graded Problem Sets are also always due at 15:00 UTC on the specified day.

WEEK 1: OVERVIEW OF MANUFACTURING SYSTEMS

Released 8/28/2018

The first week of this course is devoted to an overview of manufacturing systems: what they are, and what problems face designers and operators of these systems. We'll start off with a case that shows the benefits of the methods we will describe. We will go through some definitions and take a very basic look at the relationship between a single manufacturing operation and the system it is part of. We will establish one of the basic themes of this course: the effects of variability. We will describe some system architectures and we will discuss some important performance measures.

Graded Problem Sets #1 is due 9/11/2018

WEEK 2: PROBABILITY

Released 9/04/2018

This is the first of three weeks that will discuss randomness. This is important because most variability is due to randomness and we need to be able to quantify it and its effects on system performance. The approach in this course is to provide intuition about randomness and variability, not primarily to teach mathematics, but some mathematics will be needed. We define probability precisely and define such concepts as independence, conditional probability, the law of total probability, random variables, and others. We introduce some widely used probability distributions for discrete and continuous random variables.

Graded Problem Sets #2 is due 9/18/2018

WEEK 3: STOCHASTIC PROCESSES

Released 9/11/2018

We build on the probability basics from the previous week to discuss random dynamic systems, which is what factories are. In a stochastic process, the state of a system evolves randomly over time and the present state influences the future. We focus on Markov processes, a class of stochastic processes that is very useful for modeling real-world systems. We study both discrete-time and continuous time Markov processes. We develop transition equations and we show how to use them to calculate performance measure of complex systems. We model single unreliable machines and relate their production rates to their failure and repair behavior. We will use these ideas later to study increases and decreases of inventories.

Graded Problem Sets #3 is due on 9/25/2018

WEEK 4: QUEUING THEORY

Released 9/18/2018

Queues are stochastic processes. Queuing models are widely used to study the arrivals and departures of people or items to a storage area. We will look at some simple models of individual queues to understand how the interaction of random arrival and departure processes affect the number of items in storage and the time that they must wait to leave the system. We define the capacity and utilization of such systems. Then we will consider networks of queues and use a network model to study the behavior of material flow in a flexible manufacturing system.

Graded Problem Sets #4 is due on 10/2/2018.

WEEK 5: INVENTORY

Released 9/25/2018

Inventory is a major issue in every factory. We show how some inventory is inevitable when variability is present in a system of flows. Inventory is necessary for a factory to meet some of its performance goals, such as having products available when customers want them or meeting a specified production rate target. However, it has costs. We will describe some inventory models that deal with issues such as the trade-off between the risk of having too little inventory to satisfy all customers and having too much so that some items are unsold. We will look at economies of scale: when it is worthwhile to buy or make more than you expect to need immediately because of reduced per-item costs, even though doing so adds storage costs.

Graded Problem Sets #5 is due on 10/9/2018

WEEK 6: TOYOTA PRODUCTION SYSTEM

Released 10/2/2018

The Toyota Production System has been successful and widely adopted and imitated throughout the world. In this set of videos we describe some of its key elements, particularly how it deals with variability and how it treats the people who are a part of the manufacturing system. We discuss kanban, production smoothing, reduction of setup time, improvement activities and other topics. We briefly discuss how the Toyota Production System was influenced by its historical context.

Graded Problem Sets #6 is due on 10/16/2018

WEEK 7: SINGLE PART TYPE MANUFACTURING SYSTEMS

Released 10/9/2018

This week we describe some quantitative models of single-part-type flow lines. We start from a model of a single unreliable machine and then study a long line with several machines and infinite buffers. We introduce the concept of a bottleneck and calculate the production rate of the line. We use simulations to observe inventory accumulation. Then, we consider a line with several unreliable machines and no buffers. We calculate the production rate. These are two extremes: lines with zero buffers having zero inventory and low production rates and lines with infinite buffers with large inventories and high production rates.

Finally, we study two-machine lines with finite buffers. These models show how buffers affect production rate and inventory. They also show how the frequency and duration of disruptions affect these performance measures in ways that cannot be predicted by machine efficiency alone. We will continue this subject by studying longer lines with finite buffers in the second part of this course.

Graded Problem Sets #7 is due on 10/23/2018

EXAM 10/23/2018

This is a timed exam that covers all material presented to date. You have one week to complete the test.

The exam is due on or before 10/30/2018.