STAT 513/IE 530 — Statistical Quality Control

Spring 2019

Credit Hours: 3

Lectures: Monday Wednesday & Friday / 3:30 - 4:20 PM / WALC 1087

Instructor: Arman Sabbaghi, PhD
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Course Website: Blackboard (mycourses.purdue.edu)

Required Textbook: Montgomery D.C. (2013). *Introduction to Statistical Quality Control* (6th or 7th ed.). John Wiley & Sons, Inc.

Course Description: This course will cover the underlying statistical techniques for modern quality control. These important methodologies possess a broad scope of application, ranging from manufacturing, health care, pharmaceuticals, service industries, and other domains. Conceptual understanding, not memorization or theoretical derivations of equations, is required and emphasized throughout the course. Topics include: Six Sigma, statistical and graphical data summaries, basic tools (e.g., flowcharts, fishbone diagrams, Pareto charts), control charts for measurement and attribute data, proper and effective use of control charts, capability studies, continuous improvement, experimental design, Taguchi methodology, and acceptance sampling. Specific topics covered and the course outline are subject to change as the semester progresses.

Course/Learning Objectives:

- Acquire fluency in the language and techniques of modern quality control and its applications.
- Understand the utility of statistics for quality control.
- Apply control charts and experimental design methods to solve quality control problems.
- Utilize JMP for data visualization, statistical computation, control chart construction, and design of experiments.
  - JMP is freely available via Software Remote and in ITaP labs. Free manuals are available online.
  - Help with statistical software packages is available at the help desk in MATH G175.

Prerequisites: One semester of post-calculus statistics such as IE 230, MGMT 305, or STAT 511, or permission of the instructor.

Course Outline:

- **Week 1**: Introduction to modern quality control (Chapters 1 – 2).
  - **Lecture 1 (1-7-2019)**: Overview of statistical quality control, control charts, and experimental design.
  - **Handout (Due 1-11-2019)**: Background survey.
  - **Lecture 2 (1-9-2019)**: Six Sigma, with a focus on the Define step.
  - **Lecture 3 (1-11-2019)**: Six Sigma, with a focus on the Measure step.
  - **Homework 1 (Due 1-18-2019)**: Problems based on Chapters 1 – 2.
- **Week 2**: Overview of basic probability, statistics, JMP, and the Magnificient Seven (Chapters 3 – 5).
  - **Lecture 4 (1-14-2019)**: Review of probability distributions.
  - **Lecture 5 (1-16-2019)**: Review of statistical inference, and applications of JMP
  - **Lecture 6 (1-18-2019)**: An overview of the Magnificient Seven.
  - **Homework 2 (Due 1-25-2019)**: Problems based on Chapters 3 – 5.
- **Week 3**: The Shewhart Control Chart (Chapter 5).
  - **No lecture on 1-21-2019 (Martin Luther King Jr. Day)**.
  - **Lecture 7 (1-23-2019)**: An introduction to the Shewhart control chart. Basic assumption (spike signal) and ingredients.
  - **Lecture 8 (1-25-2019)**: Issues in the design of Shewhart control charts.
  - **Homework 3 (Due 2-1-2019)**: Problems based on Chapter 5.
- **Week 4**: Control charts for variables (Chapter 6).
  - **Lecture 9 (1-28-2019)**: Shewhart control chart for $\bar{x}$ and R. Construction via JMP.
  - **No lecture on 1-30-2019 due to adverse weather conditions**.
  - **Lecture 10 (2-1-2019)**: Issues in the design of Shewhart control charts for $\bar{x}$ and R.
  - **Homework 4 (Due 2-8-2019)**: Problems based on Chapter 6.
- **Week 5**: Control charts for variables and attributes (Chapters 6 – 7).
  - **Lecture 11 (2-4-2019)**: Shewhart control charts for $\bar{x}$ and s, and for individual measurements. Construction via JMP.
  - **Lecture 12 (2-6-2019)**: Shewhart control chart for fraction nonconforming. Construction via JMP.
  - **Lecture 13 (2-8-2019)**: Shewhart control chart for nonconformities (defects). Construction via JMP.
  - **Homework 5 (Due 2-13-2019)**: Problems based on Chapters 6 – 7.
- **Week 6**: Midterm I.
  - **Lecture 14 (2-11-2019)**: Variable sample sizes, low defect rates in control charts for attributes, and other design issues.
  - **Review Lecture (2-13-2019)**: Review of Lectures 1 - 13.
  - **Midterm I (2-14-2019)**: Primary focus: Six Sigma, basic probability and statistics, Shewhart control charts for variables and attributes.

  - **No lecture on 2-15-2019**.
- **Week 7**: CUSUM and EWMA charts, capability analysis (Chapters 8 – 9).
  - **Lecture 15 (2-18-2019)**: Introduction to CUSUM charts, their interpretations, and relevant assumptions (e.g., step signal). Construction via JMP.
  - **Lecture 16 (2-20-2019)**: Introduction to EWMA charts, their interpretations, and relevant assumptions (e.g., increasing exponential signal). Construction via JMP.
  - **Lecture 17 (2-22-2019)**: Process capability analysis by various means including control charts.
  - **Homework 6 (Due 3-1-2019)**: Problems based on Chapters 8 – 9.
- **Week 8**: Review of ANOVA and linear regression (Chapters 4.5 – 4.6).
  - **Lecture 18 (2-25-2019)**: Review of the Analysis of Variance (ANOVA).
  - **Lecture 19 (2-27-2019)**: Introduction to linear regression.
  - **Lecture 20 (3-1-2019)**: Performing hypothesis tests and creating confidence intervals from linear models.
  - **Homework 7 (Due 3-8-2019)**: Problems based on Chapters 4.5 – 4.6.
- **Week 9**: Introduction to two-level full factorial experiments (Chapter 13).
  - **Lecture 21 (3-4-2019)**: The 2^2 full factorial design.
  - **Lecture 22 (3-6-2019)**: The 2^k full factorial design.
  - **Lecture 23 (3-8-2019)**: ANOVA for two-level full factorial designs.
  - **Homework 8 (Due 3-22-2019)**: Problems based on Chapter 13.
- **Week 10**: Spring Break
- **Week 11**: Two-level full and fractional factorial experiments (Chapter 13).
  - **Lecture 24 (3-18-2019)**: Revisiting the 2^k full factorial design.
  - **Lecture 25 (3-20-2019)**: The 2^{k-1} fractional factorial design.
  - **Lecture 26 (3-22-2019)**: The general 2^{k-p} fractional factorial design.
  - **Homework 9 (Due 3-29-2019)**: Problems based on Chapter 13.
- **Week 12**: Applications of factorial designs (Chapter 14).
  - **Lecture 27 (3-25-2019)**: Design criteria for 2^{k-p} fractional factorials.
  - **Lecture 28 (3-27-2019)**: An introduction to response surface methodology.
  - **Lecture 29 (3-29-2019)**: Improving process capability with two-level factorial designs.
  - **Homework 10 (Due 4-3-2019)**: Problems based on Chapter 14.
- **Week 13**: Midterm II
  - **Lecture 30 (4-1-2019)**: From two-level to three-level factorial designs.
  - **Review Lecture (4-3-2019)**: Review of Lectures 14 - 29.
  - **Midterm II (4-4-2019)**: Primary focus: CUSUM and EWMA charts, process capability analysis, design of experiments for two-level factors, and response surface methodology.
  - **No lecture on 4-5-2019**.

- **Week 14**: Taguchi Methodology (Chapter 14).
  - **Lecture 31 (4-8-2019)**: A survey of process robustness studies/robust parameter design.
  - **Lecture 32 (4-10-2019)**: Design of experiments for robust parameter design
  - **Lecture 33 (4-12-2019)**: The signal and the noise in signal-to-noise ratios.
  - **Homework 11 (Due 4-19-2019)**: Problems based on Chapter 14 and lecture slides.
- **Week 15**: Acceptance sampling, and failure modes and effects analysis (Chapters 15 – 16).
  - **Lecture 34 (4-15-2019)**: Acceptance sampling, and why it is a bad idea.
  - **Lecture 35 (4-17-2019)**: Failure modes and effects analysis: What, why, who, when, how.
  - **Lecture 36 (4-19-2019)**: Failure modes and effects analysis: severity, occurrence, detection, and risk priority numbers.
- **Week 16**: Review for Final Exam
- **Week 17**: Final Exam

Course Work and Requirements:

	Percentage of Grade
Homework	15%
Midterm I	25%
Midterm II	25%
Final Exam	35%

- *Homework* will generally be posted on a Friday, and due the following Friday (**before lecture begins**). **No late homework will be accepted, and the grade for any late homework will be zero**. There will be 11 homework assignments accounting for 15% of your course grade. You may discuss problems with other students, but you *must* write your own solution independently, and you *must* provide the names of students with whom you had significant discussions.
- *Midterms* will be written exams, and each will account for 25% of the course grade. There will be no retaking of exams. On the rare occasion that a student is sick for an exam, the student *must* contact Dr. Sabbaghi *before* the exam begins, or accept a zero as the grade for that test.
- The *final exam* will constitute 35% of the course grade. Please do not make plans to leave campus before the scheduled final.
- Exams are based primarily on lecture and designated reading materials. You are responsible for what is discussed in class.

For both your homework and exams, please note the Purdue Honors Pledge: "As a Boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue."

Course Policies

Addressing Questions via E-mail: Please feel free to e-mail questions to the instructor, but reserve those that involve extensive computation or mathematical expressions for office hours. If your question involves programming, please be sure to e-mail a minimal working example of your code to the instructor.

Incompletes: Incompletes will only be given under emergency circumstances, e.g., a serious auto accident, death of family member, etc. (see the grief absence policy for further information). Incompletes will not be given to students failing the course.

Grading: The grading scale is predetermined so as to eliminate competition with other students, and to ensure that you always know your grade in the class. Your grade is based upon *your* performance only. Grades will not be curved.

Grade	Numerical range
A	90.00-100.00
B	80.00-89.99
C	70.00-79.99
D	60.00-69.99
F	0.00-59.99

Evaluation: Student feedback is essential for any course to be successful. Feedback questionnaires will be included in each assignment. These evaluations should be taken seriously, and will be addressed directly by the instructor.

Re-grading: All grade disputes are to be made on paper, and submitted *directly* to Dr. Sabbaghi. Discussions or arguments for re-grades will *not* be done in person. A student has until one week after receiving his/her grade to dispute the grade (in writing). Handling re-grades in this manner eliminates the "end of the semester" digging for points.

When disputing a grade, you should state the question, the dispute, and the number of points you feel you should have received for the question. If you do not state the number of points you think are reasonable for the re-grade, zero points will be give as the re-grade. Please note that when you ask for a question to be re-graded, the entire assignment may be re-graded, and there is a possibility of losing points.

Dropping the Course: The instructor reserves the right to *not* sign anyone out of the course once the deadline for dropping without the instructor's signature has passed. Please take care to pay attention to these dates.

Academic Dishonesty: Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section III-B-2-a, University Regulations] Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972].

Academic integrity is one of the highest values that Purdue University holds. You are encouraged to alert university officials to potential breeches of this value by either e-mailing integrity@purdue.edu, calling 765-494-8778, or contacting the Office of the Dean of Students (www.purdue.edu/odos). While information may be submitted anonymously, the more information that is submitted provides the greatest opportunity for the university to investigate the concern. Bonus points will be given to students who report instances of cheating.

Incidents of academic misconduct in this course will be addressed by the course instructor and referred to the Office of Student Rights and Responsibilities (OSRR, www.purdue.edu/odos/osrr) for review at the university level. Any violation of course policies as it relates to academic integrity will result minimally in a failing or zero grade for that particular assignment, and at the instructor's discretion may result in a failing grade for the course. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered. Use of instructor solution manuals or related resources will not be tolerated.

Attendance and Participation: Students: You are expected to attend lectures. You are expected to arrive on time, or before. You are expected to stay until the end of lecture unless you have asked in advance to leave early. You are expected to be prepared and participate. On the rare occasion that a student is extremely close to the cut-off value between letter grades, attendance and class participation may help.

When conflicts or absences can be anticipated, such as for many University sponsored activities and religious observations, you should inform the instructor of the situation as far in advance as possible. You should also meet with the instructor to discuss the absence and how, if possible, learning outcomes associated with any missed class activities may be addressed. For unanticipated or emergency absences when advance notification is not possible, you should contact the instructor as soon as possible by e-mail, or the Department of Statistics main office. When you are unable to make direct contact with the instructor and unable to leave word with the Department of Statistics because of circumstances beyond your control, and in cases of bereavement, you or your representative should contact the Office of the Dean of Students. The instructor will try to accommodate you either by excusing you or by allowing you an extension when possible. Ultimately, you are responsible for all required coursework and bear full responsibility for any academic consequences that may result due to your absence.

Links to the complete attendance policy and implications can be found at

www.purdue.edu/advocacy/students/absences.html and
www.purdue.edu/studentregulations/regulations_procedures/classes.html.

Instructor: You can expect that I will attend lectures. I will arrive in the lecture room prior to the start of lecture, and will end lecture on time. You can expect that I will be prepared for lecture, try my best to convey the information for the course, and show respect for all students.

If I am unable to attend lecture you will know in advance, and I will either cancel

class or provide a guest instructor. I will be present for my office hours, and available for scheduled appointments.

The amount of material covered in each lecture is governed by the speed with which we complete the material. Every group of students is different, and I would rather teach the material well (and have you learn it) than speed through the topics for the purpose of covering a preset number of topics. Accordingly, the course outline is subject to change as the course progresses.

Grief Absence Policy for Students: Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for missed assignments or assessments in the event of the death of a member of the student's family.

Counseling and Psychological Services Information: Purdue University is committed to advancing the mental health and well-being of its students. If you find yourself beginning to feel some stress, anxiety, and/or feeling slightly overwhelmed, try Well-Track. Sign in and find information and tools at your fingertips, available to you at any time. If you need support and information about options and resources, please see the Office of the Dean of Students for drop-in hours (Monday - Friday, 8:00 AM - 5:00 PM). If you or someone you know is feeling depressed and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at (765) 494-6995, and `www.purdue.edu/caps` during and after hours, on weekends and holidays, or by going to the CAPS office on the second floor of the Purdue University Student Health Center (PUSH) during business hours.

University Emergency Information: A safety briefing will be conducted on the first day of class. In the event of a major campus emergency or temporary suspension of classes, course requirements, deadlines, and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. You can get information about changes in this course by means of the course web page, or contacting the instructor via e-mail or phone. You are expected to read your Purdue e-mail on a frequent basis.

Violent Behavior Policy: Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent behavior impedes such goals. Therefore, violent behavior is prohibited in or on any university facility or while participating in any university activity.

Use of Copyrighted Materials: Among the materials that may be protected by copyright law are the lectures, notes, and other material presented in class or as part of the course. Always assume the materials presented by the instructor are protected by copyright unless the instructor has stated otherwise. Students enrolled in, and authorized visitors to, Purdue University courses are permitted to take notes, which they

may use for individual/group study or for other non-commercial purposes reasonably arising from enrollment in the course or the University generally.

Notes taken in class are, however, generally considered to be "derivative works" of the instructor's presentations and materials, and they are thus subject to the instructor's copyright in such presentations and materials. No individual is permitted to sell or otherwise barter notes, either to other students or to any commercial concern, for a course without the express written permission of the course instructor. To obtain permission to sell or barter notes, the individual wishing to sell or barter the notes must be registered in the course or must be an approved visitor to the class. Course instructors may choose to grant or not grant such permission at their own discretion, and may require a review of the notes prior to their being sold or bartered. If they do grant such permission, they may revoke it at any time, if they so choose.

Students with Disabilities: Purdue University is required to respond to the needs of the students with disabilities as outlined in both the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 through the provision of auxiliary aids and services that allow a student with a disability to fully access and participate in the programs, services, and activities at Purdue University.

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic behaviors based on disability, you are welcome to let the instructors know so that they can discuss options. You are also encouraged to contact the disability resource center at `drc@purdue.edu` or by phone 765-494-1247. If you have a disability that requires special academic accommodation, please make an appointment to speak with the instructors within the first three (3) weeks of the semester in order to discuss any adjustments. It is important to talk about this at the beginning of the semester. It is the student's responsibility to notify the Disability Resource Center (`www.purdue.edu/drc`) of an impairment/condition that may require accommodations and/or classroom modifications.

Nondiscrimination: Purdue University is committed to maintaining a community that recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. Purdue University's nondiscrimination policy can be found at `www.purdue.edu/purdue/ea_eou_statement.php`.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services, and activities consistent with applicable federal, state, and local laws, regulations, and orders, and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit `www.purdue.edu/report-hate` to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.