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 lifelong 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. Classification and properties of signals and systems.
2. Discrete and continuous-time impulse response, convolution, differential and difference equations.
3. Fourier representation of discrete and continuous-time signals.
4. Frequency response of LTI systems, sampling and reconstruction, DFT.
5. Introduction to filter design.
6. Amplitude modulation.
7. Angle modulation (FM and PM).
8. Information, entropy, and Huffman codes.

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 (Samples should be available in the course materials file for inspection.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Ability to apply knowledge of mathematics, science and engineering.</td>
<td>1-8</td>
<td>Exam 1, 2, 3</td>
</tr>
<tr>
<td>Understand the concept of a system and basic system properties.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand the analysis of linear time-invariant (LTI) systems using convolution. Learn Fourier representations of signals and apply them to the analysis of LTI systems. Understand the effect of sampling an analog signal in the frequency domain and its implications to digital signal processing. Understand the concept of modulation (AM, FM, PM) in communication systems. Understand elementary concepts in information theory.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(C) Ability to design a system, component, or process to meet desired needs.</td>
<td>5, 8</td>
<td>HW 9-12, Exam 2, 3</td>
</tr>
<tr>
<td>Can design simple frequency selective filters based on Butterworth polynomials.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(K) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.</td>
<td>5</td>
<td>HW 9</td>
</tr>
<tr>
<td>Ability to use computer tools (Matlab) to design filters and enhance understanding of the underlying concepts.</td>
<td></td>
<td></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.
The course starts with an introduction to basic system properties and examples, followed by a thorough analysis of LTI systems using the convolution equation. Exam 1 (and the associated HW exercises 1-4) focussed on this material. The average exam 1 score was 82% (for students with a C or above in the course).

Fourier series, Fourier transform, their properties and applications to analysis of signals and systems form the core of the course. Sampling theory was covered as an application of Fourier transform. Exam 2 (and the associated HW exercises 5-8) focused on this material. The average exam 2 score was 69% (for students with a C or above in the course).

This was followed by Filter design (see Criterion C below for details on this). Analog modulation techniques (AM, FM) was also covered with an emphasis on deriving the spectrum and bandwidth assessment for the different modulation schemes. Exam 3 (and the associated HW exercises 9-11) focused on this material. The average exam 3 score was 82% (for students with a C or above in the course).

A brief introduction to Information theory followed by Huffman codes was covered with an emphasis on using symbol probability information to design more efficient variable length codes. The course concluded with a discussion of discrete-time Fourier transform (DTFT) and its properties. Both these topics were covered in the Final (which was comprehensive) and in HW 12-13. The average for the Final was 79% (for students with a C or above in the course), whereas the average for HW 12 was 87%. The average for HW 13 was low (47%) but this was primarily due to the fact the many students did not turn in HW 13 (this was the last HW and the course policy allowed each student to drop the two lowest HW scores).

Based on this performance, the instructor can make a reasonable conclusion that students obtaining a C grade or better have demonstrated an ability to apply knowledge of mathematics, science and engineering.

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

Principles of Analog filter design with specific emphasis on design of Butterworth filters (see topic 5) is covered right after covering Fourier transforms (and its applications). The instructor provided detailed notes for this topic. Design equations for Butterworth filter design (obtaining filter order and 3dB frequency) are derived. Expression for the filter transfer function based on an analysis of the pole locations is also derived. Design of Huffman codes as a variable length encoding scheme is introduced.

HW 9 provides a list of problems to test the students understanding of the design process, given the specifications. In a couple of problems, the students are required to come up with the filter specifications from a problem description. The students are required to do hand calculations using the formulae
derived in class and verify them using Matlab built-in functions. The HW also requires them to verify that the design specifications are met based on frequency response plots obtained using Matlab. One HW problem introduces Chebyshev filters (Matlab commands were explained to the students) and asks the students to compare the Chebyshev filter design with a Butterworth filter design for a given specification. In addition, Exam 2 had a problem (worth 25% of the exam) on Butterworth filter design. HW 12 focuses on Information theory, Entropy and design of Huffman codes. In addition, the Final exam had a problem (worth 17% of the exam) on Huffman code design. Students obtaining a C grade or better averaged 69% on HW 9, 87% on HW 12, 69% on Exam 2 and 81% on the final. Based on this performance, the instructor can make a reasonable conclusion that students obtaining a C grade or better have demonstrated an ability to design a system, component, or process to meet desired needs.

(K) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Most of the HW exercises require the use of software (e.g. Matlab) to some extent. This criterion was assessed primarily based on HW 9. Here the students are required to design filters based on given specifications and verify that the designed filter meets the specifications. In addition, the students were required to compare the solution obtained from two different design methods. Solving this HW requires extensive use of Matlab functions. Students obtaining a C grade or better averaged 69% on HW 9. Based on this performance, the instructor can make a reasonable conclusion that students obtaining a C grade or better have demonstrated an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
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.

Based on the student performance in the specific HW and Exams (see Section IV for details), the instructor can make a reasonable conclusion that students obtaining a C grade or better have achieve criteria 3(A), (C), and (K), as it applies to EE341.

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.

The instructor observed a large variability in the student's math background and their general ability to apply their math knowledge in specific problems in Signals and Systems. As a result, there was a large variance in the exam scores with a significant number of students at both the high end and the low end of the class.

Signature __ K. Sivakumar __ Date: __January 02, 2007__

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