

## LESSON PLAN for I-year MSc (Physics)

**Subject Name:** QUANTUM MECHANICS

**Subject Code:** PPY15202

| UNIT I – GENERAL FORMALISM |   |   |
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| Lecture Hour               | Contents Description                                      | References  |
| 1                          | Postulates of quantum mechanics                           | Arthur Beiser, <i>Concepts of Modern Physics</i> , 6 <sup>th</sup> Edition, McGraw Hill, 2009. Chapter 5.1          |
| 2                          | Wave function and its physical interpretation             | Arthur Beiser, <i>Concepts of Modern Physics</i> , 6 <sup>th</sup> Edition, McGraw Hill, 2009. Chapter 5.1          |
| 3                          | Schrodinger equation, time-dependent and time independent | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 2.1 |
| 4                          | Dynamical variables and operators                         | Arthur Beiser, <i>Concepts of Modern Physics</i> , 6 <sup>th</sup> Edition, McGraw Hill, 2009. Chapter 5.6          |
| 5                          | Commutation relations of operators                        | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 3.5 |
| 6                          | Hermitian operators                                       | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 3.3 |
| 7                          | Expansion in eigenfunctions                               | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 2.2 |
| 8                          | Heisenberg uncertainty relation                           | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 3.5 |
| 9                          | Time evolution operator                                   | J.J.Sakurai, <i>Modern Quantum Mechanics</i> , Pearson, 1994. Chapter 2.1   |
| 10                         | Schrodinger and Heisenberg pictures of time evolution     | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 3.5 |
| 11                         | Time variation of expectation values                      | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 3.5 |
| 12                         | Problem solving   | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009.             |

| <b>UNIT II – DISCRETE EIGENVALUE PROBLEMS</b> |   |   |
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| <b>Lecture Hour</b>                           | <b>Contents Description</b>                         | <b>References</b>   |
| 13  | Harmonic oscillator in 1D, Analytic method (1)      | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 2.3 |
| 14  | Harmonic oscillator in 1D, Analytic method (2)      | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 2.3 |
| 15  | Abstract operator method (1)                        | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 2.3 |
| 16  | Abstract operator method (2)                        | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 2.3 |
| 17  | Schrodinger equation in three dimensions            | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 2.3 |
| 18  | Spherical polar coordinate form                     | Arthur Beiser, <i>Concepts of Modern Physics</i> , 6 <sup>th</sup> Edition, McGraw Hill, 2009. Chapter 6.1          |
| 19  | Angular momentum eigenfunctions and eigenvalues (1) | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 4.1 |
| 20  | Angular momentum eigenfunctions and eigenvalues (2) | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 4.1 |
| 21  | Total angular momentum and spherical harmonics      | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 4.1 |
| 22  | Radial equation                                     | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 4.2 |
| 23  | Hydrogen atom wave functions and their discussion   | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009. Chapter 4.3 |
| 24  | Problem solving                                     | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, McGraw Hill, 2009.             |

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|  | <b>CYCLE TEST - I</b> | <b>Unit I and II</b> |
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| <b>Unit III – PERTURBATION THEORY</b> |  |  |
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| <b>Lecture Hour</b>                   | <b>Description</b>   | <b>Reference with chapter</b>  |
| 25                                    | Time-independent perturbation theory for discrete levels (1) | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 6.1  |
| 26                                    | Time-independent perturbation theory for discrete levels (2) | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 6.1  |
| 27                                    | Degenerate cases, Removal of degeneracy                      | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 6.2  |
| 28                                    | Spin-orbit coupling  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 6.3  |
| 29                                    | Fine structure of H atom                                     | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 6.3  |
| 30                                    | Variation method   | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 7.1  |
| 31                                    | Time-dependent perturbation theory                           | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 9.1  |
| 32                                    | Constant and periodic perturbations                          | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 9.1  |
| 33                                    | Fermi golden rule  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 9.1  |
| 34                                    | WKB approximation  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 8.1  |
| 35                                    | Sudden and adiabatic approximation                           | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 10.1 |
| 36                                    | Problem solving  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009.              |

| <b>Unit IV – IDENTICAL PARTICLES AND SCATTERING THEORY</b> |   |  |
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| <b>Lecture Hour</b>  | <b>Description</b>  | <b>Reference with chapter</b>  |
| 37   | Mutual scattering of two particles, Schrodinger equation in laboratory and centre-of-mass frame | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 11.1 |
| 38   | System of identical particles   | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 5.1  |
| 39   | Symmetric and antisymmetric wave functions  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 5.1  |
| 40   | Two electron atoms  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 5.2  |
| 41   | Exchange interaction  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 5.1  |
| 42   | Spin half particles in a box  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 5.3  |
| 43   | Fermi gas and band structure  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 5.3  |
| 44   | Quantum scattering theory, differential and total cross sections                                | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 11.1 |
| 45   | Scattering amplitude, formal expressions for scattering amplitude                               | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 11.1 |
| 46   | Green functions,  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 11.3 |
| 47   | Born approximation  | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009. Chapter 11.3 |
| 48   | Problem solving   | David Griffiths, <i>Introduction to Quantum Mechanics</i> , 2 <sup>nd</sup> Edition, Pearson Publication, 2009               |

| <b>Unit V – RELATIVISTIC QUANTUM MECHANICS</b> |   |  |
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| <b>Lecture Hour</b>                            | <b>Description</b>                              | <b>Reference with chapter</b>  |
| 49   | The Klein-Gordon equation                       | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.3       |
| 50   | Charged particle in an electromagnetic field    | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.3       |
| 51   | Interpretation of the KG equation               | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.3       |
| 52   | Dirac equation                                  | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.5       |
| 53   | Free particle solution – negative energy states | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.6, 13.7 |
| 54   | Equation of continuity                          | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.2, 13.8 |
| 55   | Plane wave solutions of the Dirac equation      | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.2, 13.8 |
| 56   | Non relativistic limit of the Dirac equation    | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.6       |
| 57   | Fine structure of Hydrogen                      | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.11      |
| 58   | Dirac equation in electromagnetic field (1)     | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.9       |
| 59   | Dirac equation in electromagnetic field (2)     | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010. Chapter 13.9       |
| 60   | Problem solving                                 | Gupta, Kumar, Sharma, <i>Quantum Mechanics</i> , 29 <sup>th</sup> Edition, Jai Prakash Nath & Co, 2010.                    |

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|  | <b>MODEL EXAMINATION</b> | <b>Unit I – V</b> |
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