



**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani**  
**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani**  
**Pilani Campus**  
**AUGS/ AGSR Division**

**SECOND SEMESTER 2020-21**  
**COURSE HANDOUT**

**Date: 18.01.2021**

In addition to part I (General Handout for all courses appended to the Time table) this portion gives further specific details regarding the course.

**Course No** : PHY F421  
**Course Title** : Advanced Quantum Mechanics  
**Instructor-in-Charge** : Rakesh Choubisa

**1. Course Description:** This course will cover advanced topics of quantum mechanics. The course will start with a quick recapitulation of the basics. Then it will discuss some topics which a Master student is expected to know: such as symmetries, time-dependent perturbation, scattering, and indistinguishable particles. This course will give a glimpse of an alternate formulation of quantum mechanics (path integral formulation) and will also extend the study of quantum mechanics in the relativistic regime. This course will also time to time highlight some applications of quantum mechanics.

**2. Scope and Objectives of the Course:**

- Quantum mechanics of time-dependent systems will be discussed
- The scattering of quantum particles will be discussed
- The role of symmetries in quantum mechanics will be emphasized (concept of group theory will be introduced)
- Quantum mechanics of indistinguishable particles will be discussed (discussion on Bosons and Fermions)
- The path integral formulation of quantum mechanics will be introduced
- Quantum mechanics in the relativistic regime will be discussed

**3. Text Books:** Modern Quantum Mechanics (2<sup>nd</sup> ed.) by J. J. Sakurai and J. Napolitano, *Pearson*

**4. Reference Books:**

1. Quantum Mechanics (4<sup>th</sup> ed.) by L. I. Schiff, *McGraw-Hill*
2. Principles of Quantum Mechanics (2<sup>nd</sup> ed.) by R. Shankar, *Springer*
3. Quantum Mechanics: Fundamentals (2<sup>nd</sup> ed.) by K. Gottfried and T. -M. Yan, *Springer*
4. Lectures on Quantum Mechanics by G. Baym, *Westview*
5. Group Theory and Quantum Mechanics by M. Tinkham, *McGraw-Hill*

**5. Course Plan:**

Module No.	Lecture Session	Reference	Learning outcomes
1. Recapitulation of basics	L1.1-1.2 State vector, operator: wave function, observables; Schrodinger equation	Class notes	Students will get a chance to refresh their memory
2. Approximate methods	L4.1 Variational Methods L4.2-4.3 The WKB Method L4.4-4.7 Time-dependent Perturbation Theory	TB. Chap. 5.4 R2. Chap. 16.2 TB. Chaps. 5.5-5.9	Students will learn how to approximately solve quantum mechanical problems which are not analytically solvable
3. Scattering theory	L5.1-5.2 Scattering amplitude L5.3 The Born approximation L5.4 Partial wave analysis L5.5 Eikonal approximation	TB. Chaps. 6.1-6.7	Students will learn about this very important process in the quantum mechanical regime



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	L5.6 Low energy scattering L5.7 Resonance scattering		
4. Symmetries	L2.1 Transnational Symmetry L2.2-2.4 Rotational Symmetry L2.5-2.6 Discrete Symmetries L2.7-2.8 Gauge Symmetries	TB. Chap. 4 R1. Chap. 4 R2. Chaps. 11-12 TB. Chap. 2.7	Students will get an understanding of the role of symmetries and will learn how to exploit it to simplify a problem
5. Alternative formulation	L3.1-3.2 Path Integral Formulation	TB. Chap. 2.6 R2. Chap. 8	Students will get a glimpse of this alternative formulation of Quantum Mechanics
6. Identical particles	L6.1 Permutation symmetry L6.2 Symmetrization postulate L6.3 Two electrons system L6.4-6.5 Multiparticle states	TB. Chaps. 7.1-7.5	Students will learn how to solve multi-particle quantum systems
7. Relativistic quantum Mechanics	L7.1 Introduction L7.2 The Dirac equation L7.3 Symmetries of the Dirac equation L7.4 The central potential L7.5 The electromagnetic interaction of Dirac particles	TB. Chaps. 8.1-8.4 R3. Chap. 13.3	Students will get an exposure of the relativistic particles in the quantum regime

**6. Evaluation Scheme:**

Component	Duration	Weightage (%)	Date & Time	Nature of component (Close Book/ Open Book)
Mid-Semester Test	90 Min.	30		
Comprehensive Examination	2h	40	1/5/2021, FN	
Tutorials		20	Will be announced in the class.	Total <b>four</b> tests will be conducted, of which best three will be counted.
Assignments		10		

**7. Chamber Consultation Hour:** Will be announced in the class.

**8. Make-up Policy [Strict]:** *Strictly no make up for the tutorials.* If the student is unable to appear for the Regular Test/Examination due to **genuine exigencies\*\***, the student must refer to the procedure for applying for Make-up Test/Examination. [**\*\*Sickness leading to hospitalization and out-of-station with prior permission from/intimation to the IC**]

**9. Note (if any):** It shall be the responsibility of the individual student to be regular in maintaining the self study schedule as given in the course handout and attend lectures. Mid Semester Test and Comprehensive Examination are according to the Evaluation Scheme given in the Course Handout.

(Rakesh Choubisa)  
**Instructor-in-charge**  
**Course No. PHY F421**