To: The Engineering Faculty

From: The Faculty of the School of Materials Engineering

Re: New graduate course – **MSE 53500 – Lean Manufacturing of Materials:**

The Faculty of the School of Materials Engineering has approved the following new graduate course as of December 5, 2022 (see attached document of course description). This action is now submitted to the Engineering Faculty with recommendation for approval.

MSE 53500 – Lean Manufacturing of Materials:, Sem 1 or 2, Class 3, Credit Prerequisites: Graduate Standing OR MSE 330 and MSE 370

This course provides perspectives on materials processing and product innovation with an economic lens on efficiency and elimination of waste. It includes an historical perspective of manufacturing via the transition from mass to lean production in the automotive industry; and extends manufacturing and product development in context of emerging trends in automation (e.g., control and PAT, I4.0), modular design, supply chain, and sustainability. The class covers lean tools, focusing on value stream analyses and optimization using simulations. As an elective, the course accommodates a range of student interest profiles. It includes both individual and interest- based group assignments. The mix of students adds to the effectiveness of group exercises. A term paper enables individuals to do a deeper dive into specific interests. Overall, the course has shown to be adaptable over a broad range of students representing a variety of departments and professional backgrounds

This course was taught under a temporary course number in each spring since 2014, with enrollments between 66 and 112 (split approximately equally between online and in person).

David Bahr, Head
School of Material Engineering

Proposal for New Graduate Level Course for Academic Review MSE 53500 – Lean Manufacturing of Materials

Note: The detailed course proposal is intended for academic review by the appropriate area committee of the Graduate Council. It supplements the Form 40G that is intended for administrative review of the Graduate School and Registrar.

TO: Purdue University Graduate Council

FROM: Faculty Member: Paul Mort, David Gildemeister
Department: School of Materials Engineering
Campus: West Lafayette

DATE: October 17, 2022

SUBJECT: Proposal for New Graduate Course

1.1.1 MSE 53500 Lean Manufacturing
SEM 1 or 2, SS, Lecture 3, cr. 3

1. Course Description

This course provides perspectives on materials processing and product innovation with an economic lens on efficiency and elimination of waste. It includes an historical perspective of manufacturing via the transition from mass to lean production in the automotive industry; and extends manufacturing and product development in context of emerging trends in automation (e.g., control and PAT, I4.0), modular design, supply chain, and sustainability. The class covers lean tools, focusing on value stream analyses and optimization using simulations. As an elective, the course accommodates a range of student interest profiles. It includes both individual and interest-based group assignments. The mix of students adds to the effectiveness of group excercises. A term paper enables individuals to do a deeper dive into specific interests. Overall, the course has shown to be adaptable over a broad range of students representing a variety of departments and professional backgrounds.

2. Justification for the Course

1.2 2.1 Justification of the need for the course

The course is designed to teach engineering students the principles of Lean Manufacturing. Students include School of Materials Engineering (MSE), Industrial Engineering (IE), Mechanical Engineering (ME), Chemical Engineering (ChemE), and other technology majors. It provides undergraduates (Juniors, Seniors) with a useful perspective on industry. In addition, a significant portion of the class enrollment comes from professional master's students in various engineering

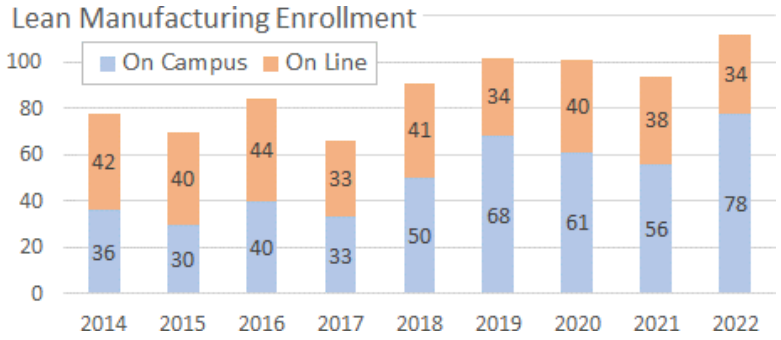
disciplines, where lean concepts have even more direct bearing on their current jobs and leadership responsibilities.

1232 Justification that course will be taught at a graduate level

MSE 53500 will be taught at the graduate level, open to upperclass undergraduates as an elective. A suitable background in statistics is recommended to support economic analyses and optimization excercises. While the course uses several different books to cover perspectives on manufacturing and product development, case studies and term paper assignments rely on literature searches, surveys, and critical analysis thereof.

1.4 2.3 Justification for online delivery

Lean Manufacturing is highly releveant among students pursuing the Masters of Science in Engineering with a materials emphasis, typically including about 40 on-line students per year. This has been fairly steady since the course's inception in 2014. Note the growing interest among on-campus students is also facilitated by having on-line content available.



3. Learning Outcomes and Methods of Assessment

1.5 3.1 Learning Outcomes

a) To understand the distinction between Mass Production and Lean Manufacturing and to analyze a facility's progress in the transition from Mass to Lean.
b) Articulate a case for Lean. Students will be able to present an argument on why Lean is a superior environment to Mass.
c) Compare and contrast the culture, organizational structure and leadership in Mass and Lean environments.
d) List and describe the Types of Waste and why waste elimination is a core component of Lean Manufacturing.
e) List and describe lean functionality (i.e. quality, continuous flow, pull systems, 5S, Visual Control, Task Planning, etc.).
f) Articulate why the "Rules in Use" were a breakthrough in understanding the Toyota Production System.
g) Develop a Value Stream Map of a manufacturing process, and explore optimization thereof using simulations and economic models,including options to mitigate changing conditions or uncertainty.
h) Understand A3 methodology and create an A3 proposal having economic justifications.
i) Understand the similarities and differences between Lean Manufacturing and Product Development.

j) Matrix exercise. An individual deep-dive survey of a specific interest selected by each student, and a group exercise to synthesize and present elements of individual surveys clustered by topical area.

13.6.2 Assessment Methods

There is a matrix of assessments: two exams (midterm, final), 5 individual homework assignments, 3 group-work assignments, and an individual term paper. The term paper is connected with one of the group-work assignments. Following Bloom's Taxonomy, the exams are intended to test foundational learning and applications thereof, homework and group exercises extend to analysis, and the term paper through to evaluation and creation of individual work

13.7.3 Final Grading Criteria

Graded homework due every 2 to 3 weeks, one midterm exam, one final exam, a literature survey on an aspect of Lean of the student's choice (within a matrix provided), and a group project synthesizing elements of individuals' literature surveys and short presentation thereof.

- Homework sets (individual)
- Case studies & peer reviews (group)
- Matrix exercise, deep-dive study:
  - Individual literature review paper
  - Synthesis and group presentation
- Midterm exam
- Final exam

Final grades will be based on A>90%, 89%<B<80%, 79%<C<70%, etc.; +/- will be assigned as appropriate within these bands. The instructors reserve the right to slide the scale down if needed (i.e. if we decide an 89% is reflective of an A, we'll do that), but we promise if the above noted scores are achieved, you will receive a grade in that letter range.

13.8.4 Methods of Instruction

Lectures will be used to help the students to achieve the learning outcomes. Lectures are recorded for asynchronous access by professional on-line students. Notes have been developed from the literature and exist as a framework in Powerpoint slides for the content.

13.9.5 Prerequisite(s)

Junior or higher standing in Engineering or Science

4. Course Instructor (either/or)

Paul Mort, Professor MSE, member of the Graduate Faculty
David Gildemeister, Professor of Practice, MSE

Profs. Mort and Gildemeister have extensive experience with the topics covered in this class, particularly those focusing on process manufacturing and product development.

5. Course Outline:

1. Historical perspective: Mass and Lean in the Automotive Industry
    a. Manufacturing
    b. Design
    c. Supply Chain
    d. Quality
2. Lean product design and startup:
    a. Economic models
    b. Protoypting
3. Lean tools:
    a. Value Stream Mapping and Optimization
    b. A3: concise proposals built on an economic framework
    c. Visual management
    d. 5S
    e. Kaizen
    f. Jidoka (Autonomation and Poke Yoke
    g. Kanban/Pull
4. Group presentations
5. Individual term papers

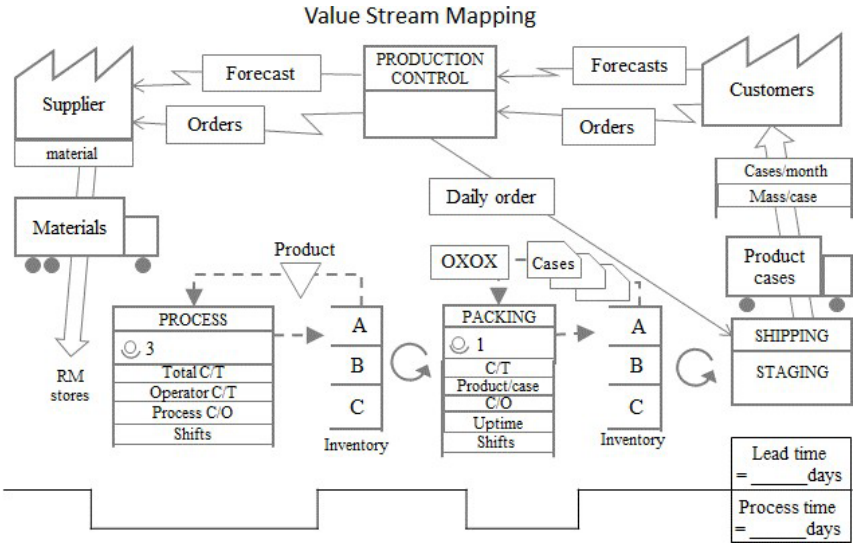
6. Reading List

- J.P. Womack, D.T. Jones, D. Roos, The Machine that Changed the World, Free Press, 1990 (2007 in paperback). ISBN-13: 978-0-7432-9979-4.
- J.K. Liker, The Toyota Way, McGraw Hill, 2004. ISBN 0-007-139231-9
- M. Rother, J. Shook, Learning to See, Lean Enterprise Institute, 2009. ISBN: 978-0-9667843-0-5.
- D. Reinertsen, The Principles of Product Development Flow, Second Generation Lean Product Development, Celeritas Publishing, 2009. ISBN 13: 978-1-935401-00-1.
- Supplemental reading posted on Brightspace as needed.
- T. Ohno, Toyota Production System: Beyond Large Scale Production, Productivity Press, 1988. ISBN 0-915299-14-3

Example Syllabus, Spring 2022

Purdue University School of Materials Engineering

MSE 535 Lean Manufacturing



Instructor Prof. Paul Mort, FLEX 3021B, 765-496-3450, pmort@purdue.edu

1.9.1 Lecture:

Synchronous, in class, MWF, 15:30-16:20, WANG 2599

Asynchronous video recorded lectures available via Brightspace, typically within an hour or two of the in-class lecture.

Office Hours: To be announced, or by appointment in FLEX 3021B or WebEx.

1.9.2 Course Description

Lean Manufacturing is about creating value. The Lean process starts with creating value for the ultimate customer which requires providing the right product at the right time for the specified price. While all manufacturing attempts to do this, what makes Lean Manufacturing distinct is the relentless pursuit and elimination of waste. Students will learn the concepts and tools of Lean which include types of waste, visual management, 5S, value stream mapping, A3, & flow and how it applies to materials systems.

The course was originally designed by Chris Owen who led Lean Project Initiatives at Alcoa Aluminum (now Arconic) in Lafayette, and has since been modified by Prof. Mort who has an industrial background with Procter & Gamble, including product development, manufacturing, process control and optimization. The course introduces Lean from an historical perspective, dives deeper into value stream mapping and optimization, and extends to Lean Product Development and Lean Startup.

Enrollment has grown to include a wider range of students, both on and off campus, having a broad range of interests including assembled-product manufacturing, materials processing, industrial engineering, engineering management, product development, systems optimization,

and start-up innovation. To better meet these diverse mastery objectives, the course requirements includes:

1. An individual literature survey according to student's specific area of interest;
2. A group presentation on a matrix topic where students are grouped based on content clustering of their specific interest areas.

1.9.3 Enduring Understandings

1. To understand the distinction between Mass Production and Lean Manufacturing and to analyze a facility's progress in the transition from Mass to Lean.
2. Value Stream Mapping. The intent is to "provide lean thinkers the most valuable tool they will need to make sustainable progress in the war against muda [waste]: the value stream map". (Rother and Shook).
3. Matrix exercise. An individual deep-dive survey of a specific interest selected by each student, and a group exercise to synthesize and present elements of individual surveys clustered by topical area.

1.9.4 Learning Objectives

1. Articulate a case for Lean. Students will be able to present an argument on why Lean is a superior environment to Mass.
2. Compare and contrast the culture, organizational structure and leadership in Mass and Lean environments.
3. List and describe the Types of Waste and why waste elimination is a core component of Lean Manufacturing.
4. List and describe lean functionality (i.e. quality, continuous flow, pull systems, 5S, Visual Control, Kanban, etc.).
5. Articulate why the "Rules in Use" were a breakthrough in understanding the Toyota Production System.
6. Understand A3 methodology and draw an A3.
7. Demonstrate ability to draw a Value Stream Map of an actual manufacturing process drawn from the literature, professor's experience, or industrial partner.
8. Understand the similarities and differences between Lean Manufacturing and Product Development.

1.9.5 Prerequisites

Junior or higher standing in Engineering or Science

1.9.6 Textbooks:

Recommended for purchase:

(1) J.P. Womack, D.T. Jones, D. Roos, The Machine that Changed the World, Free Press, 1990 (2007 in paperback). ISBN-13: 978-0-7432-9979-4. The content is basically the same for both printings. Convenient e-reader versions also available

(2) J.K. Liker, The Toyota Way, McGraw Hill, 2004. ISBN 0-007-139231-9

Optional (much will be covered in class):

(3) M. Rother, J. Shook, Learning to See, Lean Enterprise Institute, 2009. ISBN: 978-0-9667843-0-5.

(4) D. Reinertsen, The Principles of Product Development Flow, Second Generation Lean Product Development, Celeritas Publishing, 2009. ISBN 13: 978-1-935401-00-1.

1.9.7 Supplemental reading

Will be posted on Brightspace as needed.

1.9.8 Learning Environment

The research is clear that long-term learning takes place only when accompanied by deliberate, distributed practice. To accomplish that end, this class is structured so that subjects will be covered in a way to provide students opportunity to practice.

1.9.9 We expect that the student will:

1. Attend all classes or watch all videos. Attendance is expected, and video of the lecture can be provided for excused absences or special circumstances (i.e. we expect you to attend class if you signed up for the on-campus class). Electronic postings of the video will be available online for the distance students.

URL for distance students is https://engineering.purdue.edu/ProEd/current_student.

2. Read the assigned material before class. By coming prepared to class, students will be in a better position to learn the content.
3. Do good work. Utilize this opportunity to do work that will be expected of you as a practicing engineer.
4. Turn assignments in on time. Deductions will be taken for late assignments.
5. Turn off your cell phone, and only use your computer during class for class purposes.
6. Follow scholastic conduct policy: http://www.purdue.edu/univregs/pages/stu_conduct/stu_regulations.html

1.9.10 You can expect that the instructors will:

1. Provide a supportive learning environment that fosters your success.
2. Create exercises, homework assignments and tests that approach real life problems and situations (authentic performance tasks) faced by the practicing engineer.
3. Provide timely feedback on your work with the intent of facilitating your understanding of the content.
4. Follow the syllabus.
5. Structure exams to predominantly address the Learning Objectives.

1.9.11 How to approach this class:

1. You need to stay current with the lectures. Students have reported getting behind in previous courses. As some of the most important content build on previous concepts, it is important that you master one concept before being introduced to the next. This is the deliberate, distributed practice. If you do not deliberately practice the concepts in sequence, the probability of doing well in the course decreases significantly.
2. Read the material before the lecture; this provides a foundation for the concepts discussed in the lecture.
3. Get help sooner rather than later. Because of the sequential nature of the course, falling behind will likely result in the class becoming a struggle.
4. Recognize the importance of the Learning Objectives. Homework and exams will be based on the learning objectives. Make sure you understand the expectations for each learning objective. This will be especially important when preparing for exams.
5. In addition to group component of the matrixed “deep-dive” exercise, several case studies will be assigned as team projects (teams include on campus and distance students). The intent is for you to research the topic and do sufficient work to learn the subject and be able to both teach and learn from others. In preparing to engage in discussion groups on

Brightspace or other social platform, ensure that you have identified the concepts in the course that are the foundational concepts for the case study. Work with your team to ensure everyone can address the topics that have been provided.

1.9.12 Grading

This is a 500-level class that is designed to build on prior learning. The intent is to synthesize content from earlier courses taken as an undergraduate. Recognizing that some time may have lapsed and that some content may have been forgotten, assessments and feedback will be provided. The purpose for these assessments is to provide the student feedback on gaps in understanding. Students are expected to recognize gaps and to seek help either from the instructor, on-line, or from other sources. By being clear about course curricular priorities and learning expectations, the intent is that you, as the student, will take an active role in learning and mastery of the content.

Graded homework due every 2 to 3 weeks, one midterm exam, one final exam, a literature survey on an aspect of Lean of the student's choice (within a matrix provided), and a group project synthesizing elements of individuals' literature surveys and short presentation thereof.

- Homework sets (individual), 10%
- Case studies & peer reviews (group), 10%
- Matrix exercise, deep-dive study:
    - Individual literature review papers, 25%.
    - Synthesis and group presentation 15%.
- Midterm exam, 15%.
- Final exam, 25%.

Final grades will be based on A>90%, 89%<B<80%, 79%<C<70%, etc.; +/- will be assigned as appropriate within these bands. The instructors reserve the right to slide the scale down if needed (i.e. if we decide an 89% is reflective of an A, we'll do that), but we promise if the above noted scores are achieved, you will receive a grade in that letter range.