

Professor Neal R. Amundson is an influential chemical engineer and mathematician, who has helped shape future outlooks in the field of chemical engineering. His legacy will live on in the minds and hearts of those who know him, and serve as an inspiration for those to come.

Location/Dates/Times

The Shamrock Ballroom
The University Hilton Hotel
Entrance 1

Lecture 1 December 12

3:00 p.m.—4:00 p.m.

Lecture 2 December 13

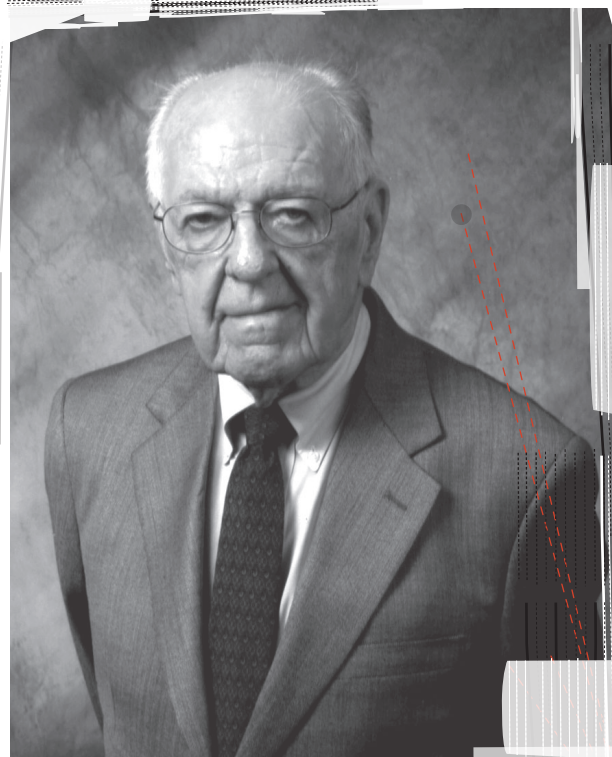
3:00 p.m.—4:00 p.m.

Lecture 3 December 14

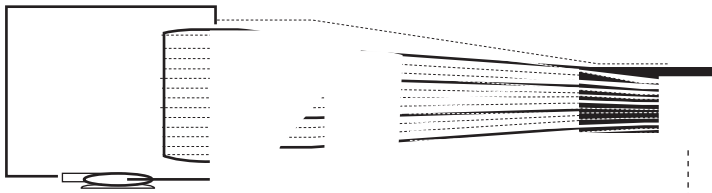
3:00 p.m.—4:00 p.m.

Neal Amundson

The Modern Chemical Engineer and Mathematician



The University of
Houston is honored
to host a series of
lectures by
Martin Feinberg
in recognition of
Neal Amundson.



The highlights of my career lie in having some very successful students. They're like your own children.

- Dr. Neal R. Amundson



In Recognition of **Professor Neal R. Amundson**

Neal R. Amundson, Cullen Professor of Chemical Engineering and Mathematics at the University of Houston, is widely regarded as the most prominent Chemical Engineering educator in the United States. His honors and awards are legion. He is a member of the National Academy of Sciences, the National Academy of Engineering, and the American Academy of Arts and Sciences. He received the NAE's Founders Award, honorary doctorates from the Universities of Minnesota, Notre Dame, Pennsylvania, Guadalajara, and Northwestern University. He received the Farfel Award, the highest faculty honor given by the University of Houston. The building that houses the Department of Chemical Engineering and Materials Science at the University of Minnesota was named "Amundson Hall" in 1979.

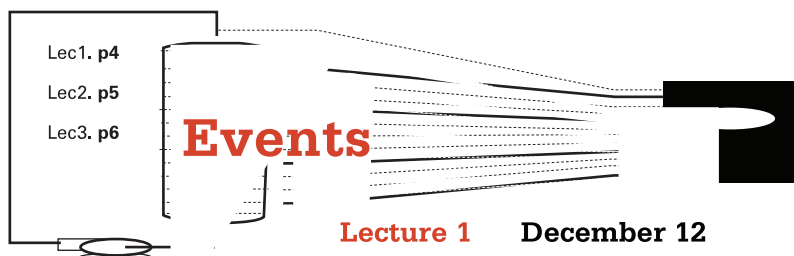
An Unsolved Problem in **Chemical Engineering**

Graduate Student Workshop

Imagine a network of chemical reactions in which various reactants interact in perhaps complicated ways to form products, some of which are desirable and some of which are undesirable. Imagine also the availability of fixed streams of the reactants that can be freely mixed in a variety of ways. One of the major problems of chemical engineering is to determine just how these streams should be mixed in order to encourage the production of desired products, while discouraging the production of undesired ones. A *general* theory for how this should be done remains elusive.

The more one thinks about the problem, however, the more it becomes clear how many different mathematical threads (e.g., dynamical systems theory, differential geometry, convexity theory, optimization theory) *must* be woven together in its solution. We'll describe the problem more precisely, and we'll try to show why so many seemingly distinct parts of mathematics inexorably come together in consideration of it. Moreover, we'll review what's known and what remains unknown.

The problem is important in its own right, but the workshop is primarily intended as a case-study in support of a much broader lesson. Very rarely are problems in applied mathematics like those at the end of a textbook chapter. Almost always, there's a need to draw on what's known from a great variety of sources and a need to invent what's not known.



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Lecture 3 **December 14**

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The Speaker's Biography

Martin Feinberg is the Richard Morrow Professor of Chemical Engineering and Professor of Mathematics at the Ohio State University. Building on earlier work with F. J. M. Horn and Roy Jackson (formerly of the University of Houston), Feinberg and his students went on to prove penetrating and sometimes surprising theorems that led to chemical reaction network theory, a body of work that connects reaction network structure to qualitative properties of the corresponding differential equations. He has also done fundamental work on the mathematics of chemical processing and on foundations of classical thermodynamics. Before moving to Ohio State, Feinberg was a Professor of Chemical Engineering at the University of Rochester. He was educated at Cooper Union (B.Ch.E.), at Purdue University (M.S.), and at Princeton University (Ph.D.).

Like the economics department at the University of Chicago and the mathematics department at New York University, the chemical engineering department that Neal Amundson created at the University of Minnesota was a rare and singular academic entity whose influence remains profound and broadly felt. Although Neal's department was generally known for bringing diverse streams of high-level science to the study of chemical engineering problems, it was the application and advocacy of modern mathematics that was the department's signature.

At the time, this was not easy, nor is it entirely easy today, for the historic relationship between mathematics and chemistry has been a strangely distant one: In nature, there are thousands of distinct chemical reaction networks in which various molecules are created in certain reactions and simultaneously consumed by still others. These intricate chemical processes are ancient, ubiquitous, and almost impossible to understand without help from mathematics. One would think, then, that chemistry should have a deep and long-standing mathematical tradition, one resembling that of celestial mechanics or of electromagnetism. Yet, it is hard to argue that, until the advent of Neal's department, there was a mathematical tradition in chemistry, at the reactor level, that had the depth or duration that one finds even in economics.

In this lecture, we'll examine aspects of the often uneasy historical relationship between chemistry and mathematics, and, paradoxically, how clues about causes for the estrangement (or at least the mutual indifference) can actually be found in the elegant and remarkable mathematical structure that chemical reaction networks present. We'll also examine why, especially in a century likely to be dominated by cell biology, there is much to be gained by both chemists and mathematicians from the more congenial relationship that Neal Amundson fostered.

Understanding Bistability in Complex Enzyme-Driven Reaction Networks

Lecture 2

The machinery of the cell consists, in large part, of a bewildering collection of distinct biochemical reactions mediated by the action of enzymes. Kinetic functions that describe the dependence of individual reaction rates on mixture composition are rarely known with great precision (if they are known at all), and so the most apt questions are often qualitative ones. In particular, one would like to know the relationship between the structure of a biochemical reaction network and its qualitative capacity to exhibit various kinds of dynamical behavior. Our special interest will be in capacity of complex enzyme-driven reaction networks to admit bistability—that is, the capacity of the corresponding differential equations to admit two (or more) distinct stable stationary states. It turns out that some rather simple classical mechanisms for enzyme catalysis already carry the capacity for bistable behavior while other large and complex enzymatic networks do not. Indeed, the connection between network structure and the capacity for bistability is surprisingly delicate. Thus, a good theory of such connections must be capable of dealing with reasonably large reaction networks and yet be subtle enough to draw dramatic behavioral distinctions between networks that are very similar. We'll describe some recent work with Gheorghe Craciun that takes us a good way down the road toward resolution of the problem. In particular, we'll consider the capacity for bistable behavior in a network underlying the action of a particular enzyme, one that is a target of classical anti-cancer therapies.

Professor Amundson is recognized as an exceptionally prolific, innovative and influential researcher. His contributions include modeling and analysis of chemical reactors, separation systems, polymerization, and coal combustion. He had a profound, pioneering impact on the education of chemical engineers, changing the teaching of the field from a qualitative, descriptive approach to precise scientific methodology.

Professor Amundson was the first to incorporate advanced mathematics into chemical engineering research and chemical engineering undergraduate and graduate education. He was the first to apply the principles of non-linear mechanics to lumped constant chemical reactor systems, enabling him to explain chemical reactor instability, oscillatory behavior, and parametric sensitivity. Amundson developed the complete theory of multi-component column chromatography, including shock interactions, which led to the determination of the underground movement of pollutants. He applied modern mathematics to multi-component and continuous distribution of component rectification and developed complete solutions.

The field of chemical reactor engineering, as well as the concept of reaction coupled with diffusion, was also first developed by Professor Amundson. With the threat of the essential use of coal, Professor Amundson initiated a systematic and exhaustive development of the gasification of coal char, the products of which would have been used in fuel synthesis. He also constructed a physical and mathematical model and participated in the systematic design of the first nuclear submarine, the Nautilus.

A native of St. Paul, Minnesota, Neal R. Amundson received a bachelor of science degree in chemical engineering, a master's degree in chemical engineering and a doctorate in mathematics from the University of Minnesota. Professor Amundson remained at the University of Minnesota, teaching both chemical engineering and mathematics. In 1949 he became head of the Department of Chemical Engineering, and he continued as department head for the next 25 years. Professor Amundson joined the University of Houston's Department of Chemical Engineering in 1977, and he also served as University Provost from 1987 to 1989. He is currently an active researcher and mentor in the Department of Mathematics at the University of Houston.