CHEE 688 Advanced Materials in Chemical Engineering Winter 2022

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CHEE 688 course-evaluation metrics (2022):

- Q1. Overall, this is an excellent course. Hill/Dorval-Courshene 4.0 (DM 3.8)
- Q2. Overall, I learned a great deal from this course. Hill/Dorval-Courshene 4.4 (DM 4.0)
- Q3. Overall, this instructor is an excellent teacher. Hill 4.2 (DM 4.0)
- Q4. Overall, I learned a great deal from this instructor. Hill 4.2 (DM 3.9)

DM = department mean.

Hill's lectures

1. Foundational molecular/atomic characteristics of materials (an undergraduate review): Atomic structure and bonding; Bonding and interaction potentials; Focus: Electrostatic Coulomb interactions; Focus: Electrostatic dipoles; Crystalline materials; Crystal structure and Bravais lattices; Polycrystalline materials; Crystallization, grains, imperfections.
2. Mechanical properties (an undergraduate review): Mechanical testing/properties Focus: Linear elasticity (infinitesimal strain and Newtonian hydrodynamics); Focus: Elastic moduli from atomic bond energies.
3. Emulsions and colloids I: Classification; Electrostatic double layers and screening; Poisson equation; Poisson-Boltzmann equation; Linearized Poisson-Boltzmann equation; Electrical force between charged interfaces; Charge-potential relationship; Nanoparticle electrokinetics survey.

4. Emulsions and colloids II: London dispersion energy; DLVO force between parallel plates DLVO interactions between bodies of finite size; Steric and depletion interactions; Aggregation and coagulation mechanisms.

5. Liquid crystals I: Nematic liquid crystals; Order parameters; Maier-Saupe mean field theory of the isotropic-nematic transition; Landau-de Gennes theory (first-order phase transitions); Appendix: Variational calculus examples; Appendix: Energy of a dielectric medium; Appendix: Exercises exploring anisotropy.

6. Liquid crystals II; Landau-de Gennes theory: Application of an external field; Effect of a spatial gradients on nematic order: Fredericks transition; Onsager theory: Excluded volume interaction (lyotropic phase transition).

7. Rheology I: Rheology concepts; Bead-spring/Maxwell model (dilute/unentangled polymer solutions); Steady-state $\langle \vec{r}\vec{r} \rangle$; Polymer-solution stress from $\langle \vec{r}\vec{r} \rangle$; Linear viscoelasticity and dynamic shear moduli; Neo-Hookean elasticity (elastomers and hydrogels); Appendix: Trouton's ratio.

8. Rheology II: Linear shear viscoelasticity; Boltzmann superposition principle (linear response); Example: Weakly cross-linked polyacrylamide networks; Multi-relaxation time phenomenological/engineering models; Example: Burgers model; Example: Wiechert model; Multi-relaxation time molecular models: Rouse and Zimm 'molecular' models.

9. Rheology III: Particulate dispersions; Averaging the stress in a dispersion: Einstein viscosity/shear modulus; Particle interactions; Drops and bubbles; Force and drag coefficient on surfactant-stabilized drops and bubbles; Microrheology; Rigid polymers.