Syllabus & Outline
CHE1434H: Lean Six Sigma for Engineers

INSTRUCTOR: Dr. Guerino Sacripante (Sessional Lecturer, Dept of Chemical Engineering)
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COURSE LENGTH: May 5th to July 21st, 2021 (13 weeks)

COURSE TIME: Wednesday's from 9:00 am to 11:55 am (Tutorial and workshop)

COURSE VENUE: Pre-recorded Lectures and virtual online Tutorial and workshop sessions using Zoom Meeting Portal

FINAL REPORT DUE DATE: July 25th, 2021.

COURSE DESCRIPTION:

Lean Six Sigma is a proven project execution methodology being employed across nearly every type of business and industry including numerous Chemical Process Industry/ companies.
This course will provide a working know-how of the *Six Sigma (DMAIC)* problem solving and process improvement protocol for *existing processes/products* and of *Design for Six Sigma* methodology for *development of new processes/products*, tailored for chemical products/ processes and chemical engineers. It focuses on *project execution* based on Six Sigma roadmaps, and selective use of work process and statistical tools from the Six Sigma "tool box". The course will include workshops, part of each class, in order best familiarize the students with the practical value of Six Sigma in manufacturing processes and R&D.

COURSE LEARNING OBJECTIVES:

At the end of the course, the student will be able to:

- have a solid command of Six Sigma methodologies
- use Six Sigma/DMAIC tools and processes for improvement, optimization or problem solving of *existing* chemical processes
- use Design for Six Sigma (DfSS) tools and processes for the development of *new* chemical products and processes
- apply Six Sigma methodology work process and statistical tools
- examine/analyze engineering processes in a structured approach and apply Six Sigma tools to various functions, operations of current processes or in the design of new processes
- use Six Sigma principles in day to day tasks

CLASS FORMAT:

There will be 11 pre-recorded lectures available online through Quercus (1.0 to 1.5 hour each) and viewed at your own time. Tutorial and workshop will be done virtually using Zoom online platform on Wednesday's starting at 9 am (1.5 hr session). Each student (or up to a group of 3 students) will be asked to select an engineering process (ie Chemical, Civil, Mechanical…), or part of it, in which he/she is or has been involved with. As part of the workshops each student will apply 10 Six Sigma/DMAIC and 10 DfSS tools, to the project selected by themselves. The statistical tools will be Excel or Software

based and will be ecommended by the instructor; therefore, each participant is required to bring a laptop to the online tutorial/ workshop sessions.
A mid-term in-class test will be given following a review of the material covered up to that point.
An overall review and workshop will be held at the end of the course.
The final report that will summarize the work performed by each participant (or team) throughout the course will be due one week after the last class lecture.

REFERENCE MATERIALS:

While there are many books on Six Sigma, the students will be given as references only information available free on the web. A list of recommended books and articles is available and will be provided if there is interest to acquire them. A selection of references is shown below:

1. iSix Sigma - http://www.isixsigma.com – "New to Six Sigma" tab or http://www.isixsigma.com/index.php?option=com_content&view=article&id=201&Itemi d=27
2. www.pmi-uny.org/download/Six_Sigma_Intro_Jan_2005.ppt
3. Sigmazone - http://www.sigmazone.com/
4. BPI Consulting, http://www.spcforexcel.com/spc-for-excel-software - use of Excel for statistical tools
5. BPI Consulting, http://www.spcforexcel.com/msa-and-spc-for-excel - MSA example
6. FMEA Info Centre, http://www.fmeainfocentre.com - risk analysis
7. Lean Software Engineering, http://leansoftwareengineering.com/pugh-decision-matrix

Textbooks (Optional):

Design for Six Sigma: The Tool Guide for Practitioners, by Lisa Reagan and Mark Kiemele. CTQ Media 2008, ISBN 0981811914

CONDUCT EXPECTATIONS

As a University of Toronto graduate student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all our living, learning and working communities. All students share the responsibility of maintaining a positive environment for the academic and personal growth of all University of Toronto community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Quercus or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

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The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

TOPICS (per class/workshop)**:**

1. Introductions, logistics (including projects selection), Introduction to Six Sigma/DMAIC and Design for Six Sigma (DfSS)

2. Six Sigma/DMAIC - DEFINE Phase: implementing Six Sigma for improvement of current processes, project assessment; project definition (charter); project definition details: problem statement, expected impact, goal, scope, schedule, resources; special process maps: SIPOC, High level and Value Stream maps and their adaptation for chemical engineering diagrams; key inputs and outputs; cause and effect/ transfer function Y=f(x); voice of the customer (VOC) and voice of business (VOB), critical customer requirements; project planning.

3. Six Sigma/DMAIC - MEASURE Phase: Value Stream map and measurements; key input, process and output variables – what to measure; Ishikawa cause and effect diagram, measurement stratification tools; operational definitions/measurement procedures; validation of measurement system; Measurement System Analysis (MSA) tools; data collection plan; data organizing tools - control charts, Pareto charts; baseline capability analysis tools; project plan update.

4. Six Sigma/DMAIC - ANALYZE Phase: data analysis – measurement system confirmation, problem stratification, process variations assessment; hypotheses for root causes of the problem; data analysis basic tools – descriptive statistics, distribution of data, normality test, control charts details, regression analysis, hypothesis testing; process tools – brainstorming, non-value added analysis, risk/failure mode and effects analysis (FMEA); root cause experimental proof; project plan check.

5. Six Sigma/DMAIC – IMPROVE and CONTROL Phase: *Improve*: generation and development of potential solutions - brainstorming; evaluation criteria – quality, cost, delivery, safety; selection of best solutions – Pugh matrix; risk assessment – Improve phase specific FMEA; “to be” process mapping; pilot – solution demo, basic DOE; results assessment; implementation plan. *Control*: standard operating procedure (SOP), control plan – measurements, sampling, monitoring plans and tools, response plan – sustaining the improvements.

6. **Mid-term test**

7. Design for Six Sigma: Six Sigma in chemical engineering research and development; Design for Six Sigma (DfSS) for development of new processes compared to Six Sigma/DMAIC for existing processes, main DfSS roadmaps and common principles; Define/Measure/Explore/Develop/Implement (DMEDI) roadmap; DEFINE: comparison with Define in DMAIC, strategic planning tools.

8. Design for Six Sigma/DMEDI - MEASURE: voice of external and internal customer (VOC) vs. voice of business (VOB); Kano analysis for VOC; translation of VOC to critical customer requirements; Quality Function Deployment (QFD) methodology and House of Quality #1; operational definitions and MSAs; other tools: affinity diagrams, tree diagrams, Pareto charts, box plots; scorecards/specifications.

9. Design for Six Sigma/DMEDI - EXPLORE: generation of design concepts; selection of best concepts – pair-wise comparison and Pugh matrix tools; House of Quality #2 in QFD for determining target specifications; risk analysis for new concepts – adapted FMEA; SIPOC and 'to be" process map; design of experiments (DOE) - introduction, DOE types/options, screening DOEs; DfSS scorecards.

10. Design for Six Sigma/DMEDI – DEVELOP (Part 1): Screening Design of Experiments for modeling and/or optimization; "mistake proofing" – redundancy design; non-value added analysis for new processes; capability analysis; final risk analysis, pilot – process optimization and debugging.

11. Design for Six Sigma/DMEDI – DEVELOP (Part 2): Full Factorial Design of Experiments for modeling, and Monte Carlo Simulation; IMPLEMENT: House of Quality #3 in QFD for process control; standard operating procedure (SOP), tolerances/specification; process control plan; QC plan; optimized process demonstration – pilot or full scale. Review of DfSS/DMEDI, Final report discussion and initiation: report subject for class groups; tasks and tools to be used; use of DMAIC or DMEDI roadmap for project (report) planning/execution.

12**. End-of-Term Quiz**

ASSESSMENT:

This course will be organized as a series of lectures (1.5 hours/week) combined with a tutorial/ workshop (1.5 Hours/ week). There are four types of evaluation in this course:

1) Assignments (20% of final mark) – Each student (or team of 2 or 3), during the workshop segment of the course, will apply the various six sigma tools into their own research proposal, and submit these tools as individual assignments. There will be about 1 to 2 assignments/ week, totaling about 20 assignments for the course.

2) Midterm Quiz (30% of final mark); Online Quiz

3) Final Report (20% of final mark) – Each student (or team of 2 or 3), will complete a detailed summary of the application and interpretation of Six Sigma methodologies into their research project.

4) End of Term Quiz (30% of final mark): Online Quiz

Course Outline

Class 1 (May 5th)

- Intro to Six Sigma Lecture
- SS/DMAIC – Define Phase Intro
- Teams selection

    Online Tutorial /Workshop to cover:

        Teams selection/formation

        Charter

    Assignment: Project Charter

Class 2 (May 12th)

- SS/DMAIC – Define Phase– Lecture & Workshop (W/S)

    Workshop to cover:

        Charter

SIPOC
Assignment: SIPOC

Class 3 (May 19th)

- SS/DMAIC – Measure Phase – Lecture & Workshop (W/S)
  Online Tutorial /Workshop to cover:
  Cause and Effect (Fishbone) Diagram
  Control Charts
  Pareto Charts
  Assignment: Cause and Effect Diagram, Control / Pareto Chart
  Measurement Analysis

Class 4 (May 26th)

- SS/DMAIC – Analyze Phase – Lecture & Workshop (W/S)
  Online Tutorial /Workshop to cover
  Descriptive Statistics
  Regression Analysis
  2 sample t-test
  Assignment: Regression Analysis, 2 sample t-test

Class 5 (June 2nd)

- SS/DMAIC – Improve Phase – Lecture & Workshop (W/S)
- SS/DMAIC – Control Phase – Lecture

  Online Tutorial /Workshop to cover
  Pugh Matrix for solution selection
  FMEA
  DOE

Assignment: Pugh, FMEA, and DOE

Class 6 (June 9th)

- **Midterm Quiz**

- Online Tutorial /Workshop to cover uncompleted assignments

Class 7 (June 16th)

- DFSS/DMEDI – Define – Lecture & Workshop (W/S)
  Online Tutorial /Workshop to cover:
  Project Charter
  Assignment: Project Charter #2

Class 8 (June 23rd)

- DfSS/DMEDI – Measure – Lecture & Workshop (W/S)
  Online Tutorial /Workshop to cover:
  Kano Analysis
  HOQ#1
  Assignment: HOQ#1

Class 9 (June 30th)

- DfSS/DMEDI – Explore – Lecture & Workshop (W/S)
  Online Tutorial /Workshop to cover:
    AHP
    HOQ#2
  Assignment: HOQ#2 and AHP

Class 10 (July 7th)

- DfSS/DMEDI –Develop Part 1– Lecture & Workshop (W/S)
  Online Tutorial /Workshop to cover: DOE#1
    Assignment: DOE #1

Class 11 (July 14th)

- DfSS/DMEDI –Develop Part 2 and Implement– Lecture & Workshop:
    Online Tutorial /Workshop: DOE #2;
    Monte Carlo Simulation

Assignment: DOE #2 and Monte Carlo

Final Report Discussions, recommended that you have an initial draft

Class 12 (July 21st)

- **FINAL TERM QUIZ**

Final Report due on, July 25h, midnight