# NS 218 Fundamentals of Nanoscience Spring 2021

## 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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Associates: Course Data:	Dilşah Nur Elmad <u>Hours:</u> Office hours:	cı dilsahelmaci@sabanciuniv.edu Mon 15.40-17.30/Thu 10.40-11.30 <i>TBA</i>

### Textbooks:

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

#### **References:**

Israelachvili, J., Intermolecular and Surface Forces, 3rd Ed. Academic Press, 2011. QD461 .187 2011

Weeks Commencing/Topics:

**Feb 22, Mar 1, and 8** Act I – A story from 1/r to  $1/r^6$  and empirical energy functions

Coulomb's law and charge interactions What do we mean by long range? 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 15, 22, and 29 Act II – Then surfaces get into the picture

Let's first unify concepts in intermolecular and inter-particle forces How do similar surfaces come together in a medium? Surface and interfacial energy 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?

Apr 5 Review and the Midterm

Apr 12, 19, and 26 Act III – Interactions lead to binding

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 3, 10, and 17 Act IV – Multiple agents cooperatively in action

(First of all, Spring will have, hopefully with more people vaccinated, with all types of blossoms knocked on our door by now! Monday lectures will be the most favorable time period to go out – but c'mon it's the day after the weekend)

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!"

May 24 Review and the Final

Class Policies Course will be online. Zoom link: https://sabanciuniv.zoom.us/j/96294995289

Grading

Quizzes: (6-best/7-8 of them), total is for 30% of the final grade <u>Midterm</u>: 30% of the final grade <u>Final exam</u>: 40% of the final grade; covers all the material