Mechanical Engineering Laboratory: A Capstone Senior Course

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Abstract

This paper characterizes the current Mechanical Engineering Laboratory course taught at Baylor University. As a course typically taken in the last semester of their senior year, student review topics taught in the fluids/thermodynamics stem of the mechanical engineering program, as well as learn new experimental techniques. For approximately the first half of the course, each week consists of a one-hour lecture, a three-hour practical measurement/demonstration session (often involving calibration techniques) and a three-hour laboratory usually using the measurement techniques talked about in the previous measurement/demonstration session. The last half of the course is a laboratory project, accomplished in teams of two. The students accomplish a written test plan and make a presentation on the test plan early in the course to get the necessary background information. This enables the students to purchase required materials and begin fabrication, if necessary, for the final project early in the course. Topics have included a force balance for the wind tunnel, automated velocity control for the wind tunnel using Labview, internal combustion engine performance, wind power, and development of a heat flux meter. The course ends with a formal final project report and a formal final briefing. While a lot of effort, the course was highly praised during the last ABET accreditation visit. Student feedback from industry also confirms this. A discussion will be made of assessment tools used in this course. This course is taken in addition to a capstone senior design course.

Introduction

All accredited engineering programs must have a component of experimental design in their curriculum. ABET Criterion 3b states "Engineering programs must demonstrate that their graduates have an ability to design and conduct experiments, as well as to analyze and interpret data[1]." How does one achieve such a desirable end? Traditionally, lecture format courses have been taught but these may not be the best way to achieve the desired result.[2,3] Most universities have blended lectures with a more hands on approach.[4-6] At Baylor University, mechanical engineering majors have two significant laboratory courses. The first is a materials laboratory in the spring of their senior year that covers the basics of materials testing; hardness, stress and strain. The course is a three credit hour course with two hours of lecture and three house of lab. Students are exposed to collecting data and writing lab reports, but at this level, they do not do error analysis outside of a histogram. In the current Baylor University curriculum, detailed laboratory measurements and error analysis are accomplished in the spring of the senior year when students are scheduled to take EGR 4335, Mechanical Engineering Laboratory (ME Lab). While the materials lab is the culmination of the materials stem in the mechanical engineering curriculum at Baylor University, ME Lab is the culmination of the fluids/thermodynamics track. It is also considered the capstone course in experimental design and measurement. This course will continue to be a key contributor to assessment as the department prepares for an accreditation visit in Fall 2006. ME Lab figures prominently in the following ABET Criterion 3 categories[1]:

b. an ability to design and conduct experiments, as well as to analyze and interpret data
g. an ability to communicate effectively
k. an ability to use the techniques, skills, and modern engineering tools necessary for an engineering practice.

The skills learned in ME Lab are a major part of the critical formation of laboratory skills in a student's engineering development at Baylor University. As such, students are exposed to many different techniques of measurement, data collection, and are required to develop communication skills, both written and oral. This paper outlines the course as it presently is being taught and highlights some of the assessment processes in place.

ME LAB Organization

ME Lab is a three credit hour course taught as one hour of lecture and six hours of laboratory. Its course description is:

> "Measurement of fluid flow, heat transfer, power, and other properties of mechanical equipment. Design of experiments, selection and use of data acquisition systems, data reporting, and presentation."[7]

Course objectives state[8]:

1. Learn the important tools and concepts associated with work in a mechanical laboratory including; experimental methods and techniques, data-analysis techniques, engineering measurement systems, and test equipment/facilities.
2. Learn how to plan and conduct an experiment
3. Learn how to evaluate experimental data
4. Learn how to present your results, in both written and oral forms

Because of the desire to give students more hands on experience, two sections of the course are offered with typically 8 to 10 students per section. The course is only taught in the spring semester. The lecture is currently given on Tuesday morning and is one hour in length. To ease professor workload, both sections are scheduled for the same lecture period. The labs are given on Tuesday and Thursday afternoons. While this would normally require six hours of lab time per lab day for the professor, the lab periods are scheduled for a one-hour overlap in the middle of the lab periods. For instance, Section 01 would meet from 1 to 4 pm but only spend from 1 to 3 pm in the laboratory. At 3 pm Section 02 would arrive in the laboratory and they would be scheduled from 3 to 6 pm. Actual laboratory time for Section 2 would be from 3 to 5 pm. The hour overlap for Section 1 and the last laboratory hour not spent in the lab for Section 2 is theoretically used by the students for reducing data. Students are not forced to work in the lab or on the computer during this hour. They are treated as responsible adults and know the requirements to get the work done by the due date, however, the professor is available during this hour should they need help.

The course content is basically divided into two parts over the 15 week semester: seven out of the first 10 weeks are devoted to developing laboratory and communication skills and the remaining eight weeks are devoted to developing and accomplishing an experimental project.

Grading Criteria

The course assessment is divided between individual (65 % of total course) and team (35 % of total course) exercises. Grading for the course is comprised of the following:

Lab Reports (7) (Individual)	30 %
Pre-labs (Individual)	10 %
Project Test Plan (Team)	10 %
Final Project (Team)	25 %
Midterm (Individual)	20 %
Professor Points (Individual)	5 %

Lab reports account for a significant portion of the final grade. The lab reports are written on a series of seven predetermined laboratories that the students accomplish in the first part of the course. The data for each lab report are taken as a section during the Thursday lab period however; the written lab report, to include data reduction, is accomplished individually. The report format used is a memo format developed at Baylor University (see appendix A) which is strictly adhered to, much like a prescribed format for publication at any conference or in any journal. This is usually the students' first exposure to such a criterion and it takes several iterations for them to get it correct. Individual written work allows for assessment of each student's written communication skills. Overall lab grades are tracked for each student as well as the "General" grade which includes format, neatness, spelling and grammar. Grading each lab report is time consuming. Lab reports are due on the following Tuesday during the lecture. Late work has a penalty of a 25 % reduction for the first 24 hours and receives a 0 % after that time period. A student must turn in a report even if it is to receive no credit. Experience shows this is sufficient time for students to accomplish quality work but initially some students wait until Monday to start their lab reports and receive low grades. Eventually students realize that more time and effort must be put into this exercise for a quality product.

For each laboratory, a prelab is given out at the end of the Tuesday laboratory period. It is due at the beginning of the Thursday laboratory period. This prelab is a short introduction which may include questions on physical concepts or contain sample data similar to what might be taken that week during the Thursday lab period. A major purpose of the prelab is to introduce the students to the calculation technique required to reduce the data to be taken. The primary focus of the course is on measurement of fluid flow and energy transfer. The experiments conducted all involve fundamental physical principles which the students are expected to know or to review on their own. A laboratory handout is given out each week at the end of the Tuesday laboratory period, well before the Thursday laboratory period, which outlines some of the fundamentals as a review. Little time is available for instruction in fluid mechanics, thermodynamics or heat transfer during the course. During the Tuesday lecture, the measurement technique is discussed using PowerPoint slides with diagrams and pictures of equipment. If the equipment is available in the laboratory it is sometimes brought into the classroom for display.

The Project Test Plan is accomplished during the fourth and fifth weeks in the semester. Prior to the semester, the professor develops a list of possible experiments from which the students, in teams of two (three if there is an odd number of students in the section), can select for their semester project. The current semester had 17 possible choices. Students are also free to develop their own experiment or to support an external agency such as the NASA Texas Space Grant Consortium. These two weeks, early in the semester, are dedicated to defining the project as well as detailing final expectations. In the third week of the course, students select teams and are given a form to, first, list the team members, and second, list their top three choices in rank order. Students can work with any individual that they choose to in their own section. The professor does not select teams. The professor collects the forms during the second week and seeks to match teams with projects based on their requests and their skill sets (i.e. Labview, Matlab, strength in a particular academic area, etc.). The lecture during the fourth week is devoted to designing experiments. The lecture during the fifth week is on report writing. During the Tuesday laboratory period of the fourth week, the student teams meet with the professor for approximately 15 minutes to further define their project. It is a time for the student to ask questions about requirements and project direction. The professor describes the vision for the project. Lab periods are then used for researching the topic. Test plan reports are due at the beginning of the sixth week Tuesday lecture. These reports follow a prescribed format which has some similarity with the ASME standard used for journal submissions[9,10]. During the Thursday laboratory period of the fifth week, the student teams make a 10 minute presentation to the other members of the section and any faculty who can attend. Five minutes of questions follow. The written report is worth 5 % of the final grade as is the presentation. Assessment of team projects will be discussed later in the paper.

The Final Project report is due on the last day of classes, the final Thursday laboratory period. During this period, students also give a 15 minute formal presentation over their topic. Presentation sessions are open to the public. Other professors and students not in the course do attend. The written project report is worth 15 % of the grade and the presentation is worth 10 %.

The midterm exam is, in reality, a final exam on first part of the course. It is a written exam accomplished during a two hour exam period. The exam consists of two parts, the first being a closed book portion testing knowledge of experimental techniques and vocabulary. The second part of the exam is given upon completion of the closed book portion of the examination. This part is open book and is more rigorous in nature, containing such things as uncertainty analysis problems, thermocouple laws, velocity measurement and data acquisition.

Lastly, professor points are points assigned by the professor based on class participation, laboratory participation, experimental notebook maintenance, completion of draft paper, etc. At 5 % of the final grade, it can make the difference if someone is close to the next higher letter grade at the end of the course.

First Part – Developing Laboratory and Communication Skills

As previously mentioned, seven of the first ten weeks are devoted to learning measurement techniques and using laboratory equipment. The current syllabus for this portion of the course is as follows:

Table 1 – First ten weeks of EGR 4334, ME Lab

Week	Tuesday Lecture	Tuesday Lab	Thursday Lab
1	Introduction	Error Analysis	Data Reduction
2	Pressure Measurement	Calibrate Transducer	Orifice Lab
3	Fluid Flow Measurement	Calibrate Hot-wire	Cylinder Drag Lab
4	Design of Experiments	Project Plan Meetings	Work Session
5	Report Writing	Work Session	Plan Presentations
6	Fluid Flow Measurement	Boundary Layer Measurement	IC Engine or Weir Lab
7	Temperature Measurement	Thermocouple Demonstration	Heat Exchanger Lab
8	Electrical Measurement	Filtering Demonstration	HVAC Fluid Flowrate Lab
9	Force, Torque and Strain	Strain gage/ bridge circuit demo	Heat Pump Lab
10	DAQ/Processing	DAQ Demo	Work session for final project

For the first half of the course, each week consists of a one hour lecture, a three hour practical measurement/demonstration session (most often involving some sort of calibration) and a three hour laboratory usually using the measurement techniques talked about in the previous measurement/demonstration session. For example, on week three, the students are taught in the lecture about fluid flow measurement to include the hot-wire anemometer. That afternoon the students calibrate a hot-wire probe using a pitot-static tube with an accurate pressure transducer as the calibration source. On the Thursday lab session, the students use that calibration to measure the downstream wake of cylinder and calculate drag using a momentum deficit technique. Week seven is dedicated to temperature measurement. The lecture covers the use of various temperature measurement devices from thermometers to thermocouples to liquid crystals. The demonstration session has various stations set up for students to experience calibration of a handheld digital thermometer using a digital calibrated source and both boiling water and $0^{o}C$ water/ice slurry. Various types of thermocouples are available for students to make measurements of voltage and to convert voltages to temperature using the tables. Zero reference junctions are displayed and used. Integration with a data acquisitions system is also demonstrated. The experiment for that week is to characterize the performance of a shell and tube heat exchanger using temperature measurements obtained with a data acquisition system.

Assessment in a course that has teams presents a problem. Sixty-five percent of the graded items are accomplished individually. Prelabs are similar in concept to homework and are very straightforward to grade. Again, this is an individual grade. Lab reports are graded according to a guide which is given to each student on the first day of class (see Appendix A). The grading sheet describes what is to be included in each lab report section. Often the students do not refer to this guide and waste valuable points by not including all that is required. While the entire lab is about communicating data and results, ten percent of the lab grade specifically assesses written communication and is devoted to format, neatness, spelling and grammar.

Participation in class and in the lab exercises is noted by the professor. While the Tuesday lab period is a hands-on demonstration, it has no formal grade yet it does have deliverables at the end of the lab period, for instance, a calibration graph of a pressure transducer. Notes are made by the professor for positive traits, group leadership and how well the student interacts with other students. This assessment becomes part of the 5 % Professor Points. In the Thursday lab period students are collecting data for their lab write-up. Students are required to have a spreadsheet/data sheet and will be graded on completeness of the sheet when the lab is turned in. In the Thursday lab, students again are presented with the task and are not necessarily told how to complete the lab. Decisions on data points and number of samples must be made by the group. Observations are made by the professor as to which students are leaders for the lab period.

During week four, the students are beginning to learn about their chosen project. Project assignments and teams are announced during the lecture. Students are asked to make an appointment for 15 minutes during the afternoon lab period to discuss the project further with the professor. Here is where the scope and expectations are discussed. This portion of the course is a group project and students work in teams of two (one group of three if there is an odd number). The dilemma for this portion of the course is how to assess individual contributions and record an individual grade. A new procedure is being implemented which requires students to attach a cover letter to the Test Plan Report detailing the contributions of each team member to the overall project. Grades can then be assigned individually; however, the grades may in actual fact be the same for each team member. During the project presentations, the professor assesses each team member individually (See Appendix B). Students are also asked to review and critique the presentations (See Appendix C). Students put their names on their critique sheets and these are collected at the end of the presentations. The individual student responses to the presentations are part of the Professor Points. A student who does not accomplish the evaluation in a serious manner will lose points on the final grade. All the critiques are gathered, compiled, and type-written comments are given to each student/team. Feedback to the presenters is important for their improvement. The Test Plan Report is evaluated using the form in Appendix D. The project is graded and individual grades can be adjusted based on their contribution to the report. Handouts for the Test Plan Presentation and Report are given to the students so they are aware of what is required for each section of the report. ASME writing standards are used where applicable and a writing guide is given to each student to help them understand what is required.

Lastly, a traditional exam is given to evaluate knowledge gained from the first part of the course. This is the only exam in the course as there is no final exam. The final report is in lieu of a final exam. The exam is given in two parts. The first part is a closed book exam which evaluates knowledge and some application of the material. The second half of the exam, given to the student when the closed book portion is completed, is comprised of problems over measurement techniques and equipment. An uncertainty analysis problem is also included on the exam. Questions can be worded to specifically support aspects of the ABET Criterion 3.

Second Part – Applying Laboratory and Communication Skills

During the last part of the course the students work on their assigned project. The lecture hour is used for students to meet with their professor and report weekly progress. Students are asked to have a list of accomplishments for the previous week and what goals are set for the next week. Problem areas or areas where the professor could help are discussed. Previously identified in the Test Plan Report were items that needed to be purchased or designed and built. Ideally these should be accomplished by the beginning of this portion of the class. Lab periods are work sessions and allow the student teams to have a time in their busy schedule where they can work together without conflicts. The professor is available during these times for questions or support on their project. Students enjoy this self-paced work environment; however, the weekly meetings do provide accountability. Students are required to keep one lab notebook per team and these are evaluated during the weekly meetings. Students are asked to turn in a draft of the final report one week prior to the final project due date. Students who do not turn in substantial drafts run the risk of losing Professor Points. Detailed requirements are given to the students for the final presentation and report. This is a formal presentation and formal report which translates to business attire for the presentation and a complete report with abstract, table of contents, nomenclature, lists of figures and tables, etc. Fifteen percent of the final project grade is given to spelling, organization and grammar. The grade for the entire report is an indication of the team's ability to communicate difficult concepts. Again, with the final report the student team turns in an executive summary detailing what the team members contributed and may be used to adjust the final project grade. Individual peer assessment is done by private e-mail at the end of the course. For the presentation, students are graded individually.

Reflections on the Course

The ME Lab course is a very time intensive course for both professor and student. At the beginning of the course, students are asked to write a lab report each week and they often feel this is excessive. Because of the individual nature of assessment, this is a necessity as students must be evaluated on their written communication ability. At the beginning of the course skill levels in the area of writing are varied, however, by the end of the course marked improvement is shown and students have confidence in their abilities. These communication skills are often not appreciated until the student enters the workplace. Several student comments sum up the experience:

"I learned more in ME Lab than I ever did in the tech writing course we have to take as engineers. I wanted to tell you thanks for all of your hard work because it has really helped."

"Recently I have been working on a report for a project and it reminds me of ME Lab. It really is very similar and I think they have been pleasantly surprised with my writing and proof reading skills. And of course I know how to make all the spreadsheets and documents look good. It is a lot like the report we wrote at the end of the semester for the engine. It feels like home!! So, thanks for all you taught us because I'm already using it. And, something else I learned, documentation on your work is a very valuable thing. We worked on a project before this and I felt like I was on the phone all the time asking why someone had done something or where they got their information. It is good to come in knowing that things need to be uniform and documented, especially when working with a team."

The course was also highlighted in the most recent ABET accreditation visit as a course which "offers a wide array of practical experiments while integrating uncertainty analysis and design of experiments content." Clearly, the course fulfils its responsibilities and has a definite impact on the students.

Future of ME Lab

While the course is fulfilling its purpose, a concern of the author is the lateness in which it occurs in the curriculum. A student on the four year traditional track must then take ME Lab and the senior capstone design course concurrently. This creates time pressures that stretch the students. For this reason, each year there are a number of students who opt to take ME Lab in the spring (the only time it is offered) and then graduate in December, taking the capstone design course (offered every semester) during the fall semester. Faculty numbers and availability preclude offering ME Lab each semester. Another concern is that the student's major lab experience is occurring in what is usually the last semester of their academic career. Recently, Baylor University has increased its emphasis on faculty research. The current curriculum does not prepare students to support the research initiatives until they graduate. This has prompted a series of discussions about shifting the lab experience to the fall semester of the junior year. In the spring of the junior year the students would then be better prepared when taking the materials lab course. A one credit hour fluids/thermo lab would occur in the fall of the senior year leaving the spring semester of the senior year to take the capstone design course. Schedule changes are being considered and course development is underway with possible implementation in three years.

Conclusion

This paper has highlighted the ME Lab course as it is currently taught at Baylor University. It is a course which covers a variety of topics all designed to improve the laboratory skills of the students and to satisfy ABET Criterion 3 outcomes. The course is very time intensive and the students are asked to use their communication skills to a high degree. Students are exposed to various laboratory methods of measurement of basic fluid flow, temperature and pressure. A variety of laboratory tools are used from basic manometers to sensitive micromanometers, hot-wires, and calibration-quality pressure transducers. The end result is increased student skills which leads to confidence in their abilities as they graduate and pursue careers. Assessment tools are also discussed in the context of ABET assessment requirements. The course, in its present form, accomplishes its outcomes however; it is desired to expose the students to these skills earlier in the academic curriculum so that they can be reinforced in other courses and research laboratories.

References

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Ken Van Treuren is an Associate Professor in the Department of Engineering at Baylor University. He received his B. S. in Aeronautical Engineering from the USAF Academy and his M. S. in Engineering from Princeton University. He completed his DPhil in Engineering Sciences at the University of Oxford, UK. At Baylor he teaches courses in laboratory techniques, fluid mechanics, energy systems, propulsion, and freshman engineering.

APPENDIX A – Lab Report Memo Format and grading guide

DATE: (date lab is due)
TO: Dr. Kenneth W. Van Treuren
SUBJECT: (Lab title, followed by lab number)
FROM: (your name) sign your name adjacent

<u>Introduction & Theory</u>: (do not indent for paragraphs, use block format, # paragraphs sequentially)

1. This handout serves as the MEMO LETTER REPORT GUIDE for EGR 4335, Mechanical Engineering Laboratory. The letter report will be no more than two pages (single spaced, Times New Roman 10 font) in length (not including attachments) with one-inch margins and divided into the sections. For this section, give a short statement of the purpose and engineering application of the laboratory experiment (Your own words). What has been done and what is the point of the present experiment? No major theory development to be given here. Just give important relationships/equations and describe variables. Note assumptions.

<u>Apparatus & Experimental Procedure</u>: (continue paragraph numbering using the next number. Do not start with "1" for subsequent sections.)

2. Give a short description of the apparatus employed. No sketch required but a sketch should be included in the attachments. Give a short description of the experimental procedure. Note any potential problems areas.

<u>Results</u>: Several paragraphs may be needed.

3. State the results with sources for error. Refer to the appendix. Discuss results. Do results agree with theory and with expected or accepted values? Discuss significance of results and relate to engineering application. Grading will be greatly influenced by correct versus incorrect results. An attractive report with incorrect results will likely receive a fair grade! On the other hand, a hastily done report with correct results will not receive an excellent grade.

<u>Attachments</u>: (A list of the attachments will be included directly below the body of the letter and each will be labeled in the order referred to in the report)

a. Laboratory Handout - (Instructor Furnished)
b. Data Reduction Tables
   Tables should have borders and titles. Show units under labels. Highlight important results by using shading.
c. Graphs/Figures
   The Graph should have sufficient information for the reader to understand without reference to report. Graphs must use standard conventions such as dependent variable on horizontal axis and independent variable on the vertical axis. Graphs must be numbered and given a descriptive title. Axis must be labeled and units indicated. Provide legend if needed. When possible use multiple plots on a single graph. Using a leader, reference the equation to the data on the plot.
d. Sample Calculations
   These should clearly show all typical calculations including data reduction, least squares data fitting, and error analysis. Reference sample hand calculations to the spread sheet (if used) by shading the appropriate cells. Show units clearly and how they cancel. Mathcad may be used instead of hand calculations if enough steps are included and the unit system is consistent.
e. Data Sheet
   Xerox coy of the original data sheet.
f. Other Appendices as necessary.

Ten percent of the report will be based on presentation, neatness, grammar, etc.

LETTER REPORT CHECKLIST
MECHANICAL ENGINEERING LAB

STUDENT NAME________________________ LAB NO_________

GRADED BY___________________________ GRADE__________

	LOW	MED	HIGH	AVG
I. Introduction (10%)	(1)	(2)	(3)	___
A. Explain the purpose(s) of the experiment	___	___	___	
B. Explain the engineering application	___	___	___	
C. Overview of the experiment	___	___	___	
II. Theory (10%)				___
A. Equations.	___	___	___	
B. Variables/symbols defined	___	___	___	
C. Assumptions/appropriateness	___	___	___	
III. Apparatus (10%)	___	___	___	___
IV. Experimental Procedure (5%)				___
A. Procedure	___	___	___	
B. Trouble points	___	___	___	
IV. Results (25%)				___
A. Results/Conclusions	___	___	___	
B. Comparison with theory	___	___	___	
C. Comparison with other accepted data	___	___	___	
D. Relevance to engineering	___	___	___	
V. Attachments (30%)				___
A. Tables of Results (Data).	___	___	___	
B. Graphs, labeled, units, legend, ect	___	___	___	
C. Sample Calculations	___	___	___	
B. Error analysis	___	___	___	
VI. General (10%)				___
A. Format and Neatness	___	___	___	
B. Grammar and Spelling	___	___	___	

Comments

APPENDIX B – Professor Evaluations of Student Presentations.

TEST PLAN and FINAL PROJECT PRESENTATION GRADING SHEET

PROJECT TITLE:__________________________ **Evaluator**:

Students:

UNDERSTANDING OF THE PROJECT ________/40

- Discussed previous work
- Understanding of instruments
- Able to answer questions

TECHNICAL ACCURACY AND COMPLETENESS ________/30

- Accurate theory presentation
- Uncertainty analysis

ORGANIZATION AND DEVELOPMENT ________/20

- Logical, well thought-out
- Not too short or too long (approx. 15 min.)
- Smooth transitions

PROFESSIONALISM/APPEARANCE ________/10

- Communicated clearly and effectively
- Used presentation materials effectively
- Polished

(**ADDITIONAL COMMENTS**: Use back side)

Suggested Grade:____________ (A 90 B 80 C 70 D 60 F Below 60)

APPENDIX C – Student Oral Presentation Critique Form

EGR 4335 Mechanical Engineering Laboratory
ORAL PRESENTATION EVALUATION SHEET

Name ________________________________ Test Plan or Final Presentation (Circle one)

INSTRUCTIONS: Evaluate the other presentations in the following categories and place a score from **1 to 5** (**1** being **well below average** and **5** being **well above average**) in each of the blocks. Total the scores for each individual and place this value in the Total column. If you have any written comments for a particular individual (things that were extremely well done or suggestions to improve their presentation) please write the comments below the blocks. Do not rate yourself!!!!!!!

Individual	**Understanding of Project**	**Technical Accuracy and Completeness**	**Organization/ Development**	**Professionalism/ Appearance**	**Total**

Comments
____
____
____

Individual	**Understanding of Project**	**Technical Accuracy and Completeness**	**Organization/ Development**	**Professionalism/ Appearance**	**Total**

Comments
____
____
____

Individual	**Understanding of Project**	**Technical Accuracy and Completeness**	**Organization/ Development**	**Professionalism/ Appearance**	**Total**

Comments
____
____
____

Individual	**Understanding of Project**	**Technical Accuracy and Completeness**	**Organization/ Development**	**Professionalism/ Appearance**	**Total**

Comments
____
____
____

APPENDIX D – Project Report Evaluation Forms

EGR 4335 TEST PLAN GRADE SHEET

Name ______________________________

	POINTS
OVER ALLAPPEARANCE *Neat, typed, project title and key players included* *References included*	*/10*
OBJECTIVES *What will be measured and why* *Well stated, concise*	*/10*
BACKGROUND *What's been done before* *Why the research is important* *Brief explanation of theory*	*/10*
EXPECTED RESULTS · *What are the expected magnitudes of the measured parameters? Why?*	*/5*
REQUIRED EQUIPMENT AND SUPPORT *Detailed listing of model and serial numbers.* · *What needs to be done before testing can take place.* *Software required.*	*/10*
SETUP *Detailed description of how the equipment should be set up.* *Includes sketch.*	*/10*
CALIBRATION INFORMATION *Who, when, how?*	*/10*
EXPERIMENTAL PROCEDURE *Step-by-step plan for completing testing.* *Includes test matrix*	*/15*
UNCERTAINTY ANALYSIS *Includes the governing equation (if none - state so and describe the process by which fixed uncertainty is calculated).* *Includes all sources of error.* *States how instrument error was arrived at (e.g. manufacturer's specs, calibration etc.)*	*/10*
TIME LINE *This should be detailed enough to include items such as lab prep, model fabrication, software development, initial testing, actual test runs, data reduction, report preparations, etc.*	*/10*
TOTAL	*/100*

EGR 4335 Final Project Grade Sheet

NAMES____

ABSTACT	/5
Title Page, TOC, List of Fig, etc	/5
INTRODUCTION	/15
Method	/10
Results	/20
Conclusions and Recommendations	/10
References	/5
Appendix	/15
Writing/Organization	/15

Comments: