TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

CAPITA SELECTION OF CONDENSED MATTER PHYSICS

by

Efta Yudiarsah, Ph.D.

Undergraduate Program in Physics
Faculty of Mathematics and Natural Sciences
Universitas Indonesia
Depok

November 2016

PREFACE

In this Capita Selection of Condensed Matter Physics course, students learn a variety of current research topics and both numerical and analytical methods commonly used on these topics. The research topics fall into the categories of strong electron interactions, nanophysics, and mesoscopic physics. Meanwhile, the numerical and analytical methods studied include Green's function, linear response theory, static and dynamical mean field approximation, etc.

To train students' abilities to become lifelong learners, students will study these topics and methods with a student-centered learning approach. However, there is a small part about certain concepts and techniques that must be conveyed by lecturers using lecturer-centered methods. Students will be taught to learn research topics and methods from the first source in the form of the publication of research results in journals.

This Learning Design Book was prepared as a complement to teaching in the Department of Physics, Faculty of Mathematics and Natural Sciences at the University of Indonesia. This book is a guide for activities during the learning process. Thus the learning process carried out by students can be directed and in the end, the learning objectives can be achieved.

I would like to express my gratitude to my fellow lecturers in the Physics Department who compiled the teaching instructional design for their respective subjects at the Physics Department Meeting of the Faculty of Mathematics and Natural Sciences UI. I would also like to thank the Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Indonesia for holding a Work Meeting of the Physics Department at Seruni Hotel, Cisarua, West Java, November 5 to 7, 2014 so that the author can finish writing this teaching instructional design. Finally, the authors would also like to thank the Work Meeting committee for working hard so that the meeting could run well.

Depok, November 7th 2016

Efta Yudiarsah, Ph.D.

I. General Information

1.	Name of Program / Study Level	:	Physics / Undergraduate
2.	Course Name	:	Capita Selection of Condensed Matter Physics
3.	Course Code	:	SCFI604613
4.	Semester	:	7
5.	Credit	:	3 credits
6.	Teaching Method(s)	:	*Collaborative Learning*
7.	Prerequisite course(s)	:	Introduction to Solid State Physics
8.	Requisite for course(s)	:	-
9.	Integration Between Other Courses	:	Solid-State Physics 1 and 2
10.	Lecturer(s)	:	Efta Yudiarsah, Ph.D.
11.	Course Description	:	The Capita Selecta of Condensed Matter Physics course covers four major topics, namely strongly correlated electron systems, nanoscience, mesoscopic physics, and numerical and analytical methods. Students study this subject using active learning methods, namely interactive lectures, and cooperative learning. Students have the opportunity to practice integrating the understanding of the basic concepts of physics, analytical skills, and numerical abilities in studying the two topics above. Students also practice explaining and analyzing natural phenomena and human engineering results within the scope of incompressible matter physics by using basic physics concepts and studying their application to technology. In addition, students can develop the ability to synthesize and evaluate both qualitatively and quantitatively phenomena in the field of solid-states by using basic physics concepts. After attending this course, first-year students are expected to be able to explain current phenomena in the field of compressed matter physics and their application to future technology, including concepts, analytical and numerical methods for calculating related physical quantities [Competency-Based Curriculum Dept. Physics Faculty of Mathematics and Natural Sciences UI 2011 and PHKI Universitas Indonesia 2009]

II. Course Learning Outcome (CLO) and Sub-CLOs

A. CLO

After completing this lecture, students are competent in explaining the current phenomena in the field of condensed matter physics and its application for future technology, including concepts, analytical and numerical methods for calculating related physical quantities. (ELO 3,5,6 and 7)

B. Sub-CLOs

1. Explains the phenomenon of strongly correlated electron systems, namely Graphene, Hubbard Model and Mott Insulator (C4)
2. Describes physical phenomena in nano-sized systems, namely nanoparticles, nanowires, and nanotubes (C4)
3. Describes physical phenomena in mesoscopic systems from: Quantum Dots, Quantum Hall Effect, Single-Electron tunneling, spintronics, and molecular electronics (C4)
4. Using analytical and numerical methods such as Green's function, linear response theory, static and dynamical mean field approximation (C3)

III. Lesson Plan

Week	Sub-CLO	Study Materials	Teaching Method	Time Required	Learning Experiences (*O-E-F)	Sub-CLO Weight on Course (%)	Sub-CLO Achievement Indicator	References
1	1	Strongly correlated electron systems	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	6	Explains the phenomenon of strongly correlated electron systems in Graphene	[1]
2	1	Strongly correlated electron systems	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	6	Explains the phenomenon of strongly correlated electron systems in Hubbard Model	[1]
3	1	Strongly correlated electron systems	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	6	Explain the phenomenon of strongly correlated electron systems in Mott Insulator	[1]
4	2	Nanoscience	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	6	Describes physical phenomena in nano-sized systems	[1]
5	2	Nanoscience	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	6	Describes physical phenomena in nano-sized systems in nanoparticles	[1]
6	2	Nanoscience	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	6	Describes physical phenomena in nano-sized systems in, nanowires	[1]
7	2	Nanoscience	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	6	Describes physical phenomena in nano-sized systems in nanotubes	[1]

8	**Midterm Exam**							
9	3	Mesoscopic System	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	8	Describes physical phenomena in mesoscopic systems from: Quantum Dots and Quantum Hall Effect	[1]
10	3	Mesoscopic System	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	8	Describes physical phenomena in mesoscopic systems from: Single-Electron tunneling and spintronics	[1]
11	3	Mesoscopic System	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	8	Describes physical phenomena in mesoscopic systems from: molecular electronics	[1]
12	4	Analytical and Numerical Methods	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	8	Using analytical and numerical methods with Green's function	[1]
13	4	Analytical and Numerical Methods	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	8	Using analytical and numerical methods with linear response theory	[1]
14	4	Analytical and Numerical Methods	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	8	Using analytical and numerical methods with, static mean field approximation	[1]
15	4	Analytical and Numerical Methods	*Collaborative Learning*	150 minutes	O : Interactive Lectures (20%) E : *Collaborative Learning* (70%) F : Quiz (10%)	8	Using analytical and numerical methods with dynamical mean field approximation	[1]
16	**Final Exam**							

*) O : Orientation
E : Exercise
F : Feedback

References:

1. Books/journals that are related to the discussion.

IV. Design of Assignment and Exercise

Week	Assignment Name	Sub-CLO	Assignment	Scope	Working Procedure	Deadline	Outcome
1	Individual Assignment/ Homework 1	1	Question(s)	Fenomena sistem elektron terkorelasi kuat yaitu pada Graphene	Individual	One week	Written Report
2-3	Summary Paper 1	1	Summarize literature related to the topic	phenomenon of strongly correlated electron systems of Graphene	Individual	Three weeks	Written Report
4	Individual Assignment/ Homework 2	2	Question(s)	Phenomenon of strongly correlated electron systems of Hubbard Model and Mott Insulator	Individual	One week	Written Report
5	Quiz 1	2	Question(s)	Physical phenomena in nano-sized systems of nanowires	Individual	40 minutes	Written Report
6-7	Summary Paper 2	2	Summarize literature related to the topic	Physical phenomena in nano-sized systems of nanotubes	Individual	Four weeks	Written Report
8	Midterm Exam						
9	Individual Assignment/ Homework 3	3	Question(s)	Physical phenomena in mesoscopic systems from: Quantum Dots, Quantum Hall Effect, Single-Electron tunneling, spintronics, and molecular electronics	Individual	One week	Written Report
10-11	Summary Paper 3	3	Summarize literature related to the topic	Physical phenomena in mesoscopic systems from: Quantum Dots, Quantum Hall Effect, Single-Electron tunneling, spintronics, and molecular electronics	Individual	Three weeks	Written Report

12	Quiz 2	3	Question(s)	Physical phenomena in mesoscopic systems from: Quantum Dots, Quantum Hall Effect, Single-Electron tunneling, spintronics, and molecular electronics	Individual	40 minutes	Written Report
13	Individual Assignment/ Homework 4	4	Question(s)	Using analytical and numerical methods with Green's function and Linear Response Theory	Individual	One week	Written Report
14	Summary Paper 4	4	Summarize literature related to the topic	Using analytical and numerical methods with Static and Dynamical Mean Field Approximation	Individual	Four weeks	Written Report
15	Presentation	4	Presentation	Using analytical and numerical methods with Green's function and Linear Response Theory. Using analytical and numerical methods with Static and Dynamical Mean Field Approximation.	Individual in class	100 minutes	Student powerpoints
16	Final Exam						

I. Assessment Criteria (Evaluation of Learning Outcomes)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Individual Assignment/ Homework	1,2,3,4	Assignment File	4	15
Summary Paper	1,2,3,4	Paper Summary File	4	30
Quiz	2,3	Test Sheet	2	10
Presentation	4	Assessment Sheet	1	10
Discussion and Q&A	4	Assessment Sheet	1	5
Midterm Exam	1,2	Individual Assignment Evaluation	1	15
Final Exam	3,4	Individual Assignment Evaluation	1	15
Total				**100**

V. Rubric

A. Criteria of Presentation Assessment

Score	Presentation Delivery
85-90	The groups are proficient to convey explanations logically, smoothly, and on time and competent in answering questions from fellow students and lecturers.
75-84	The groups are proficient to convey explanations logically and smoothly and can answer questions from fellow students and lecturer, but cannot manage time well.
65-74	The groups are proficient to convey explanations fluently but cannot convey the logic of their reasoning.
55-64	The groups are less proficient to convey explanations well and on time, and are less able to convey the logic of their reasoning.
<55	

B. Criteria of Essay Assessment

Score	Answers Quality
100	Answers are very precise and all the concept and main component are explained completely
76-99	Answers are fairly precise and the concept and main component are explained fairly complete
51-75	Answers are less precise and the concept and main component are explained less complete

26-50	Answers are poorly precise and the concept and main component are explained poorly complete
<25	Answers are wrong

VI. Attachment: Sample of Examination Papers

1. Multiple Choice

1. Berikut ini adalah jenis Carbon nanotube:

A. Zig-zag carbon nanotube

B. Spherical carbon nanotube

C. Random carbon nanotube

D. Banch carbon nanotube

E. Branhing carbon nanotube

2. Pada sebuah lempengan graphene, di sekitar $k = 0$, elektron berprilaku seperti

A. nutrino

B. hole

C. eksiton

D. polariton

E. polaron

3. Dua kuantum dot yang terbuat dari satu macam bahan dengan ukuran yang berbeda akan memberikan

A. warna yang sama

B. warna yang berbeda

C. gabungan dua warna

D. tidak ada yang berbeda

E. tidak ada jawaban yang cocok

2. Essay

Suatu system electron terkorelasi kuat dimodelkan dengan model Hubbar. (30 point)

a. Hitunglah fungsi Green model tersebut.

b. Interpretasikan kerapatan keadaan sistem tersebut.