Appendix F – Performance Criteria for Student Outcomes

Outcome 1. An ability to apply knowledge of mathematics, science, and engineering.

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Ability to apply knowledge of probability and statistics, including applications appropriate to electrical[1] engineering.	Insufficient understanding of probabilistic foundations.	Understanding of the axioms of probability and their consequences and single random variables.	Good ability to apply conditional probability, multiple random variables, correlation, properties of expectation and limit theorems to solve problems relevant to electrical engineering.	Thorough ability to apply probabilistic methods to solve problems relevant to electrical engineering.
b) Ability to apply knowledge of mathematics through differential and integral calculus.	Insufficient knowledge of calculus.	Able to evaluate derivatives and integrals in various coordinate systems.	Ability to solve second-order differential equations and select appropriate solution for physical systems.	Able to develop equivalent circuit models and solve associated mathematical models for electrical engineering problems.
c) Ability to apply knowledge of advanced mathematics (linear algebra) and circuit theory.	Unable to formulate a simple circuit problem using linear algebra.	Able to correctly formulate and solve simple circuit problems using linear algebra.	Able to correctly formulate and solve circuit problems using linear algebra.	In addition to the "Satisfactory" requirements, able to interpret and analyze the characteristics of the solutions using linear algebra and relate results to relevant characteristics of physical models.
d) Ability to apply knowledge of advanced mathematics (differential equations) in the context of electrical engineering.	Unable to formulate and solve differential equations for systems problems.	Able to solve first-order differential equations with sinusoidal and exponential inputs.	Able to formulate electrical engineering problems as differential equations and solve them by at least one technique.	Able to formulate electrical engineering problems as differential equations and the mastery of multiple techniques for solving them.

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Outcome 1, continued

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
e) Ability to apply knowledge of advanced mathematics (complex variables) and circuit theory.	Unable to do complex number arithmetic.	Able to do complex arithmetic, but unable to effectively apply complex variables to obtain sinusoidal responses of circuits.	Able to formulate and solve sinusoidal responses of circuits using complex variables.	In addition to the "Satisfactory" requirements, able to interpret and analyze the characteristics of the solutions of circuits using complex variables and their relationship to real-time forms.
f) Ability to apply knowledge of advanced mathematics (discrete mathematics for probability) in the context of electrical engineering.	Insufficient understanding of counting principles and simple set theory operations.	Basic understanding of fundamental set theory operations.	Able to solve combinatorial problems using simple set theory operations and counting principles, (e.g. permutations and combinations).	Thorough ability to apply combinatorial techniques and set theory operations to solve problems relevant to electrical engineering.
h) Ability to apply knowledge of sciences (defined as biological, chemical, or physical science) and device theory.	Insufficient knowledge of physical sciences and inability to understand related concepts in electrical engineering (such as, solid state electronics and EM theory).	Understanding of physical sciences and ability to formulate and solve related simple problems in electrical engineering.	Able to formulate and solve problems, and also have the ability to correctly analyze and interpret related physical phenomena and structures.	In addition to the "Satisfactory" requirement, have the skills to analyze/solve complex problems or design simple electronic structures.

Note: Rubric 1g (Ability to apply knowledge of advanced mathematics – discrete mathematics for computer science) is no longer being evaluated effective Fall 2010 when the BS Computer Engineering program was established.

Outcome 2. An ability to design and conduct experiments, as well as to analyze and interpret data.

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Experimental design	No knowledge of scientific methods and procedures. Incapable of designing or evaluating experiments.	Knows proper scientific methods and procedures, but is unable to properly implement them. Can design and evaluate experiments only with assistance.	Understands and uses proper scientific methods and procedures. Can design and evaluate simple experiments.	Understands and uses proper scientific methods and procedures. Can design and evaluate more complex experiments.
b) Knowledge of theory, of the testing methods, and the experimental protocols	Does not understand the theory behind the experiment, cannot use the testing methods appropriately, and collects measurements randomly.	Knows some of the theory, but fails to see the connection with the experiment; knows how to use the methods only by following detailed descriptions, and strictly follows directions of the handouts.	Understands well the theory and its connection with the experiments. Knows how to use the testing methods appropriately (filling in details if necessary), and understands the meaning of most protocols' directions.	Has perfect knowledge of the theory and can anticipate the most likely outcome of the experiment; knows all the details of the methods and is able to provide full justification of the protocols used.
c) Experiment execution	Has to rely on other students/the instructor to execute the simplest measurement.	Follows instructions on the handouts, but would not be able to modify it to different situations if not minimally.	Can perform experiments with some degree of independence; does not strictly rely on handouts and/or the instructor.	Can perform the experiments without any detailed instructions.

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Outcome 2, continued

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
d) Data collection, analysis. representation, and interpretation	Left to oneself, cannot gather any meaningful data. Is unaware of the concept of inaccuracy. Sees no need in data analysis. Reports purely unprocessed data, where clearly spurious results are never recognized. Little or no attempt at interpreting the data collected in the experiment.	Only the most basic data are collected. Is aware of inaccuracies, but can deal with it only occasionally. Applies data analysis only if instructed. Charts data sporadically. Occasionally identifies some artifacts/errors due to assumptions, but does not know how to deal with them. Interprets some data but some significant errors in interpretation.	Most data are collected appropriately. Is aware of inaccuracy, and in most cases is able to identify it and quantify it. Knows how to apply data analysis techniques. Often uses appropriate mathematical and charting tools to analyze and represent data. Significant level of interpretation attempted and most interpretations appropriate. Typically identifies artifacts/errors due to assumptions, reports them, and sometimes finds appropriate explanations.	All required data are collected and correctly reported. Always identifies and quantifies causes of inaccuracy. Has a deep knowledge of data analysis techniques and applies it appropriately. Always uses mathematical and charting tools to analyze and represent data. Always recognizes/isolates experimental artifacts and errors due to assumptions and constraints, explains them, and suggests solutions. Accurate and appropriate interpretation of data. Not under- or over-interpreted.

Outcome 3. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Design strategy	No design strategy.	Can follow a provided design strategy.	Can develop and follow a design strategy to meet a specified need with guidance.	Can develop and follow a design strategy to meet a specified need with little or no guidance.
b) Realistic design constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Disregards or does not understand design objectives and realistic constraints.	Can identify and meet some of the realistic design constraints with guidance.	Can identify and meet all of the realistic design constraints with guidance.	Can identify and meet all of the realistic design constraints with little or no guidance.
c) Quality of design	Cannot create a design.	A design is obtained but not checked for quality.	Multiple designs are obtained but the optimal one is not identified.	Multiple designs are obtained and the optimal design is identified and adequately justified.
d) Engineering standards	Unaware of any standards.	Can identify some standards relevant to the design problem with guidance.	Can identify and apply all standards relevant to the design problem with guidance.	Can identify and apply all standards relevant to the design problem with little or no guidance.

Note: Rubric 3d (Engineering standards) is evaluated in applicable courses, such as EE 496.

Outcome 4. An ability to function on multidisciplinary teams.

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Fulfill team role's duties	Does not perform any duties of assigned team role.	Performs very little duties.	Performs nearly all duties.	Performs all duties of assigned team role.
b) Share equally	Always relies on others to do the work.	Rarely does assigned work—often needs reminding.	Usually does the assigned work—rarely needs reminding.	Always does the assigned work without having to be reminded.
c) Listen to other teammates	Is always talking—never allows anyone else to speak.	Usually doing most of the talking—rarely allows others to speak.	Listens, but sometimes talks too much.	Listens and speaks a fair amount.

Outcome 5. An ability to identify, formulate and solve engineering problems.

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Solution strategy	Has no solution strategy.	Can formulate some solution strategies but requires guidance to find strategies and solutions.	Develops and follows acceptable solution strategies. Able to solve moderately difficult engineering problems.	Develops and follows efficient strategy leading to correct solutions. Able to solve difficult engineering problems.
b) Applying theoretical concepts	Cannot apply theoretical concepts to EE problem solving.	Can apply at least some of the theoretical concepts to EE problem solving.	Applies most of the theoretical concepts to EE problem solving.	Applies all of the theoretical concepts to EE problem solving.
c) Identify and formulate engineering problems	Unable to identify EE problems in an assignment or project.	Can identify and formulate at least half of the EE problems in an assignment or project.	Can identify and formulate all of the EE problems in an assignment or project.	Can identify and formulate all of the EE problems in an assignment or project, and can integrate their solutions effectively.

Outcome 6. An understanding of professional and ethical responsibility.

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Demonstrate knowledge of ethical dilemmas and resolution approaches	Cannot recognize ethical dilemmas.	Recognizes dilemmas but cannot indicate any path to resolution.	Recognizes dilemmas and can describe general dilemma resolution approaches.	Can clearly apply a resolution approach to a particular ethical dilemma.
b) Demonstrate knowledge of a professional engineering code of ethics	Unaware of any codes of ethical behavior.	Student is aware of the existence of the code of ethics of the professional society in the engineering discipline.	Knows about various aspects of code of ethics but sometimes confuses personal ethics with professional ethics.	Can clearly establish that he/she has read and understands a professional code of ethics.
c) Evaluate the dimensions of professional engineering practices	Can only describe ethical issues or applications outside engineering or that do not clearly involve ethics.	Can distinguish engineering ethics from personal ethics.	Can show familiarity with tools for applying ethics to engineering practice.	Can describe an application of a professional code of ethics related to engineering, with a clear connection between the code provisions and the application.
d) Demonstrate knowledge of ethical use of intellectual property	Cannot identify intellectual property.	Recognizes intellectual property, but cannot identify ethical considerations.	Recognizes intellectual property and describe legal and ethical considerations, without distinguishing between legal and ethical considerations.	Can clearly distinguish legal and ethical considerations regarding intellectual property.

Outcome 7. An ability to communicate effectively.

The outcome has four performance criteria: (1) written report organization and style, (2) written report content, (3) oral presentation content, and (4) oral presentation delivery. For each performance criteria, we have a collection of hallmarks. The scoring rubrics are with respect to these hallmarks.

Written Report Organization and Style Hallmarks

- The report is organized into chapters and or sections including an introduction section and a conclusions, summary or final remarks section. The chapters and sections should be properly numbered and titled.
- There should be a description of the organization of the report presented somewhere at the beginning, e.g., in the introduction section. The description should briefly explain the chapters and sections to give the reader an overview.
- Sentences and paragraphs are clear and well organized.
- Chapters and sections are clear and well organized. There should be good transitions between paragraphs.
- There should be no spelling or grammatical errors
- The report should follow any formatting instructions including but not limited to margins, font size, abstract, spacing, cover page format, etc
- There should be a list of references and the list should follow the IEEE reference style or similar style.
- Figures and tables should be properly formatted. Figures should have captions and tables should have titles, and the captions and titles should be well written. Figures and tables should be numbered. They should appear either on the same page they are first referenced, after they are first referenced (e.g., on the next page), or in the back of the report.
- All unfamiliar technical terms should be italicized on first use and defined.
- Tables and figures should be properly referenced within the text of the report. Citations to the reference list should be done properly.

Written Report Content Hallmarks

- There should be a description of what the report is about including objectives, and if appropriate, motivation
- The accomplishments and results are presented.
- Clear description of procedures and work involved is given
- Backgound material is presented, such as previous work, modeling information, etc.
- Conclusions, summaries, and interpretations of the results are given wherever appropriate.
- There should be concluding statements including summary of task, and any suggestions for future work.
- A sufficient number of figures and tables are in the report. The figures and tables are clear, and they should improve the clarity of the report.
- References to other work and documents and all appropriate citations are given within the body of the report.

Oral Presentation Content Hallmarks

- Clear, strong thesis statement
- Main points were clear
- Main points were substantive
- Supporting evidence was provided when necessary
- Sources of information were cited.
- Review of main points were included in conclusion
- Concluding statement was clear - presentation ended smoothly

Oral Presentation Delivery Hallmarks

- Extemporaneous delivery
- Effective eye contact
- Clear vocal delivery
- Appropriate and effective language use
- Effective articulation and pronouncement of words
- Well prepared slides (if appropriate) with sufficient figures and tables and or other appropriate visual and audio aids.
- Provides clear and appropriate answers

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Written report organization and style	Does not meet half of the hallmarks at a high level or there is at least one hallmark with no effort.	Meets at least half the hallmarks at a high level and has some effort in the remaining hallmarks.	Meets nearly all hallmarks at a high level and has some effort in the remaining hallmarks.	Meets all hallmarks at a high level.
b) Written report content	Does not meet half of the hallmarks at a high level or there is at least one hallmark with no effort.	Meets at least half the hallmarks at a high level and has some effort in the remaining hallmarks.	Meets all nearly all hallmarks at a high level and has some effort in the remaining hallmarks.	Meets all hallmarks at a high level.
c) Oral presentation content	Does not meet half of the hallmarks at a high level or there is at least one hallmark with no effort.	Meets at least half the hallmarks at a high level and has some effort in the remaining hallmarks.	Meets all nearly all hallmarks at a high level and has some effort in the remaining hallmarks.	Meets all hallmarks at a high level.
d) Oral presentation delivery	Does not meet half of the hallmarks at a high level or there is at least one hallmark with no effort.	Meets at least half the hallmarks at a high level and has some effort in the remaining hallmarks.	Meets all nearly all hallmarks at a high level and has some effort in the remaining hallmarks.	Meets all hallmarks at a high level.

Outcome 8. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Global economy	Does not understand that engineering is in a global economy.	Understands EE is in a global economy but does not understand how engineering solutions affect the economy and vice versa.	Can identify how engineering solutions affect the global economy.	Can discuss how engineering solutions in a technical field might affect the global economy in the future.
b) Societal	Is unaware that engineering solutions can impact the society.	Is aware that engineering solutions can impact the society.	Is aware that engineering solutions can impact the society, and can discuss how a specific engineering solution may impact the society.	Can analyze comprehensively how an engineering solution might impact the society both positively and negatively. Can discuss the tradeoffs.
c) Environment	Is unaware that engineering solutions can impact the environment.	Is aware that engineering solutions can impact the environment.	Is aware that engineering solutions can impact the environment, and can discuss how a specific engineering solution may impact the environment.	Can analyze comprehensively how an engineering solution might impact the environment, including some quantitative estimates of the impact.

Outcome 9. A recognition of the need for, and an ability to engage in life-long learning.

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Recognition of the need for life-long learning	Not aware of the need, and wait for someone to tell them what to do.	Aware of the need, but do not actively search and learn new tools and methods	Aware of the need, and actively search and learn new tools and methods.	Aware of the need, actively search and learn new tools and methods, and show the potential to learn beyond the project need.
b) Ability to engage in life-long learning	Cannot identify deficiencies and new tools/methods needed for the project.	Able to identify deficiencies and new tools/methods needed, but is not able to use them very well.	Can identify deficiencies and new tools/methods needed in research, apply them in projects, with limited understanding of the theory or method behind the tools/techniques.	Can identify deficiencies and new tools/techniques needed in research, is able to master the use of them, and is able to explain the basic concepts and theory behind them.

Outcome 10. A knowledge of contemporary issues.

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Contemporary ethical issues	Poor or no knowledge of contemporary engineering ethics.	Some knowledge of contemporary ethics with fair grasp of concepts.	Good knowledge of contemporary ethics and good grasp of concepts.	Very good knowledge of contemporary ethics and understands more difficult issues.
b) Contemporary technical issues	Has poor knowledge of current technical issues.	Has some knowledge of current technical issues, but not well articulated.	Has reasonable knowledge of current technical issues and can discuss these issues.	Has very good knowledge of current technical issues and has some vision.
c) Contemporary political, economic, and social issues	Has little or no understanding of current political, economic, and social issues.	Has some understanding of current political, economic, and social issues, but does not connect well to engineering problems.	Has understanding of current political, economic, and social issues and makes some connection to engineering problems.	Has in depth understanding of current political, economic, and social issues and makes good connection to engineering problems.

Outcome 11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Performance Indicator	Unsatisfactory	Marginal	Satisfactory	Exemplary
a) Laboratory equipment	Does not know how to use laboratory equipment, even with guidance.	Able to use most of the equipment but with repeated guidance.	Able to use all the equipment with guidance.	Able to use all the equipment with little or no guidance.
b) Research resources	Does not show any interest in outside sources.	Able to use the Internet and library resources to gather some information towards an assignment.	Able to use the Internet and library resources to find information to adequately complete an assignment but misses some key references.	Able to use the Internet and library resources to complete an assignment.
c) Software design tools, e.g., CAD, Matlab, Excel	Cannot use software tools.	Able to do simple tasks with software tools.	Able to do moderately difficult design tasks with software tools.	Able to do complicated design tasks with software tools.

Note: Rubric 11a (Laboratory Equipment) is retroactively not required to be evaluated for EE students in the Systems Track per 9/24/14 ABET Committee Meeting.