Final reports for Physics 187

Each student is responsible for producing a final paper and powerpoint presentation for Physics 187. Your report must introduce the field explaining what are the principal questions and discuss their significance in terms of both the underlying physical principles and their biological relevance. In addition, each report will present in greater detail one particular theoretical calculation and/or experiment. You audience is your fellow classmates. You may assume that we understand the fundamental physics and have taken the class, but you must explain the particular features of the system on which you are reporting at a sufficient level of detail that we all will learn some new physics and be able to understand the presented calculation or experiment. As a rough guide, you should expect reports to be seven to ten pages in length and to provide a reasonable set of references.

In addition, please prepare a fifteen-minute lecture on your report either via computer or on the white board. During that time you will explain your report to the class. At the end, there will be a five-minute question and answer period from the class (and from your professor!). Be prepared to answer questions!

There are a number of topics that you can study for your report. Below I present a few options and some suggested references. All of the books referenced can be found in our library and all of the papers are already online on our class website.

Please look over these topics, skim some of the papers that you find interesting, and then make an appointment to talk to me about your proposed project. You are not required to choose one of these topics, but, if you wish to work on a different idea, please see me to get prior approval.

Proposed Topics:

Note in the following I refer to the following books.

1. Jackson = Meyer B. Jackson, *Molecular and Cellular Biophysics*. (Cambridge University Press, Cambridge, 2010).

2. Nelson = Philip Nelson, Biological Physics: Energy, Information, Life. (W.H. Freeman, New York, 2004).

3. Howard = Jonathon Howard, Mechanics of Motor Proteins and the Cytoskeleton. (Sinauer Ass. Inc., Sunderland Massachusetts, 2001).

4. Berg = Howard C. Berg, Random Walks in Biology. (Princeton University Press, Princeton, 1993).

5. Boal = David Boal, Mechanics of the Cell. (Cambridge University Press, Cambridge, 2002).

1. Proteins – folding, mechanics, and function.

Books: Jackson Chapters 2,3, & 5. Nelson Chapters 9,10.

* J. F. Swain and L.M. Gierasch, The changing landscape of protein allostery, Current Opinion in Structural Biology 16, 102-108 (2006).
* H. Toncrova and T.C.B. McLeish, Substrate-modulated thermal fluctuations affect long-range allosteric signaling in protein homodimers: Exemplified in CAP, Biophysical Journal 98, 2317-2236 (2010).
* R. Melin et al., Designability, thermodynamic stability, and dynamics in protein folding: A lattice model study, Journal of Chemical Physics 110, 1252 (1999).
* K. Dill, Dominant forces in protein folding, Biochemistry 29, 7133 (1990).
* J.D. Bryngelson and P.G. Wolynes, Spin glasses and the statistical mechanics of protein folding, Proc. Natl. Acad. Sci. 84, 7524-7528 (1987).
* A.I. Jewett, V.S. Pande, and K.W. Plaxco, Cooperativity, smooth energy landscapes and the origins of topology-dependent protein folding rates, J. Mol. Biol. 326, 247-253 (2003).

2. Semiflexible polymers and the cytoskeleton

Books: Jackson Chapter 3, Howard Chapters 6-9, Boal

* F.C. MacKintosh, J. Kas, and P.A. Janmey, Elasticity of semiflexible biopolymer networks, PRL 75, 4425 (1995).
* K. Kroy and E. Frey, Force-extension relation and plateau modulus for worm-like chains, PRL 77, 306 (1996).
* M. Dogterom and S. Leibler, Physical aspects of the growth and regulation of microtubule structures, PRL 70, 1347 (1993).
* M. Dogterom and B. Yurke, Measurement of force-velocity relation of growing microtubules, Science 278, 856 (1997).
* E. Farge and A.C. Maggs, Dynamic scattering from semiflexible polymers, Macromol. 26, 5041-5044 (1993).
* D. Stamenovic and D.E. Ingber, Models of cytoskeletal mechanics of adherent cells, Biomech. Model Mechanobiol. 1, 95-108 (2002).

3. Swimming at Low Reynolds Number

Books: Nelson Chapter 5 and Berg

* E.M. Purcell, Life at low Reynolds number, Am. J. Phys. 45, 3 (1977).
* E. Lauga and T.R. Powers, The hydrodynamics of swimming microorganisms, Rep. Prog. Phys. 72, 096601 (2009).
* G. Taylor, Analysis of the swimming of microscopic organisms, Proc. R. Soc. Lond. A 209, 447-461 (1951).
* H. C. Berg, Motile behavior of bacteria, Physics Today January 2000.
* A. Sokolov, et al., Concentration dependence of the collective dynamics of swimming bacteria, PRL 98, 15102 (2007).
* C. W. Wolgemuth, Collective swimming and the dynamics of bacterial turbulence, Biophysical Journal 95, 1564-1574 (2009).

4. Neurons and action potentials

Books: Jackson 11, 15, 16. Nelson 11 & 12.

* S. Goldstein and W. Rall, Changes of action potential shape and velocity for changing core conductor geometry, Biophysical Journal 14, 731 (1974).
* A.L. Hodgkin and A.F. Huxley, Action potentials recorded from inside a nerve fibre, Nature 144, 710 (1939).
* A.L. Hodgkin and A. F. Huxley, A quantitative description of membrane current and its application to conduction and excitation in nerve, Bulletin of Mathematical Biology 5, 25-71 (1990).
* E. M. Izhikevich, A simple model of spiking neurons, IEEE Transactions on neural networks, 14, 1569 (2003).
* W. Rall, Electrophysiology of a dendritic neuron model.
* Branch input resistence and steady attenuation for input to one branch of a dendritic neuron model, Biophysical Journal 13, 648 (1973).

5. The mechanics and thermodynamics of molecular motors

Nelson Chapters 10, 11. Howard

* F. Julicher, A. Ajdari, and J. Prost, Modeling molecular motors, Reviews of Modern Physics 69, 1269 (1997).
* M. J. Schnitzer, K. Visscher, and S.M. Block, Force production by single kinesin motors, Nature Cell Biol. 2, 718 (2000).
* J. Howard, Molecular Motors: structural adaptations to cellular functions, Nature 389, 561 (1997).
* K. Svoboda, P.P. Mitra, and S.M. Block, Fluctuation analysis of motor protein movement and single enzyme kinetics, PNAS 91, 11782-11786 (1994).
* A. Mogilner and G. Oster, Polymer motors: Pushing out the front and pulling up the back. Curr. Biol. 13, R721-R733 (2003).
* C.S. Peskin, G. M. Odell, and G.F. Oster, Cellular motions and thermal fluctuations: The Brownian ratchet, Biophysical Journal 65, 316 (1993).

6. DNA and RNA

Jackson Chapters 3, 11.

* J.D. Moroz and P. Nelson, Torsional directed walks, entropic elasticity, and DNA twist stiffness, PNAS 94, 14418-14422 (1997)
* T. Strick, J.-F. Allemand, V. Croquette, D. Bensimon, Twisting and stretching single DNA molecules, Progress in Biophysics and Molecular Biology 74, 115-140 (2000).
* J.- L. Viovy, Electrophoresis of DNA and other polyelectrolytes: Physical mechanisms, Reviews of Modern Physics 72, 813 (2000).
* C. Albrecht et al., DNA: A programmable force sensor, Science 301, 367 (2003).
* W. Gelbart, et al., DNA-inspired electrostatics, Physics Today September 2000.
* B. Maier and J.O. Radler, Conformation and self-diffusion of single DNA molecules confined to two dimensions, PRL 82, 1911 (1999).
* R. Bundschuh and T. Hwa, Statistical mechanics of secondary structures formed by random RNA sequences, PRE 65, 031903 (2002).
* A. M. Yoffe, et al., Predicting the sizes of large RNA molecules, PNAS 105, 16153 (2008).
* D. Collins, et al., Verification of the Crooks fluctuation theorem and recovery of RNA folding free energies, Nature Let. 231 (2005).