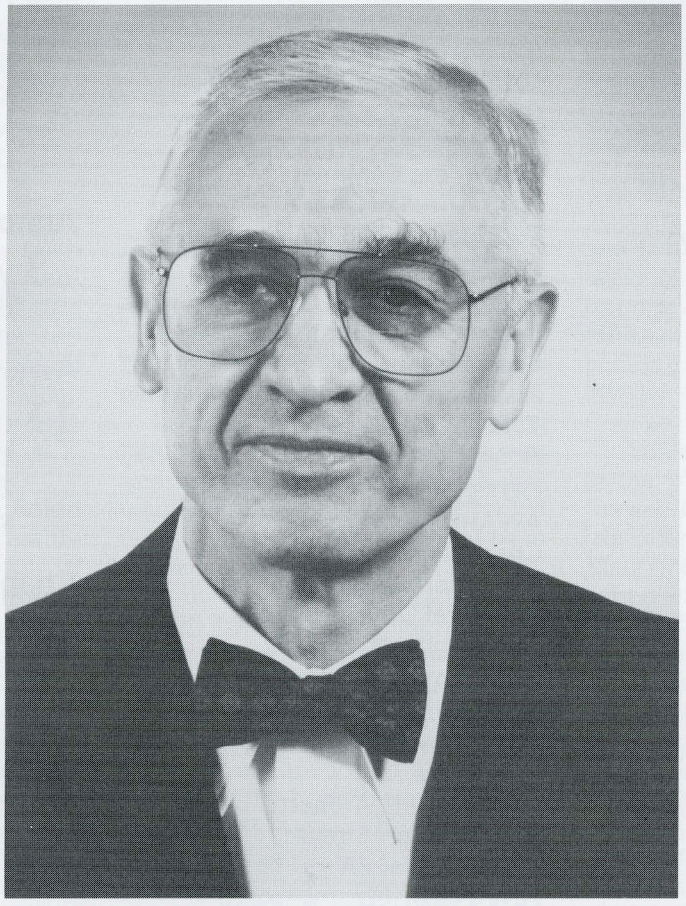
BRIDGE of Eta Kappa Nu



Dr. Nick Holonyak, Jr.
Author, Feature Article:
From Carbide Lamps to Semiconductor Lamps

Also Featured:

Zeta Pi's Certificate of Merit Report

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Editor and Business Manager
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Contributing Editors
Nick Holonyak
Alan Lefkow

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Nominations Invited for The Fifth Vladimir Karapetoff Eminent Members' Award

Dr. Vladimir Karapetoff

Nominations for the fifth Vladimir Karapetoff Eminent Members' Award are now being solicited. Nomination forms and guidelines may be obtained from Donald Christiansen, Eminent Member Committee Chairman, 434-A West Main Street, Huntington, N.Y. 11743.

In 1991, the Eta Kappa Nu Board of Directors announced the establishment of an award in honor of Vladimir Karapetoff, an Eminent Member of HKN and Fellow of IEEE, who died in 1948. The first award was given on April 27, 1992.

The award, the Eta Kappa Nu Vladimir Karapetoff Eminent Members' Award, is made annually to an electrical engineering practitioner who has distinguished him/herself through an invention, a development, or a discovery in the field of electrotechnology. The fund to support the award was initiated through a bequest from Dr. Karapetoff's wife, R. M. Karapetoff Cobb, herself a distinguished chemical engineer.

A monetary honorarium is provided to the recipient (or shared by the recipients) of the award.

Factors that will be weighed by the jury will include the impact and scope of applicability of the invention, development, or discovery; its impact on the public welfare and standard of living and/or global stability; and the effective lifetime of its impact.

Dr. Karapetoff was born in St. Petersburg, Russia, January 8, 1876. His father was an engineer and his mother a student at a military medical school.

Dr. Karapetoff emigrated to the United States in 1902, and became a naturalized citizen in 1909.

In 1904 he joined the engineering faculty of Cornell University as an assistant professor. In 1908 he was made a full professor and continued in that capacity until he retired from active teaching in 1939.

In an account of Dr. Karapetoff's career, his Cornell University colleagues R. F. Chamberlain, N. A. Hurwitz, and Everett M. Strong, recalled his continuing dedication to Eta Kappa Nu. During World War II he was commissioned a Lt. Commander in the U. S. Navy. But beginning in 1942, Kary, as he was known to his associates, began to lose his sight in both eyes, and despite temporary relief through operations, he ultimately lost his sight and schooled himself in Braille and "talking books."

Even after his blindness he seldom missed the annual Eta Kappa Nu Award dinner in New York City, and would address them in "refreshingly original and lucid expositions" of his technical interests. Fellow HKN members viewed these occasions as sort of a "national Kary reunion." His handicap notwithstanding, his cheerfulness, determination, and ingenuity prevailed.

His colleagues remembered him as an accomplished musician on piano, violincello, and double bass. He toured the country giving recitals and lectures on Wagner, Liszt, and other major composers, and developed a five-string cello on which violin music could be played. He received an honorary Doctor of Music degree from New York College of Music.

Professor Simpson Linke, writing in the Winter 1984-85 *Engineering Cornell Quarterly*, cited the following excerpt from Karapetoff's *Electrical Laboratory Notes*, published in 1906, as reflective of the flavor of EE studies in that era:

> In coming to the laboratory, bring with you a slide rule, an inch rule or tape, a speed counter, a screw driver and a pair of plyers [sic]. This will save you time and trouble of looking for them or borrowing them. Do not forget to have a pocket knife for skimming off wire; a bicycle wrench is also sometimes very handy to have.

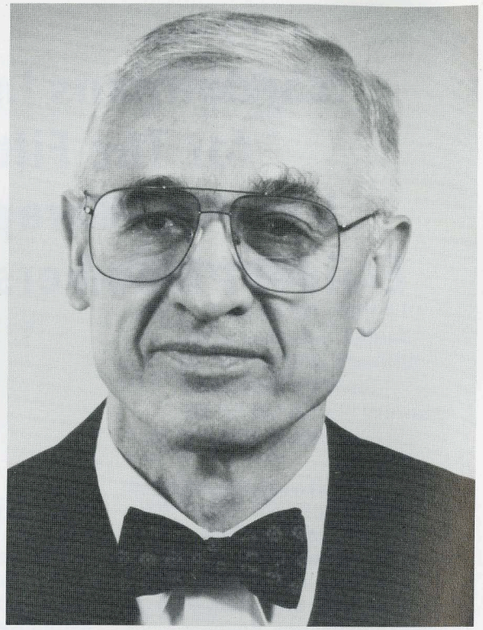
Dr. Karapetoff was the author of several standard texts on electrical engineering that were widely used and revised through several editions, as well as other texts on electrical and magnetic currents, electrical testing, and engineering mathematics.

He was a member of AIEE, the Franklin Institute, the AAAS, the American Mathematical Society, the Mathematical Society of America, the American Physical Society, the U. S. Naval Institute, and the U. S. Naval Reserve Officers' Association.

From Carbide Lamps to Semiconductor Lamps

by Dr. Nick Holonyak, Jr.

Electrical Engineering Research Laboratory, Center for Compound Semiconductor Microelectronics, and Materials Research Laboratory University of Illinois at Urbana-Champaign, Urbana, Illinois 61801



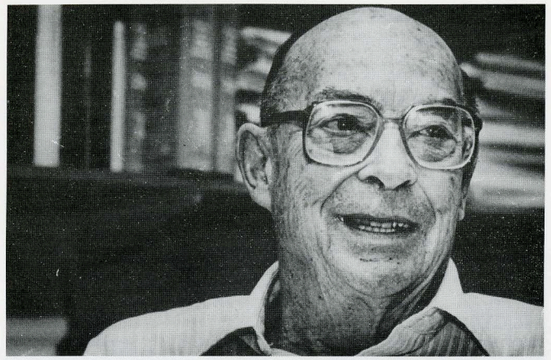
EDITOR'S NOTE: Bridge is honored to present this personal story by Dr. Holonyak. He is to receive the 1995 Japan Prize in Tokyo later this Spring...the prize is Japan's highest scientific award.

When I left the coal fields of Southern Illinois at the end of World War II (WW II) to study electrical engineering at the University of Illinois (Urbana), the original home of Eta Kappa Nu, little did I know what I would witness, what an adventure this would become. All that I knew from teen-age experimenting with Model-T Ford spark coils, electric bells, and crystal set radios was that electrical effects intrigued me more than the carbide lamps and even miners' blasting powder we had at home, and the chemistry one of my teachers wanted me to study. Also, I knew I didn't wish to continue working, beyond WW II holiday and summer work, as a section hand on the Illinois Central Railroad (1944–1946), nor spend more time in a coal mine than the two days I went underground with my father. Maybe a Carpatho-Rusyn immigrant could tolerate digging coal for decades, but I wasn't sure I could, or even wanted to.

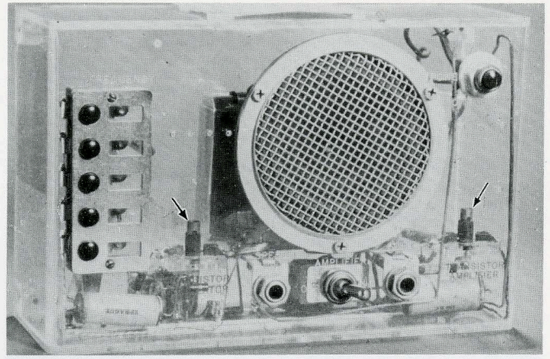
Instead of being intimidated by the returning World War II veterans, and all the electronics they knew because of WW II radar experience, I felt I could keep up in class because of my good high school mathematics background. So, I proceeded to use my WW II section hand earnings to become an electrical engineer and to study electronics, vacuum tube electronics which was very ably taught by young war-experienced non-Ph.D. assistant professors whom Bill Everitt hired and made into teachers while permitting them to complete Ph.D.'s. This was an astute move that solved a teacher-shortage problem, as well as injected electronics experience and a taste for electronics into a department lacking in this area. Who could have predicted the metamorphosis, the revolution that was about to occur in electronics?

It was all lucky for me, because by the time John Bardeen came to Illinois in 1951 as a professor of electrical engineering and physics and demonstrated to us his historic portable two-transistor oscillator-amplifier box, not a "black box" but an instant-turn-on transparent plastic box, I was already comfortable with vacuum tube electronics, and had turned down an offer to work in the Illiac project, a vacuum-tube-based "first" among the large scale computers. Instead I began Ph.D. study in device electronics working on a multipactor project. After a year working on a microwave cavity multipactor, and demonstrating a 3 gHz multipactor-generated bunched electron beam, I shifted to a new EE Department project and laboratory founded by John Bardeen. In spite of what some others might have thought of John's teaching, I liked what I was learning from him, first, in atomic physics and then semiconductors, and I started (one of two graduate students and two post-docs) to learn and to work on semiconductors, p-n junctions, and transistors in John's laboratory. Since John had a B.S. and M.S. in electrical engineering, and a Ph.D. in mathematics (not physics), maybe it was appropriate that I became his first student.

Much to the consternation of some of my "tube lab" friends in the same EE building (historic old Electrical Engineering Research Laboratory, now demolished in



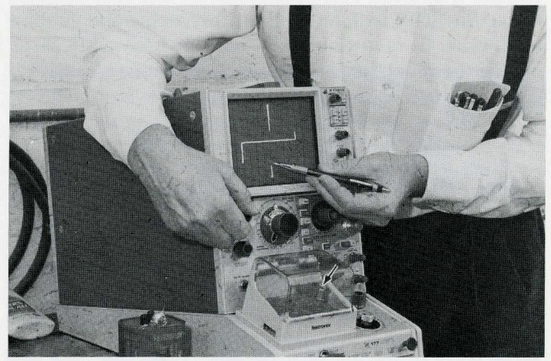
John Bardeen, the "godfather" of modern electronics, at age 80. Bardeen and Brattain discovered the transistor December 16, 1947, and, when Bardeen then identified carrier injection with a current, the transistor era began (and continues).



John Bardeen's portable ("instant-ON") transistor oscillator-amplifier box. The famous "box" was made in 1949, uses two point-contact transistors, still operates, and is in a U of I museum. (These were the first two transistors seen in Urbana - 1951.)

the interest of "progress"), it appeared to them that I had blundered and wasn't doing much more than working on some slightly more advanced form of old fashioned crystal-set radio device. After all, what was there that could compete with the all-powerful vacuum tube? In fact, milliwatts from a point contact transistor compared to the watts and watts from tubes was an object of derision. With Bardeen's guidance, and some valuable help from R. N. Hall (my colleague later at General Electric) on the occasion of some Urbana lectures, I learned to make alloyed Ge p-n junctions. Hall's alloy process for making p-n junctions, and, needless to say, billions of transistors, was, if properly considered, nothing less than local liquid phase epitaxy (LPE). In a sense this was the forerunner of all of the epitaxial methods used later to make p-n junctions. Using Hall's alloy process, I'm perhaps the first person to make a p-n junction as a graduate student. My friend Zhores Ivanovich Alfërov, who just visited Urbana (Sept. 1994), says that he too was mastering and using the alloy process to make p-n junctions at the same time in Leningrad, and as a consequence made the first Russian transistors. In any case, at Illinois I was the first to make p-n junctions.

I should mention that in spite of the fact that John Bardeen was not yet a Nobelist, all of us in John's lab were keenly aware that he was, indeed, much, much more of a talent than any of the other people around us. We could sense or feel that John was special. That would merely become more evident with time and the great fame about to descend on John. He was the kind of person who would even send his former graduate student stationed in the Army in Yokohama a greeting card from the 1956 Nobel prize ceremonies. I am sure our high regard for Bardeen had a large effect on us. It defined for us a whole different perspective on learning and research, on what mattered and didn't matter.



Holonyak demonstrating (in 1994 in old EERL) the first (1958) Si shorted-emitter symmetrical switch, which was the progenitor of all of today's TRIAC and wall-dimmer devices. This first symmetrical switch (hand-made in 1958 at GE) survives and still operates. (The arrow identifies the device.)

When Walter Brattain would visit from Bell Labs to consult with John, I remember watching very closely as they worked in our laboratory at the blackboard near my lab office. It was fascinating to observe how Bardeen corrected Brattain's mistakes, and then to see Brattain's response, which was partly in the coal-miner's language I understood so well (or could even repeat in basic Slavic). We were privileged to see how problems were identified and solved by the two "giants" who invented the transistor.

After a thesis on surface problems involving Ge p-n junctions, I decided, most fortuitously, to go to Bell Telephone Labs (BTL, 1954) to work for John Moll on

Si switching devices, specifically, on diffused-impurity Si transistors and p-n-p-n switches. At the time the only diffused-impurity Si devices were the solar cell and simple rectifiers, and yet John Moll firmly believed we should, and could, make switching devices in Si (not Ge!) by impurity diffusion, which, incidentally, I already knew about because of some of John Bardeen's interests and projects at Illinois. I don't know if any of us knew in the beginning how correct John Moll was. Within a year a handful of Bell Labs people set in motion the Si technology that Bill Shockley, with Bell's generosity, took to the West Coast shortly later, and that then with spin-off after spin-off generated Silicon Valley.

From 1954 to 1955, mainly with Moll's guidance and persuasion of Jack Morton, we learned to metallize Si with Al and Au and to make sophisticated Si p-n junctions, transistors, and p-n-p-n switches, the last becoming the Si controlled rectifier (SCR, later renamed the thyristor). Incidentally, although Shockley took credit for the p-n-p-n switch, which was based on the "hook" collector of Bardeen and Brattain's point contact transistor, I give the credit for our success (and hence the SCR) to John Moll for foreseeing and guiding our effort. In fact, Shockley was nowhere near us or our work on Si p-n-p-n switches and various transistors when the first diffused-impurity Si devices were built.

I want to especially mention that our BTL colleague Carl Frosch made a major contribution to impurity-diffused Si devices with his discovery of the secret of the oxide on Si and oxide masking. Some of our Si crystals were, in fact, the first on which he put the oxide and diffused some of the junctions that were part of our device experiments. Without Frosch's oxide, today there would be no integrated circuits. It is sad that Frosch's name is not better known. What a wonderful person, and fine colleague! I'm proud to say that I knew him. (I don't mind mentioning further that I consider Moll's and Frosch's contributions beyond all others in the realization of the integrated circuit.) The consequence of all of this was that we had pretty much set the course for what would be the future Si technology. The scale of this story is too great to tell here in any significant detail and has to be the subject of a separate account, which Moll and I are preparing. Rather than the Si device story, I wish to tell how we introduced the first practical light emitting diode (LED). how does one go from Si to III-V semiconductors and LED's?

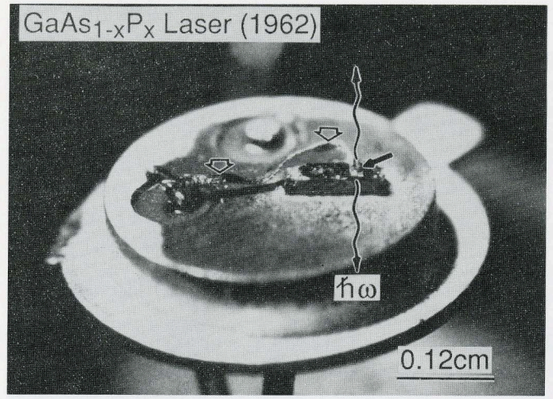
From BTL I went into the Army in order to meet a draft board obligation. In due course the Army sent me to Japan and, through John Bardeen, I met (1956) and became friends with George (Mitio) Hatoyama and Makoto Kikuchi. Hatoyama later was the founding director of Sony's research laboratory and Kikuchi was his successor. It is interesting that in Japan at Denki Shikenjo (MITI) I gave some Si device seminars for Kikuchi and his colleagues, but heeded the BTL lawyers' warning that I was not to talk about oxide masking. Maybe I am the first, with Kikuchi, to introduce diffused-impurity Si technology in Japan (1956–57). I should mention that, on Kikuchi's request, I managed to get a piece of BTL Si sent to me quickly via Army mail so that Shibuya could do a hot-electron measurement. Maybe this was Japan's first piece of "good" Si. I doubt that anyone started Si "rolling" in Japan before Kikuchi and I did. Also, in Japan I was conscripted at the Signal Supply Center to work on some of Signal Intelligence's problems, and perhaps some day it will be possible to tell more of the Cold War story and how devices get built in the field (not the same as in Urbana or at BTL).

In any case, when I left the Army (1957) I went to GE (General Electric) Syracuse and back to work on Si devices, in fact, right back to work on Si p-n-p-n switches which at GE, because of Ray York, had become the SCR. This was something I understood (Si switches) and, besides helping York's people to understand p-n-p-n switches, we quickly converted the SCR into TRIACs and other forms of symmetrical switches via the shorted-emitter (which, incidentally, much later took me for expert testimony to Julius Hoffman's court, Chicago, 1967). At first this did not interest our patent attorney, and later, because of slow filing, led us into a patent interference with Bob Noyce, then of Fairchild. The interesting thing about this work, besides the fact that we won the patent interference in spite of late filing, is that all thyristors employ shorted emitters, as well as all wall light dimmers. (Recently when I bought a wall light dimmer, the lady who sold it to me wondered if I knew anything about such elements and their use because of all the questions I asked about her store's product.)

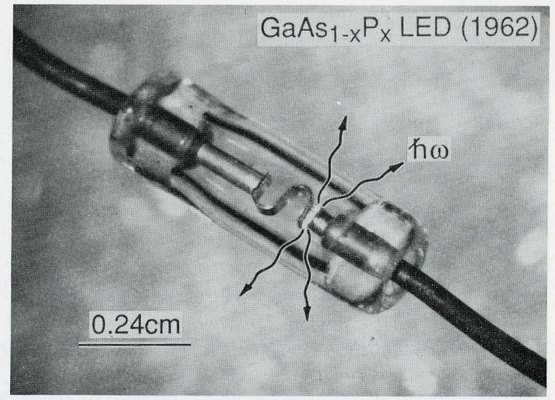
To me, an EE, SCR's, thyristors, TRIAC's, p-n-p-n devices were all switches and negative resistance devices, and at once made the tunnel diode interesting because it was less of a switch and a simpler negative resistance device, just a single junction. Hence, because of my familiarity with Si technology, I quickly built (1959) Si tunnel diodes and with my GE colleagues observed (4.2 K) phonon-assisted tunneling. This was the first observation of inelastic tunneling and the beginning of tunneling spectroscopy, which now has essentially a forgotten origin.

Unlike the p-n-p-n family of devices which handle large currents and large voltages (e.g., thyristors now handle tens of megawatts), tunnel diodes were very limited in voltage range, somewhere of the order of the semiconductor energy gap (~ 1 V). This made it interesting (1959–60) to look at the III-V family of materials, and led immediately to GaAs tunnel diodes and maybe to more problems than answers. Unfortunately, or maybe fortunately!, GaAs tunnel diodes were prone to failure. Hall tried some doping tricks with Mg and Hg to solve the problem and I tried amphoteric doping, simultaneous p and n doping, with Ge, and then made a more fundamental step.

I decided I could modify and use closed-tube vapor phase epitaxial (VPE) techniques, which then were being explored on Ge (an elemental material), to make VPE GaAs tunnel junctions (a compound material). My

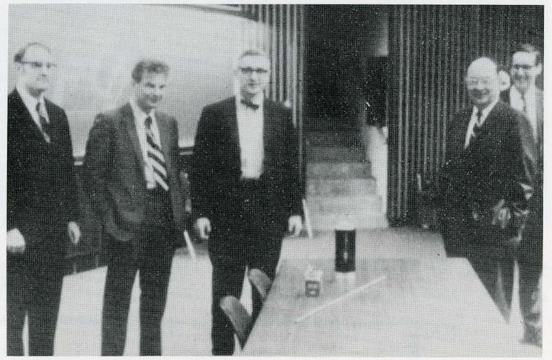


The first visible-spectrum laser (1962), the III-V alloy crystal $Ga(As_{1-x}P_x)$ which is identified with the little arrow on the right. The stubby open arrows identify a bent nickel lead attached to the crystal and to a current lead on the TO-18 header. This laser diode is the progenitor of the first visible-spectrum light emitting diodes (LEDs), which were first offered for sale by GE in 1962.



One of the first packaging schemes for the GaAsP LED (1962), which was simply a glass pigtail diode package with a GaAsP p-n junction replacing the usual Si p-n junction.

John Bardeen and Holonyak looking at experimental red-orange-yellow-green (ROYG) $In_{1-x}Ga_xP$ LEDs (1970-71) in Holonyak's old EERL laboratory in Urbana. InGaP now modified into In(AlGa)P by Al-Ga substitution via Dupuis-style metalorganic chemical vapor deposition is the source of today's super high brightness ROYG LEDs.



Bardeen semiconductor seminar series in Urbana in the spring of 1971. From the left: R. D. Burnham (Holonyak Ph.D. student), Z. Alfërov (Leningrad), Holonyak, Bardeen, Charlie Duke (now Xerox), and, partially hidden, G. Kleiman. Burnham was the speaker and described InGaP synthesis and laser operation (1970-71!).

colleagues at GE who grew our crystals considered me crazy for thinking I could do this, and then for doing it. They attributed this to the fact that I was an EE and would have known better and not attempted it had I been a chemist. I learned not only how to make p-n junctions in GaAs via VPE, but also how, in general, to grow III-V semiconductors via VPE. Also I could make heterojunctions, as well as the usual homojunctions, and described this work in some detail in widely circulated Air Force reports and, of course, in disclosures to our patent attorney. In addition, I showed my work to two visitors, F. V. Williams and R. Ruehrwein (Monsanto); Ruehrwein, with his chemist's background, promptly wrote a disclosure on what then became perhaps the most famous patent in the field of vapor phase epitaxial growth of III-V crystals. In any case, in the interest of still higher voltage tunnel diodes than possible with GaAs, I used VPE methods (1960) to synthesize higher bandgap (red-spectrum) $GaAs_{1-x}P_x$ and also made $GaAs_{1-x}P_x$ tunnel junctions. Near the end of 1960 I already knew how to make $GaAs_{1-x}P_x$ and $GaAs_{1-x}P_x$ p-n junctions ($E_g \sim h\eta \sim 2.0$ eV), as well as

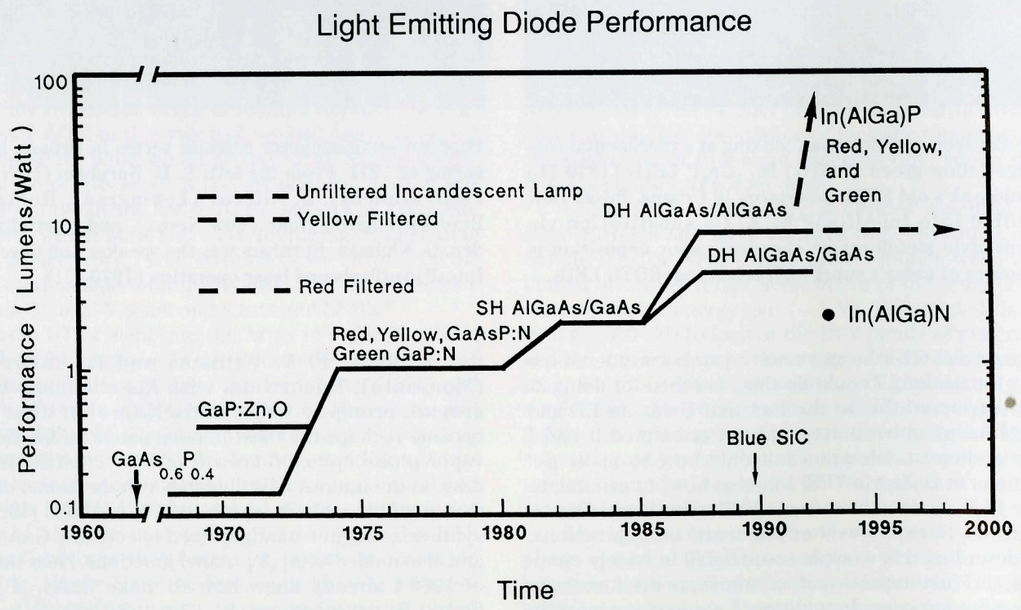
$GaAs_{1-y}P_y$-$GaAs_{1-x}P_x$ (y>x) heterojunctions.

By the time of the 1962 IEEE Device Research Conference (DRC), I had two years of experience in the synthesis and VPE growth of $GaAs_{1-x}P_x$ and in making red-spectrum p-n junctions in a so-called direct-gap semiconductor, a material like GaAs but not restricted to infrared (IR) wavelengths. At this point tunnel diodes were not as interesting to me as what I had gotten into, VPE III-V crystal growth and various new device possibilities, including light emitters. When Rediker's group (Lincoln Laboratory, MIT) reported, at the 1962 DRC (July), success in transmitting signals with the IR output of GaAs p-n junctions, several of us speculated that a laser could be built with a p-n junction, now proven to be a powerful IR light source, and this, indeed, occurred before year's end.

I thought I could realize a red-spectrum $GaAs_{1-x}P_x$ p-n junction laser ahead of everybody because of the convenience of working in the visible spectrum, but by thinking in terms of putting a p-n junction in an external-cavity laser resonator, I was behind my Schenectady colleague Bob Hall who was clever enough to use the GaAs crystal itself as the cavity resonator and could use a snooper-scope to see what he was doing. After I gave up cleaving attempts on large-grain polycrystalline material and devised a simple polishing scheme to make a Fabry-Perot cavity, I quickly realized a $GaAs_{1-x}P_x$ laser. It turned out that I was one of the first to make a semiconductor laser (the second with a Fabry-Perot cavity), and the first to make a laser on a "homemade" crystal, a red-spectrum III-V alloy. At a conference in Schenectady on November 28, 1962, Bob Hall and I presented our work to a large group of invited representatives from the Defense Department. Hall talked about GaAs in the morning and I about $GaAs_{1-x}P_x$ in the afternoon. This presentation to a large group in the GE Schenectady auditorium turned out to be the first conference on semiconductor lasers.

As part of my talk, which was recorded on a Dictaphone belt and (as poor as it is) still exists, I described the operation of $GaAs_{1-x}P_x$ not just as a laser but also as a visible-spectrum light emitting diode (LED). In fact, at the Schenectady meeting I gave away some $GaAs_{1-x}P_x$ LEDs assembled in little pigtail glass diode packages, and volunteered somewhat later (Readers Digest, Feb, 1963) that the LED exceeded the laser in importance. General Electric quickly offered Hall's IR lasers for sale, and at a more exorbitant price my red lasers and LED's. The first practical LED was out in the world (1962), and it was a direct-gap III-V alloy. I felt, and continue to feel, that it was important to build light emitters where the human eye sees, i.e., wider bandgap visible-spectrum p-n junctions.

The $GaAs_{1-x}P_x$ laser, indeed, gave an unambiguous start to the first practical LED, which in the figure below is the point (arrow, 1962) way over at the lower left. This figure, supplied by my former student and now colleague of many years, George Craford (Hewlett-Packard), shows how LEDs have evolved in performance over the years, in fact, decades. (Science and engineering do not give instant answers. It takes time. If you are not a believer, you get nothing!) In the interest of brevity I will not describe all the steps and plateaus in LED performance in this figure, except to say that the figure starts with a direct-gap III-V alloy semiconductor on the left, the prototype red-spectrum alloy $GaAs_{1-x}P_x$ (1962), and then at the far right (1994–95) climbs, because of the alloy $In_{0.5}(Al_xGa_{1-x})_{0.5}P$ grown



Academician Zhores Alfërov (Director of the Ioffe Institute, St. Petersburg) and Holonyak examining quantum well heterostructure laser crystals in old EERL (~1990). The first p-n diode quantum well lasers were grown, via liquid phase epitaxy, behind the lab table in the picture in early 1977.

lattice matched to GaAs, to well above the performance of conventional incandescents. In other words, III-V alloys have prevailed as LED's, and still continue to improve. Also, concerning the figure, the lower left hand corner is where I started and the upper right hand corner, and beyond, is where my former students have taken LEDs.

It is worth mentioning that our Air Force supported work at GE from 1960 to 1962 and construction of a visible-spectrum $GaAs_{1-x}P_x$ laser proved that III-V alloys were not inherently highly disturbed and riddled with defects. This was a mistaken belief of many early workers, as well as some high-placed managers who had wrongly decreed that GaP was the ultimate LED material. $GaAs_{1-x}P_x$, and later its direct-gap relatives $Al_xGA_{1-x}As$ and $In_xGa_{1-x}P$ (and now the latter modified by Al-Ga substitution into $In_{0.5}(Al_xGa_{1-x})_{0.5}P$), and their capability for laser operation, were inherently more efficient sources of recombination radiation (photons) than indirect-gap (non-laser) materials such as GaP; hence, the alloys at the upper right in the figure. Furthermore, III-V alloys made possible the construction of single (SH) and double heterojunctions (DHs), i.e., a wider bandgap hole (p) and electron (n) emitter on either side of a narrower gap active region. This proves to be advantageous for reasons of carrier injection and also in allowing escape of photons from the active region (less absorption), and is, of course, part of the design of the high brightness red-orange-yellow-green (ROYG) In(AlGa)P LED's of the upper right hand corner of the figure.

For the high brightness ROYG In(AlGa)P LED's at the upper right of the figure (and climbing up beyond the boundary of the figure!), part of the basis for the

high performance is the fact that the GaAs substrate has been removed and replaced with GaP, which is transparent (ROYG) and allows escape of a significant fraction of the potentially 100%-quantum-efficiency internally-generated recombination radiation. This work of the last year of George Craford and his group at H-P, particularly that of his younger co-worker recently hired from our laboratory, Fred Kish, has put ROYG LED's well beyond incandescent lamps in performance. The LED has now put conventional lamps and lighting under long range threat, particularly as the blue emitter $In(Al_xGa_{1-x})N$, which is analogous to $In(Al_xGa_{1-x})P$, is further developed. Since Craford and I are preparing an explanatory article on LED's, I won't go into great detail here to explain, but it is not too difficult to show that the direct-gap III-V alloy LED is an ultimate form of lamp; in principle, it cannot be exceeded. Experimental practice is now catching up with this fact. It will be interesting in the next decade or more to see how the semiconductor lamp will proceed to dominate more and more of the lighting function, not just the display function.

In a brief article I can't possibly tell all that I have witnessed in how electronics has changed, because of the semiconductor, in the 40 years since I received my Ph.D. in John Bardeen's laboratory (Urbana). When I came to the University of Illinois at the end of World War II, I had no inkling that I would even see, let alone take part in, the overthrow of the vacuum tube in electronics. Who would have guessed what Bardeen's identification of minority carrier injection would portend for the future of electronics? Who would have guessed that Bardeen and Brattain's point contact transistor and its "hook collector," not to mention minuscule (milliwatt) power level, would become the premier power device (SCR-thyristor) that now controls the megawatt power grid? Who would have guessed that a unique substance, the semiconductor, would permit electronics to be some kind of unique tri-particle performance in a crystal, some sort of quantum "dance" of electrons, holes, and photons—all three!?

I want to mention finally that electronics (EE) brought me into contact with a wide range of interesting and talented people. Perhaps none exceeded John Bardeen in sheer genius and depth. It will take historians some time to tell all about John and his work. Many of the others whom I met and worked with, or simply knew, in their own ways were especially able and made important contributions. It has been my good fortune to have known and even to have worked with some of the giants who created the wondrous electronics now part of our daily lives. I still see this level of person in the form of graduate students coming into the field, and there is indeed still much to study and build in semiconductors to attract them, as, in fact, is happening with, for example, alloy III-V light emitters. I don't for a moment think Bardeen's generation and my generation did "it" all, and there is, to be sure, every reason to encourage the young people still coming into the field of semiconductor devices. Very simply, there is no other way to do electronics.

1992-93 Chapter Awards

by Alan Lefkow

The Outstanding Chapter-Activities Award program epitomizes the characteristics of a successful member of Eta Kappa Nu. Members' election to Eta Kappa Nu demonstrates their academic ability. But members, working together in concert as a college chapter demonstrate their humanitarian side with their activities of service to their fellow students, their department, their school, and the community at large. In return, the Chapter Award program provides recognition of college chapters for their programs of service to their students and community.

For the academic year 1992–93, seven college chapters received awards for having an outstanding program of activities. Awards are broken into three categories. *Certificate of Merit* winners are recognized as up-and-coming chapters whose programs demonstrate unselfish dedication to their fellow students and community. *Honorable Mention* winners are recognized as truly outstanding chapters whose extensive program of activities stands out from the rest. The *National Winner* is simply that chapter whose program stands out above all these others.

For the 1992–93 school year, seven chapters received recognition for their programs of excellence. Beta chapter of Purdue University copped the National Winner award, their twelfth win in as many years. Beta Epsilon chapter of the University of Michigan, and Iota Xi chapter of the University of Arizona received Honorable Mention awards. Four other chapters were cited for their meritorious programs and received Certificates of Merit. They were Gamma Mu chapter of Texas A & M University, Delta Pi chapter of Colorado State University, Nu chapter of Iowa State University, and Zeta Pi chapter of the State University of N.Y. at Buffalo.

Outstanding chapters are selected based on their annual chapter report. Any chapter that sends in an annual report is automatically entered into the competition. Reports arrive at National after the end of the academic year and into early fall. They are judged in the winter, and the winners announced by spring. The Chapter Award program is also unique. One winning award can touch the hearts of a whole chapter. The award plaques themselves have been made as rich as possible. The National and Honorable Mention winners receive metal plaques engraved in color. The Certificate winners receive their awards laminated in walnut.

Winning chapters send in reports of distinction that do justice to their programs of activities, and many of these reports have been published in the pages of BRIDGE as examples to others. Desktop publishing and other professional services on campus have contributed to annual reports that look as good as the chapter they portray. A winning report requires hard work, but then so does an outstanding program of activities. The Certificate of Merit Report of Zeta Pi is presented here as an encouraging example of a Winning Report.

ETA KAPPA NU
ZETA PI CHAPTER

1992-1993
ANNUAL REPORT

ETA KAPPA NU, ZETA PI CHAPTER
STATE UNIVERSITY OF NEW YORK AT BUFFALO
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING
201, BELL HALL
AMHERST, NY 14260
JULY 1993

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INTRODUCTION

Welcome to Eta Kappa Nu, Zeta Pi Chapter at the State University of New York at Buffalo (UB). UB is fast becoming one of the premier public research institutions in the united states. UB offers degrees in Electrical, Mechanical & Aerospace, Civil, Chemical, Industrial and Engineering Physics. There are around 25,000 full time and part time students at UB of which around 3,500 are Engineering students.

In the past years Buffalo has grown into one of America's gateways to our neighbors in Canada. As home of the 1993 World University Games, Buffalo is also becoming a city of international stature. Growth of local professional sport teams including the Bisons (Baseball), Bills (Football), Sabres (Ice Hockey), Blizzard (Indoor Soccer) and the Buffalo Bandits (La Crosse) have accompanied a move from "Rust Belt" heavy industry to a modern industrial setting. We at the University of Buffalo and the Zeta Pi chapter of Eta Kappa Nu are proud to be part of this national and international blossoming.

Eta Kappa Nu provides a variety of services to its members and to the community at large: Technical course surveys, Review sessions etc. and food and clothing drives. This coming year should be even better. We have already planned Student-mixers, Carnival booths and picnic for the beginning of next semester.

ACKNOWLEDGEMENTS

Concept and Editing: **Senaka Balasuriya**

1992-1993 OFFICERS

PRESIDENT .....Jeff Antkowiak

VICE PRESIDENT.....Bill Leiker

TREASURER.....Anthony Petro.

CORRESPONDING SECRETARY..... .Scott Culverwell

RECORDING SECRETARY.....Ron Laemmerhirt

BRIDGE CORRESPONDENT..... .. ..Sumita Mishra

FACULTY ADVISOR..... . .....Dr. Darold Wabshall

CHAIRMAN CHAPTER EVENTS.....Dan Williams

FUNDRAISERS:

I. UGLIEST PERSON ON CAMPUS:

This fund raiser was for the American Diabetes Association. A service fraternity asked all the Student Association groups if they would like to participate. Bill Leiker, the vice-president, put in a picture of himself. The picture was put up in the Student Union with a bin for money or "votes". There were four other groups that participated.

Bill made announcements in all his classes as well as did a lot of campaigning in the Student Union. He came in a close second (Even though he was undoubtedly the ugliest person on campus.) to the pep band. An amount totalling around $100 was presented to the American Diabetes Association.

There were a few goals that were accomplished. Bill wanted to raise money for the American Diabetes Association. This also gave the Zeta Pi Chapter some kind of recognition on campus.

II. STUDENT ASSOCIATION HOMECOMING CARNIVAL BOOTH:

When the flyer came in from the SA this was seen as a great opportunity for us. They were asking organizations to have a booth at the homecoming carnival as a way to have little fund-raiser. Sumita Mishra and Scott Culverwell went to the organizational meetings, kept the volunteering members of Eta Kappa Nu informed and set up the out booths. Our booth was a ball toss into a bin. This event was also a very good chance to meet the new inductees and to get them acquainted to the kind of programs we have. We always had at least two of out members at the booth, usually 3 or 4.

This was held on the 23rd of October 1992.

III. BUFFALO MISSION FOOD/CLOTHING DRIVE:

This was something last years officers did and it went o really well! So, Bill called the Buffalo Mission and set up the week of November 15th to get some barrels for clothes/food

donations. We ran the drive with at least w people per hour. After the drive Jeff (the president) and Bill (VP) counted $328.41. Jeff presented the Mission with a check for $330. The Mission picked up many bagfuls of clothes.

IV. BLOOD DRIVE:

Eta Kappa Nu co-sponsored a blood donation campaign with the law school. The law school provided donors while HKN provided helpers. Maria Summa of the Buffalo branch of the Red Cross Society was very impressed with the turnout and the volunteering members of Eta Kappa Nu. She was also very impressed with the work ethic of the members of out club. She is the organizer of blood drives and had told Bill she hopes HKN will continue this same program again and again. This whole program came about by chance when Bill one day ran into a blood donation campaign and inquired about the possibilities of having another blood donation campaign at the University at Buffalo campus. Then Bill got to the members on the Vax. About 13 members signed up for the drive. Maria Summa also send about 20 posters which we put up around the campus.

INTRAMURALS -VOLLEYBALL:

The Intramural Volleyball tournament was a good opportunity for us to spend some time relaxing and enjoying ourselves while at the same time get together and get to know the club members better. Due to the fact that people have different levels of experience in Volleyball we played in the co-recreational league. Bill also asked Gwen Hancock, the president of the Society of Women Engineers if there was any interest in her organization. This resulted in a roster of about 23 people from both organizations, which took part in the league as one team as HKN had only one female member.

Dan Williams captained the team and he really worked hard with the team to improve ourselves. The team ended up getting to the finals of our time slot! There we lost in straight sets. The name of out team was shockers which we hoped to be in the spring semester. And, as it turned out we were the shockers in the spring semester. The league was on Wednesday nights from 9:30- 11:30 and we never had to forfeit due to lack of people.

Goals accomplished included giving the people a chance to drop the books and getting out organization know around campus.

REVIEW SESSIONS

September 1992- May 1993

General Description:

Throughout the year the members of Eta Kappa Nu have been successful in conducting review sessions for junior level and senior level classes. These review sessions were conducted for 3 junior level classes and a sophomore level class. In most cases the Teaching Assistants from that class conducted the review sessions.

Fall 1992

ECE 350 Physical Electronics
ECE 378 Digital Principles

Spring 1993

ECE 351 Physical Electronics 2
ECE 202 Circuit Analysis

Each sessions was held in a medium sized lecture hall and consisted of three parts

1. Formal review of test material
2. Solutions to generic problems
3. Individual questions

Much preparation time was spend by the members to prepare view-graphs, slide projections and to reserve a class room for the session. All preparations from previous years were utilized and present material was saved for the coming years. A significant amount of time was spent on this project

For the program, the chapter needed only to purchase a box of transparencies and a few marking pens. The review has been viewed as an enormous success and has achieved the acclaim of some of the professors. This program has provided enormous amounts of visibility for Eta Kappa Nu among Electrical Engineering students.

The response from the review sessions has been positive and many new suggestions were offered by the students which hopefully can be taken into account when conducting other review sessions in the future. Next year we hope to increase the review sessions tosome sophomore level classes.

SPRING 1993 INDUCTEES:

April 26, 1993

In April of 1993. Ztz Pi chapter held its annual spring initiation. Approximately 18 students were initiated inn an on-campus ceremony. Our chapter advisor Dr. Wabschall attended and helped with the initiation ceremony.

JUNIORS:

William Ballisteri
Robert Chu
Samuel DiPasquale
Christopher Riehl

SENIORS:

Bryan Laskowski
Lockshan shum
Lisa Dorn
James Waring
Paul Brown
Jennifer Polzin
Brian Nugent
Monis Mirza

1993 -1994 OFFICERS:

PRESIDENT .....David Leone

VICE PRESIDENT.....Jordan Rosenthal

TREASURER.....Senaka Balasuriya

CORRESPONDING SECRETARY..... Frank Pellegrino

RECORDING SECRETARY.....Justin Smith

BRIDGE CORRESPONDENT.....David Guglielmi

FACULTY ADVISOR..... .....Dr. Darold Wabshall

TECHNICAL ELECTIVE SURVEY

November 1992 & April 1993

1. **GENERAL DESCRIPTION:**

Since 1989, when the idea was created, the ECE Technical Elective Booklet has grown to be a very popular and sought-after tool for ECE junior and Seniors. The purpose of this booklet is to pass onto the juniors and 1st semester seniors the experience of the older ECE sutdents concernig the course material and the course in general. This time , as opposed to before, only Eta Kappa Nu members were asked to comment on course objectives. The compiled responses were published and the finished booklet was made available to all ECE undergraduates. The surveys were conducted each semester and booklets made available in November of 1992 and April of 1993. The Technical Elective Survey was conducted by Ron Laemmerhirt and the booklet publication was funded by the ECE department.

ECE Technical Elective Booklet

Fall 1993

Eta Kappa Nu

Zeta Pi Chapter

Introduction

This is the Fall 1993 version of Eta Kappa Nu's Technical Elective Booklet. The intention of this document is to allow Juniors in the ECE Department to share in the knowledge and experience concerning 400 level ECE electives gained by others. Survey forms, like the one at the end of this document, are distributed to students and faculty members. The forms are completed anonymously, and the results compiled to make this booklet.

We welcome completed survey forms on all ECE, SYS, and other technical electives in which ECE Seniors may find themselves (such as high-level MTH courses). You may use the survey form at the back of this booklet, or obtain another from the Eta Kappa Nu office in Trailer F.

Disclaimer

Eta Kappa Nu distributes, collects, and compiles surveys in order to present the opinions of students and professors who have had experience with a particular technical elective. HKN does only a cursory check on the information presented—in no case should you depend upon this booklet as anything more than a guideline. Courses evolve and are taught differently by different professors, and there is no guarantee that our respondents have not made errors when completing their surveys.

You are hereby warned: Eta Kappa Nu takes **no** responsibility for the accuracy of the information contained within. All of the opinions contained within are those of our respondents, and not necessarily those of Eta Kappa Nu, its officers, or its members.

About Eta Kappa Nu

Eta Kappa Nu is the International Electrical Engineering Honor Society, with over 150 college chapters throughout the United States, Europe, Asia, and South America. The chapter of HKN here at UB is known as the Zeta Pi chapter. The purpose of Eta Kappa Nu is simple: to establish recognition and to honor those who have exhibited distinguished academic accomplishments.

Eta Kappa Nu provides opportunities for its members to become involved in academic, career-related, and social activities involving electrical engineering, the university, and the community. Past activities have included faculty-student mixers, seminars, plant tours, review sessions, banquets, parties, access to engineering societies such as IEEE or NSPE, and the design and construction of our own campus monument.

	1992–1993 Officers	1993–1994 Officers
President:	Jeffrey Antkowiak	David Leone
Vice-President:	William Leiker	Jordan Rosenthal
Treasurer:	Anthony Petro	Senaka Balasuriya
Recording Secretary:	Ron Laemmerhirt	Justin Smith
Corresponding Secretary:	Scott Culverwell	Frank Pellegrino
Bridge Correspondent:	Sumita Mishra	David Guglielmi
Chairman Chapter Events:	Dan Williams	

Acknowledgements

Original Concept and Survey Design: Thomson Koon
TEX design of Surveys and Booklet Design: Geoffrey Burr
Compilation: Ron Laemmerhirt
Editing: Ron Laemmerhirt

This booklet was printed: April 16, 1993

ECE 401—Transmission Lines

Dr. Gillette

Text:	"Microwave Transmission"
Prerequisites:	none
Design Credits:	1
Class size:	20
Graduate—Undergraduate Ratio:	1:10
Laboratory Section:	No
Computer project:	No
Course project:	No
Homework collected:	Yes
Grading system:	3 Exams – 33.3% each

Recommendations:

"Good class for those interested in RF and microwave."

Student Feedback

Workload:	
Professor's lecture style:	1–5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
# of hours spent on the course per week:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 410—Electronic Instrument Design

Dr. Wobschall

Text:	Circuit Design for Electronic Instrumentation
Prerequisites:	ECE 351 & 353, Senior Standing
Design Credits:	4
Class size:	50–75
Graduate—Undergraduate Ratio:	1:5
Laboratory Section:	Lab open 20 hours a week for general use
Computer project:	No
Course project:	Yes
Homework collected:	No Homework
Grading system:	3 Exams – 15%, 20%, 15% 4 Lab Experiments – 5% total Final Lab Project – 45%

Recommendations:

"The final project requires a consistent effort throughout the semester."
"Good for those interested in Analog design."
"Very good course, learn a lot, all 'students' in the department should take it."
"Start the project early."
"Difficult but good. A challenging course."

Student Feedback

Workload:	
Professor's lecture style:	1–5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on each lab report:	
# of hours spent on the course per week:	
of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 419—Industrial Control Systems

Dr. M. Safiuddin

Text:	"Linear Control Systems" ($ 60)
Prerequisites:	MTH 242
Design Credits:	none
Class size:	30
Graduate—Undergraduate Ratio:	1:1
Laboratory Section:	No
Computer project:	No
Course project:	Yes. Literature Search. Paper.
Homework collected:	Yes
Grading system:	25% – Homework 35% – Midterm 40% – Final

Recommendations:

"Excellent course to learn about control system theory."

Student Feedback

Workload:	
Professor's lecture style:	1–5 scale
Difficu[Blty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on the course per week:	
# of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 427—Plasma Physics I

Dr. Benenson

Text:	Intro. to Plasma Physics and Controled Fusion
Prerequisites:	Permission of Instructor
Design Credits:	0
Class size:	10
Graduate—Undergraduate Ratio:	9:1
Laboratory Section:	no
Computer project:	no
Course project:	Yes
Homework collected:	Yes
Grading system:	30% – project presentation 30% – project report 30% – final exam 10% – homework

Recommendations:

"Eta Kappa Nu currently has no other information on this elective."

Student Feedback

Workload:	
Professor's lecture style:	1–5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on each lab report:	
# of hours spent on the course per week:	
of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 442—Operating System Concepts

Dr. DeWald

Text:	"Operating System Concepts" ($50)
Prerequisites:	none
Design Credits:	none
Class size:	10 – 20
Graduate—Undergraduate Ratio:	1:2
Laboratory Section:	none
Computer project:	none
Course project:	Yes – Presentation and Report
Homework collected:	Yes – 2 or 3 times a semester
Grading system:	40% – Exam 1 40% – Project 5% – Class Participation 5% – Attendance

Recommendations:

"Good for those interested in software engineering."
"Make sure you can memorize fairly well."
"Is a class that will help you talk in front of people."

Student Feedback

Workload:	
Professor's lecture style:	1–5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on the course per week:	
# of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 448—Microelectronic Device Fabrication

A.M. Kriman

Text:	Semiconductor Integrated Circuit Processing
Prerequisites:	ECE350
Design Credits:	2
Class size:	23
Graduate—Undergraduate Ratio:	1:1
Laboratory Section:	No
Computer project:	No
Course project:	Yes, 4 projects
Homework collected:	Yes, 6 homeworks
Grading system:	35% – homework 65% – projects

Recommendations:

"You will learn how most solid state devices are made"–Kriman.
"New course; there is no other current information on this elective."

Student Feedback

Workload:	
Professor's lecture style:	1–5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on each lab report:	
# of hours spent on the course per week:	
of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 470—Digital Circuits Lab

Dr. Schmitt

Text:	none
Prerequisites:	Senior Standing
Design Credits:	2.0
Class size:	70
Graduate—Undergraduate Ratio:	0:1
Laboratory Section:	Yes
Computer project:	No
Course project:	No
Homework collected:	No
Grading system:	3 Tests – each 33%

Recommendations:

"Easy course if you take good notes."
"Take it if you like digital. Very good course."

Student Feedback

Workload:	
Professor's lecture style:	1-5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
# of hours spent on the course per week:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 475—Minicomputer Systems & Interfacing

Dr. Demjanenko

Text:	None Required. Some Optional.
Prerequisites:	ECE 379
Design Credits:	2
Class size:	40–50
Graduate—Undergraduate Ratio:	1:1
Laboratory Section:	Yes, 3–4 labs per semester
Computer project:	Yes, the labs are computer programs.
Course project:	Yes, paper hardware design.
Homework collected:	Yes
Grading system:	Midterm – 25% Final – 30% Homework – 5% Labs – 25% Paper Hardware Design – 15%

Recommendations:

"Good course, but workload is heavy."

Student Feedback

Workload:	
Professor's lecture style:	1-5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on the lab:	
# of hours spent on the course per week:	
# of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 482—Power Engineering I

Dr. Dollinger

Text:	"Electric Power Transmission Systems"
Prerequisites:	none
Design Credits:	3
Class size:	30–40
Graduate—Undergraduate Ratio:	1:4
Laboratory Section:	Yes
Computer project:	Yes
Course project:	Yes – CAD and Paper Design
Homework collected:	Yes
Grading system:	2 tests – 40% CAD Project – 20% Presentation – 20% Homework and Tours – 20%

Recommendations:

"Good course if you're interested in power engineering."
"Interesting class if you don't mind professor's lecture style."

Student Feedback

Workload:	
Professor's lecture style:	1-5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on the course per week:	
# of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 483—Communications Systems I

Dr. Caprio

Text:	" Communications Systems, Halkin" ($50)
Prerequisites:	ECE 303 and EAS 305
Design Credits:	0.5
Class size:	10
Graduate—Undergraduate Ratio:	0:1
Laboratory Section:	No
Computer project:	No
Course project:	No
Homework collected:	Yes
Grading system:	2 tests – 60% Homework – 40%

Recommendations:

"Professor is excellent."
"Anyone interested in communication systems should take it. Good course."

Student Feedback

Workload:	
Professor's lecture style:	1-5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
# of hours spent on the course per week:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 487—Information Structures

Dr. Upadhyaya

Text:	"Data Structures and Program Design in C"
Prerequisites:	Knowledge of a high level language
Design Credits:	1
Class size:	35
Graduate—Undergraduate Ratio:	0:1
Laboratory Section:	No
Computer project:	Yes, 2 C programs.
Course project:	No
Homework collected:	3 times/semester
Grading system:	2 exams – 15% and 20% Homework/Projects – 10% and 20% 3rd exam – 35%

Recommendations:

"Good course to learn C and data structures."
"It would help to learn the basics of C before taking the course."

Student Feedback

Workload:	
Professor's lecture style:	1-5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on the course per week:	
# of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 495—High Voltage Engineering

Dr. Laghari

Text:	
Prerequisites:	
Design Credits:	
Class size:	
Graduate—Undergraduate Ratio:	
Laboratory Section:	
Computer project:	
Course project:	
Homework collected:	
Grading system:	

Recommendations:

"Eta Kappa Nu currently has no information on this elective."

Student Feedback

Workload:	
Professor's lecture style:	1-5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on the course per week:	
# of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 493—Engineering Optics

Dr. Malone

Text:	"Contemporary Optics for Engineers"
Prerequisites:	ECE324 Recommended
Design Credits:	None
Class size:	10–20
Graduate—Undergraduate Ratio:	1:1
Laboratory Section:	Yes
Computer project:	No
Course project:	Yes
Homework collected:	No
Grading system:	Midterm – 40% Final – 40% Term Paper – 20%

Recommendations:

"Necessary for fiber optic studies later. Will study geometric optics, fourier transforms, etc." – Dr. Malone

Student Feedback

Workload:	
Professor's lecture style:	1-5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on each lab report:	
# of hours spent on the course per week:	
of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

ECE 497—Intro to VLSI Design

Dr. Sridhar

Text:	"An Engineering Approach to Digital Design" "Principles of CMOS VLSI Design"
Prerequisites:	ECE 379
Design Credits:	2
Class size:	50
Graduate-- Undergraduate Ratio:	1:1
Laboratory Section:	Yes
Computer project:	No, but SUN cluster used for labs and projects
Course project:	Yes, Design a chip.
Homework collected:	Yes
Grading system:	1 Exams – 50% Project – 50%

Recommendations:

"Good class to learn VLSI tools. Do project early."

Student Feedback

Workload:	
Professor's lecture style:	1-5 scale
Difficulty of material:	1=easy (to understand)
Appropriateness of tests:	5=hard (to understand)
Project Difficulty:	
# of hours spent on the course per week:	
# of hours spent on the project:	
Is it easy to preregister for?	
Are old exams available?	
Is the professor helpful?	

Fall 1993 ECE Technical Electives

Course	Title	Professor	Credits		
			Total	Lab	Design
ECE 401	Transmission Lines	Gillette	3		1
ECE 410	Electronic Instrument Design I	Wobschall	4	4	4
ECE 419	Industrial Control Systems	Safiuddin	3		
ECE 427	Plasma Physics I	Benenson	3		
ECE 439	Internship	Benenson	4		2+
ECE 442	Operating Systems Concepts	DeWald	3		
ECE 448	Microelectronic Device Fabrication	Kriman	3		2
ECE 460DOL	Special Topics:High Freq. Power Supplies	Dollinger	4		
ECE 470	Digital Circuits Lab	Schmitt	4	4	2
ECE 475	Minicomputer Systems & Interfacing	Demjanenko	4	4	2
ECE 482	Power Engineering I & Lab	Dollinger	4	4	2
ECE 483	Communications Systems I	Caprio	4		0.5
ECE 487	Information Structures	Upadhyaya	3		1
ECE 493	Engineering Optics	Malone	3		
ECE 495	High Voltage Engineering	Laghari	4		
ECE 497	Intro to VLSI Electronics	Sridhar	4		2
SYS 435	Continuous Control Systems	Mook	4	4	2

This table is derived from various sources.
It is not an official ECE department publication.

ECE Faculty

Name	Office	Phone
Raj Acharya	131 Bell	x2318
Wayne A. Anderson	208 Bell	x2422
David M. Benenson	213 Bonner	x3109
Ping-Chin Cheng	301 Bonner	x3115
Victor Demjanenko	130 Bell	x2423
Richard E. Dollinger	313 Bonner	x3117
Patrick Dowd	239 Bell	x2406
Kasra Etemadi	217B Bonner	x3120
Adly T. Fam	132 Bell	x2423
A. Scott Gilmour	215C Bonner	x3110
Donald D. Givone	134 Bell	x2423
Raj K. Kaul	245 Bell	x2427
A.M. Kriman	215E Bonner	x3110
Amlan Kundu	133 Bell	x2406
Hoi-Sing Kwok	214 Bonner	x3119
Javaid R. Laghari	316 Bonner	x3115
Tein-Hsiang Lin	137 Bell	x2318
Pao-Lo Liu	215A Bonner	x3120
Dennis P. Malone	312 Bell	x2948
Stephen Margolis	244 Bell	x2596
M. Safiuddin	240 Bell	x2427
Walter J. Sarjeant	314A Bonner	x3117
Erich Schmitt	241 Bell	x2427
Peter D. Scott	136 Bell	x2318
David T. Shaw	330B Bonner	x3112
Mehrdad Soumekh	128 Bell	x2425
R. Sridhar	135 Bell	x2318
Ozan K. Tonguz	246 Bell	x2406
Shambhu J. Upadhyaya	129 Bell	x2425
James J. Whalen	215B Bonner	x3110
Chu R. Wie	201 Bonner	x3119
Darold C. Wobschall	213 Furnas	x3135

CHAPTER ACTIVITIES
1992-93

Annual Report Zeta Xi Chapter

University of Massachusetts at Dartmouth

A LETTER FROM THE PRESIDENT

As the 1992–93 academic year comes to a close it is with great pride that I endorse this year as a very successful and motivating one. Through the dedication and efforts of our members and committed officers our chapter successfully completed several new activities and projects. Among them was an unprecedented celebration of an official initiation ceremony. This letter is a tribute to their perseverance and hard work towards bettering our chapter.

Sincerely,
Paul J. Pacheco
President

OFFICERS AND DATA

1992–1993

President.....Paul J. Pacheco
Vice President...David R. Fitzpatrick Recording
Secretary.....Thomas R. Gomes
Treasurer.....Melanie Wong
Corresponding Secretary.....Kimberly Duff
Bridge Correspondent
Secretary.....Robert M. Gagnon
HKN Faculty
Advisor.....Dr. Robert H. Caverly

SOCIAL FUNCTIONS

Introductory Meeting

Everyone can understand how difficult it is to capture the attention of a group of busy engineering students. It seems the only way to break them away from their work is to offer them free food. It was no wonder that by sheer mention of the word "pizza" in the meeting announcement that we received a tremendous turnout at our introductory meeting. All HKN members and several faculty members were present to welcome the new inductees into the society. Inductees were informed about the society's pledge requirements and introduced to the other members of the society and attending faculty. By the end of the evening the inductees were not only well informed about the university and HKN, but they were also well fed.

End of the Year Bash

Since pizza seemed to be a good catalyst for the stimulation of engineering social behavior we decided to use it again. This time it was called the END OF THE YEAR BASH—sponsored by both IEEE and HKN. This was a great opportunity for all to relax and enjoy themselves just before the tortures of finals. The party was well attended and proved to be a fun time for all.

Initiation Ceremony

In one of the most mysterious and mystical events of the year we held our initiation ceremony. Just to give you a taste of what happened picture seven robed figures silhouetted by candle light, inductees being led through the dark and damp bowels of the university into the induction hall. It gives me shivers just thinking about it. This is the first time in over eight years that we have practiced the official induction ceremony. It was without a doubt a great experience for all who attended.

HKN Banquet

The last social activity of the year was the HKN banquet. At the banquet certificates were awarded to the current officers as well as to the new members. Speaking at this year's banquet ceremony was Dr. Karen Payton. Dr. Payton grew up in southern California and received her B.S. in Electrical Engineering and Biomedical Engineering from Carnegie-Mellon University in Pennsylvania. She later went on to earn her M.S. and Ph.D. in Electrical Engineering from Johns Hopkins University doing her doctoral dissertation on "Vowel processing by a model of the auditory periphery." Dr. Payton held a three year postdoctoral fellowship at MIT in the research laboratory of electronics "Sensory Communications Group." Since 1989 she has held an Assistant Professorship at UMass Dartmouth and maintained a Visiting Scientist position at MIT. Her research interests now include: speech intelligibility, speech perception, and signal processing.

Dr. Payton's speech contained her work in the interpretation of speech signals and the work done for the hearing impaired at MIT. We would like to take this opportunity to thank Dr. Payton again not only for speaking at our banquet, but also for her work with the hearing impaired.

FUND RAISERS

Top 10 T-shirt Sales

To foster engineering camaraderie at the university, HKN started the Top 10 Reasons Why I Am In Engineering T-shirt activity. This yearly activity is begun with posters being mounted throughout the engineering buildings that asked all to write down the main reason they became an engineering student. Well, after long hard hours of deliberation over hundreds of entries we were able to narrow the list down to these Top 10 Reasons Why I Am In Engineering for 1993.

1. The reasons are left to the student as an exercise.
2. Commander Montgomery Scott is my hero.
3. My mind was in the right-half plane.
4. I'm in engineering?
5. Nothing else is tough enough.
6. The aftermath after the math.
7. I thrive on frustration.
8. I didn't suffer enough as a child.
9. 'cause I have no clue.
10. It sounds impressive so people think you're really smart.

You should have read the ones that we had to throw out, WOW!!! Now seen spotted all over campus are engineers displaying with pride, the top 10 reasons that they are in engineering.

OUTSTANDING ACHIEVEMENT

Recognized for his outstanding scholastic achievement as an electrical engineering student and HKN member is Stephen P. Longworth. Among his honors this year was his acceptance to the graduate study program at MIT and scholastic achievement awards at the UMass Dartmouth Honors Convocation as well as graduating Magna Cum Laude with a B.S. in Electrical Engineering this June. We are all very proud to have Steven Longworth as a member of the Zeta Xi chapter of HKN at UMass Dartmouth.

FUTURE ACTIVITIES

The new officers for the 93–94 year have a mountain of work ahead of them. One of their tasks for this year will be to organize the first annual Freshman Engineering Contact Program (FECP). The job of the FECP is to help in the transition of incoming freshman engineers by supplying them with an upperclass contact. These contacts will be helpful in course selection, professional guidance, orientation and even peer counseling. The initiation phase of this activity will take place at a beginning of the year mixer where the new students will have the opportunity to mingle with faculty, other freshmen engineers and other FECP contacts on a social level. We are sure the FECP will be instrumental in making the transition into the university an easier and more enjoyable experience.

"A YEAR IN REVIEW"

Summary Letter from the Advisor

Dear Eta Kappa Nu Members,

This year has been quite a busy one for the Zeta Xi chapter at the University of Massachusetts Dart-

mouth. This year's officers, Paul Pacheco, David Fitzpatrick, Thomas Gomes, Melanie Wong, Kimberly Duff and Robert Gagnon are to be commended for their hard work and dedication toward Eta Kappa Nu. The officers' meetings were always lively, with many ideas presented, and some implemented. This was also not a shy group of officers either; several of my ideas were rejected by the officers! Among the novel ideas implemented this year was a new chapter initiation requirement: all officers presiding over the ceremonies were to be wearing brown robes, hoods and rope sashes. The robes were made by the officers and will be used at all future Zeta Xi chapter initiation ceremonies. There were many other functions organized by the officers that are detailed in the yearly report. Even though Zeta Xi is a small chapter, the hard work of the officers and members made up for it in quality.

In summary, it has been a fun year to be faculty advisor for the chapter. It has been a pleasure to work with such a dynamic group of people and I am looking forward to even better things next year.

Sincerely,

Robert H. Caverly, Ph.D.
Professor

Annual Report Chi Chapter

Lehigh University

OFFICERS AND DATA

President .....Beth Nussbaum
Vice President .....Jack Romaine
Treasurer .....Rick Niejadlik
Secretary .....Neil Cohen
Faculty Advisor .....Doug Frey
No. of Members 17
No. of Initiates 9
No. of Meetings 6

ACTIVITIES

Tutoring

New activity. We required all new and old members to assist in tutoring younger electrical engineering students. We tutored the three courses: Introduction to Electrical Engineering, Motors and Semiconductors courses three times a semester. This is a new program that we initiated this year to develop a better relationship with our department and help other electrical engineers excel. Because of our efforts, we have gained respect and appreciation from our faculty and have been asked to continue this program. Each participant contributed between 2 and 4 hours of their time in the classroom and an unquantifiable amount of time preparing for these small group sessions.

Candidate's Day

This was also a new program. About 5 of our members contributed one Saturday of the semester to present the engineering college and electrical engineering department to prospective freshman. They served as tour guides, assisting high school students and their parents around the campus while giving them particular insight into the EE department.

Induction

We used the evening of the new member induction as an opportunity to encourage interaction between students, and provided a speaker from the electrical engineering faculty. The students and speaker stayed after the induction for several hours to eat dinner and get to know one another. We feel that this was a valuable inclusion in the initiation.

Social Interaction

We used our final meeting as an opportunity for social interaction between the student members, EE graduate students and our faculty advisor. We provided food, beverages, and the room, while our members got to know one another. We are hoping to continue this and include more faculty in the future.

Beth Nussbaum
April 27, 1993

Annual Report Epsilon Eta Chapter

Rose-Hulman Institute of Technology

OFFICERS AND DATA

Number of Members 26
Number of Meetings.....8

Officers for 1992–93

President .....Jason A. Mix
Vice President.....Brent Hoffman
Treasurer.....Jeff Swartz
Recording Secretary .....Eugene Park
Corresponding Secretary .....Theron Nelson
Bridge Correspondent .....None
Faculty Advisor .....Dr. Frank Acker

Officers for 1993–94

President .....Tim Walker
Vice President .....Daniel Janko
Treasurer.....Julian Waldby
Recording and Corresponding Secretary .....Jay Moorman

REPORT OF MEETINGS

9-17-92 Meeting to discuss new ideas for the chapter's activities for upcoming year, and to discuss the file system in the library.
9-29-92 Update file system in library.
10-3-92 Our chapter manned the electrical engineering laboratories of Rose-Hulman to demonstrate some of our equipment during homecoming.
11-5-92 Discussed a trip to a nearby graduate school and reviewed the list of eligible prospective HKN members for the winter quarter.
12-5-92 Went to Purdue to view VLSI and computing facilities and to ask questions about their graduate school.
2-8-93 Held an informal question and answer meeting for the prospective new HKN members.
2-15-93 Held meeting to distribute ballots for voting on new members. Petitions for membership in HKN due.
2-16-93 Ballots for new members due.
3-22-93 Executive meeting for initiation ceremony practice.
3-23-93 Initiated 16 new HKN members and held an initiation dinner at Gerhardt's Bierstube with the E.E. faculty. Also held a meeting to decide the Outstanding Sophomore ECE Student-a local HKN award.
3-24-93 Report Outstanding Sophomore ECE Student to school.
3-27-93 Judged local science fair and chose best 'Electrical Project' for Eta Kappa Nu award of $100.
5-18-93 Meeting to elect new officers and distribute ballots for a new member.
5-19-93 Ballots due for new member.
5-21-93 Initiation ceremony for new member.
5-21-93 Formally transfer control of the Epsilon Eta chapter to the new officers.

Jason A. Mix
Former President

Timothy Walker
President

Annual Report Gamma Theta Chapter

University of Missouri-Rolla

INTRODUCTION

The Gamma Theta Chapter represents Eta Kappa Nu on the campus of the University of Missouri-Rolla (UMR). We seek to uphold the principles of integrity and professionalism intended by the founding members of HKN, to assist in the development of students in electrical engineering, and to have opportunity to be involved with other successful EE students. The chapter is involved in many activities which give the members an opportunity to provide service through voluntary participation. We have numerous local elective offices in addition to the national offices, which allows many of the members to take responsibility and be involved in the affairs of the chapter. We try to present a positive image of Eta Kappa Nu, and participate in several activities which serve the other electrical engineering students who do not belong to HKN.

OFFICERS AND DATA

Faculty Advisors ...Dr. Marissa Crow
Dr. Steve Watkins
Total Number of Active Members.....60

Winter 1992

President .....Todd Sublette
Vice President.....Dharmesh Bhakta
Recording Secretary .....Jerry McGarity
Corresponding Secretary.....Angela Thias
Treasurer .....Christine Sheehy
Bridge Correspondent.....Rod Mell
Historian.....Nick DiMercurio
Student Council Representative.....Ted Hilmes
Banquet Chairman ...James Kuhlman
Membership Chairman....Sonal Patel
Tour Chairman .....Ray Seggelke
Pledge Chairman .....Warren Waas
Help Sessions.....David Brown
Special Projects.....Steve Nicholson
Lab Insurance .....Blair Jones
Refreshments.....James Murphy
Number of Business Meetings 6
Number of New Initiates 15

Spring 1993

President .....Warren Waas
Vice President.....Steve Nicholson
Recording Secretary.....Tom Rogge
Corresponding Secretary.....Jeff Weldele
Treasurer .....Bill Alexander
Bridge Correspondent .....Jon Tandy
Historian .....Ahmad Rahimi
Student Council Representative.....Mark Lanigan
Banquet Chairman .....Steve Ruffing
Membership Chairman Randy Pogue
Tour Chairman .....Rodney Nelson
Pledge Chairman.....Steve Poulsen
Help Sessions.....Jeff Yost
Special Projects.....Brian Olsen
Lab Insurance .....Jerry McGarity
Refreshments.....Jeff Watrous
Number of Business Meetings 7
Number of New Initiates 22

INITIATION

Our chapter's pledging process begins each semester with a "smoker," a meeting to which all those prospective pledges who meet membership requirements are invited. They are informed of what Eta Kappa Nu is all about and what will be required of them to join. During the next few days interviews are conducted by current members of HKN to find out something about the pledges. Those who volunteer to interview will verify that the pledges do meet the academic requirements and have the character becoming a member of HKN, and try to answer their questions about the organization.

All pledges are required to attend a workday, to assist the chapter in some service project. During Pledge Week the pledges are to dress up every day and wear a nametag so that everyone will know that they are receiving this honor. The pledges sand, stain, and paint their plaques, leaving the back unvarnished, to get the signatures of current student and faculty members of HKN. Each pledge is also supposed to sell two tickets to the initiation banquet. During the Spring semester a volleyball game was scheduled for members and pledges as part of the Pledge Week activities.

At the end of Pledge Week the pledges have to take three tests. In the first they are required to write out the HKN preamble from memory. Then they take a test over the chapter and national bylaws. Extra credit is given for any names of current members or pledges which they can remember. The third test is a grueling Circuit Analysis test, written by several of the members. This test is usually fun, at least for the HKN members who have already taken it and who are now watching the pledges take theirs. Then after the tests, there is a pledge party for all members and pledges to relax and get to know each other better.

The initiation banquets were held at Zeno's Steak House on November 22 and April 17. The

pledges were taken through the formal initiation ceremony, and then we enjoyed a great meal. Awards for best plaque and best pledge were given during the evening.

This year the Gamma Theta Chapter honored four outstanding UMR professors with membership in Eta Kappa Nu. The professors were not required to perform all the usual initiation activities, but they did attend the initiation ceremony and banquet. These professors were nominated for membership according to the provisions in the national constitution, after it was discovered that they did not already belong to Eta Kappa Nu. We are honored to have them as fellow members of this honor society.

EE Tours—HKN Ambassadors

The Gamma Theta Chapter had the opportunity of conducting tours of the Electrical Engineering building fore prospective students and their families. Beginning in October 1992 continuing through the spring semester, members of HKN were requested to volunteer for leading these tours. This position was eventually given the title "HKN Ambassador." Each Ambassador gave a practice tour with a faculty member or another student before actually giving the tour to prospective students.

The tours were coordinated through the secretary of the electrical engineering department, and the registrar's office. Students coming to the campus would visit the financial aid office, etc., and sometimes be given a tour of the campus. Those who had expressed an interest in majoring in electrical would also be offered the opportunity of touring the EE department.

HKN Ambassadors tried to answer any questions the student might have about the Electrical Engineering program, or about University life in general. They described the various areas that an EE student would study and perhaps specialize in, including communications, circuits, power, and control systems. They also discussed other opportunities for student involvement at UMR, such as the Coop program, membership in IEEE and other student organizations, and getting involved in undergraduate research.

Tours were given to high school graduates planning on coming to Rolla, and to transfer students. The tours consisted of a 15-20 minute walk through the Electrical Engineering building, pointing out things of interest such as the computer lab and other EE labs, and giving an overview of the EE curriculum at UMR. Then the prospective student was allowed to talk with a faculty member about the University and the EE department. On April 5–8 the Ambassadors also gave tours to students from the Freshman Engineering program.

Tour committee members truly were ambassadors of UMR, and for this reason tried to maintain a high level of professionalism and respectable appearance. Many of the students given tours had not made a final decision as to whether they would attend Rolla, and the Ambassadors tried to present a positive perspective on the EE department and the University as a whole.

Hobby Club

The Gamma Theta Chapter has a room in the Electrical Engineering building called the Hobby Club. We keep a large supply of electrical components on hand for people working on personal projects. These can be bought from the hobby club at minimal price and greater convenience than from a store, because students can purchase an individual resistor or capacitor instead of having to buy a whole package.

We also maintain a large stock of parts manuals, oscilloscopes and other equipment, several breadboards, wires, and tools, which are helpful for students trying to work on a project or build a prototype circuit. This spring semester we also were able to purchase a computer for the hobby club through the UMR Student Council, thanks to the efforts of our student council representative. The computer will soon be connected to EE computer network so that hobby club members can have access to the campus computing facilities. Our chapter plans to keep a lot of our HKN records on the computer

During our initiation activities, pledges have to participate for several hours in a workday. Usually the project they end up doing is helping to organize and clean the hobby club room, going through old files, etc. This not only gives them a good service project to do, it also acquaints them with the equipment and facilities which are available in the hobby club. The hobby club is open as much as possible during the Pledge Week so the pledges can come in and use HKN's sandpaper, stain, paint, and varnish to work on their plaques.

All present and past members of the Gamma Theta Chapter are automatically lifetime members of the hobby club, and are entitled to use the equipment we have available. Other students who are not members of HKN can buy a membership to the hobby club on a semester or yearly basis, allowing them to use these facilities also. The hobby club provides a valuable service to the students of UMR and Eta Kappa Nu.

Lab Insurance

At UMR the electrical engineering students are required to take four undergraduate labs. Occasionally something goes wrong in a lab, and the student may be responsible for destroying some minor piece of equipment. But fortunately for some other students, they are at least partly covered by HKN lab insurance.

Our chapter sells lab insurance at the beginning of each semester to students who are enrolling in one of the EE labs. The insurance sells for only a few dollars, and will cover the student up to $300 if some equipment is damaged due to their error. The money from the sales is put into a fund to accumulate in the event of a claim on it.

In actuality, students seem to be pretty careful and the labs are fairly safe, particularly those in which there is some danger of damage to equipment or students. There is rarely an occurrence of destruction of property. We have never had a major claim against the insurance fund, so it has continued to accumulate over the past several years that we have been providing this service to the UMR students. This is just one more way that the Gamma Theta Chapter is contributing to the electrical engineering program at our university.

Help Sessions

In past semesters HKN has tried to provide help sessions for beginning Circuit Analysis students. Pledges have been required to sign up for one or two nights to lead the help sessions during the week. This practice has met with varying success at times, and usually suffers from low attendance by students.

During the spring 1993 semester the help session program was attempted again and expanded to include the second Circuit Analysis class required for mechanical engineering majors. The Gamma Theta Chapter members were given the opportunity to volunteer to lead these help sessions.

At the beginning of the semester there was good attendance. This began to wane by the end of the semester, until most of the sessions were cancelled. However, the M.E. Circuit Analysis class was heavily attended up to and including finals week. The students seemed very appreciative of the help they obtained, and most felt they learned the material better and were better prepared for exams.

Other Activities

The Gamma Theta Chapter was involved in other activities, and is preparing for other activities in the future. At the beginning of the Fall semester, HKN co-sponsored an EE picnic with the local chapter of IEEE. The picnic was open to EE professors, students, and their guests. It is a good way to start out the school year.

We attempted to sell doughnuts on Friday mornings during the fall semester, in an attempt to raise a little money. This went all right, and several of the students and faculty bought some. But the demand was not high enough to make much of a profit, and the doughnut sales were finally discontinued.

We also purchased a variety of shirts and sweaters from a local store, with the Eta Kappa Nu logo imprinted on them in full color. There were several styles and colors available. Many of these were sold to the chapter members and pledges each semester. Some of the HKN Ambassadors who led the tours wore their HKN polo shirts on the days when they were scheduled to do the tour.

For the future, the chapter has voted to begin selling GRE manuals to those who will be studying for the graduate program entrance exam. We also may be selling lab kits to students enrolling in the electronics lab, with the possibility of buying them back and reselling them. This would help UMR students reduce their education costs. It was also suggested that we keep a current address record on computer of past members of Eta Kappa Nu, so that current members would have the opportunity of networking when seeking for employment.

Annual Report
Tau Chapter
University of Cincinnati
OFFICERS AND DATA

Fall 1992
Number of Members.....26
Number of New Initiates.....0
Number of Business Meetings.....7

President .....Sean Hodge
Vice President.....John Bellando
Treasurer.....Kevin McGonagle
Recording Secretary .....Jenny Tsuei
Corresponding
Secretary .....Greg Brockman
Bridge Correspondent.....None
Faculty Advisor .....Dain Samples

Winter 1993
Number of Members.....35
Number of New Initiates.....9
Number of Business Meetings.....6

President .....Sean Hodge
Vice President.....John Bellando
Treasurer.....Kevin McGonagle
Recording Secretary .....Jenny Tsuei
Corresponding
Secretary .....Greg Brockman
Bridge Correspondent.....None
Faculty Advisor .....Dain Samples

Fall 1992
Number of Members.....43
Number of New Initiates.....8
Number of Business Meetings.....7

President .....Sean Hodge
Vice President.....John Bellando
Treasurer.....Kevin McGonagle
Recording Secretary .....Jenny Tsuei
Corresponding
Secretary .....Greg Brockman
Bridge Correspondent.....None
Faculty Advisor.....Phil Wilsey

PROGRAM AND ACTIVITIES

The **Activity, Old, New,** or **C** (Continued), and **Man Hours** are listed below, respectively:

Fall 1992		
Fundraiser	Old	10
ECE Lounge Cleaning	Old	4
Grad School Info. Seminar	Old	2
Winter 1993		
Initiation Ceremony & Banquet	Old	8
Incoming Students (Open House)	Old	12
Networks Tutoring	Old	5
Euchre Tournament	Old	3
Spring 1993		
Fundraiser	Old	10
ECE Lounge Cleaning	Old	4
Initiation Ceremony & Banquet	Old	8
Freshman Info Session	New	2.5
Spring Picnic	Old	5
Faculty Advisor's Wake & Ceremony	New	8
Junior Class Info. Session	New	1
Networks Tutoring	Old	5

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