**09-535/09-735: Applied Topics in Macromolecular and Biophysical Techniques**
**Fall Semester**

***Instructor:*** Dr. Maumita Mandal MI-308 x 8-4213, mandal@cmu.edu

***Prerequisites:*** 09-214 or 09-345 AND 03-121 or 03-231 or 03-232 AND 33-111 or 33-106 or 33-107 or permission from the instructor.

***Total Units***: 9 (Graduate Course:12)

***In-Class hours:*** 3 ***Out of Class Hours:*** 6 (Graduate: 9)

***Meeting Days/ Times:*** Tuesdays & Thursdays: 10:30-11:50 AM, MI- 355.

***Course Description:*** This course covers two main aspects aimed at understanding the structure-function relationships of biomolecules by using:
1) The principles and applications of thermodynamics and kinetic approaches, and
2) The instrumentation of optical and sensor-based systems to study the biomolecular dynamics.

*Topics to be covered include*: Biochemical applications of thermodynamics, thermal melting, differential scanning and isothermal calorimetry, binding energetics, surface plasmon resonance, absorption and fluorescence spectroscopy, interaction of light with living matter, circular dichroism spectroscopy and optical rotatory dispersion, optics and image formation, limit of resolution, electronic detectors and cameras, Fluorescence microscopy and anisotropy, Other high resolution fluorescent techniques (single-molecule FRET, Fiona, Shrimp, Shrec), Force spectroscopy (optical tweezers, magnetic tweezers, atomic force microscopy), Applications to single-molecules and molecular motors. This course is particularly aimed at science and engineering majors interested in interdisciplinary research or involving optical tools and methods. Graduate students who have taken one semester Physical Chemistry course are also eligible with the approval from the instructor.

***Assessment:*** In-class weekly quizzes and monthly Exams. The Exams are either problem based (written style) or classroom discussions based on the research articles. The final exam constitutes a 20 minute classroom presentation followed by 10 minutes discussion at the end of the semester. Students taking 09-735 for 12 units are required to write a research proposal similar to submitting a grant (NIH format, 8 pages research proposal plus references). The presentation topic will be selected from the list of topics given by the instructor.

***Syllabus:*** The course has been designed into ***four*** modules. Each module covers the following topics that will be covered in 4 weeks.

1. **Thermochemistry:** Biochemical applications of Thermodynamics, Ionic effect on Protein-Nucleic acid interactions, Molecular thermodynamics, Differential scanning calorimetry.

2. **Molecular Structures and Interactions:** Electromagnetic spectrum, Protein and Nucleic Acids spectrum, Fluorescence, and Fluorescence polarization, Optical rotatory dispersion and circular dichroism of nucleic acids and proteins.

3. **Life in Motion, Molecular Motors:** What are molecular motors, Dynamics of molecular motors, and analyzing motors in action?

4. **Single-Molecule Methods**: Fluorescence methods (FRET, FIONA, Fluorescence anisotropy) Optical tweezers, Magnetic Tweezers, Atomic Force Microscopy, Applications of single-molecule methods in molecular motors study.

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| Week | Topics |
|---|---|
| 1 | Binding energetics and receptor-ligand interactions |
| 2 | Thermal Melting, Isothermal Calorimetry |
| 3 | Differential Scanning Calorimetry |
| 4 | Thermodynamics continued |
| 5 | Surface Plasmon Resonance |
| 6 | Molecular Interactions in Macromolecules |
| 7 | Circular Dichroism and Optical Rotatory Dispersion: Proteins and Nucleic Acids |
| 8 | Molecular Motors and Machines: Basis of functioning and architecture |
| 9 | Fluorescence Spectroscopy: FRET |
| 10 | Applications of Fluorescence Spectroscopy: anisotropy and DNA:protein binding interactions |
| 11 | FIONA (single **F**luorophore **I**maging with **O**ne **Na**nometer resolution) |
| 12 | Other fluorescence high resolution techniques: SHRIMP and SHREC |
| 13 | Force spectroscopy: Optical Tweezers, Magnetic Tweezers and Atomic Force Spectroscopy |
| 14 | Optical Tweezers and Mechanical manipulations of DNA |
| 15 | Optical tweezers & Atomic Force Microscopy |