

Spring Semester (2016)

School of Nano Science, Institute for Research in Fundamental Sciences (IPM), Tehran, Iran

Lecturer: Ali Naji (School of Physics, IPM)

Tutor: Bahman Roostaei (School of Physics, IPM)

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**Instructions and Suggested Topics for Term Essays****Due date: June 20, 2016**

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The students may *write* and *present* a term essay for **extra credit** on a subject relevant to the topics discussed in this course. You can choose *your own essay subject* or select a specific subject in one of the rather-general categories listed (in no particular order) below. You need to confirm the subject of your essay with me beforehand.

- 1:** Phase transitions in colloidal systems including hard and soft spheres and patchy colloids
- 2:** Strongly correlated Coulomb fluids in soft matter and biological physics
- 3:** Path-integral approaches to flexible and semi-flexible polymers (including DNA)
- 4:** Statistical physics of fluid membranes: Equilibrium properties and dynamics
- 5:** Statistical physics of tethered membranes (including graphene), crumpling transition, etc
- 6:** Topological phase transitions including Kosterlitz-Thouless transition in 2D Coulomb gas, 2D melting, etc
- 7:** Recent advances in Casimir effect, Casimir nano-machines, etc
- 8:** Casimir effect in novel materials: Graphene, topological insulators, meta-materials, etc
- 9:** Pseudo-Casimir effect in confined soft matter, e.g., in liquid crystalline films
- 10:** Renormalization group approaches to wetting phenomena
- 11:** Disordered systems including (spin) glasses, directed polymers in random media, etc
- 12:** Stochastic dynamics of molecular motors and their collective behavior
- 13:** Stochastic (hydro-)dynamics of self-propelled particles and bacterial microswimmers
- 14:** Quantum phase transition in transverse-field Ising model
- 15:** Quantum phase transition in quantum rotor model
- 16:** Kosterlitz-Thouless transition in Josephson junction arrays
- 17:** Mott insulator to superfluid quantum phase transition in Bose-Hubbard models
- 18:** Quantum phase transition between different plateaus of integer quantum Hall states
- 19:** Compressible-incompressible quantum phase transition in bilayer quantum Hall systems
- 20:** Physics of Wigner crystals (classical and quantum) and other two-dimensional strongly correlated systems

**General instructions:**

The above topics mostly belong to very well developed areas of research and a vast literature exists on each subject. The purpose of your essay is by no means to present a comprehensive review of those subjects. The purpose of your essay are however as follows:

► As a PhD student you should be able to search the literature on a given subject efficiently to find out the sources that present the subject the most comprehensible. Usually the journals that publish review articles or textbooks are good references. *Be careful on what you find on internet:* Some may not be reliable sources. Good reviews/books are often written by reputable authors and published in reputable journals and are usually very well-cited.

► As an author you must be able to write an informative, concise and accurate scientific essay. In the introduction, you should be able to first present the context, explain the specific subject in question in simple (yet professional)

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language suitable for general readership, present some of the motivations for past and/present research on the subject (and why it is interesting!), and give an overview of the main advances accompanied with a list of key references, and finally explain the purpose and/or scope of your essay. The rest of the essay should clearly discuss the key model(s) and/or phenomena you will consider in the essay and the experimental and/or computational achievements related to those; and without going too much into technical details, you can talk about some technical details but this part should not be the focus of your essay.

► It is very important that your essay is expressed in *your own words*. It must be an *original* work. If you need to quote from a paper or a book, you should use quotation marks with proper citation and note that quoting exact phrases in scientific writing is rare. You should cite appropriate sources, where you refer to results from other works. Familiarize yourself with the *ethics of scientific writing* and instances of *plagiarism* and make sure you follow the former and avoid the latter in the strictest sense of the word; if you had any doubts, feel free to discuss them with me or your tutor.

**Additional remarks:**

► Your essay must be prepared in English; have it proof-read carefully for any typos or grammatical errors.

► Your essay must be prepared using  $\text{\LaTeX}$  and you need to submit the .tex, .pdf and all figure files. Use the  $\text{\LaTeX}$  template to be distributed by email for typesetting your essays. Do not modify the layout, line spacing, font size, etc or the *documentclass* of this template and avoid unusual options/packages.

► Your essay should not exceed 25 pages with the given (preprint-style) template including the title page, body text, figures and references (as a rule of thumb, the introduction should not take more than five pages and the reference list more than two pages in a 25-page essay with the given style). Do not use more than five figures.

► Remain faithful to the terminology and notation customarily used in the literature.