Welcome to ECE 2704 for Fall 2014. After some introductions, this first class meeting will be split into two parts. The first part will cover the course content, the second will cover the course administration.

Course Content

This course is about (obviously from the title) signals and systems. Signals are a way to communicate information. We model them as mathematical functions. Just a few examples of signals include power lines, audio, images, computer programs, DNA, and Electromagnetic radiation. Systems transform signals into other signals in order to store them, transmit them, encrypt them, enhance them, detect them, control them, translate them, etc. We model systems as differential equations, so that we can analyze, synthesize, and design systems for specific purposes.

This course focuses on continuous, real signals of time: their representation, characterization, and manipulation, and on continuous linear time-invariant systems, a fundamental and important class of systems. ECE 3704 covers discrete time signals and systems.

So this course boils down to studying

$$y(t) = T[x(t)]$$

where $x(t)$ is the input to the system $T$, which transforms it into the output $y(t)$. You can think about this graphically as in figure 1.

We will focus on models $T$ representing electrical circuits and physical models. Below is a "mind map" of the content we will be covering over the semester.

Why is this material important? This material’s development dates to the early-mid twentieth century and is one of the pillars
of modern technology. It is the core of the engineering discipline, a common thread across all majors. In a real sense you have seen this material before as it is largely the same as linear differential equations, however because we need to be able to reason about and design such systems we need additional tools and insight beyond what generally interest (non-applied) mathematicians. Here are just a few examples of questions one can answer with signals and systems.

- **Analyze Signals**: what information is in this signal? is there some unexpected signal content (corruption or noise)? could there be hidden information in this signal?

- **Design Systems**: how do I design this circuit to do what I want? can I be confident it should produce the expected or desired output before construction, i.e. has or meets some performance criteria?

- **Filter Signals**: can I remove some information I am interested in (decode)? can I reduce the impact of corruption or noise? can I add information to the signal (encode)?

- **Control**: Can I make sure this mechanical system, perhaps part of a robot, performs within some bounds of stability?

- **Modeling**: can I model some real system (ecological, biological, physical) as a linear system so as to study its behavior and possibly control it?

All of the above are related, but the last two, Control and Modeling, are intimately connected through something known as the "Good Regulator Theorem" – any good controller (regulator) of a system is a model of that system.

What are the prerequisites for the course? This course models signals and systems as mathematical functions. As such we use the tools of calculus and differential equations heavily. Although most physical signals are real valued, complex valued representations will be very important in the analysis and design of systems. Since we use many examples from linear circuits you also need a good background in first and second order circuits. Problem Set #0, already posted and due in class on Monday tests your background in these four areas. If you are taking this out of sequence (ahem, CPE seniors) then you will need to do some work to refresh your math and circuit skills. Take problem set #0 seriously. We will be using Matlab in the course for some basic computation, plotting, and in-class examples, so I will assume you can write and run basic matlab scripts and navigate the user interface. Some problemsets have an experimental component requiring the use of lab-in-a-box. These are designed to
reinforce the course concepts with hands-on experience. The circuits are generally not complicated to construct but tend to focus on design and experimental analysis, with short write-ups. In particular there is no validation. You can (and really should) work together in small groups on the problem sets, however everyone should write up their own solutions, build their own circuits, and run their own experiments.

Finally, the formal learning objectives for the course are that having successfully completed this course, the student will be able to:

a. Describe a physical process in terms of signals and systems and describe the properties of the system

b. Calculate the Fourier series of a periodic signal

c. Calculate the spectrum of a signal using the Fourier transform

d. Solve a differential equation using the Laplace transform.

e. Calculate the steady state output of a system from the frequency response plots

If you and I have done our jobs, then everyone should have mastered each of these abilities by the end of the semester.

Course Administration

Note: this section is just a summary of the course administration. The website contains a detailed description of all course policies and should be consulted when administrative questions arise. PLEASE READ IT.

First off, how to get help. We will be using an online tool called Piazza (piazza.com), a question-answer/forum-like site that is much better than Scholar’s tools. We will use it rather than an email listserv for group communication. Any general or specific questions about problems, deadlines, policy, etc. should be posted to Piazza so that everyone can learn and contribute, and so that communications are as efficient and fast as possible. However, for personal or confidential issues, the best way to contact me outside of class is via email.

Instead of regular office hours I hold a group help session each Friday evening (as it happens, the day before exams and when problem sets are due). If you need to have a 1-on-1 meeting with me to discuss something of a confidential nature just send me an email to schedule an appointment, providing a list of your available times. In addition, the TA will hold regular office hours each week, the times and location of which will be announced soon. So there is no excuse
for you to not get help soon after you need it – take advantage of this.

I run my courses a bit different. I assign readings, generally from the textbook, that should be read **before each class**. These are kept short, generally no more than 1-2 sections. Before each class you complete an online quiz via scholar to test your comprehension of that material and to set the stage for the class meetings. These must be completed by 8 am the morning of class so that I have time to review the results and tailor that class meeting accordingly. The class meetings generally consist of a short lecture integrated with a review of the warmup, followed by examples.

Each class meeting is listed on the website schedule with the assigned reading. The relevant reading is also part of the warmup description in Scholar (under Tests and Quizzes). This means that I am testing you on material before we have covered it in class. However, the warmups are for extra credit only and do not penalize your grade. This approach makes the most efficient use of class time, helps you develop independence and personal engagement with the material, and helps you keep up with the course.

So, the course workflow looks like the following. Each class meeting, MWF, you read, do the warmup and go to class. Every 1-2 weeks there is a problem set due on the material. Problem set solutions are turned in at the beginning of class on Mondays, with solutions posted 3-4 days later. Guidelines for homework can be found below; please read and follow them. You will be assigned a randomly generated ID number for this class to use on assignments (both problemsets and exams). This will be given to you via email.

Regarding late homework, you get three free late days to use during the semester in case of an emergency or if you just get behind as the semester progresses. Try to save them for later in the semester when you are more likely to need them.

Lastly, the thing you probably care most about, grading. The problem sets constitute 25% of the overall grade and are graded in a strict fashion, with little partial credit. There are two midterm exams and a final, together making up 75% of the grade. The final exam is split into three parts with the first two parts giving you the opportunity to replace a midterm exam grade. The third part of the final is required. Exams are graded a little more leniently than the problem-sets, given the pressures of a timed exam, with partial credit. The grading scheme is designed to test the level to which you have mastered the material and I do not curve (although I might drop a poorly worded or confusing question from consideration).
Problem Set Guidelines and Advice

In order for me to evaluate your work it is important that you develop good technical communication skills. The majority of graded work will consist of written solutions to the problem sets and exam questions. It is important that this work be neat, legible, and communicate your understanding. I cannot grade what I cannot follow. So, to this end here are some guidelines and advice. This may seem a bit rigid, but this ensures that I can grade your work accurately and in a timely manner, and that no work gets lost in all the shuffle. A portion of the grade is reserved for how well you have communicated through your solutions.

You will be assigned a randomly generated ID number for this class to use on assignments. This serves two purposes. It allows me to return work to you en-mass without compromising your right to privacy and it anonymizes the grading process somewhat to prevent bias from creeping in. Please use this rather than your name, student ID, etc. on submissions.

While I don’t really care exactly what paper you use, please ensure it is 8.5 x 11 paper. I recommend either "engineering paper", plain printer paper, or graph paper. Collate and staple your solutions in the upper left corner prior to submission. Use only one side of the paper.

For each page of work you submit, divide the top half inch or so into three columns. In the left-most place the problem set number, in the middle one your randomly assigned ID number for this class, and in the right-most, the current page of the total.

Number each problem as in the assignment (i.e. if you skip a problem leave that number out). Start by copying the problem in its essence (you don’t have to copy it word for word). If you start a new problem on a page anywhere other than the top, draw a line across the width of the page immediately above it, but prefer to start problems on a new page.

As you develop your solutions roughly (mentally) divide the paper into two columns. Use the left for the solution steps and the right for figures, diagrams and explanations of your steps (reasons or rationale). When you have a final answer, draw a box around it as a highlight. You should show most if not all steps in your reasoning, leaving few gaps. Leaps of logic, "and then a miracle occurs", will reduce your grade. Remember, the goal is to communicate your understanding.

Your writing should be legible, but don’t obsess over it. I recommend using a pencil to make corrections easier. It is unlikely that you will produce acceptable work the first pass through a problem,
so plan on copying your solution, enhancing it for completeness and clarity. If you have time you should do this on exams as well.

The next pages show an example, first showing my first pass through a solution, followed by the final result. This gives you an idea of what I am looking for.
\( \cos(\pi x - 5\pi) \)

\( t = 0 \quad \cos(-5\pi) = -1 \)

\( 20\pi t - 5\pi = 20\pi (t - \frac{5\pi}{20\pi}) = 70\pi (t - \frac{1}{4}) \)

\( 20\pi t = \pi \frac{1}{4} \)

\( t = \frac{1}{4} \)

\( f = \frac{1}{T} = 20 \text{ Hz} \)

\( \cos(20\pi t) \)

\( 20\pi t \neq -5\pi = \frac{-5\pi + \pi}{2} = -\frac{4\pi}{2} \)

\( 20\pi t = \frac{\pi}{2} \)

\( t = \frac{1}{40} \)
\[ u(t) + r(t-1) - r(t-2) - 2 \theta(t-2) + u(t-4) = 0 \]

\[ u(t) + r(t-1) - r(t-2) - 2 \theta(t-2) + u(t-4) = 0 \]

Check: \( \int = 4 + \frac{1}{2} = 4 \frac{1}{2} \)
1. \( x(t) = \cos(20\pi t - 5\pi) \)
   
   Find fundamental period
   
   \( \omega = 20\pi \quad T = \frac{1}{10} \)
   
   Plot is \( \cos(20\pi t) \) shifted by \( t_0 = \frac{1}{4} \)
   
   \( \mathbf{2} \quad \text{\scriptsize{Not to scale}} \)

2. \( t = 0 \rightarrow \cos(-5\pi) = 1 \)
3. \( 7\pi - 5\pi = \frac{2\pi}{2} \rightarrow t = \frac{1}{4} \)
4. \( 7\pi - 5\pi = -2\pi \rightarrow t = \frac{1}{2} \)
5. \( 7\pi - 5\pi = -\frac{2\pi}{2} \rightarrow t = \frac{3}{8} \)
6. \( 7\pi - 5\pi = -3\pi \rightarrow t = \frac{3}{10} \rightarrow T \)
\[ x(t) = u(t) + r(t-1) - r(t-2) - 3u(t-2) + u(t-4) \]