Analytical Chemistry

CHM1102H *Biosensors & Chemical Sensors*
(Cross-listed Undergraduate CHM414H)
This course concerns current research and advances in analytical chemistry. There will be a strong emphasis on the principles of chemical and biological sensor technology, including different transduction mechanisms, device architectures and the necessary theoretical background material. Specific devices include electrochemical, optical (fiber-optic and surface plasmon resonance) and acoustic wave sensors. The use of molecular recognition and the chemical modification of transducer interfaces to achieve chemical selectivity (including biological, biomimetic, polymeric, self-assembled monolayer and synthetic host-guest systems) will be discussed, together with appropriate methods for surface characterization and analysis. Other topics will include flow injection and microfluidics technologies, chemometric techniques, and the so-called "electronic nose".

CHM1103H *Advanced Topics in Analytical Chemistry*
(Cross-listed Undergraduate CHM414H - UTM)
An overview of both recent and fundamental developments of instrumentation that are revolutionizing the field of analytical chemistry, with an emphasis on applications in biological chemistry and biotechnology. Topics will include specialized mass spectrometry techniques, including secondary ion, fast atom bombardment and ion cyclotron resonance mass spectrometry methods; GC/MS and LC/MS interfaces; a survey of surface-oriented techniques including x-ray photoelectron spectroscopy, Auger electron spectroscopy, Raman spectroscopy, attenuated total reflection methods, total internal reflection fluorescence methods; Fourier transform theory and methods; microcomputer interfacing and chemometrics.

CHM1104H *Separation Science*
(Cross-listed Undergraduate CHM416H)
This course is intended as an extension of the material dealt with in CHM 317H. Initial discussion will focus on the scope of separation technology of all kinds in chemistry in general and analytical chemistry in particular. Areas considered will include precipitation, fractionation, extraction techniques and a detailed consideration of a unified theory of separation. Thin layer, gas and liquid chromatographies will be reviewed, and advanced methods and techniques described. Other topics will include: ion, size exclusion, supercritical fluid and affinity chromatographies: gel and capillary electrophoresis; field flow techniques; and various extraction methodologies (liquid-liquid, solid phase, supercritical fluid). While examples will be drawn from a variety of sources, the emphasis will be on biological and biochemical applications.

CHM1105H *Separations, Chromatography and Microfluidics*
(Cross-listed Undergraduate CHM416H - UTM)
Separation science will be explored by building on a survey of fundamental physical principles to understand processes of extraction, and technologies such as solid phase microextraction, supercritical fluid extraction, immunoaffinity extraction and molecularly imprinted polymers. Plate and rate theory will be developed to consider various forms of gas and liquid chromatographic methods, including hyphenated techniques that bridge to information detectors such as mass spectrometers. New opportunities for chromatography and separations by movement to small scale size will be considered by focusing on microfluidics, electro-osmotic flow and chip based microdevice applications. Applications examples will focus on problems in life sciences, forensics and environmental chemistry.

CHM1106H *Lab Instrumentation*
(Cross-listed Undergraduate CHM417H)
This course provides an introduction to building and using optics- and electronics-based instrumentation for laboratory research, as well as for implementing custom software control. Lecture topics include passive electronic components, diodes and transistors, operational amplifiers, light sources and detectors, reflectors, refractors, polarizers, and diffractors, LabView programming and many others. Lectures are supplemented by laboratories in which students work in teams to build fluorescent detection systems for chromatography over the course of several weeks.

CHM1107H *The -Omics Revolution and Mass Spectrometry*
Biology is in the midst of a 'systems' revolution, which emphasizes the evaluation of interactions between hundreds-thousands of biomolecules in parallel. This paradigm, which has spawned the ever-growing number of '-Omics' disciplines, has been driven in part by tools developed by analytical chemists (e.g., microfluidics, multiplexed separations, high resolution spectroscopy). One analytical technique that has had a particularly important role in the revolution is mass spectrometry. In CHM 1107, we take a detailed look at mass spectrometry and associated methods, and survey the state-of-the-art in other analytical tools that are driving the -Omics revolution.

CHM1108H *Mass Spectrometry Fundamentals and Instrumentation*
Mass Spectrometry is today best-known for the significant role that it plays in biological analysis (proteins, peptides, drug discovery). This relatively new-found eminence derives from a long history of discovery and innovation in environmental monitoring, air quality, materials identification, quality control, even extra-terrestrial atmospheric determination. Mass Spec can be broadly classified as Organic or Inorganic, for which the instrument configuration and methods are very distinct. The course will focus on the technology of mass spectrometry rather than the applications: theory, structures, modes of operation, strengths and weaknesses of various mass analyzers, ionization sources and detector systems. It will deal extensively with ion dynamics in electrostatic and dynamic fields, and the considerations for ion optical design. Extension of the capabilities of mass spectrometry will be introduced through the thermodynamics and kinetics of ion-molecules reactions that can be employed for the resolution of both organic and inorganic isobars.

CHM1150H *Advances in Electroanalytical Chemistry and Electrochemical Sensors*
This course will provide the fundamentals of electrochemistry as applied to solve problems of analysis, and will examine potentiometry and voltammetry as the basis for problem solving. The course will focus on electrode types and materials, surface derivatization methods for preparation of chemically-modified electrodes, pulse forms and sequences for voltammetry, electron transfer and relay systems for 'molecular wiring', and examples of applications of technology in solving problems. Electrochemical sensors such as those for glucose analysis will serve as a platform for consideration of device engineering, and to examine requirements for commercialization of device technologies.

CHM1152H *Chemical Sensors*
The fundamentals of design and operation of all major types of chemical sensors and biosensors will be presented and critically evaluated. Emphasis will be placed on the problems that are encountered with the development of reliable and practical biosensors, using case histories of commercial devices as a point of reference. A survey of the physical principles of function of electrochemical, optical and piezoelectric transducers will be used to illustrate how different systems can be advantageous in handling different applications. Discussion will focus on examination of the technical problems and potential solutions that are required for further development of sensor technologies.

CHM1157H *Applications of Chemometrics*
This course will focus on selected methods of statistics and mathematics as applied to topics in analytical chemistry. Topics will include: factor and principle components analysis, optimization theory, experiment design, neural networks, fuzzy logic, pattern recognition, cluster designation, and transformations and filtering for spectroscopy and imaging. The intention is to provide an overview, to define elements of a 'toolbox' that has practical use. Examples of approaches to problem solving, software, and sources of software for applications of chemometrics will be used to highlight topics, rather than detailed mathematical solutions.

CHM1190Y *Analytical Chemistry Seminar*