This course extends the knowledge of the analytical chemistry to include the fundamental principles and application of modern instrumental methods including spectroscopic, spectrometric, and separation methods. The topics covered have applications to many subject areas in Natural Sciences, Life Science and Engineering.

This course is presented in a lecture/discussion format. The content of the course includes:

Part I:
I. Electrolysis
   A. Electrogravimetry
      a) Analysis and Electrode
      b) Separation
      c) Non-potentiostatic Method
         i) Concentration Polarization
         ii) Kinetic Polarization
         ii) Overpotential
      iv) Ecat Adjustment
      v) I-V Behavior During Electrolysis
   d) Potentiostatic Method
      i) Three-Electrode System
      ii) Potential and Current Changes
   B. Coulometry
      a) Analysis
   II. Amperometry
      A. Analysis
      B. O2 Measurement
      C. Glucose Electrode
      D. Blood Glucose Monitor
      E. Chromatographic Detector
   III. Voltammetry
      A. Applied Potential, Eappl
         a) Linear Sweep
         b) Staircase
         c) Square Wave
      B. Current, i
      C. Basis of Analysis
         a) Faradaic and Charging Currents
         b) Supporting Electrolyte
         c) Vitamin C Analysis
      D. Cyclic Voltammetry
E. Sampled Current Polarography
F. Square Wave Voltammetry
G. Stripping Method

Part II:
I. Introduction to Instrumental Analysis
II. Fundamentals of Spectroscopy/Spectrometry
   A. Introduction to Spectroscopy
   B. Characteristics of Electromagnetic radiation
   C. Wave Property of Light and Optical Component
      a) Interference
      b) Transmission
      c) Reflection
      d) Refraction
      e) Scattering
      f) Diffraction
   D. Particle Property of Light and Its Use
      a) Photoelectric effect
      b) Absorption
      c) Emission
   E. Spectroscopy
      a) Type of Spectroscopy
      b) Nature of Excitation
III. UV and Visible Absorption Spectrometry
   A. Range and Type of UV/Vis Radiation
   B. Principle
      a) Molar Absorptivity
      b) Spectroscopic Process
      c) Effect of Multichromophores
      d) d, f-electron Transition
   C. Measurement
      a) Standard Addition Method
      b) Solvent Selection
      c) Solvent Effect
      d) Beer’s Law and Its Limitations
      e) Spectrophotometric Uncertainty
   D. Instrumentation
      a) Single-Beam and Double-Beam Instruments
b) Sample Cell and Construction Materials
c) Source
d) Slit
e) Detector
E. Spectroscopic Information
a) Imaging
b) Qualitative
c) Quantitative
F. Spectral Analysis
a) Woodward-Fieser Rules
IV. Luminescence Spectroscopy
A. Luminescence
B. Principle
a) Spectroscopic Process
b) Quantum Yield
c) Favorable Condition for Luminescence
d) Emission Spectrum
e) 90° Detection
f) Luminescence Intensity
g) Type of Luminescence
C. Instrumentation
D. Spectroscopic Information
a) FL System
b) Fluorescent Agent
c) Use of Excited-State Molecules
d) Fluorescence Resonance Energy Transfer
V. Infrared Spectroscopy
A. Range and Type of IR Radiation
B. Principle
a) Molecular Excitation
b) Type of Molecular Vibration
c) Normal Mode of Vibration
d) Spectroscopic Process
e) IR-Active Vibration
C. Instrumentation
a) Nondispersive Instrument
b) Dispersive Instrument
c) Sample Cell and Construction Materials
d) Source
e) Wavelength Selector
f) Detector
D. Spectroscopic Information
a) Functional Group
b) Quantitative
VI. Raman Spectroscopy
A. Principle
a) Polarizability
b) Raman Scattering
c) Energy Shift
d) Raman-Active Vibration
e) Raman Scattering Intensity
f) Advantage Over IR
B. Instrumentation
a) Laser
C. Spectroscopic Information
D. Raman vs. IR
VII. Atomic Spectroscopy
A. Spectroscopic Process
a) Absorption
b) Emission
B. Atomization
a) Flame
b) Furnace
c) Plasma
C. Spectral Line Shape
a) Natural Line Width
   i) Heisenberg Uncertainty Principle
   ii) Full Width at Half Maximum
b) Pressure Broadening
c) Doppler Broadening
d) Background Radiation
e) Molecular Emission
f) Self-Absorption
D. Spectrometer Design
a) Main Components
b) Component Layout
c) Sources
VIII. Nuclear Magnetic Resonance Spectroscopy
A. Principle
a) Range of Radiation
b) Nuclear Spin
B. Instrumentation and Measurement
a) Phase Coherence
b) Magnetic Resonance
c) Secondary Field
IX. Mass Spectrometry
A. Ionization Method
a) Gas-Phase Ionization
i) Electron Impact
ii) Chemical Ionization
iii) Field Ionization
b) Liquid-Phase Ionization
i) Inductively Coupled Plasma
ii) Electrospray Ionization
c) Solid-Phase Ionization
i) Fast Atom Bombardment
ii) Matrix-Assisted Laser Desorption/Ionization
B. Mass Analyzer
a) Double Focusing
b) Time-of-Flight
c) Quadrupole
d) Ion Trap
C. Detector
a) Faraday Cup
b) Channel Electron Multiplier
c) Multichannel Plate
D. Spectral Analysis
X. Analytical Separation
A. General Description
a) Solvent Extraction
b) Mobile and Stationary Phases
c) Classification
d) Elution
B. Principle
a) Migration Rate
b) Retention Time
c) Flow Rate – Flow Velocity Relationship
d) Migration Rate - Distribution Constant
e) Retention Factor
f) Selectivity Factor
g) Band Broadening
h) Column Efficiency
i) Column Resolution
j) Column Resolution

XI. Gas Chromatography
A. Separation Process
B. Injection and Detection
C. Detector
D. Sample Preparation

XII. High-Performance Liquid Chromatography
A. Chromatographic Process
B. Injection and Detection
C. Reversed-Phase Separation
D. Gradient Separation