The Initial Dickson Faculty:
Robinson, Thomas, Shimoda, Golden, Dickson, and Kidnay
Philip F. Dickson was born in Huron, South Dakota in 1936 and earned an undergraduate degree with honors in 1958 from South Dakota School of Mines and Technology. He earned a Ph.D. in Chemical Engineering with a minor in Physical Chemistry from the University of Minnesota in 1962. He served in the U.S. Army reserves. Phil then worked briefly for Esso Research in New Jersey and for Esso Production in Texas, before departing due to his daughter’s severe allergy.
Phil was hired by Jim Gary, joining the Mines faculty in 1963. At Mines he taught mainly courses in transport phenomena, especially heat transfer. His initial research efforts were in multiphase reaction kinetics and heat transfer as well as transient reactor behavior. He had a significant research program in heat transfer of different asphalt pavements, and requirements for cold weather paving, including determination of the thermal conductivity of solids such as asphalt, glasphalt, concrete, and oil shale. Over his career he supervised over 48 graduate students in these areas. He became Department Head in 1972.

Teaching in Colorado, Phil developed an interest in one of the principal state natural resources, Oil Shale, and he was a consistent session chair in the School of Mines Annual Oil Shale Symposium. His initial research was on fundamental heat transfer in Oil Shale retorts. He developed a major research program with Vic Yesavage on the utilization of Shale Oil as a feedstock for Petrochemical Production. The study included measuring and kinetic modelling of Steam Pyrolysis for a number of different Shale Oil liquids. He also taught a very successful industrial oriented short course to over 500 people on “Oil Shale: Its Production, Properties and Utilization.” In addition, Phil authored the Oil Shale section of the 1981 edition of the Kirk Othmer Encyclopedia of Chemical Technology.

One of Phil’s major contributions was faculty diversity. Phil hired a number of research-active faculty including the inaugural female departmental faculty, Annette Bunge. At this juncture, we take a brief detour to discuss the history of women students and faculty in the department.
The women at the Colorado School of Mines are true innovators, who have gone beyond stereotypes to pioneer the way for the success of other female engineers. Only four percent of the U.S. population are engineers, but female chemical engineers are a much smaller portion of that population, so they must develop a good deal of self-assurance.

Consider Florence Caldwell, the first Mines woman graduate, in an 1898 Mines class of ten (1). Florence came to Mines after attending two other colleges in Ohio, and was the exception in a class of “rough and ready” miners, graduating as a civil engineer. Over the first 75 years after Mines started in 1874, there were only three other women graduates, the last of whom, Jacquelyn Borthick Kircher was a 1949 graduate of one of the first classes in Petroleum Refining Engineering (PRE) (2).

Jackie Borthick: The First Woman to Graduate from the PRE Department in 1949.

Jackie applied to Mines, as a graduate of Kent Preparatory School in Denver, where she became interested in math and chemistry. She followed in the footsteps of her brother Gilbert D. Borthick (PRE, 1948; MSc PRE 1951) who was one year ahead of her. Jackie, like the other early Mines women, was challenged to find the necessities of life (e.g., places to eat, women’s restrooms, etc.) on a campus built for men. She was treated as an oddity until her fellow students saw her ability, and then she was readily accepted in student society. She married her classmate Rex E. Kircher (PRE 1949) one day after graduation, and worked as an engineer in California (2).

The number of Mines women continued to be low. In 1952, the cover of Life magazine featured Mines’ sole coed Nancy Early, before 900 of her classmates, in a photograph entitled “The Longest Dateline in the World.” But by 1970, the number of women students had swelled to enable completion of the first women’s residence hall, named for Florence Caldwell (1). By 1974 only 51 women had graduated from the school; that total had surpassed 100 by 1977, and by 1979 the number of Mines women was 1 percent of the student body, contrasted against 3 percent of the national engineering student body (2). Cheryl Anderson became the first woman president of the AIChE student chapter in 1973-1974, Phil Dickson’s second year as Department Head.
As the number of women undergraduates increased, the women graduate student population also began to increase in 1979, as the department placed more emphasis on research. Marcia Huber was the first woman to receive a Ph.D. in the department in 1985, as Mike Jones’ advisee. In the following year, Vicki Niesen was the second woman to receive a Ph.D. with Vic Yesavage as her advisor.

In 2018, the number of women (graduates and undergraduates) in the CBE major were 45% of the total 766 CBE majors - a female percentage 50% higher in the CBEN major than the Mines average (4). One departmental goal would be to have both the student and faculty percentages of each gender reflect that of the general population.

In 1974, Julia Alexander was hired in Humanities and Social Sciences as the first Mines woman faculty. In 1981 Annette Bunge, the first woman faculty member in Chemical and Petroleum Refining, came fresh from her doctorate at the University of California, Berkeley. Brief biographies of Annette and other faculty hired by Phil Dickson are in chronological hiring order in this chapter, following the “Student Stories” section. All department faculty biographies are alphabetized in Appendix II.

Yet the total number of women faculty at Mines continued to be low, as shown in Figure 2. (3)
Just prior to the Dickson years, in 1965, the State of Colorado began a Blue Ribbon, out-of-state committee to study Colorado higher education. In 1968, the Chairman of the Colorado Commission on Higher Education published its report to evaluate the Colorado School of Mines. The report stated, “If Mines is to continue to educate for leadership in the mineral industry, its graduate programs must be materially strengthened…. The amount of support for research and other activities by Federal Agencies is extremely low.” (Carl W. Borgmann Report, Colorado Commission on Higher Education, 1968).

This report encouraged Phil Dickson's aggressive promotion of graduate research, already begun in the department by Jim Gary. Phil encouraged significant research growth within the department, by hiring and encouraging research-active faculty: Vic Yesavage (1973), Tony Hines (1975), Dendy Sloan (1976), future Department Head Bob Baldwin (1976), Mike Graboski (1977), Mike Jones (1978), Annette Bunge (1981), and Sami Selim (1982).

Phil remained Department Head until his sad and untimely death in 1983. As a tribute, the Philip F. Dickson Memorial Fund was established at Mines in 1984. He was survived by his wife Georgeann and three children.
Here is a student story from the Dickson years, that involves starting a new company. We hope all alumni will consider returning to their Alma Mater to tell us their stories


The education that I received at the Colorado School of Mines was a key factor in the creation of a group that employs 175 people around the world. Multiphase Solutions, Incorporated (MSi) was founded by three CSM alumni: Trent Brown, Vicki Niesen, and Dale Erickson (and University of Texas alumnus Michael Mai).

In 2004, MSi was purchased by Wood Group and was renamed Intelligent Operations. This group provides software which monitors 10% of the world’s gas supply. It also has the largest flow assurance group in the world and has done over 4,000 studies. The start of the focus on flow assurance started in 1983, when Dale Erickson worked with Dr. Sloan to develop the first commercial simulator for hydrate prediction. The effort was aided by the strong foundation that Dale received from the math department at CSM in numerical methods.

The key factor in performing flow assurance studies is the ability to look at a wide range of issues in a practical way. Next is the ability to look at the results from commercial simulators and determine if the simulation is providing realistic answers (back of the envelope calculations). All of the courses from the Chemical Engineering Department at CSM provided these skills and all of the principles at the original MSi can be traced back to CSM over 30 years ago.

However, the excellence at CSM has continued and we have hired many graduates. Currently in Houston, we have eight grads (shown in the picture on the following page) and two more recent grads on the way. As a footnote, I got my Ph.D. from Rice University and I’m the only person at MSi who ever went to Rice. Also, we have more CSM grads than grads from University of Texas, University of Houston, and Texas A&M University (despite working in Texas). CSM provides someone with the best skills for practical application in the upstream oil field of any other school in the world. I am thankful for the wonderful five years that I spent getting my B.S. and M.S. degrees.
Victor F. Yesavage obtained his B.ChE. at the Cooper Union in 1962, before his M.S. (1964) and Ph.D. (1968) in Chemical Engineering at the University of Michigan. He then worked for Shell Oil Company modeling multiphase reactors (1969-1972) and doing environmental engineering (1973).

Vic joined Mines in 1973 as an Assistant Professor, advancing to Associate Professor (1977) and then Full Professor in 1982. He taught the inaugural Mines environmental engineering course, and he taught every required undergraduate course in the Chemical Engineering curriculum, except Petroleum Refining.

With the opening of the Coady Computer Laboratory in 1995, Vic began developing user-friendly interactive process simulations using Aspen+, including Aspen+ sections in Mass Transfer and Design.

After the 1973 Arab oil embargo, and the increase in government energy funding, together with co-Principal Investigators Dickson and Kidnay, Vic acquired $500,000 (1975 dollars) in government funding. This had a significant effect of shifting emphasis in the department from teaching to a balanced teaching-research department.

Vic's research was primarily in two areas: shale oil and thermodynamics. He advised over sixty graduate students, of which at least ten entered academia. In addition to Vic’s research with Phil Dickson on shale oil as a petrochemical intermediate, he also co-taught a short course with Phil to over 500 industrial engineers and scientists – “Shale Oil: Its Production, Properties and Utilization.” In the area of thermodynamics, he advised over three decades of graduate student research in calorimetry, equations of state, experimental vapor-liquid equilibria, and CO₂ and H₂S gas absorption.

Vic retired from the department as Emeritus Professor in 2006.
Anthony L. Hines obtained his B.S. (1967) from University of Oklahoma in Chemical Engineering, and worked two years for Warren Petroleum (1967-1969) before obtaining his M.S. from Oklahoma State University (1972) in Chemical Engineering. He then obtained his Ph.D. (1973) from the University of Texas at Austin, in Mechanical Engineering.

Tony began professing at the Georgia Institute of Technology from 1973-1975. He came to Mines in 1975 as an Assistant Professor in the Department of Chemical and Petroleum Refining Engineering, progressing to Associate Professor in 1977. Tony taught courses in heat, mass, and fluids transfer.

In 1980, Tony accepted the position as Professor and Head of the Department of Chemical Engineering at the University of Wyoming. In 1983, he became Associate Dean of Engineering at Oklahoma State University. From 1987 until 1992, Tony held the Ketcham Chair of Chemical Engineering and was Dean of the College of Engineering at the University of Missouri-Columbia. He held a number of industrial positions before becoming Dean of Engineering at the University of Iowa from 1999 until 2000, when he left to become Senior Vice President of Operations of Walter Industries. Tony retired to become a futures trader and author of mass transfer texts in 2004.

Tony is a Fellow of the American Institute of Chemical Engineers. He holds one patent, has 93 refereed publications, has co-authored two books, and has advised 34 M.S. and Ph.D. Students.
E. Dendy Sloan obtained his B.S. (1965), M.S. (1972), and Ph.D. (1974) all in Chemical Engineering from Clemson University. Between his B.S. and M.S. degrees, he worked six years for E.I. DuPont de Nemours, installing chemical plants in four different states. In 1975, he did postdoctoral research at Rice University in natural gas hydrates.

Dendy began as an Assistant Professor at Mines in January of 1976, progressing through the ranks of Associate Professor (1979) and Full Professor (1983); he held Visiting Chairs in Japan (1996), and New Zealand (2002). While at Mines, he taught every required undergraduate course, except Petroleum Refining, and advised or co-advised 129 graduate students and postdoctoral researchers.

Dendy principally did research in natural gas hydrates, with over 250 refereed publications and five books on hydrates. He was named to the inaugural chaired professorship in the department, as the Gaylord and Phyllis Weaver Chair (1992-2009). Upon transitional retirement in 2009, he broadened his academic interest and spent a decade studying neuroscience at the University of Colorado. Dendy co-authored two editions of the text, *Neuroscience, Memory, and Learning* with Mines Professor Cynthia Norrgan (M.D., Ph.D.).

Dendy holds five patents and is a Registered Professional Engineer in the State of Colorado. He is a Fellow of the American Institute of Chemical Engineers. Dendy chaired the ASEE Education and Research Methods Division (1983-85), the ASEE Chemical Engineering Division (1985), and the Publications Board of *Chemical Engineering Education* (1990 – 2006). He was elected chair of the inaugural Mines Faculty Senate (1989), and was the first Board of Trustees faculty representative. He was named the 1996 SPE Distinguished Lecturer, and the 1997 Mines Faculty Senate Distinguished Lecturer.

He has been given a number of awards, including Outstanding Faculty Member in Chemical Engineering (3 times), the 1988 President’s Award as the Outstanding Educator at Mines, the Donald L. Katz Research Award from the Gas Processors Association (2000), the 2011 Lifetime Achievement Award from the International Conference on Gas Hydrates, and the 2013 Distinguished Achievement Award from the SPE Offshore Technology Conference. Upon his retirement in 2011, he was given the Mines Trustees George R. Brown Medal, and he was named University Professor Emeritus. He continues to teach one course entitled “Neuroscience, Memory, and Learning.”
Bob Baldwin obtained his B.S. (1969) and M.S. (1972) in Chemical Engineering from Iowa State University, before coming to Mines to complete his Ph.D. (1975). Bob was such an outstanding scholar that he was named a Mines Instructor in 1975, before completing his doctorate, and he was named an Assistant Professor in 1976. He then spent one year in 1978 -1979, in the U.S. Department of Energy Fossil Energy Program, before returning to Mines. He was promoted to Associate Professor in 1980, and Full Professor in 1985.

Bob was named Chemical Engineering and Petroleum Refining Department Head in 1990, where he served until 2000. Bob led the department to many advances during the last decade of the millennium, including such things as doubling the number of faculty and students, doubling the research volume of the department, and doubling the size of the building. He was named Emeritus Professor of Chemical Engineering in 2004 upon his retirement from Mines. For details the reader is referred to the chapter, “The Baldwin Years (1990-2000).”

Bob was the Program Director and an academic founder of the Petroleum Institute in Abu Dhabi, United Arab Emirates where he worked from 2002 until 2007. In 2008, Bob returned to Golden with the National Renewable Energy laboratory, where he currently serves as Principal Scientist in the National Bioenergy Center.
Michael C. Jones obtained his B.S. from the University of London (1955) in Chemical Engineering and went into the British Royal Navy from 1955-1957. Then Mike worked as a Process Engineer for Royal Dutch Shell, first in the Netherlands (1957-1960), and then for Shell Development Company in Emeryville, California (1960-1962).

Mike obtained his M.S. in Chemical Engineering (1964) from the University of California, Berkeley, before becoming a Chemical Engineer at the National Bureau of Standards (NBS) in Boulder, Colorado. He returned to Berkeley for his Ph.D. (1970) in Mechanical Engineering, then completed another eight years at NBS Boulder.

In 1978, Mike joined the Mines Chemical and Petroleum Refining Engineering department as Associate Professor, where he served until 1984, teaching mainly fluids and heat transfer, and doing research. In 1984, Mike returned again to NBS Boulder (then named the National Institute of Standards and Technology), where he became Group Leader (1990) in Transport Processes, then Assistant Director of the Chemical Science and Technology Laboratory, serving in that capacity until his retirement.

Michael S. Graboski received his B.S. (1967) from Rutgers University, and his M.S. (1970), and Ph.D. (1977) from Pennsylvania State University, all in Chemical Engineering. In 1967 Mike was a plant engineer for Humble Oil and Refining. Mike came to Mines in 1977 as an Assistant Professor, and was promoted to Associate Professor in 1981.

While at Mines, Mike taught courses in kinetics and thermodynamics, and did research in fuels. In 1984, Mike became Vice-President and Director of Research for Syngas Systems, and he became the Director of the Colorado Institute for Fuels and High Altitude Engine Research beginning in 1990. Mike retired from Mines as Professor Emeritus in 2000.
As noted in the above section “Women in Chemical & Biological Engineering,” in 1981 Annette became the first woman faculty member in the department, achieving promotion to Associate Professor in 1985 and Full Professor in 1991. She was the first female Assistant Professor at the school to achieve the rank of Professor.

She taught graduate and undergraduate courses in transport, and for many years, the graduate applied math course. In research, Annette adapted to changing funding sources by moving from her doctoral work on enhanced oil recovery to remediation of chemically contaminated soils, then to membrane methods for wastewater cleanup, and finally to absorption of chemicals in human skin, which has been her primary focus since 1990.

In 1987, Annette became the Director of the Mines Center for Waste Management, and served as the Director of the Mines Center for Environmental Risk Assessment (2008-2012) after becoming Professor Emerita in 2005. From 2010 until the present, Annette continues to serve as Research Professor and Graduate Professor continuing her research with a very active program in human skin research, collaborating with scientists at several universities.

Annette has won a number of awards, including the 2010 Mines Faculty Senate Distinguished Lecturer Award and the 2011 George R. Brown Mines Board of Trustees Medal for distinguished service to the field of engineering education.

Annette Bunge
This section of brief faculty bibliographies of the Dickson Years is concluded with a tribute to a fallen faculty hero, Sami Selim, written by Professor Emeritus Victor Yesavage. In many ways Sami’s life illustrated not only his genius and love of teaching, but his ability to profess, almost in a religious sense. Sami Selim’s life demonstrated what it means to live a life of the mind, and a life of service.

Despite a heroic effort to endure a crippling rheumatoid arthritis, one of Sami’s most enduring traits was the will to do what it took to get the job done. A typical encounter with Sami might involve entering the building at 10 am to turn in final grades only to find Sami leaving to go home and get some sleep because he had been grading all night long to get his grades in on time.

Sami Selim was born in Sirs Ellian, Menoufia, Egypt in the Nile delta, the second of seven siblings, on January 24, 1942. He loved music, playing the accordion in high school. He loved sports and also played basketball in high school. Sami was, as one might imagine, a very good chess player, and took up the piano as he grew older.

He earned an undergraduate degree in Chemical Engineering at the King Fahd University of Petroleum and Minerals (KFUPM) in 1962 in Egypt and came to the States where he earned a second degree in Chemical Engineering from Carnegie Mellon in 1966. In graduate school at Iowa State University he earned both an M.S. in Mathematics in 1969 and a Ph.D. in Chemical Engineering in 1970, where he worked for Dick Seagrave. He then served as a Postdoctoral Fellow at Iowa State from 1970 to 1974, interrupted by a year as Associate Vice President for Technical Planning, Ministry of Industry, Cairo, Egypt.

Sami then was hired by the University of Petroleum and Minerals in Dhahran, Saudi Arabia as an Assistant and later an Associate Professor. It was here that he was first diagnosed with rheumatoid arthritis. It was recommended that he emigrate to the United States where he could receive better medical treatment. He obtained an Associate Professor appointment at Texas Tech University where he worked from 1979 to 1982. He came to Mines in 1982, in part because of the close connections the Mines’ Chemical Engineering Department had with Iowa State. In spite of continually worsening arthritis, he remained at Mines until his death in 2000.

Sami did take a brief leave to study computer-aided design at Phillips Petroleum, to bring that knowledge back to the Coady computer lab in the department. Sami also did a research semester in Paris. During his time at Mines, he met his wife Barbara; they lived in a home beside North Table Mountain. Here, they were fabulous entertainers, Sami continued playing piano despite his crippling arthritis. A list of adjectives that might be used to describe Sami would almost certainly include the following: scholar, educator, mentor, leader, colleague, friend.
Scholar:
If you look up “scholar” in the dictionary, you will find that it means a “learned person - one trained in a special branch of knowledge.” Sami was clearly one of the brightest chemical engineers that most of us have ever known. His knowledge of transport phenomena and applied mathematics was unparalleled in our department and university, and he was highly respected throughout the country and world in his areas of expertise. His academic curiosity and overall professional abilities are best demonstrated by the extremely wide range of areas in which he published.

Sami’s first publications during graduate school were under Don Kirkham in the “Soil Science of America Journal” on seepage through soil bedding, work that he continued to pursue in collaboration with his brother, Magdi. His doctoral publications were moving boundary problems, usually involving complementary error function math, that are more representative of what we would expect from Sami. While in Saudi Arabia, he published works on computation of electric field potential. At Texas Tech, in addition to numerical analysis, he began publishing in the field of particle sedimentation.

At Mines, he began working with Dendy Sloan studying hydrate plug dissociation, while continuing his work on fine particle suspensions. He maintained a major interest in numerical and analytical solutions to fluid and heat transfer problems throughout his career at Mines. Along the way he studied drying of water-based inks with Vic Yesavage. In addition, he studied the precipitation of nano-size magnetic particles in suspension, which resulted in two patents. Later he began studying gas absorption with chemical reaction. This led, with Vic Yesavage, to the analysis of CO₂ and H₂S gas absorption considering the phase equilibria modelling, the stagewise mass transfer and the column simulation. All this work continued as crippling rheumatoid arthritis continued to take its toll.

Educator:
Sami felt that his primary job was to teach others and as such served as Associate Editor of Chemical Engineering Education. The quality of his teaching was the standard to which other faculty could aspire. He taught almost every required course in our undergraduate curriculum and every required transport and mathematics-oriented course in the graduate program. Not only did he teach these courses, but he taught them well. It was generally a test of faculty members’ egos when they either team taught a course or taught an alternate section of a course with Sami. Regardless of the effort put in, the student evaluation could never approach that of Sami’s. On the other hand, if a faculty member was assigned a new course, he would immediately determine if Sami had previously taught the course. If so, there would most likely be an outstanding set of course notes that could be borrowed. In his teaching career, Sami earned outstanding teacher awards four times. He consistently received grades of 4.0/4.0 in his student evaluations. His teaching was consistently evaluated as exemplary.
Mentor:

Again, if you go to the dictionary, a mentor is a “wise and loyal friend who is also a teacher and advisor.” Perhaps Sami’s greatest contribution was in his ability to mentor graduate students and faculty. Sami literally poured himself into a quest to instill a love of knowledge and discovery in our students. As an example, he was able to encourage busy graduates students to sign up for his special problems courses for the sake of academic curiosity. One such course was a one-hour introduction to the highly mathematical topic of Green’s functions. Almost every student or faculty member that ever came to Sami’s office for help came back again for insight, advice or to simply see what Sami thought about a particularly vexing problem. Many students held Sami as a parental image and would do anything for him because they knew that he would do anything for them. As an indication of his academic and intellectual mentorship, seven of his Ph.D. students went on to academic positions after graduation.

Leader:

One aspect of leadership is leading by example. This was specifically demonstrated by his constant demonstration of a positive attitude despite his crippling arthritis. Sami also showed true leadership at CSM due to the work that he did to introduce flowsheeting and computer-aided chemical process design throughout our undergraduate curriculum. Previously, process simulation was only incorporated in mass transfer and design. Sami worked with Aspen+ Technology and Phillips Petroleum to learn how to perform computer-aided process simulation and then to help the faculty introduce this technology in every course that we teach. Associated with this effort, he emerged as a leader in defining the content of what we teach in Chemical Engineering at Mines. At the graduate level, he ran the Ph.D. qualifying exam.

Colleague and Friend:

While his health problems limited his physical activity in later years, his mental activities remained extremely strong. We will all remember “Dr. Sami” as the consummate professor: a brilliant lecturer, superb theoretician, gifted problem solver, and a world-class example of the phrase ‘absent-minded professor’. He is well remembered by all his friends and colleagues that served in the department, and by those many students who were privileged to have benefited from Sami’s wit and wisdom both inside and outside of the classroom.

Following his death on June 27, 2000, the Sami Selim Memorial Fellowship Fund was established as an endowed fund though the Colorado School of Mines Foundation. It is still in existence today and offers fellowship awards for graduate or undergrad students pursuing a course of study in the Department of Chemical and Biological Engineering.
Ron Miner
Laboratory Coordinator, 1974-2003.

With Phil Dickson’s initiative to increase graduate research, as well as the normal departmental duties, the new Laboratory Coordinator Ron Miner had his hands full in 1974. However, Ron was more than up to the job. He was very optimistic and energetic, and did the job of two technicians: one maintaining the Unit Operations laboratory, and a second helping graduate students and faculty build many specialized pieces of research equipment.

Perhaps more than anyone single person, Ron was responsible for organizing the experimental equipment to bring Mines to first rate Chemical Engineering research. Ron Miner’s outstanding effort was recognized in 1999 by two major service awards: the Mines Classified Employee of the Year Award, and the Colorado Governor’s Outstanding Service Award.

Ron retired with his family and son Randy in Alaska in 2003.
1983 Curriculum

Freshman Year

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<td>GE 101 General Geology</td>
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<td>HU 121 Man and His Vision: Utopia and Beyond</td>
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<td>PA 101 Physical Education</td>
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Sophomore Year

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### Junior Year

#### Fall Semester
- **BE 320 Mechanics of Materials**: 3 Sem Hrs.
- **BE 381 Electronics and Control Systems**: 4 Sem Hrs.
- **CH 323 Organic Chemistry I**: 3 Sem Hrs.
- **CR 307 Unit Operations I**: 3 Sem Hrs.
- **CR 421 Engineering Economics**: 3 Sem Hrs.
- **Total**: 16 Sem Hrs.

#### Spring Semester
- **CH 324 Organic Chemistry II**: 4 Sem Hrs.
- **CR 308 Unit Operations II**: 3 Sem Hrs.
- **CR 309 Process Simulations**: 3 Sem Hrs.
- **CR 407 Chemical Engineering Thermodynamics**: 3 Sem Hrs.
- **PH 214 Physics III or PH 309 Modern Physics**: 3 (3) Sem Hrs.
- **PH 219 Physical Measurements**: 1 Sem Hrs.
- **Total**: 17 Sem Hrs.

#### Summer
- **CR 312 Unit Operations Laboratory (6-week Summer Term)**: 6 Sem Hrs.

### Senior Year

#### Fall Semester
- **CR 403 Process Dynamics**: 3 Sem Hrs.
- **CR 405 Mass Transfer**: 3 Sem Hrs.
- **CR 409 Petrochemical Processes**: 3 Sem Hrs.
- **CR 418 Catalysis and Kinetics**: 3 Sem Hrs.
- **EC 311 Principles of Economics I**: 3 Sem Hrs.
- **EN 412 Rhetoric-Exposition**: 3 Sem Hrs.
- **Total**: 18 Sem Hrs.

#### Spring Semester
- **CR 402 Engineering Design**: 3 Sem Hrs.
- **EC 312 Principles of Economics II**: 3 Sem Hrs.
- **EN 400 Technical Communications**: 3 Sem Hrs.
- **Humanities-Social Sciences Elective**: 3 Sem Hrs.
- **Electives**: 6 Sem Hrs.
- **Total**: 18 Sem Hrs.

#### Total Degree Hours
- **144 Sem Hrs.**

### References: