



# University of Rajasthan Jaipur

## SYLLABUS

### M.Sc. PHYSICS

(Annual Scheme)

M.A./M.Sc. (Previous) Examination 2021

M.A./M.Sc.(Final ) Examination 2022

*Rej Nain*

Dy. Registrar (Acad.)  
University of Rajasthan  
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## NOTICE

The Ordinance governing the examinations in the Faculties of Arts, Fine Arts, Social Sciences, Science, Commerce and Law are contained in a separate booklet. The students are advised to refer to the same.

- Changes in Statutes/Ordinances/Rules/Regulations/Syllabus and Books may, from time to time, be made by amendment or re-making and a candidate shall, except in so far as the University determines otherwise, comply with any change that applies to years he has not completed at the time of change.
- All court cases shall be subject to the jurisdiction of the Rajasthan University head quarter at Jaipur only and not any other place.

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## SCHEME OF EXAMINATION (Annual Scheme)

Each Theory Paper	3 hrs. duration	100 Marks
Dissertation / Thesis/ Survey Report/Field Work, if any.		100 Marks

- The number of papers and the maximum marks for each paper / Practical shall be shown in the syllabus for the subject concerned. It will be necessary for a candidate to pass in theory part as well as in the Practical part (Wherever prescribed) of a subject/paper separately.
- A candidate for a pass at each of the Previous and the Final Examination shall be required to obtain (i) atleast 36% marks in the aggregate of all the papers prescribed for the examination and (ii) atleast 36% marks in practical (s) wherever prescribed at the examination, provided that if a candidate fails to secure atleast 25% marks in each individual paper at the examination, and also in the test dissertation/Survey report/Field Work, wherever prescribed, he shall be deemed to have failed at the examination notwithstanding his having obtained the minimum percentage of marks required in the aggregate for that examination. No division will be awarded at the Previous Examination. Division shall be awarded at the end of the Final Examination on the combined marks obtained at the Previous and the Final Examinations taken together, as noted below:

First Division 60%	} of the aggregate marks taken together of the Previous and the Final Examinations.
Second Division 48%	

All the rest will be declared to have passed the examination.

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4. If a candidate Clears any Paper (s) / Practical (s) / Dissertation prescribed at the Previous and/or Final examination after a continuous period of three years, then for the purpose of working out his division the minimum pass marks only viz. 25% (36% in the case of practical) shall be taken into account in respect of such Paper (s) / Practical (s) / Dissertation as are cleared after the expiry of the aforesaid period of three years : provided that in case where a candidate requires more than 25% marks in order to reach the minimum aggregate as many marks out of those actually secure by him will be taken into account as would enable him to make up the deficiency in the requisite minimum aggregate.
5. The Thesis/ Dissertation/ Survey Report/ Field Work shall typewritten and submitted in triplicate so as to reach the office of the Registrar atleast 3 weeks before the commencement of the theory examination. Only such candidates shall be permitted to offer Dissertation/ Field Work/ Survey Report/ Thesis (If provided in the scheme of Examination) in lieu of a paper as have secured atleast 55% marks in the aggregate of all the paper prescribed for the previous examination in the case of annual scheme irrespective of the number of paper in which a candidate actually appeared at the examination.

N.B.—Non-Collegiate candidates are not eligible to offer dissertation as per provisions of O.170-A.

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Syllabus : M. Sc. Physics /

M. Sc PHYSICS PREVIOUS

Paper-I	: Classical Mechanics and Mathematical Method in Physics	Max. Marks 100 Time 3 hrs.
Paper-II	: Classical Electrodynamics	Max. Marks 100 Time 3 hrs.
Paper-III	: Quantum Mechanics, Atomic and Molecular Physics	Max. Marks 100 Time 3 hrs.
Paper-IV	: Electronics, Numerical Methods and Computer Programming	Max. Marks 100 Time 3 hrs.

PAPER - I : CLASSICAL MECHANICS AND MATHEMATICAL METHODS IN PHYSICS

Max. Marks 100

Duration 3 hrs.

Note : In all Ten questions are to be set, Five from each section. Candidates are required to attempt five questions in all, taking at least two questions from each section.

Section A

1. Holonomic and nonholonomic constraints: D'Alembert's Principle. Generalized Coordinates, Lagrangian, Lagrange's equation and its applications. Velocity dependent potential in Lagrangian formulation. Generalized momentum, Legendre transformation, Hamiltonian, Hamilton's Canonical equation.

2. Calculus of variations and its application to simple problems. Hamilton's variational principle, Derivation of Lagrange's and Hamilton's Canonical equation from Hamilton's variational principle. Extension of Hamilton's Principle for nonconservative and nonholonomic systems, Method of Lagrange's multipliers. Conservation Principle and Noether's theorem. Conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and space and isotropy of space respectively.

3. Canonical transformation, integral invariants of Poisson brackets as canonical invariants. Equation of motion in Poisson bracket formulation, Infinitesimal contact transformation and generators of symmetry, Liouville's theorem, Hamilton Jacobi equation and its application.

4. Action angle, variable adiabatic invariance of action variable : The Kepler problem, action-angle variables, secular frequencies.

## Section B

5. Coordinate transformation in  $N$ -dimensional space: Contravariant and covariant tensor, Jacobian, Relative tensor, pseudo tensors (Example: change density, angular momentum) Algebra of tensors, Metric tensor, Associated tensors, Riemannian space (Example: Euclidean space and 4-D Minkowski space), Christoffel symbols, transformation of Christoffel symbols, Covariant differentiation, Ricci's theorem, Divergence, Curl and Laplacian in tensor form, Stress and Strain tensors, Hook's law in tensor form, Lorentz Covariance of Maxwell equation, Klein-Gordon and Dirac equation, Test of covariance of Schrodinger equation.

6. Group of transformations. (Example: symmetry transformation of square, Generators of a finite group, Normal subgroup, Direct product of groups, Isomorphism and Homomorphism, Representation theory of finite groups, Invariant subspace and reducible representations, irreducible representation, Crystallographic point groups, Irreducible representation of  $C_{2v}$ , Translation group and the reciprocal lattice.

7. Fourier Transforms: Development of the Fourier integral from the Fourier Series, Fourier and inverse Fourier transforms: Simple applications: Finite wave train, Wave train with gaussian amplitude, Fourier transform of derivatives, solution of wave equation as an application, Convolution theorem, intensity in terms of spectral density for quasi-monochromatic EM waves, Momentum representation, Application to hydrogen atom and harmonic oscillator problems, Application of Fourier transform to diffraction theory: Diffraction pattern of one and two slits.

8. Laplace transforms, and their properties, Laplace transform of derivatives and integrals, derivatives and integral of Laplace transform, Laplace transform of periodic functions, inverse Laplace transform, Convolution theorem, Impulsive Function, Application of Laplace transform in solving linear differential equations with constant coefficient with variable coefficient and linear partial differential equation.

## Reference Books:

1. Goldstein—Classical Mechanics.
2. Landau and Lifshitz—Classical Mechanics.
3. A. Raychoudhary—Classical Mechanics.
4. Mathematical Methods for Physicists: George Arfken (Academic Press).
5. Applied Mathematics for Engineers and Physicists: L. A. Pipes (McGraw-Hill).
6. Mathematical Methods—Potter and Goldberg (Prentice Hall of India).
7. Elements of Group Theory for Physicists: A. W. Joshi

## PEPER - II : CLASSICAL ELECTRODYNAMICS

Max. Marks 100

Duration 3 hrs.

Note: In all Ten questions are to be set. Five from each section. Candidates are required to attempt five questions in all, taking at least two questions from each section.

## Section A

1. Electrostatics: Electric field: Gauss law, Differential form of Gauss law, Another equation of electrostatics and the scalar potential, surface distribution of charges and dipoles and discontinuities in the electric field and potential, Poisson and Laplace equations, Green's Theorem, Uniqueness of the solution with Dirichlet or Neumann Boundary conditions, Formal solution of Electrostatic Boundary value problem with Green's Function, Electrostatic potential energy and energy density, capacitance.

Boundary-Value Problems in Electrostatics: Methods of Images, Point charge in the presence of a grounded conducting sphere, point charge in the presence of a charge insulated conducting sphere, Point charge near a conducting sphere at fixed potential, conducting sphere in a uniform electric field by method of images, Green function for the sphere, General solution for the potential, Conducting sphere with Hemispheres at different potential, orthogonal functions and expansion

2. Multipoles, Electrostatics of Macroscopic Media Dielectrics: Multiple expansion, multipole expansion of the energy of a charge distribution in an external field, Elementary treatment of electrostatics with permeable media, Boundary value problems with dielectrics, Molar polarizability, and electric susceptibility, Models for molecular polarizability, Electro-static energy in dielectric media.

3. Magnetostatics: Introduction and definition, Biot and Savart law, the differential equation of magnetostatics and Ampere's law, Vector potential and Magnetic induction for a circular current loop, Magnetic fields of a localized current distribution, Magnetic moment, Force and torque on and energy of a localized current distribution in an external magnetic induction) Macroscopic equations, Boundary conditions on  $D$  and  $H$ , Methods of solving Boundary-value problems in magnetostatics, Uniformly magnetized sphere, Magnetized sphere in an external field, Permanent magnets, Magnetic shielding, spherical shell of permeable material in an uniform field.

4. Transverse electromagnetic waves

Derivation of the equations of Macroscopic Electromagnetism, Poynting's theorem and conservations of energy and momentum for a system of charged particles and EM fields. Conservation laws for macroscopic media. Electromagnetic field tensor. Transformation of four potentials and four currents. Tensor description of Maxwell's equation.

Section B

5. Plane Electromagnetic Waves and Wave Equation: Plane wave in a nonconducting medium. Frequency dispersion characteristics of dielectrics, conductors and plasmas, waves in a conducting or dissipative medium, super position of waves in one dimension, group velocity, causality connection between  $D$  and  $E$  Kramers-Kronig relation.

6. Magnetohydrodynamics and Plasma Physics: Introduction and definitions. MHD equations Magnetic diffusion viscosity and pressure, Pinch effect, instabilities in a pinched plasma column. Magnetohydrodynamic waves. Plasma oscillations, short wave length limit of plasma oscillations and Debye shielding distance

7. Covariant Form of Electrodynamics Equations: Mathematical properties of the space-time special relativity, invariance of electric charge covariance of electrodynamics, Transformation of electromagnetic fields.

Radiation by moving charges: Liénard-wiechert Potentials for a point charge. Total power radiated by an accelerated charge: Larmor's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, Radiation emitted by a charge in arbitrary extremely relativistic motion. Distribution in frequency and angle of energy radiated by accelerated charges. Thomson scattering and radiation, scattering by quasifree charges, coherent and incoherent scattering, Cherenkov radiation.

8. Radiation damping, self fields of a particle, scattering and absorption of radiation by a bound system: Introductory considerations, Radiative reaction force from conservation of energy, Abraham Lorentz evaluation of the self force, difficulties with Abraham Lorentz model. Integro-differential equation of motion including radiation damping, Line Breadth and level shift of an oscillator. Scattering and absorption of radiation by an oscillator. Energy transfer to a harmonically bound charge.

Reference Books:

1. J.D. Jackson—Classical Electrodynamics
2. Panofsky and Phillips Classical Electricity and Magnetism
3. Introduction to Electrodynamics—Griffiths
4. Landau and Lifshitz. Classical Electrodynamics

PAPER - III : QUANTUM MECHANICS, ATOMIC AND MOLECULAR PHYSICS

Max. Marks 100

Duration 3 hrs.

Note : In all Ten questions are to be set. Five from each section. Candidates are required to attempt five questions in all, taking at least two questions from each section.

Section A

1. (a) States, Amplitudes and Operators: States of a quantum mechanical system, representation of quantum - mechanical states, properties of quantum mechanical amplitude, operators and change of state, a complete set of basis states, products of linear operators, language of quantum mechanics, postulates, essential definitions and commutation relations.

1. (b) Observable and description of system: Process of measurement, expectation values, time dependence of quantum mechanical amplitude, observables with no classical analogue, spin, dependence of quantum-mechanical amplitude on position, the wave function, super-position of amplitudes, identical particles.

2. Hamiltonian matrix and the time evolution of Quantum mechanical States: Hermiticity of the Hamiltonian matrix, Time independent perturbation of an arbitrary system, simple matrix examples of time independent perturbation, energy given states of a two state-system, diagonalizing of energy matrix, time independent perturbation of two state system the perturbative solution: Weak field and strong field cases, general description of two state system. Pauli matrices, Ammonia molecule as an example of two state system.

3. Transition Between Stationary States: Transitions in a two state system, time dependent perturbations- The Golden rule, phase space, emission and absorption of radiation, induced dipole transition and spontaneous emission of radiation, energy width of a quasi stationary state.

The Co-ordinate Representation: Compatible observables, quantum conditions and uncertainty relation, Co-ordinate representation of operators, position, momentum and angular momentum, time dependence of expectation values, the Ehrenfest's theorem, the time evolution of wave function, the Schrodinger equation, energy quantization, periodic potential as an example.

4. Symmetries and Angular momentum: (a) Compatible observables and constants of motion, symmetry transformation and conservation laws.

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representations of the angular momentum operators and their eigenstates, coordinate representations of the orbital angular momentum operators and their eigenstate (spherical harmonics), composition of angular momentum, Clebsch-Gordan coefficients tensor operators and Wigner Eckart theorem, commutation relations of  $J_x, J_y, J_z$  with reduced spherical tensor operator, matrix elements of vector operators, time reversal invariance and vanishing of static electric dipole moment of a stationary state.

## Section B

5. Hydrogen Atom : Gross structure energy spectrum, probability distribution of radial and angular ( $l=1, 2$ ) wave functions (no derivation), effect of spin, relativistic correction to energy levels and fine structure, magnetic dipole interaction and hyperfine structure, the Lamb shift (only a qualitative description).

6. Interaction with External Fields : Non degenerate first order stationary perturbation method, atom in a weak uniform external electric field and first and second order Stark effect, calculation of the polarizability of the ground state of H-atom and of an isotropic harmonic oscillator, Degenerate stationary perturbation theory. Linear Stark effect for H-atom levels, inclusion of spin-orbit and weak magnetic field, Zeeman effect, strong magnetic field and calculation of interaction energy.

7. Systems with Identical Particles: Indistinguishability and exchange symmetry, many particle wave functions and Pauli's exclusion principle, spectroscopic terms for atoms.

The Helium atom, Variational method and its use in the calculation of ground state and excited state energy, Helium atom, The Hydrogen molecule, Heitler-London method for  $H_2$  molecule, WKB method for one dimensional problem, application to bound states (Bohr-Sommerfeld quantization) and the barrier penetration (alpha decay, problems).

8. Spectroscopy (qualitative) : General features of the spectra of one and two electron system-singlet, doublet and triplet characters of emission spectra, general features of Alkali spectra, rotation and vibration band spectrum of a molecule, P, Q and R branches, Raman spectra for rotational and vibrational transitions, comparison with infra red spectra, general features of electronic spectra, Frank and Condon's principle.

## Reference Books :

1. Ashok Das and A.C. Melissinos, Quantum Mechanics- A modern Approach (Gordon and Breach Science Publishers).
2. P.A.M. Dirac, Quantum Mechanics.
3. E. Merzbaker, Quantum Mechanics, Second Edition.

4. L.P. Landau and E.M. Lifshitz, Quantum Mechanics-Non relativistic theory (Pergamon Press)
5. A. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, Third Edition (Mac Millan India Ltd.)
6. G. K. Woodgate, Elementary Atomic Structure, Second Edition Clarendon Press, Oxford.
7. T.A. Littlefield- Atomic and Molecular Physics.
8. Eisnberg and Rasmuk- Quantum Physics of Atoms, Molecules, Solids and Nuclear Particles.
9. White - Atomic Spectra.
10. Herzberg- Molecular Spectra.

## PAPER - IV : ELECTRONICS, NUMERICAL METHOD AND COMPUTER PROGRAMMING

Max. Marks 100

Duration 3 hrs.

## Note :

1. In all Ten questions are to be set. Five from each section. Candidates are required to attempt five questions in all, taking at least two questions from each section.
2. Simple calculator is allowed in the examination hall.

## Section A

1. Operational Amplifiers : Differential amplifier - circuit configurations - dual input, balanced output differential amplifier. DC analysis - AC analysis, inverting and non inverting inputs, CMRR - constant current bias level translator.

Block diagram of a typical Op-Amp-analysis. Open loop configuration, inverting and non-inverting amplifiers. Op-amp with negative feedback - voltage series feed back - effect of feed back on closed loop gain, input resistance, output resistance, bandwidth and output offset voltage - voltage follower.

Practical op-amp-input offset voltage - input bias current - input offset current, total output offset voltage, CMRR frequency response. DC and AC amplifier, summing, scaling and averaging amplifiers, instrumentation amplifier, integrator and differentiator.

2. Oscillators and Wave Shaping Circuits: Oscillator Principle- Oscillator types, Frequency stability, response. The Phase shift oscillator, Wein bridge Oscillator, LC tunable oscillators, Multivibrators- Monostable and Astable, Comparators, Square wave and Triangle wave generation, Clamping and Clipping.

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## Syllabus : M. Sc. Physics / 12

3. Digital Electronics : Combinational Logic : The transistor as a switch, Realisation of OR, AND, NOT, NOR and NAND gates, Exclusive OR gate, Boolean algebra - Demorgan's theorems Adder, Subtractor, Comparator, Decoder/ Demultiplexer Data selector/multiplexer - Encoder.

Sequential Logic: Flip - Flops : one - bit memory, The RS Flip-flop, JK Flip- Flop, JK master slave Flip - Flops, T Flip - Flop, D Flip - Flop, Shift registers - synchronous and asynchronous counters- cascade counters, Binary counter, Decade counter.

Basic concepts about fabrication and characteristics of integrated circuits.

4. Microprocessors : Introduction to microcomputers : memory - input/output - Interfacing devices 8085, CPU - Architecture - BUS timings - Demultiplexing the address bus generating control signals - Instruction set - addressing modes - Illustrative programmes - writing assembly language programmes looping, counting and indexing - counters and timing delays - stack and subroutine.

## Section B

5. Errors in numerical analysis: Source of error, Round off error, Computer Arithmetic, Error Analysis, Condition and stability, Approximation, Functional and Error analysis, the method of Undetermined Coefficients.

Use of interpolation formula, Iterated interpolation, Inverse interpolation, Hermite interpolation and Spline interpolation, Solution of Linear equations : Direct and Iterative methods, Calculation of eigen values and eigen vectors for symmetric matrices.

6. Solution of Nonlinear equation: Bisection method, Newton's method, modified Newton's method, method of iteration, Newton's method and method of iteration for a system of equations Newton's method for the case of complex roots.

Integration of a function: Trapezoidal and Simpson's rules, Gaussian quadrature formula, Singular integrals, Double integration.

7. Integration of Ordinary differential equation : Predictor - corrector methods, Runge-Kutta method, Simultaneous and Higher order equations.

Numerical Integration and Differentiation of Data, Least-Squares Approximations, Fast Fourier Transform.

Some elementary information about Computer: CPU, Memory, Input Output devices, Super, Mini and Micro systems, MS-DOS operating system, High Level Language.

8. Fortran 77 : Variables, Expressions, Jumping, Branching and Looping statements, Input/ Output statement, Statement for handling Input/ Output Files, Subroutine, External Function, special statements: COMMON, ENTRY, FORMAT, PAUSE, EQUIVALENCE. Programming of simple problems involving use of interpolation differentiation, integration, matrix inversion and least square analysis.

## Reference Books :

1. Ryder—Electronic Fundamentals and applications.
2. Millman and Toub—Pulse, Digital and Switching wave forms.
3. Millman and Halkias—Integrated Electronics.
4. Ryder—network Lines and Fields.
5. Bapat—Electronics Devices and Circuits.
6. A Ralston and P. Rabinowitz, A First Course in Numerical analysis Mc Graw Hill (1985)
7. S.S. Sastry, Introductory Methods of Numerical Analysis, Prentice-hall of India (1979).
8. Ram Kumar, Programming with Fortran 77, McGraw-Hill (1986).
9. "Electronic Devices and circuit theory" by Robert Boylested and Louis Nashelsky PHI, New Delhi, 1100 001, 1991
10. "OP Amps & Linear integrated circuits," by Ramakant A. Gayakwad PHI, Second Edition, 1991.
11. "Digital principles and Applications" by A.P. Malvino and Donald P. Leach, Tata McGraw - Hill company, New Delhi, 1993.
12. "Microprocessor Architecture, Programming and applications with 8085/8086 by Ramech S. Gaonkar, Wiley - Eastern Ltd., 1987.

## LIST OF EXPERIMENTS FOR M.Sc PREVIOUS

## Scheme :

The examination will be conducted for two days, 6 hrs. each day. The distribution of the marks will be as Follows :

	Marks
Two experiments	120
Viva	40
Record	40
<b>Total</b>	<b>200</b>
<b>Minimum Pass Marks</b>	<b>72</b>

## List of Experiments (any eighteen) :

1. To design a single stage amplifier of a given voltage gain and lower cut off frequencies.
2. To determine the

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3. To design a RC coupled two stage amplifier of a given gain and the cut off frequencies.
4. To study Hartley oscillator.
5. To Study Transistor bias Stability.
6. To design a Multivibrator of given frequency and study its wave shape
7. To study the characteristics of FET and use it to design an relaxation oscillator and measure its frequency.
8. To study the characteristics of an operational amplifier.
9. To study the characteristics of a UJT and use it to design a relaxation oscillator and measure its frequency.
10. To study the addition, integration and differentiation properties of an operational amplifier.
11. Determine Plack constant using solar Cell.
12. To determine Plack constant and work function by a photo-cell.
13. To study regulated power supply using (A) Zener diode only (b) Zener diode with a series transistor (c) Zener diode with a shunt transistor
14. To verify Fresnel's formula.
15. To study the percentage regulation and variation of Ripple factor, with load for a full wave rectifier.
16. To study analog to digital and digital to analog conversion.
17. To study a driven mechanical oscillator.
18. To verify Hartmann's formula using constant deviation spectrograph.
19. To find  $e/m$  of electron using Zeeman effect.
20. To find Dissociation energy to I.
21. Study of CH Bands.
22. Salt Analysis/Raman effect (Atomic).
23. Design and study of pass filters.
24. Michelson Interferometer.
25. Fabry perot Interferometer.
26. Determination of velocity of Ultrasonic waves.
27. Study of Elliptically polarised light by Babinet Compensator.
28. Verification of Cauchy's Dispersion relation

## M. Sc PHYSICS FINAL

Paper-V	: Advanced Quantum Mechanics and Introductory Quantum Field	Max Marks 100 Time 3 hrs
Paper-VI	: Nuclear Physics	Max Marks 100 Time 2 hrs.
Paper-VII	: Statistical and Solid State Physics	Max Marks 100 Time 3 hrs.
Paper-VIII	: (A) Microwave Electronics	Max Marks 100 Time 3 hrs.
OR		
Paper-VIII	: (B) Plasma Physics	Max Marks 100 Time 3 hrs.

## PAPER - V : ADVANCED QUANTUM MECHANICS AND INTRODUCTORY QUANTUM FIELD THEORY

Max. Marks 100

Duration 3 hrs.

*Note : In all Ten questions are to be set. Five from each section. Candidates are required to attempt five questions in all, taking at least two questions from each section.*

## Section A

1. Scattering (non-relativistic) : Differential and total scattering cross section; transformation from CM frame to Lab frame, solution of scattering problem by the method of partial wave analysis, expansion of a plane wave into a spherical wave and scattering amplitude, the optical theorem, Applications - scattering from a delta potential, square well potential and the hard sphere scattering of identical particles, energy dependence and resonance scattering. Breit-Wigner formula, quasi stationary states.

The Lippman-Schwinger equation and the Green's function approach for scattering problem, Born approximation and its validity for scattering problem, Coulomb scattering problem under first Born approximation in elastic scattering.

2. Relativistic Formulation and Dirac Equation : Attempt for relativistic formulation of quantum theory. The Klein-Gordon equation, Probability density and probability current density, solution of free particle K.G. equation in momentum representation, interpretation of negative probability density and negative energy solutions.