هيئة تقويم التعليم
Education Evaluation Commission
المركز الوطني للتقويم والاعتماد الأكاديمي
National Center for Academic Accreditation and Evaluation

ATTACHMENT 5.

COURSE SPECIFICATIONS
(CS)

Quantum Theory of Many Body Physics (PHYS 515)

Second Quantization & Statistical Mechanics, Green's Functions and Field Theory, Fermi Systems, Linear Response, Bose Systems, Field Theory at Finite Temperature, Physical Systems at Finite Temperatures. Real-Time Green's Functions and Linear Response.

Course Specifications

Institution: King Saud University	Date: 3/1/2018
College/Department : **Science / Physics and Astronomy**	

A. Course Identification and General Information

1. Course title and code: **Quantum Theory of Many Body Physics (PHYS 515)**

2. Credit hours: **<u>3(3+0)</u>** (Three)

3. Program(s) in which the course is offered.
(If general elective available in many programs indicate this rather than list programs)

Graduate Program

4. Name of faculty member responsible for the course: **Prof. Dr. Thabit Barakat**

5. Level/year at which this course is offered: **Master of Science in Physics (M. Sc), Theoretical Physics , Third Semester**

6. Pre-requisites for this course (if any): **Advanced Quantum Mechanics (PHYS 505)**

7. Co-requisites for this course (if any): **Statistical Physics (PHYS 506)**

8. Location if not on main campus:

9. Mode of Instruction (mark all that apply):

a. traditional classroom	■	What percentage?	85%
b. blended (traditional and online)	☐	What percentage?	
c. e-learning	■	What percentage?	10%
d. correspondence	☐	What percentage?	
f. other	■	What percentage?	5%

Comments: Quantum Field theory is the most complete microscopic theory we have today describing the physics of energy and matter. It has successfully been applied to explain phenomena ranging over many orders of magnitude, from the study of elementary particles on the sub-nucleonic scale to the study of neutron stars and other astrophysical objects on the cosmological scale. Only the inclusion of gravitation stands out as an unsolved problem in fundamental quantum theory.

B Objectives

1. What is the main purpose for this course?

To understand what is finite Temperature Field Theory, what kind of observables can one study, and can finite Temperature Field Theory tested in the laboratory.

2. Briefly describe any plans for developing and improving the course that are being implemented. (e.g. increased use of IT or web based reference material, changes in content as a result of new research in the field)

   - **Enhancing the use of credible web resources as an extra resources for the course materials.**
   - **Electronic materials have been utilized to support the lecture course material.**
   - **The course material was posted on the Web that could be accessed by the students enrolled in the course only.**

C. Course Description (Note: General description in the form used in Bulletin or handbook)

Course Description:

Quantization of the scalar, Maxwell and Dirac fields, Green's functions, propagators and micro-causality, Interactions, electron-photon coupling and QED S-matrix and perturbation theory, Feynman rules.

1. Topics to be Covered		
List of Topics	No. of Weeks	Contact hours
Second Quantization & Statistical Mechanics: Second quantization, basic concepts; The occupation number representation; The boson creation and annihilation operators; The fermion creation and annihilation operators; The general form for second quantization operators; Change of basis in second quantization; Quantum field operators and their Fourier transforms; Second quantization, specific operators; The harmonic oscillator in second quantization; The electromagnetic field in second quantization; Operators for kinetic energy, spin, density, and current; The Coulomb interaction in second quantization; Basis states for systems with different kinds of particles; Second quantization and statistical mechanics; The distribution function for non-interacting fermions; Distribution functions for non-interacting bosons.	2	6
Green's Functions and Field Theory: Free fermion Green's function; Time-ordered correlation functions; Equal-space Green's function and tunneling; Fermion spectral function; Equal-time Green's function and the shape of the Fermi surface.	3	9
Fermi Systems: Many−fermion systems; The exact solution of free fermion systems; Majorana fermions; Hrtree−Fock approximation.	2	6
Bose Systems: Free boson systems and second quantization; Path integral approach to interacting boson systems; Path integral representation of interacting boson systems; Phase transition and spontaneous symmetry breaking; Low-energy effective theory; Perturbation theory and Feynman rules.	2	6
Field Theory at Finite Temperature: Finite (and high) temperature field theory: General remarks; Dimensional reduction and effective field theory; The example of the Phi 4(d,1) quantum field theory; Renormalization group at finite temperature; One-loop effective action; perturbation theory and Wick's theorem for finite Temperatures.	2	6
Physical Systems at Finite Temperatures: Nuclear Forces; many particles in a shell.	3	9
Real-Time Green's Functions and Linear Response: Linear responses and response functions; Time-ordered correlation functions and the path integral; Effective theory; Time-dependent response and dissipation; Correlation functions at finite temperatures; Relation between correlation functions; Temperature Green's function and analytic continuation.	1	3

2. Course components (total contact hours and credits per semester):

		Lecture	Tutorial	Laboratory/ Studio	Practical	Other:	Total
Contact Hours	Planed	3×15=45					45
	Actual	3×15=45					45
Credit	Planed	3hrs/weak					3
	Actual	3hrs/weak					3

3. Additional private study/learning hours expected for students per week. **1 hour weekly for solving related problems.**	NO

4. Course Learning Outcomes in NQF Domains of Learning and Alignment with Assessment Methods and Teaching Strategy

On the table below are the five NQF Learning Domains, numbered in the left column.

First, insert the suitable and measurable course learning outcomes required in the appropriate learning domains (see suggestions below the table). **Second**, insert supporting teaching strategies that fit and align with the assessment methods and intended learning outcomes. **Third**, insert appropriate assessment methods that accurately measure and evaluate the learning outcome. Each course learning outcomes, assessment method, and teaching strategy ought to reasonably fit and flow together as an integrated learning and teaching process. (Courses are not required to include learning outcomes from each domain.)

Code #	NQF Learning Domains And Course Learning Outcomes	Course Teaching Strategies	Course Assessment Methods
1.0	**Knowledge**		
1.1	• to introduce the basic ideas of quantum field theory • to understand how quantum mechanics and special relativity combine to produce realistic theories of particle creation and annihilation; • to develop calculational techniques to at least the level of tree-level Feynman diagrams for quantum electrodynamics • to provide the foundation for more advanced studies in quantum field theory.	Lectures: - Introductory lecture to illustrate the significant of the course and the topics to be covered. - Assigned 5 minute of each lecture to discuss with the students the most important terms and equations are given in the last lecture. - Classroom tutorial discussions in solving selected home assigned problems from each text book chapter.	- Class work including short quizzes - Student's participation, homework assigned questions, and evaluation - Midterm exams. - Final exam
1.2	• analyse a problem by applying fundamental laws in a sophisticated context; • apply abstract concepts to real-world situations; • solve relatively complicated problems using approximations;		

	• participate as an effective member of a group in discussions and collaborative assignments; • manage time effectively in order to be prepared for group discussions and undertake the assignments and exam. •		
2.0	**Cognitive Skills**		
2.1	Utilize critical thinking techniques to cause, listen, make observations, and draw conclusions. Convert word problems to the appropriate mathematical language. Solve quantitative problems and demonstrate reasoning clearly and completely.	- Problems - Promote the use of Internet research - Relate between theoretical and applied knowledge. - Scientific debate among the students for analyzing or comparing the different terms studied in the topics will be covered in this course	Short answer questions: Brief answers that can measure analysis, problem-solving and evaluative skills. - Case and open problems: An intensive analysis of a specific example
3.0	**Interpersonal Skills & Responsibility**		
3.1	• The students will have the ability to work beneficially in grouping. • Students should be in charge for their own education that requires using means to find new information data, or techniques of analysis. • Give the students confidence to think critically and engage in deliberations with the instructor in classroom.		
4.0	**Communication, Information Technology, Numerical**		
4.1	• Build up the scientific terms and skills • Expand communication skills with others using websites or e-mail • Student will have adequate understanding in information technology that will allow them to gather, interpret, and communicate information and ideas. • Students will have enough background in statistical or mathematical techniques that will facilitate them to be relevant in interpreting and suggesting solutions.		
5.0	**Psychomotor**		
5.1	Not applicable		

5. Schedule of Assessment Tasks for Students During the Semester

	Assessment task (i.e., essay, test, quizzes, group project, examination, speech, oral presentation, etc.)	Week Due	Proportion of Total Assessment
1	Class activates (in class quizzes, and homework)	weekly	20%
2	Midterm Exam (I)	6^{th} week	20%
3	Midterm Exam (II)	12^{th} week	20%
4	Final Exam	15^{th} week	40%
5			
6			
8			

D. Student Academic Counseling and Support

1. Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice. (include amount of time teaching staff are expected to be available each week)

- Students can approach during the office hours for the faculty member to ask questions to clarify some points missed during the lecture.
- Students can communicate with the teaching staff through the website and ask questions related to all aspects of the lesson. The students will get written answers as soon as possible.
- The teaching staff are available during all the day, where they are ready to clarify any points related to the course.

E Learning Resources

1. List Required Textbooks

Quantum Theory of Many-Particle Systems
Alexander L. Fetter and Walecka, John Dirk
San Francisco : McGraw-Hill, [2003]

ISBN: 0070206538

List Essential References Materials (Journals, Reports, etc.)

3. List Electronic Materials, Web Sites, Facebook, Twitter, etc. **Websites on the internet that are relevant to the topics of the course**
4. Other learning material such as computer-based programs/CD, professional standards or regulations and software. • Multi media associated with the text book and the relevant websites

F. Facilities Required

Indicate requirements for the course including size of classrooms and laboratories (i.e. number of seats in classrooms and laboratories, extent of computer access, etc.)
1. Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.) • Lecture room with at least 25 seats • Auditorium of a capacity of not less than 100 seats for large lecture format classes
2. Technology resources (AV, data show, Smart Board, software, etc.) • Data Show • White board • Internet
3. Other resources (specify, e.g. if specific laboratory equipment is required, list requirements or attach list) • Not required for this course

G Course Evaluation and Improvement Processes

1. Strategies for Obtaining Student Feedback on Effectiveness of Teaching • Summative evaluation occurs at the end of a semester. The evaluation is performed by the recent students of the class. Students have the choice to reflect on the teachers' instruction without fear of punishment because course evaluations are entirely secret and nameless. This can be done in one of two ways; either with a paper form or with online technology.

This feedback is to be used by teachers to improve the quality of their instruction. The information can also be used to evaluate the overall effectiveness of a teacher.
2. Other Strategies for Evaluation of Teaching by the Instructor or by the Department • Formative evaluation is performed by peer consultation. Other experienced teachers will review one of their peer's instructions. The reason of this evaluation is for the teacher to obtain useful analysis on teaching. Peer feedback is given to the instructor typically in the form of an open session meeting.
3. Processes for Improvement of Teaching **Attending workshop, reading books, and the searching for e-resources.**
4. Processes for Verifying Standards of Student Achievement (e.g. check marking by an independent member teaching staff of a sample of student work, periodic exchange and remarking of tests or a sample of assignments with staff at another institution) • Check marking by an independent member teaching staff of a sample of student work. • periodic exchange and remarking of tests or a sample of assignments with staff at another institution
5. Describe the planning arrangements for periodically reviewing course effectiveness and planning for improvement. • Reviewing students feed back • Update text books • Consulting other top universities course specifications and contents

Name of Course Instructor: Prof. Dr. Thabit Barakat

Signature: ______________________ Date Specification Completed: ____________

Program Coordinator: ____

Signature: _________________________ Date Received: 3/1/2018