I. Assessment Outcomes from the Course Syllabus

☒ (A) Ability to apply knowledge of mathematics, science and engineering.
☒ (B) Ability to design and conduct experiments as well as analyze and interpret data.
☒ (C) Ability to design a system, component, or process to meet desired needs.
☐ (D) Ability to function on multidisciplinary teams.
☐ (E) Ability to identify, formulate, and solve engineering problems.
☐ (F) An understanding of professional and ethical responsibility.
☐ (G) Ability to communicate effectively in written and oral formats.
☐ (H) A broad education necessary to understand the impact of engineering solutions in global, economic, and societal context.
☒ (I) Recognize the need for, and have the ability to engage in life long learning.
☐ (J) Have a broad education and knowledge of contemporary issues.
☒ (K) Ability to use techniques, skills and modern engineering tools necessary for engineering practices.

II. List of Course Topics from the Course Syllabus

1. Maxwell’s equations and the wave equation.
2. Plane wave propagation, transmission, and reflection, polarization.
3. Waveguides, fiber optics, resonators.
4. Antennas, antenna arrays.
### III. Course Assessment Summary Table: one row of the table should be devoted to each of the checked outcomes in Part I.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Topics</th>
<th>Specific Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Ability to apply knowledge of mathematics, science and engineering.</td>
<td>1, 2, 3, 4, 5</td>
<td>Exam 1</td>
</tr>
<tr>
<td>(C) Ability to design a system, component, or process to meet desired needs.</td>
<td>3, 4, 5</td>
<td>Exam 2</td>
</tr>
<tr>
<td>(K) Ability to use techniques, skills and modern engineering tools necessary for engineering practices.</td>
<td>5</td>
<td>Exam 4</td>
</tr>
</tbody>
</table>

### IV. Using the table as a guide, for each outcome summarize your evaluation of the students’ achievement of that outcome; cite student performance on the identified measures as evidence to support your conclusions.

(A) Ability to apply knowledge of mathematics, science, and engineering.

While there are many opportunities to evaluate this outcome, Exam 1 has been selected for this report. Table A1 shows how Exam 1 covered mathematics, science, and engineering.

**Table A1. Details of how Exam 1 covered the three disciplines involved in Outcome (A).**

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Facet of Exam #1 that Covered the Discipline:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>Plane Wave Propagating with Attenuation</td>
</tr>
<tr>
<td>Science</td>
<td>Plane Wave Obliquely Incident on the Planar Interface Between Two Dielectrics</td>
</tr>
<tr>
<td>Engineering</td>
<td>Smith Chart</td>
</tr>
</tbody>
</table>

For the mathematics discipline, students demonstrated mastery of complex algebra by answering questions about a plane wave propagating with attenuation in a conducting media. They showed an understanding of how the complex propagation constant decomposes into the attenuation constant and the phase constant. In addition they showed the relationship between attenuation constant and the characteristic depth of penetration (skin depth) for the plane wave propagating into the conducting material.

For the science discipline, students demonstrated their understanding of the physics of a plane wave obliquely incident upon a planar interface between two dielectrics. In that work they were required to show understanding of the “plane of incidence”, polarization, the law of reflection, Snell’s law of refraction, and the boundary conditions imposed on tangential fields.

The engineering discipline was represented on this exam with the Smith chart, a very versatile device that is used by engineers working with wireless communication...
systems. In Exam 1 the Smith chart was applied to a plane wave normally incident upon a planar interface between two dielectrics. Specifically the students worked a problem that included normalized input impedance, complex reflection coefficient, standing wave ratio, how movement in space corresponds to rotation on a Smith chart, and how the Smith chart can be used to locate positions in space where destructive interference dominates.

Figure A1 shows the histogram of scores for Exam 1. The mean, maximum, and minimum scores were 86%, 99%, and 66%, respectively. For this offering of EE351, course averages less than 71% were considered equivalent to course grades of C- and below, thus 71% is a meaningful threshold in Figure A1. Scores less than 71% were 66%, 67%, and 68%. These students went on to finish the course with grades of C, A-, and B+, respectively. Thus only one student (the one receiving a C for the course) might not have demonstrated sufficiently strong ability to apply knowledge of mathematics, science, and engineering. This student’s overall course average was the lowest (of those passing the course with a C or better) and his attendance record was “weak”. Adding an attendance component to the grading rubric would have pushed this student into the C- regime (or the student would have improved their attendance and perhaps improved their course average.)

![Figure A1. Histogram for Exam 1.](image)

(C) Ability to design a system, component, or process to meet desired needs.

For this outcome Exam 2 is considered. In this exam the problem shown in Table C1 was included. The students must design a waveguide such that the middle of the dominant mode frequency range is at a specified value. Design equations must be used to obtain the correct width and height for the guide.
Table C1. One of the problems on Exam 2.

Design an air-filled rectangular waveguide that has $a = 2b$ (width is twice the height) and has the middle of the dominant mode frequency range at 23.6 GHz. Recall that $\mu_0 = 4\pi \times 10^{-7} \text{H/m}$ and $\varepsilon_0 = 8.854 \times 10^{-12} \text{F/m}$. Assume that the walls of your guide are made from perfect electric conductor. The grader will gladly evaluate your expressions with a calculator or with Matlab but you must define the numerical values for all parameters appearing in your equations. Clearly describe your procedures.

Figure C1 shows the histogram for this exam. The mean, maximum, and minimum scores were 93%, 100%, and 66%, respectively. Note that there were 5 students with a score of 100%. Clearly most students demonstrated an ability to design a system, component, or process to meet desired needs. For Exam 2 there was only one student with a score below 71%. This student received a score of 66% on Exam 2 and received a course grade of C (his score on Exam 1 was 77%). This student exhibited two weaknesses: poor attendance and weak participation in homework assignments. This student received a 78% on the final exam. Again it is a C student that makes it difficult to state categorically that all of the students showed an acceptable ability to design a system, component, or process to meet desired needs; however, the balance of the class clearly demonstrated this ability. Making attendance a graded component might have strengthened this student’s abilities in EE351. In addition to that, placing more weight on homework might have inspired this student to learn the material more thoroughly.

![Histogram for Exam 2](image-url)
(K) Ability to use techniques, skills and modern engineering tools necessary for engineering practices.

For evaluation of Outcome “K”, Exam 4 is invoked. Exam 4 focused on the use of finite element methods to solve problems in electrostatics. The finite element method is used in many modern electromagnetics modeling software packages. On the exam, students demonstrated their understanding of the finite element method and the ways that Matlab and finite elements can be used by the engineer to model electrostatic problems. Figure K1 shows the histogram for this exam. The mean, maximum, and minimum scores were 85%, 100%, and 50%, respectively. Note that 7 students receive a score of 100%. The student receiving the 50% finished the course with a grade of “D” thus that score can be ignored for this analysis. Besides the 50% score, other scores less than 71% were 64%, 69%, and 69%. These scores should be considered “marginal” performance if one is to argue that all of the students with a C or better showed an acceptable ability to use techniques, skills and modern engineering tools necessary for engineering practices. Additional inspection of the performance of these three marginal students shows that their scores on the final exam were 72%, 81%, and 83%, respectively, and their grades for the course were C, B-, and C, respectively. The student receiving a course grade of B- received 100% on an extra credit homework problem that asked the students to use commercial finite element software (QuickField at the URL: www.quickfield.com) to model the electrostatic fields associated with a coaxial cable. The effect of finite element grid coarseness on equipotentials was investigated. Nearly 70% of the students participated in the extra credit homework problem that took them deeper into finite element analysis. It appears that two students remain “difficult cases” where it is not clear that they displayed a suitable ability to use techniques, skills and modern engineering tools necessary for engineering practices.

![Exam 4, EE351, Spring 2007](image)

**Figure K1.** Histogram for Exam 4.
V. Qualitative Assessment of Student Performance: using the arguments above and other data support the claim that students who completed this course with a grade of C or better have achieved each of the intended outcomes of this course.

This assessment report points out an interesting situation: for C students that carefully monitor their “pool of points”, it is difficult to use exam scores to reach a definitive conclusion regarding adequate performance in all outcomes that pertain to this course. It is not practical to copy and keep a record of all exams; however, by expanding the class spreadsheet it is possible to record individual student scores on each exam question. In the future this instructor plans to keep an accurate record of points received by each student on each exam question. This will allow the assessment process to identify students that lost all points on an exam question being used as an assessment tool. The EE Curriculum Committee should consider asking all instructors to keep such detailed records to facilitate assessment report writing and to improve the accuracy of the assessment tools.

VI. Concerns: state any concerns you may hold about this class – were the students adequately prepared coming into it? Are there topics or outcomes where (some) students were weak after completing the course? Other concerns? Were there any comments on students’ course evaluations that should be addressed in future instances of the course? This section is very important for improving our program: it provides critical input to the curriculum committee for identifying areas requiring attention.

There were four students for which it was difficult to state categorically that they displayed acceptable abilities for the Outcomes being evaluated in this course. These were students scoring less than 71% on a specific measure and receiving a C for the course. These C students apparently carefully monitored their “pool of points” and were willing to “shoot for a C”, presumably to free up time for other courses or for activities outside of coursework. Thus there is a very real challenge to evaluate these “borderline” students. New EE351 policies that could help this instructor evaluate these students would be to make attendance mandatory and to make homework scores a larger fraction of the course grade. Concerns here are that cheating becomes more enticing when homework is heavily weighted and roll call and excuse monitoring detracts from the teaching and learning process.

On a positive note, students appeared much more skilled this semester at using Matlab software. The TA and instructor held a Matlab workshop at which we were expecting “introductory” Matlab questions; however, students instead focused their questions on how to use Matlab to solve the antenna problem being considered. It was a pleasant surprise that class time was not expended on trivial Matlab questions. Introducing Matlab earlier in the student’s curriculum is already yielding benefits.

Many students appeared to enjoy applying Matlab to finite element analysis. They also appeared to enjoy using the commercial software package QuickField to model electrostatics problems. Future offerings of this course should include one additional homework problem that uses the QuickField software package (assuming that the instructor uses finite element analysis for their numerical methods prototype).

The electrophysics area committee should consider the following changes to the formal EE351 syllabus:

1) Fiber optics should be located in the “plane wave” topics rather than in the “waveguide” topics. Thus it would be presented using the tools of ray tracing, oblique incidence, and total internal reflection rather than the tools of cylindrical waveguide theory.

2) The “waveguide” topics should specify “rectangular waveguides” and “rectangular resonators.”

Signature __________________________________________ Date: __________

Please email a copy of the completed form to Patricia Arnold, patricia@eecs.wsu.edu and deliver a signed hardcopy to her mailbox.