Advanced Statistical Methods for Engineering Research

EMEN 5610
Course Syllabus & Content Outline

Fall, 2014

Dr. Ray L. Littlejohn
W. Edwards Deming Professor of Management
Engineering Management Program

1. Course Description

This course combines intermediate and advanced statistical methods (specifically ANOVA) with practical research applications and computer software. It also explains and gives practical experience in the use commonly used statistical experimental design models including Two and Three-Way Analysis of Variance as well as Linear Regression (time permitting) for the solution of common business and industrial research problems. The statistical models are implemented and interpreted in the context of actual data sets using statistical software programs. Mandatory Prerequisites are: EMEN 5005 and EMEN 5900; OR APPM 4570/5570 and APPM 4580/5580, or the equivalent as assessed and approved solely by the instructor.

2. The Course Website and D2L

Unlike in the past, this semester I will be using D2L (Desire 2 Learn) as the Learning Management System for this class, NOT eCollege. You should take some time get familiar with D2L and the class website. In order to access D2L simply navigate to http://learn.colorado.edu. Once there you should look for our class (EMEN 5610) in the *2014 Fall Term group. Click on it to enter our class. All of the course content will be available to you by clicking the Content menu item in the gold bar of our page. You will see all of the content Modules on the left side. In the Administrative Information Module you will be able to get the Admin information for this course. Check out the site by browsing it heavily so you can become familiar with the site.
A Note on eMail Addresses and eMail in General
The University’s official means of communication is via your Colorado.edu email address. And, it is automatically set up in D2L to communicate that way. Therefore, every communication that I send will be through D2L and it will use your CU email address. So, plan on checking it and using it. You may redirect it as you like, but I will be sending correspondence to you via your CU email address.

In the past I have been totally overloaded responding to emails concerning class content. And, for particularly confusing topics I have had to respond with similar things numerous times. Therefore, this semester I will be using Discussion Forums on D2L they are linked up on the class website within each Lecture Unit. (The Discussion icon is a pair of green and blue text balloons.) You are encouraged to post any and all or your questions there. I will respond to each for all to see. As with all Discussion forums you should browse earlier posts to be sure your question has not already been posted and answered. And, if you would like to, if you are so inclined, you can respond to each other’s posts. I will not have a TA for this course, so I will be the primary responder. And, just so you now, when you make a post I will get an email message so your posts will not go unnoticed.

3. The Course Calendar and Schedule
The Course Calendar and Schedule is provided on the D2L class website in the Administrative Information Module. It lists all of the class events for the course, week by week. It should be your primary guide for knowing what we will be covering on a given week (class period).

4. Synchronous (Distance) Attendance in Class
This semester we are using BlueJeans (replacing Go To Meeting) to permit real time class “attendance” for distance students. On the course D2L website (described in the Welcome letter and in paragraph 2 above), you will find detailed instructions concerning how to make sure you are able to use BlueJeans by downloading and testing a required plug-in. Log in instructions are also on the D2L site as well as having been sent in the Welcome letter. However, as a precaution the login information, after you set up, per the instructions described above is: https://bluejeans.com/874597620

5. Instructor
Dr. Ray L. Littlejohn
Office: ECOT 414 – College of Engineering & Applied Sciences
Office Hours: Wednesday 10:00 am - 12:00 pm
            Friday 10:00 am - 12:00 pm

            Other days and times by appointment/arrangement, by phone per
            below, or by specially arranged BlueJeans sessions.

e-mail: Ray.Littlejohn@colorado.edu
Telephone (Office): 303-492-2034 or (Alt) 720-515-6066

6. Textbook / References

We will not be using a published textbook for this class. We will however be using
Text material as opposed to Power Point slides as the primary content delivery
mechanism for this class. The class text material was originally developed by Dr.
Jeffrey Luftig, but I have modified the, rather heavily in some instances, to fit my
style and approach.

For those of you who would like some information on reference books for this
course, I provide the following:

1. The text that was recommended for 5900, Design of Experiments in Quality

2. The large PDF files that were used in 5900 and served as the basis for the
   above book: Experimental Design and Industrial Statistics – Level 3, by
   Jeffrey Luftig, Luftig & Warren International, 1993 will also be used to
   support some of the lecture material. If you need copies of these files, the
   will be made available.

   For actual Experimental Design text books, there are 3 “classics”. The first
   one is pretty easy and the other two are industry standard and very
   comprehensive but are a bit more complicated. If you plan to really get into
   Experimental Design and the statistical analysis of the data from
   experiments, you might consider getting copies of them. They are:

   Charles R. Hicks, Saunders College Publishing, 1982. This text is pretty
   easy to read and is consistent with what you have learned in the past.
   Used copies should be pretty inexpensive.

Edition, by B. J. (Ben) Winer, McGraw-Hill, 1971. Later editions of this classic are available and involve co-authors who picked up the gauntlet when Winer died. They are OK, but they are not the solo Winer book. Used copies of the 2nd edition should be pretty inexpensive if you can get one. (Collectors may be snapping them up, I don’t know.)

5. The second of the Golden Oldies: Experimental Design: Procedures for the Behavioral Sciences, 1st Edition, By Roger E. Kirk, Brooks/Cole, 1968. This one truly is a classic. It is so popular and well known that, like Winer’s book, it is just referred to by the author’s last name: that is, “Kirk” or “Winer” (and even “Hicks” who is in that category too, though quite a bit lower on the scale, ordinarily). Kirk, is in its 4th Edition, published by Sage Publications, 2013. In the 4th edition you get everything form the 1st edition has and more, and not much of the original material has been changed unlike the more current versions of Winer.

So, the recommendation is Kirk, 4th Edition then Winer, 2nd Edition if you really want to get the nitty gritty of experimental design.

6. And, is in 5900, a textbook that is highly recommended as a compendium of statistical tests for any student serious about utilizing statistical methods in research is the Handbook of Parametric and Non-Parametric Statistical Procedures by David Sheskin, published by CRC Press. It is in the 5th edition and is a book that you should have as a reference text for both academic and professional situations. It is my personal favorite and I have purchased upgraded editions over the years. It definitely is a “go to” reference book.

Some of the other textbooks though not necessarily on ‘Experimental Design’, which will provide details on statistical analysis for some of the material presented in this course include the following publications. (The following list is only a sample of references and is not intended to constitute a collectively exhaustive list):


7. Course Structure / Approach

The Course Calendar and Schedule document outlines, by week, the content material that will be covered. For each topic covered, it will be the student's responsibility to:

1. have read/studied/acquired the assigned content material before the corresponding lecture; and

2. attend the class, and participate in classroom discussions of the material presented (on-campus students)

OR

(distance students) watch the relevant class video, and post questions associated with the content on the course website, and

3. complete and submit by the required due dates all homework assignments made following each content unit. These assignments are designed to allow the student to confirm that the content presented in any given content unit has been learned and mastered, before material of increased complexity is presented in subsequent lectures.

There are two major course requirements, Homework assignments and a Term Team Project and one minor requirement, Binary Assignments.

(1) **Homework Assignments:** Each student will complete and electronically submit all homework assignments. The 9 assignments in this course are equally weighted. (For details see the Course Calendar and Schedule on the course website.)

(2) **Term Team Project:** Students will be assigned to teams, and each team will be provided with a research problem and associated data set from an actual business application (i.e. Research Study). It will be the team's responsibility to:
(a) Perform all correct and appropriate statistical analyses required to answer the research question(s);

(b) Prepare a report suitable for presentation to a Chief Executive Officer and management team in business or industry; and

(c) Provide a presentation to the class on the methods utilized, techniques employed, and the results obtained. The members of each team will receive the same grade for the final project.

(3) Binary Assignments: AS in the past, binary assignments will be used to introduce in a fast and easy way very important concepts that are intended to provide insight and understanding. They will serve as “border busters” in the sense that their contribution is rather minor and there is no reason for not get the maximum possible benefit from them. Their contribution is described in the next section.

8. Assignments, Grading & Final Course Grade Calculation

Homework Assignments:
There will be 9 Homework Assignments due throughout the semester. They will be evaluated and a point score given, as well as a proportion score based on the highest student score. These assignments will be formally assigned when we finish each lecture section and will be due one week later. (See the details in the Course Calendar and Schedule posted on the course website.) The combination of all of the homework assignments will constitute 85.5% of the final course grade, 9.5% each.

Team Project:
As described above, the participants in the course will be divided into teams and assigned a real business project on which to work. The final presentation for the team project is scheduled for class time (5:30 PM until) on Tuesday, 16 December in the same room where we will hold class. (Based on what I have been able to schedule at this time this should be firm, but just in case, we may have to be flexible on the time. I will provide absolute confirmation as soon as I can. The Team project will be worth 9.5% of your final grade, just like each homework assignment.

Binaries:
In addition to the homework assignments and the term project as described above, I will make use of several Concept assignments previously called “Binary
Assignments.” Now, however, they will not be worth just 1 or 0, they will be scored on a 1-10 point rating scale. At the end of the semester, the score on each binary item will be accumulated and the total for all of the “binaries” will be divided by the total number of binary points, making a proportion. This proportion score will constitute the remaining 5% of your final course grade. These binary points are basically my gift of 5% to you, so there will be NO additional allowances in scores when it comes time to assign final grades. If you are just under the line, you will NOT get the higher grade. So make sure you do the best you can on everything, especially these freebies, all along the way so you will have no regrets in the end. Remember, I don’t “give you a grade”, I simply report the grade you earned!

**Final Course Grades:**
The final grade for the course will be assigned on the basis of the following weighting:

- Homework Assignments 85.5% (0.855)
- Team Project 9.5% (0.950)
- Binaries (Boarder Buster) 5.0% (0.050)

For purposes of illustration, the final grade will be calculated by assigning the weighted averages of the scores received

e.g.  
Homework Assignment 1: 83.55  
Homework Assignment 2: 95.05  
Homework Assignment ……: ....  
Homework Assignment 9: 91.37  
Average Homework Score: 88.50  
(for All 9 Assignments)

Team Research Project Score: 97.50

Binary Score: 97.00

Total Weighted Average = (88.50*0.855) + (97.50*0.095) + (97.00*0.050) = 89.78

The following table will be used for assigning all course grades in the ranges specified based on total weighted average scores. The final weighted average from the example above corresponds to a B+ which is the grade that was earned.
The D2LGradebook:
After grading each submission, it will be entered into the D2LGrade book and will be available for examination at any time.

All assignments are expected to be completed in conformance with generally accepted standards associated with Academic Honesty. The CU Honor Code website provides and explanation of these standards. With each unit of work you will be asked to sign the Pledge and make it a part of your submission. If you at any time have any questions regarding what is and is not appropriate in this area, make certain to speak with the Instructor.

9. Syllabus addendum for the EMP – Fall 2014 (rev. 08/19/2014)

PROGRAM & UNIVERSITY PROVISIONS AND REQUIREMENTS

a. Positive Learning Environment

The University of Colorado Boulder (CU-Boulder) is committed to maintaining a positive learning, working, and living environment. The University of Colorado does not discriminate on the basis of race, color, national origin, sex, age, disability, creed, religion, sexual orientation, or veteran status in admission and access to, and treatment and employment in, its educational programs and activities. (Regent Law, Article 10, amended 11/8/2001). CU-Boulder will not tolerate acts of discrimination or harassment based upon Protected Classes or related retaliation against or by any employee or student. For purposes of this CU-Boulder policy, "Protected Classes" refers to race, color, national origin, sex, pregnancy, age, disability, creed, religion,
sexual orientation, gender identity, gender expression, or veteran status. Individuals who believe they have been discriminated against should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Student Conduct (OSC) at 303-492-5550. Information about the ODH, the above referenced policies, and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://hr.colorado.edu/dh/.

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, color, culture, religion, creed, politics, veteran’s status, sexual orientation, gender, gender identity and gender expression, age, disability, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See policies at http://www.colorado.edu/policies/classbehavior.html and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code.

b. Academic Integrity, Plagiarism, and the EMP Honor Code Quiz

All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Information on the CU Honor Code can be found at http://www.colorado.edu/policies/honor.html and at http://honorcode.colorado.edu.

The faculty of the Engineering Management Program (EMP) believe that a culture of integrity is essential to both the long-term, personal success of our students and to the economies and countries in which they live and work. Therefore, EMP has created an Honor Code Violation Policy that specifies a program-specific, academic consequence for a second violation of the CU Honor Code:

EMP HONOR CODE VIOLATION POLICY

Any and all violations of the CU Honor Code in EMP classes will be
reported to the Honor Code Council. As per CU’s policy, the faculty member will determine the academic sanction for an offense. The CU Honor Code Council will determine any additional, non-academic sanctions. This portion of EMP’s policy is a restatement of the Honor Code policy approved by the CU Board of Regents.

A second violation of the CU Honor Code by any Engineering Management graduate student will result in the academic sanction of dismissal from the Engineering Management graduate program.

The development of the Internet has provided students with historically unparalleled opportunities for conducting research swiftly and comprehensively. The availability of these materials does not, however, release the student from citing sources where appropriate; or applying standard rules associated with avoiding plagiarism. Specifically, the instructor will be expecting to review papers written by students drawing ideas and information from various sources (cited appropriately), presented generally in the student's words after careful analysis, synthesis, and evaluation. An assembly of huge blocks of other individuals' existing material, even when cited, does not constitute an appropriate representation of this expectation. Uncited, plagiarized material shall be treated as academically dishonest. If the student is confused as to what constitutes plagiarism, s/he should review the CU Honor Code on this topic, and refer to the following excellent resources:
http://www.northwestern.edu/uacc/plagiar.html and
http://owl.english.purdue.edu/owl/printable/589/

Students agree that by taking this course all required papers may, at the discretion of the instructor, be subject to submission for a Textual Similarity Review to Turnitin.com for the detection of plagiarism. All submitted papers will be added as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers in the future.

Finally, the Engineering Management Program faculty have established a policy whereby all students enrolled in an EMP course must, at the beginning of each semester, take and pass a basic quiz about the CU Honor Code. Each student must take the quiz once each semester, regardless of how many courses they are taking in the department. You must receive 100% on the quiz in order to pass the exam. The instructions and quiz will be made available on D2L when the student enrolls for any EMEN course or any course cross-listed, co-listed or co-located with an EMEN course.

c. Disability Services

If you qualify for accommodations because of a disability, please submit to your
professor a letter from Disability Services in a timely manner (for exam accommodations provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at dsinfo@colorado.edu. If you have a temporary medical condition or injury, see Temporary Medical Conditions: Injuries, Surgeries, and Illnesses guidelines under Quick Links at Disability Services website and discuss your needs with your professor.

If you have a temporary medical condition or injury, see Temporary Injuries under Quick Links at Disability Services website and discuss your needs with your professor.

d. Religious Observances

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or class attendance. Students for whom religious observances conflict with class schedules should contact the instructor no later than two weeks before the potential conflict to request special accommodations. See full details at http://www.colorado.edu/policies/fac_relig.html.

e. Class Attendance for On-Campus Students

Unfortunately, some on-campus students have used the availability of the lecture videos to stop attending classes, and rely instead on the videos to learn the material. In the opinion of the faculty, this choice often results in a significant reduction in the quality of the educational experience for both on-campus and distance students; therefore, EMP has established the following policy for all on-campus students registering for an EMEN course:

Class attendance for all on-campus students is expected and required. Unexcused absences may incur a penalty against the student’s final grade.

f. Access to Recorded Course Lectures

The lecture videos are available for streaming and downloading via Desire2Learn (D2L) by all students registered for their respective EMEN course; whether they are on-campus or distance students. This improves the quality of the educational experience for all students, enabling any student to review each lecture as many times as needed to master the material. If you have difficulties accessing the video, FIRST check Technical Help / FAQ at:
https://cuengineeringonline.colorado.edu/distance-delivery/technical-help-faq. If you are still experiencing difficulties, please contact: caete@colorado.edu.

g. **E-mail Account**

You are expected to use your CU student e-mail account. All of your e-mail from professors and the university will be sent to your CU e-mail account. You can choose to redirect your CU email to an alternate (work/personal) email account. For assistance in activating your email account and forwarding email, contact the Help Desk at 303-735-HELP or Help@colorado.edu.

h. **Recording of EMP classes**

Please note that students attending EMP classes live, whether on-campus or via teleconferencing, may be recorded.

i. **Proper Use of Copyrighted Materials**

The Engineering Management Program (EMP) has a large distance learning population and, as such, many copyrighted materials are offered electronically to students. EMP has the responsibility to comply with the copyright law regulating distance education for a non-profit, state institution, i.e., the Technology, Education and Copyright Harmonization (TEACH) Act of 2002. It's the student’s responsibility to comply with U.S. copyright law with respect to the use and sharing of the electronic materials (this includes the videos of class lectures) provided within the program.

j. **Appropriate Classroom Use of Laptops**

Although having a laptop in class opens up new learning possibilities for students, sometimes students utilize it in ways that are inappropriate. It is easy for your laptop to become a distraction to you and to those around you. Therefore, please refrain from instant messaging, e-mailing, surfing the Internet, playing games, writing papers, doing homework, etc. during class time. Acceptable uses include taking notes, following along with the instructor on PowerPoint, and other directed class activities, as well as working on assigned in-class activities, projects, and discussions that require laptop use.

More follows….
## 10. Lecture Topics & Associated Discussion Points (A general outline.)
(See the Course Calendar and Schedule for Specific details.)

<table>
<thead>
<tr>
<th>Primary Lecture Topic</th>
<th>Case Studies</th>
<th>Statistical Tests Reviewed &amp; Discussion Points</th>
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<tbody>
<tr>
<td>Introduction to the Course &amp; Course Requirements Review</td>
<td>N.A.</td>
<td>N.A.</td>
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<tr>
<td>* Syllabus</td>
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<td>* Content Outline</td>
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<td>* Assignments / Papers</td>
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<td>* Examination</td>
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<td>* Suggested Support References</td>
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<td>Review of EMEN 5900 / APPM 4580/5580 Final Examination Solutions</td>
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<td>* One Way ANOVA &amp; Blocking</td>
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<td>* Post-Hoc Analyses and Procedures</td>
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<td>* Non-Parametric Analyses and their Post-Hoc Procedures</td>
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<td>Primary Lecture Topic</td>
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<td>Statistical Tests Reviewed &amp; Discussion Points</td>
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<td>Two Factor Analyses</td>
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<td>* The Design &amp; Analysis of Factorial Experiments for 2 Factors : The Basics based on 2x2 designs.</td>
<td>The Case of the Flagging Labels : Maximizing Label Adhesion for Anheuser-Busch (J=3, K=3)</td>
<td>* Two Way ANOVA - Model I</td>
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<td>Setting Up the Lincoln, Nebraska Injection Molder (J=2, K=4)</td>
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<td>Designing a Humidity-Resistant Packaging Method for Baked Goods (J=5, K=4)</td>
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<td>The Case of the Saw Blade Suppliers : Make Us More Money (J=2, K=2)</td>
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<td>Rolling Can Stock : Where’s the Earing Coming From ? (J=3, K=3)</td>
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<td>Primary Lecture Topic</td>
<td>Case Studies</td>
<td>Statistical Tests Reviewed &amp; Discussion Points</td>
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<td>The Design &amp; Analysis of Factorial Experiments with More than 2 Treatments</td>
<td>How Should I Run My Heat Treat Furnace ? (J=2, K=2, L=2; Model I, Fully Crossed)</td>
<td>* Three Way ANOVA - Model I</td>
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<tr>
<td>* The Design &amp; Analysis of $2^3$ Factorial Experiments</td>
<td>Can I Control Density on the Molded Preforms ? (J=2, K=3, L=2; Model I, Fully Crossed)</td>
<td>* Three Way ANOVA - Model II</td>
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<tr>
<td>* The Design &amp; Analysis of Factorial Experiments : 3 or More Factors at 2 or More Levels</td>
<td>Let's Eliminate Earing Once and for All ! (J=3, K=3, L=15; Model III, Fully Crossed)</td>
<td>* Three Way ANOVA - Model III</td>
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<td>Should We Purchase the New Bubble Gauge ? (J=3, K=3, L=3, M=5; Model III, Partially Nested)</td>
<td>* Underlying Assumptions and Determining Expected Mean Squares / Appropriate Error Terms (AETs)</td>
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<td>* When There's No AET : The Quasi-F Ratio &amp; Satterthwaite's Formula</td>
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<td></td>
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<td>* Fully Crossed, Partially and Fully Nested Designs</td>
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<td></td>
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<td>* Advanced Interaction Analysis: Making Interactions Your Client's / Company's Friend</td>
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More follows...concerning the supplemental topics of Simple and Multiple Regression analysis, the Lecture 11 Material. This material was previously covered before Team Projects were utilized. However, since the Team projects are important they take precedence over this material which is now considered to be optional. N, it is listed next for informational purposes.
<table>
<thead>
<tr>
<th>Primary Lecture Topic</th>
<th>Case Studies</th>
<th>Statistical TestsReviewed &amp; Discussion Points</th>
</tr>
</thead>
</table>
| Review of Content from EMEN 5005/5900 & APPM 4570/5570, APPM 4580.5580) – Simple Regression and Multiple Regression. | Sample Data Sets & Problems for Review Provided by Instructor (Course Website) | * Using Simple Regression to Describe a Linear Relationship  
* Testing Inferences About the Population Regression Line, the Intercept ($\beta_0$), and Slope ($\beta_1$), and the Underlying Assumptions of the Model  
* Assessing the Fit of the Regression Line – Using the ANOVA Table  
* The Coefficients of Correlation, Determination, and Alienation  
* Prediction and Forecasting; Confidence and Prediction Limits  
* Using SPSSPc for Correlation & Regression Analyses (both Simple and Multiple).  
* The t-test for means via regression.  
* ANOVA Via Multiple Regression.  
* Generating Output & Testing Assumptions Using MVPStats and SPSSPc |
<p>| Measures of Relationship: Indices of Association and Correlation. (We will not likely have time to cover all of these techniques, | Lecture Presentation Handout (pdf file) Provided by the Instructor | An overview of the major indices and tests associated with measures of relationship for Nominal, Ordinal, and Continuous |</p>
<table>
<thead>
<tr>
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<tr>
<td>but I will make them available to your if you don’t already have them from EMEN 5900.</td>
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<td>variables, including:</td>
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<td>Multiple Regression is too important as a supplemental topic to not cover, so it</td>
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<td>* Contingency Table Analysis; Phi, C, V</td>
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<td>will be given primary emphasis over these measures of association and correlation!</td>
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<td>* Youden’s J-Index of Predictive Efficiency</td>
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<td>* Cohen’s Kappa</td>
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<td>* Kendall’s Coefficient of Concordance</td>
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<td>* Spearman’s Rank Correlation Coefficient</td>
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<td>* The Biserial and Point-Biserial Coefficients</td>
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