Dear Colleagues, students, alumni, friends and collaborators,

It is an honor to be asked to share my story and perspective at UofL with you. I hope you will find my perspective on being a professor interesting, and perhaps even a career that you too might aspire to. Being a professor IS the greatest job there is. But most people don’t understand what a professor is. Simply, a professor is someone who professes some truth whether factual, spiritual or philosophical. A professor shares truth even in the face of hostile opposition to such views, (e.g., the earth is round, all objects fall at the same speed, particles are also waves). A professor without a job still continues to profess, even on the street corner to anyone who will listen. (Fig. 1) For instance, I used to go to technical conferences and always carry a folder with my copies of my presentations to show to anyone who would listen during breaks and receptions – at least until a colleague made a joke about it. I was informed that professors need to check their “weapons” outside the meeting place.

Before being a professor, I was a student, and have remained a student to this day. At Shawnee Mission South High School in Overland Park, Kansas I was in Advanced Placement English and Calculus. For college in 1971 I was comfortable selecting either Electrical Engineering or English degree programs. With the Vietnam War at its height and the all the hotly debated political, moral, ethical and spiritual issues I selected English, where I could learn more about the variety of human views, philosophies and creeds. My parents wanted me to get as far along in my studies as possible, in case I was drafted, and would be better positioned for military service away from the front lines. During my freshman year at Duke University, my dorm had a lottery for the student with the lowest draft number. I “won” the bet with a 6 in the draft. At the time, it appeared that I would certainly be drafted. So I transferred to my local school, the University of Kansas, to be closer to my friends before joining the service. Sometime after starting at KU, President Nixon ended the draft entirely.

Lawrence Kansas was the total experience inside and outside the classroom. I learned a lot just walking around and visiting various classrooms, libraries, labs and studios. The greatest impact on me was the music scene (local clubs, KU sponsored popular music concerts, and School of Music events). I volunteered to be a one-night roadie for Ted Nugent’s concert. Backstage us roadies discover a large buffet including Heineken beer. We would have cleaned it off except the band’s manager noticed the growing hoard of hungry students and informed us that the food was only for the band. One beautiful Saturday morning in Spring I was up early and walking through the deserted center of campus. Sitting on the steps of the administration building was a white haired man in a white tee shirt. I sat down next to him and had a pleasant talk about nothing in particular. It turned out that he was Dave Brubeck and he had given a concert the night before. His wife Lola, who wrote the lyrics to Take Five, was nearby photographing the buildings. I don’t recall if I knew his music at the time, but he was one of the nicest people to talk to.
There is not enough space to list all the music concerts I went to, but the Lawrence Opera House did have many small-label and starting artists, including blues artists Son Seals and Koko Taylor, and Ricky Skaggs promoting his first record. I did go to an infamous 3 day festival called Sedalia Nation by the Kansas City Star. Kansas also offers great bluegrass and I attended the National Flatpicking championship in Winfield Kansas with my sister around 1974, where the then new band Hot Rize was headlining. One infamous influence, because of our shared love of absurdist humor, was the local band the Barking Geckos band, especially their song Frijoles (performed at the National Surrealist Party Convention 1976). The Kool Jazz Festival (Fig. 2) at sold out Royals Stadium, including Marvin Gaye, Nancy Wilson and B. B. King was one of the most congenial and pleasant concert experiences for me.

At KU I was even able to learn a little about music in two electives – Native American Music (from Anthropology) and Modern Music. For the anthropology course I even visited Haskell Indian Nations Institute (also in Lawrence, where Jim Thorpe attended) and interviewed some of the students about their awareness, interests and taste in Indian music (e.g. the modern song “one-eyed Ford”). For the Modern Music course one composer stood out, was Xenakis (who formerly was an engineer) and who began composing on computer. He used random number generators to select notes for large orchestra pieces and was a huge star in the 70’s and was frequently reported on in Time magazine. I remember in my Fortran programming class, programming (on punch cards) a short composition using random number generators.

So when I graduated in 1975 with my B.A. in English and with the possibility of military service a distant memory I only began to think about “a job”. So mostly, I decided to stick around Lawrence that summer and really focus on learning to play guitar well. What I learned, fairly fast, is that if I wanted to work in the music industry, I needed to contribute in some other way. I began volunteering for recording and mixing, including for the Kansas City public parks concert series and for a local video production company Centron. In the Fall I became Road Manager (the one and only roadie and sound and lights technician) for the band The Blue Things. Blue Things had been a national band in the 60’s but now just toured at small clubs through the Midwest playing top 40 songs, like the Eagles Best of My Love and KC and the Sunshine Band Get Down Tonight. We drove from small town to small town, did a few shows, and stayed at the dumpiest of motels. It was a lot of fun! We broke for Christmas and since I was taking a bus home, I left with the bandleader my electric guitar (on loan from a friend in Lawrence) and half my wages.  The band

Figure 2. Advertisement for Kool Jazz Festival from KC Star.  

Figure 3.  As far as I got on building a guitar.
disbanded after the break, and I lost my wages and guitar. This led me to try to build a replacement guitar for my friend. (Fig. 3) I gave up working on it when I misplaced some of the fret positions about the same time I started engineering school. It’s a good thing that eventually Igor, the band’s booking agent, got the guitar back, because of the mistakes on the guitar, and a newly acquired distaste for woodworking.

So in January 1976 I revised my music career path with, for the first time, focusing on job security. I enrolled in KU’s Electrical Engineering B.S. program with the plan to complete my degree in five semesters by May 1978. The capstone of the degree would be the last semester EE elective in acoustics. Then I planned to look for jobs in the audio industry. I even visited Crown Amplifier to introduce myself before I graduated. However, my plan changed again when I took the acoustics course. For the course term paper I selected a project on Surface Acoustic Wave devices made from piezoelectric crystals. I had just learned about them from an IEEE Special Topics issue on the topic that a professor had discarded outside his office. The fascinating aspect of the SAW device is that the Fourier transform of the electrode pattern corresponds to the frequency response of the device. Fourier transforms had been my favorite engineering topic. At the time I did all the property proofs and continued to redo the proofs at the start of several Fourier transform related projects and courses throughout my career.

When I saw that several articles in the IEEE Proceedings were by Texas Instruments scientists, I decided to interview with TI when they came to campus. The head of the Radar and Microwaves Division, Russ Logan, was very impressed with my interest in SAW devices, he gave me his card and said he would bring me down to Dallas for an interview. The semester was almost over and I hadn’t heard from Russ. I called and said I had an offer from a local company Kustom Electronics, which makes police radar guns (I wasn’t aware back then that they also made guitar amps, elsewhere, in Chanute, KS) but that I would really prefer to work for TI. He put me on hold and when he got back he said something like: “Somehow your application was placed in the wrong pile.” It must have been in the right pile, if the applications were strictly on grades.

When I joined TI (Fig. 4), I continued to remain a student. I spent a lot of time finding research papers and copying them in the TI libraries. I took 1-2 graduate courses per semester over the Dallas-Fort Worth TAGER distance learning network. I also took many short courses and workshops at TI on both technical and professional topics, including microwave filter design, HP network analyzer measurements, Juran Quality, writing large group proposals, Karrass Negotiating.

By 1980 I decided, with TI’s support, to take a leave of absence to complete my M.S.E.E. at KU with an MS thesis on SAW devices. During this time I also learned a lot about basketball, and in particular UofL basketball. I took a non-degree credit gym course in basketball. We met in Allen Field House (“The house that Wilt built”) on the basketball court. We would continue to play pickup games after the class, including with some of the sports stars. One aggressive rebounding effort led to me spraining my ankle so bad that all the color drained from my face and I went into shock. The next day I called the Chair of Math

Figure 4. The TI logo or “bug” written on a silicon wafer. Around 1982 I wrote the computer XY stage control code for a custom laser direct write system for the SAW devices group.
from whom I was taking a special topics course on Digital Signal Processing to tell him I could not attend because of the sprain. Later that day, he and the other two students showed up without warning at my very dumpy apartment and we proceeded with class as usual!

I became a fan of UofL Basketball while watching the 1980 March Madness Tournament. Often after a hard day of classes I would go to a local beer bar. (At that time bars could only serve 3.2% beer, and the drinking age was 18). I sat on a stool at the bar, drank beer and ate peanuts. (Throwing shells on the wood floor was encouraged.) The small TV was always on over the bar and it seemed Louisville was always on. The playing style of Louisville was incredible, but more than anything else, I was amazed at how Darrel Griffith (Fig. 5) always retied his shoes before each free throw – without bending his knees! Of course his steals and jump shots were remarkable. I assumed at the time that UofL was a little known underdog (not true), and they quickly became my favorite.

On my return to Dallas I was assigned to work on a project on adaptive fine tuning of the frequency response of surface acoustic wave filters. This became my dissertation topic for my Ph.D. at Southern Methodist University. The method consisted of mechanically shortening the length of the electrodes and measuring the changes in frequency response. Then these perturbation measurements were used to compute an optimized frequency response. Fig. 6 shows that sidelobe levels of the frequency response were lowered after the compensation. This device is shown in the photograph. An interesting feature is that the surface wave is transmitted from the upper left interdigitated transducer to the transducer on the lower right. The double wide electrodes in the center serve as a directional coupler that moves the

Figure 5. Darrel Griffith is ranked second on the NBA list of highest leapers with a vertical leap of 48” behind only Michael Jordan, who is also listed at 48”.

Figure 6. A SAW device (left) that was tuned by experimental feedback of electrode lengths to lower the sidelobe levels (before and after on right). An example of an interdigitated electrode or IDT (center). The device (left) has two IDT’s and a longer directional coupler between the IDTs. The curves on the IDT are the impulses responses of the transducer before and after tuning (by removing the exposed chrome). The impulse response of IDT1 is convolved with IDT2 to give the designed frequency response. The compensation method corrects for non-ideal impulse responses of the IDTs. From PhD Dissertation 1988.
wave from the upper side to the lower side. This coupler is included to separate the surface wave from generated bulk waves that can reflect off the bottom of the substrate and back into the receiving transducer.

On completing this project I was invited to join the Deformable Mirror Devices Group, also in TI’s Central Research Lab (CRL). The projects I worked on were applications in optical signal, information and computing of the deformable mirror device (DMD, which today is referred to as the Digital Light Processing device or DLP). At the time, the current version of the DLP that is pervasive in projectors from classrooms to movie theaters had not been invented. All earlier versions had insufficient performance for volume markets. The purpose of the CRL research group was in large part to secure continuing research funding to sustain the device development R&D efforts until a commercially viable DMD could be developed. I was witness to the breakthrough discovery, which was the demonstration of the torsional mirror pixel. (Fig. 7) This simple element overcame two problems with the previous cantilever pixels. One problem was that the least bit of processing residue on the mirror hinge caused the mirrors to unpredictably tilt up or down from the nominal flat position. The second problem was that the tilt angle could be quadrupled over that of cantilever, which for the first time enabled sufficient contrast in projector applications between “on” and an “off” pixels. The day the experimental torsion pixel was fabricated, Larry Hornbeck, the inventor and driving force behind all DMD device technology (by this point a decade long effort) saw this element and rushed off to his office. Over the next 2-3 months I would see him working feverishly in his office and generating piles of paper that became a 51 page patent.

Figure 7. The breakthrough torsional mirror pixel, the current pixel where the mirror is supported on top of the torsional element, and a fully packaged commercial DLP. Attributions: Hornbeck U.S. Patent 5061049, Texas Instruments, Binant

Upon joining the optical signal processing group I had the eye-opening realization that all my understanding of acoustic waves for filtering and one-dimensional signal processing, generalized to two-dimensional signal and image processing. NASA and DoD were interested in using DMDs as optical phased arrays to perform live image correlation for pattern recognition and object tracking. Their preferred optical signal processing architecture was the 4f correlator where a laser illuminated DMD1 in the input plane, is Fourier transformed to the focal plane. A complex valued spectrum on DMD2 in the focal plane multiplies the incident spectrum. This product is Fourier transformed to the image plane which gives the correlation between the image on DMD1 and image corresponding to the spectrum on DMD2. This is the same relationship that gives the impulse response of the two IDT’s in a SAW device. (Fig. 6)
The mentioned agencies did eventually secure funding from the DoD agency DARPA to fund the development of a piston motion (pure phase) DMD. In fact, with my first federal funding, which was from DARPA, I received a prototype test array of piston mirrors that TI had made for them. However, this type of analog pixel is much more difficult to reliably fabricate and control than the DLP bistable pixels for display applications, and this device was never successfully commercialized. At UofL I was able to continue my optical signal processing research by adapting liquid crystal displays to behave as phase modulators. (Fig. 8)

At TI while considering the use of cantilever pixels as phase modulators, I became aware that pixel arrays when illuminated by laser light produce a cloud of background noise everywhere in the focal plane. I noticed that the pixel tilts differed slightly from each other (due to the surface contamination mentioned above) and that these random tilts led to the white noise background. After joining UofL I learned that this phenomenon, caused by interference between randomly phased scatterers (such as a rough surface), is referred to a “speckle” or “laser speckle”. (Fig 9) There is a large body of knowledge on the statistics of scattering from random surfaces. These ideas formed the basis for a proposal to DARPA, my first successful proposal for Federal research support.

Playing around with the equations of Fourier transforms of pixel arrays, where each pixel modulation is a random variable, I found that it was fairly easy to calculate the average diffraction pattern and its standard deviation. (Fig. 10) Since computer programs can generate random numbers for the pixel phase values, then it is possible to program any Fourier transform pair – at least in an average sense. The expected value of the diffraction pattern is identical to the desired Fourier transform. I named this method Pseudorandom Encoding (PRE). The actual pattern is accurate to the limits set by the standard deviation, which decreases with increasing numbers of pixels, by the law of large numbers. There is also a white background of speckle noise that is equal to the energy blocked or filtered out by the desired (non-random) modulation.

Figure 8. An early phase modulator that I reverse engineered from a handheld liquid crystal television. Since then I received many other developmental modulators from companies and laboratories with much more ideal properties than the TV.

Figure 9. Publicity shot for my DARPA award of me in my lab next to three laser speckle patterns. The green spot is composed of fine grain speckle, the yellow pattern uses a tilted lens to form speckle of variable sizes, and the red set of lines is an interference pattern from two points (Young’s fringes). With only two random rough scatterers only Young’s fringes can form. However, the interference between numerous random scatterers across a random rough surface produces a speckle pattern. Photographed by Gil Courson, Courier Journal.
Figure 10 presents an example of the method. The top left image shows a desired diffraction pattern. The right image is a pseudorandom phase modulation. The depth of modulation is small in the center and increases to a full 360 degrees away from the center. One could equally well take a piece of glass and using sandpaper, increasingly roughen the glass away from the center. The second and third row of images shows additional desired diffraction patterns and the actual (simulated) diffraction patterns. The intensities are saturated to bring out the otherwise faint white noise speckle pattern background. The diffraction pattern noise can be further reduced by using light modulators with more pixels or averaging together the diffraction patterns realizations produced by several different random seeds – which are both demonstrations of the law of large numbers. In fact, the method works because the optical waves from every pixel overlap, interfere and add together close to the optical axis in the focal/Fourier/Fraunhofer plane. (first schematic in Fig. 10).

Since the invention of PRE in 1994, I studied many applications and extensions of the method, including live generation of laser spots for targeting and tracking moving objects at a distance, focusing the same laser beams through a microscope and using the beam to hold and move micron sized objects (so-called “optical tweezers”), and recording random modulation patterns in photoresist that when used as a photomask produces a smooth 3D relief pattern in photoresist (referred to as grayscale photolithography). Figure 11 shows undergrad, Meng and NSF Graduate Fellowship awardee David Hill using the grayscale lithography system. Four other Meng students successfully defended theses with me on studying extensions of PRE (Robert Nonnenkamp, Shaad...
A Manual sophomore, Matt Reese, did an advanced simulation study on PRE that resulted in his first journal paper. He is now Professor of Theoretical Physics at Harvard (though the paper is minor compared to his other High School awards, including 6th place nationally in the Intel Talent Search).

I consider that my invention of PRE was the first of my three main discoveries. The second discovery and third discoveries occurred simultaneously. In order to profile the random rough surfaces I was making (according to PRE theory) I was awarded an optical profiler and a contact profiler (referred to as an Atomic Force Microscope – AFM) from National Science Foundation around 1998. This AFM was Kentucky’s first AFM (except perhaps for experimental lab systems built in our Physics department). The profiling probe for the AFM is typically a nanometer sharp tip on a silicon cantilever. I thought it would be interesting to see if we could use the AFM to perform nanolithography. My new postdoc Sergei Lyuksyutov (now a Professor of Physics at University of Akron) took to this project with a passion.

While we were able to write nanoscale patterns on silicon, the tip quickly lost its sharpness due to friction and electrochemical wear. It also was not very conductive, which limited voltage-controlled lithography. This led various members of my lab to search for a way to attach or grow a long, constant diameter tip on an AFM cantilever. Our first attempt, led by postdoc Steve Harfenist (now Professor of Physics Keene State College) was to grow silicon nanoneedles on an AFM by a method of chemical vapor deposition (CVD) studied by Chemical Engineering Professor Mahendra Sunkara.

The attempts failed spectacularly, but they led to the two other key discoveries, including an alternative method of growing nanoneedles on AFM tips. I’ve always viewed this moment of discovery to be similar in spirit to the Reese’s Peanut Butter Cup commercial: “Hey, you got peanut butter on my chocolate.” “You got chocolate on my peanut butter. Mmmm!” In fact, both of these observations led since then my continued research and teaching activities in the topic of “nanostructure self assembly”.

The original CVD approach required that a small drop of melted gallium needed to be placed on the tip to locate the site for the growth of the needle. Placing the gallium there was not a problem. However during the CVD reaction, the droplet would never stay at the site. We tried to localize the drop by overcoating the tip with an electron beam resist and then patterning a small opening through the resist to the tip. We also coated the exposed tip with gold to increase adhesion of the droplet to the tip.
The ebeam resist was exposed by putting the tip in contact with a substrate and applying a large voltage so that current (i.e. electrons) passed through and exposed the resist between the tip and substrate. When Steve tried one of these experiments he found that when he pulled the tip away from the substrate there was a sub-micron fiber, hundreds of microns long on the tip. (Fig. 12) The fiber formed because the solvent in the resist was not completely dried out and still tacky at the time of the experiment. However, I thought this was a very interesting result that was worth further study. (In fact, I continued this line of investigation on the “directed self-assembly” of polymer nanofibers right up to my retirement.)

I asked Steve to see if he could draw additional fibers and get electron microscope images of them, which he worked on over the next week. He would place small drops of the polymer PMMA (trade name Plexiglass) dissolved in toluene on a substrate and then dipping an AFM tip in the droplet draw fibers which dried out and solidified during drawing. Nanometer diameter fibers of near constant diameter were easily drawn with very simply mechanical control. For example, postdoc Eric Nelson working at his desk, with no more than a Fisher Price kids microscope, hand drew 2 micron fibers on the end of a 125 micron fiber optic, and even was able to transmit laser light from the fiber optic to and through the smaller fiber. (Fig. 12) In order to make the idea understandable to a general audience, I also asked Steve to go out to the parking lot one hot summer day and for him to step on chewing gum until he produced a nanometer fiber. After a few attempts he found a sample that, under the electron microscope, did have a nanometer diameter fiber.

After learning how to draw fibers between two points to make suspension bridges, he soon after began drawing arrays of fibers all at once by brushing a liquid drop over an array of micropillars. (Fig. 13) We published on this study within about a year of the fortuitous mistake, as well as received a $1.3M grant from National Science Foundation from their Nanotechnology Interdisciplinary Research Team (NIRT) program.

Figure 12. Long PMMA microfiber that was hand-drawn on the end of a much thicker fiber optic. Laser light from the fiber optic is shown coming out of the end of the fiber. The twist in the fiber can couple and feedback light, serving as a “ring resonator”. Image from my 2004 ACS publication.

Figure 13. Hand-brushing of arrays of nanofibers onto silicon micropillar arrays. Replacing a single tip with the equivalent of an array of tips leads to a very robust and reliable way to make self-assembled arrays of near identical fiber bridges, and in a matter of seconds. The first photo shows 200 nm fibrin bridges formed below the tips of the pillars. The second photo shows nano-trampolines supported between four pillars. The trampolines form at slower brushing speeds than the fibers. From my 2009 RSC publication.
There were many fabrication extensions and variations that we pursued over the years. The last extension I pursued is a method of building networks of fibers in 3D from films of patterned polymers. It should be possible to layer these films on top of integrated circuits during their manufacture. The same wafer stepper exposure tool (193 nm wafer steppers) could also be used to expose the films. Heating the films to around 120°C causes the film to transform controllably from an array of holes into an array of nanofibers. There are ways to interconnect the fibers between all film layers to create a 3D network. The fabrication method was conceived as one that would be compatible with the front-end processing equipment and manufacturing rate requirements (100 wafers per hour) of semiconductor factories.

The other fortuitous mistake was that Mehdi Yazdanpanah (a PhD graduate student at the time) noticed that the gold coated AFM tips, when placed next to a gallium droplet changed over time to a silver color, expanding over time from the droplet. Looking at the film in the electron microscope we could see that very interesting and varying patterns of islands and wires formed depending on distance from the droplet. (Fig. 15) Mehdi on his own initiative began studying gallium reactions and these interesting spreading patterns with dozens of different metals. Many of these metals produced bundles of rod-like crystallites with the silver-gallium reaction producing the longest and highest aspect ratio rods, that we referred to as nanoneedles.

Noting that the silver-gallium nanoneedles seemed to grow nearly parallel to the direction of gallium spreading, it seemed to me that we might be able to grow nanoneedles directly on the tip of an AFM probe. Dipping a silver coated tip into a melted drop of gallium resulted in 100 nm diameter needles that would grow (in around 1 minute) to any length we chose up to even a millimeter, which is 1000× thinner and 10× longer than the width of a human
hair. (Fig. 16) These results are all the more interesting because gallium melts just above room temperature. You could say, gallium 
*melts in your mouth, not in your hand.*

There are many interesting studies we performed using the nanoneedles for measurement and manipulation of nanostructures under the AFM and inside the electron microscope. Around 2007, Mehdi became interested in commercializing the nanoneedles and related applications. I helped him in developing proposals for technology transfer and commercialization. Proposals for small business development (SBIR) seemed a lot like research proposals, except the hypothesis was how much revenue and profit one could expect to generate down the road if the technology barriers could be overcome. I noticed that even in other research proposals to Department of Defense, Department of Homeland Security and NASA, that a business case was often needed to justify the funding, so helping Mehdi in this way proved useful for my own research.

Mehdi did very well in securing funding from State and Federal agencies for his company NaugaNeedles, and his company also had a revenue stream for selling customized AFM probes and doing contract research work. The company survived for 15 years, closing only recently. Mehdi also received two significant honors (with substantial cash awards) related to spinning-off this technology. One was the local *Vogt award*, and the most significant one was an Entrepreneurial Postdoctoral Fellowship from the *Kauffman Foundation*. This later award required him to attend regular training on entrepreneurship at the Kauffman Foundation for two years, including meeting with teams of mentors from business and academia. As his academic mentor I attended one meeting each year. From this I learned a lot more about commercialization.

Figure 15. Patterns of gold islands and nanowires self-assembled diffusion of gallium into a gold film. After diffusion, the gallium and exposed silicon dioxide were etched away to form the suspended nanowires. From my 2004 AIP publication.

Figure 16. A silver-gallium alloy nanoneedle on the end of an AFM tip. Note that the silver coating above the needle has been dissolved away and incorporated into the needle. The image on the right shows that the same needle is flexible and “springy” (resilient) as it is used to deflect a suspended polymer fiber. The blue line shows a mechanical model fitting to the buckled shape of the needle, and was used by postdoc Vladimir Dobrokotov (now a Professor of Physics at Western Kentucky University) to determine the elastic constants of the alloy and the fiber. From my 2008 IOP publication.
For me the biggest thrill was that the Kauffman Foundation is in Kansas City and so I very much enjoyed these visits to my hometown, especially since they put me up in a luxury hotel next to the historic and gorgeous Plaza. Kauffman spares no expenses, so one year (2009) when I was on sabbatical in Paris, they flew me back for the annual meeting.

So that sums it up for my three major research contributions. For those interested, the many details and other results can be found in my various publications (ERINC website, Researchgate). By no means am I saying that my three ideas are the best ideas among all those I’ve been exposed too. But they are special to me because they motivated me to continue to study and delve deeper into these ideas. These three ideas motivated so much of the extensive research, development and intellectual breakthroughs of my students, postdocs and collaborators, most of whom are co-authors on my (our) publications.

Being involved in research also exposed me to many other amazing ideas from my colleagues, which is one of the truly rewarding benefits of working and studying in corporate R&D and academia for all my adult life. If you are interested, I would be pleased to write a sequel to this article on the 10 great ideas I learned from my colleagues.

For completeness let me briefly summarize my teaching and service activities. I have taught many different topics, but my favorite topics are the ones that help me gain deeper and broader perspective on my research. UofL has been extremely supportive in permitting me to develop and teach courses that grow out of my research. These include a series of optics courses (optical signal processing and holography, optical computing, optical electronics and lasers) from my early years at UofL and Nanotechnology courses (Nanotechnology, Fundamentals of Polymer MEMS, and Nanostructure Self Assembly I, II and III) from later years. I also found that teaching several existing courses contributed to my research (including Digital Signal Processing, Random Processes, and Electromagnetics I and II). Even if you think you learned a course as a student, there is always more to learn each time you teach the same material. What I did learn from my courses certainly helped my research and the abilities of my students involved in that research.

Service is not only expected of professors, but of members of any profession, and in general, all citizens in society. Our ECE 496 Professional Topics Course covers most of the professional advice I give to students and colleagues. I view it as the icing on cake of mostly technical education that our students receive. I covered as many topics as I could think of that I thought engineers would encounter throughout their careers. Some of these topics included ethical standards and why they exist, whistleblowing (risks, rewards, protections), academic freedom, the role of the engineer in society and societal engineering, various careers and career paths, non-traditional opportunities like patent law, grad and post grad opportunities, consulting, start-up companies, negotiation strategies (based on Karrass), intellectual property rules, laws, invention disclosures, patents and open source, standards and standards organizations, preferred corporate employee environments (the HP way, Dilbert Principle, especially “Out at 5” in chapter 26), planning/saving for retirement. After we’ve been in the profession a while most of us confront these issues, but it could help students more quickly deal with such issues when they start out on their careers.

A very specific service activity I did was developing an ECE Department recruiting slideshow in 2014 explaining why students should consider pursuing a degree in ECE. The slideshow describes
the various ECE specialties and summarizes the job market for Electrical Engineering graduates circa 2014. This activity also gave me an opportunity to **incorporate a painting** that honors and worships the myths, history and the pioneers of electricity and magnetism (the painting by Raoul Dufy and related music by George Gershwin both from the same year 1934 are presented in a short video [here.](#))

For at least the last 7 years at UofL I served on several Speed School and University-wide committees that have worked on various rules and policies on governance of the university. Given the **monastic origins of universities**, the rules and objectives of universities are usually (but not always) quite different from those of corporations. One of the cornerstones of UofL rules (which is described in its constitution **The Redbook** is that of “**shared governance**” in which each student, staff employee, faculty member and administrator are given “jurisdiction” of those matters that they know the most about. This model gives primacy and due deference to those members of the UofL community who are closest to the situation at hand. It encourages open discussion and cooperation between all parties to elicit the most useful and creative ideas for improving and moving UofL forward. Without going into specific instances, consider how it would make no sense for The President to tell a professor what material should be taught in Circuits I. Shared governance only improves quality and creative adaptation to the needs of the UofL Community.

In these days of underfunding of education and daily crises on so many fronts, we often forget about working together to solve our problems. Over these last few years, I found many times that decision making groups (at all levels) had forgotten or did not even understand UofL’s shared governance policies. A few faculty working to remind UofL about the governance model is not sufficient to renew our commitment to shared governance. My UofL friends, I ask you to read The Redbook and work to learn and practice shared governance. For my friends who are outside UofL, I ask you to learn and participate in the shared governance opportunities in your organizations. It will ensure that your organization will hear and act on the best ideas and most creative solutions to moving your organization forward. In short, do whatever you can to support, bring out, listen to and act on the best ideas of your colleagues.

That’s about it for this professor. If you caught me on the streetcorner, that’s what I’d profess to you. But this professor of philosophy can more likely be found (occasionally) at **Sergio’s World Beers** where I now do my best professing and philosophizing. As a final illustration of the mind of a professor consider this [NPR essay](#) from the viewpoint of a physicist. So far, one month in, there isn’t much to report about retirement, but I would be more than pleased to learn about how things are going with you, my former students, colleagues, supporters, and friends.