NS 218 Fundamentals of Nanoscience
Spring 2022

Intended Audience:
A sophomore level hands-on course for MAT, BIO, and ME majors, PHYS minors, or anyone interested in understanding phenomena governing the behavior of structures in the 1-100 nm size range.

Objective:
Throughout the Semester, we will make *models to crystallize our thinking* ---you know what, actually *to start thinking*. Via models we will develop intuition and heuristics to come up with conjectures/hypotheses to be tested by experiments (in wet lab and/or in silico). Accordingly, these will provide a helping hand towards having a knowledge base on how man-made nanostructures and biological nanomachines behave. At the end, we will have the insight for junior-senior level courses where both extensive measurements on materials and biological systems on all scales are made, and the formation of higher order structure is discussed.

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Course Data: Hours/Room Mon 17.40-19.30; Thu 18.40-19.30/FASS G018
Office hours: *TBA*

Textbook:
Dill, K.A., Bromberg, S., and Stigter, D., *Molecular Driving Forces*, Statistical Thermodynamics in Biology. Garland Science, 2nd Ed., 2011. QC311.5 .D55 2011.

Reference:
Israelachvili, J., *Intermolecular and Surface Forces*, 3rd Ed. Academic Press, 2011. QD461 .I87 2011

Weeks Commencing/Topics:

Feb 28, Mar 7, and 14 Act I – A story from $1/r$ to $1/r^6$ and empirical energy functions

Entropy as multiplicity and its role in nanoscience
Coulomb's law and charge interactions
- What do we mean by long range and how do they get weaker?
- The thermal energy steps on the stage

Dipoles – are they to stay fixed?
Polarizability
- Is it a material constant?
- Induced dipoles – are they ubiquitously observable?

van der Waals interactions
Hydrogen bonds

Mar 21, 28, and Apr 4 Act II – Then surfaces get into the picture

Forces between particles and surfaces
- SFA and AFM – are we getting serious, can we measure these forces?
- Hamaker constants

Ions take a role again – they shield charged objects in water
- Debye length and Bjerrum length; any other length of similar spirit; would you suggest one?

To what extent it is possible to unify concepts in intermolecular and inter-particle forces?
How do similar surfaces come together in a medium?
- Surface and interfacial energy

Apr 11 Review and the **Midterm**

Apr 18, 25, and May 9 Act III – Interactions lead to binding
(**May 2** Spring Break)
Chemical kinetics – A quick recapitulation of NS 10X courses
The effect of temperature; is this thermal energy again?
How is it different from physical kinetics?
Binding and Adsorption Processes
The Langmuir Model – we better recollect our thermodynamics fundamentals
The Michaelis–Menten Model; yes, another old but not aged model
Sabatier's Principle – too many names floating around here! No worries just to shorten the syllabus
Delicacy – binding should be neither too tight nor too weak

May 16, 23, and 30 Act IV – Multiple agents cooperatively in action

Self-assembly
Benjamin Franklin spirit
Amphiphilic molecules – what shapes of micelles do they form and why?
Biological machines
Are they different from thermodynamic cycles via which macro engines operate?
Time and length scales in the Nano-world
And "Curtain!"

June 6 Review and the **Final**

Class Policies
Course will be hybrid.
Zoom link:
https://sabanciuniv.zoom.us/j/98348925459

Grading
Participation: 10% of the final grade
Midterm: 40% of the final grade
Final exam: 50% of the final grade; covers all the material
For a passing grade, need to collect 45% before participation added.