UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics **TIME ALLOWED: 3 hrs.**
PAPER: I (Solid State Physics-II) **MAX. MARKS: 50**

NOTE: Attempt any FOUR questions, in all by selecting at least ONE question from each section.

Section-I

Q.1.

a. Define and derive Fermi energy and density of states for 3D free electron gas.

b. Show that the kinetic energy of a 3D gas of N electrons at 0k is $U_0 = \frac{3}{5} N E_F$ (7.5, 5)

Q.2.

a. Discuss Kronig-penny model for the motion of an electron in a periodic potential.

b. How does the band theory of solid lead to the classification of solids in to conductors, semiconductors and insulators. (9.5, 3)

Q.3.

a. What is Hall Effect? Give an elementary theory of it. Mention its important uses.

b. What is the Wiedmann-Franz Law? (8.5, 4)

Q.4.

a. Using Langevin's classical treatment, show that the orbital motion of the electron gives rise to diamagnetic susceptibility under the influence of magnetic field 'B'.

b. Explain the origin of the paramagnetic behavior of the conduction electrons of a metal and derive an expression for the Pauli spin magnetization of the conduction electrons. (6, 6.5)

Section-II

Q.5.

a. How is an abrupt p-n junction defined? Draw schematic diagrams specifically showing the relative positions of band edges and Fermi level for a p-n junction in thermal equilibrium.

b. Starting with the Poison's differential equation and assuming an abrupt p-n junction, show that $N_d d_n = N_a d_p$, when $x = -d_p$ and $x = d_n$. Also find the length of depletion region on n and p sides. (6, 6.5)

Q.6.

a. How is the conductivity of a semiconductor affected by doping? Show that the Fermi energy level in the band pictures of a semiconductor shifts either towards the conduction band edge or the valence band edge depending on the type of doping.

b. Show that the effective mass of an electron in a crystal depends on the curvature of the energy band. Discuss the physical basis for the effective mass of an electron in a crystal. (6, 6.5)

Q.7.

Write notes on the followings: (6, 6.5)

a. Donor and Acceptor states.
b. Effective Mass

UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: II (Statistical Physics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 50

NOTE: Attempt FOUR questions, in all by selecting at least ONE question from each section. Try to be focused and give only precise answers, of the asked questions.

Section-I

Q.1.
(a) Starting with the formula for the ensemble averages, obtain the condition for a system in equilibrium. Hence show that a system in equilibrium moves on a surface of constant P. (4)
(b) If P is a function of energy only and $\partial E/\partial t=0$, what kind of ensemble do we have and what can we say about the entropy of the system? Explain. (4)
(c) Discuss the analytical nature of $P(q,p)$ for a micro-canonical ensemble representing a system of two independent free particles of mass M moving in one dimension on a line segment of length L, where the energy of the system is E_o. (4.5)

Q.2.
(a) Consider a higher volume $d\Gamma$ in the Γ space of a system of N particles. Write down an expression for the volume of $d\Gamma$. Hence write down a formula for the total accessible phase space $\Delta\Gamma$ of the system if it is a perfect gas confined to a volume V. Leave the momentum space in the form of an integral without carrying out a detailed calculation. (3)
(b) Why is the quantity $h/(2\pi MkT)^{1/2}$ identified with a wavelength? (2)
(c) If the temperature difference between the source and surroundings is small then show that the Stefan's law reduces to Newton's law of cooling. (4)
(d) A wire of length $1m$ and radius $1mm$ is heated via an electric current to produce $1kW$ of radiant power. Treating the wire as a perfect blackbody and ignoring any end effects, calculate the temperature of the wire. (3.5)

Q.3.
(a) The Maxwell's distribution for velocities of molecules is given by

$$N(v)dv = 2\pi N(m/2\pi kT)^{3/2} v^2 \exp(-mv^2/2kT)dv$$

Calculate the value of $\langle 1/v \rangle$. (3)
(b) The expression for the entropy of perfect gas is

$$\sigma = N \log\left[V\left(\frac{4\pi M}{3}\right)^{3/2}\left(\frac{U}{N}\right)^{3/2}\right] + \frac{3}{2}N$$

Here the symbols V, U and N stands for the volume, the number of particles and potential energy respectively. M is the mass of each particle.
Show that this formula does not preserve the additive property of entropy. Give reason for this anomaly. Also prove that this anomaly can be removed by the use of Stirling's approximation and write down the corrected formula in terms of thermal De-Broglie wavelength.

$$\lambda = \frac{h}{(2\pi MkT)^{1/2}}$$ (5.5)

(c) Assuming that the hydrogen molecules have a root-mean-square speed of $1,270$ m/s at $300K$, calculate the rms at $600\ K$. (4)

PTO

Q.4.

Write notes on the following: (6,6.5)

(a) Helmholtz free energy and Gibbs free energy.
(b) Energy distribution of conduction electrons in metals.

Section-II

Q.5.

(a) Describe Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics and distinguish between them, especially from the point of view of Pauli's exclusion principle and the indistinguishability of identical particles. (3.5)
(b) Show that the distinction between the three types of statistics vanishes in the limit of high temperature. Give a physical interpretation of why this happens. Approximately how high should the temperature be for the distinction between the three statistics to become unimportant? (2)
(c) Write down the formula for the Δn number of quantum states in phase space $\Delta \Gamma$ of a system of N particles, each with spin I. (3)
(d) Classify the following between Bosons and Fermions and state the criterion which statistics has been applied for this classification:
- Electrons, Protons, Photons, Phonons.
- Neutrons, H-atoms, He-atoms, Spin zero particles. (4)

Q.6.

A system of N identical spin zero bosons each of mass m, is confined to a box of volume $V=L^3$ at temperature $T>0$.
(a) Derive an expression for the density of single particle states $g(\epsilon)$ as a function of single particle energy ϵ. Use this result to write down a general expression for the number of particles $n(\epsilon)$ having energy between ϵ and $\epsilon + d\epsilon$. (4)
(b) Use the expression of $g(\epsilon)$ derived in *part (a)* to calculate the value of critical temperature $T=To$ below which Bose-Einstein condensation occurs. Here assume that the volume V is constant. (4)
(c) Estimate the temperature at which the root-mean-square of nitrogen molecule in earth's atmosphere equals the escape velocity from earth's gravitational field. Take the mass of nitrogen molecule = *23.24 amu*, and radius of earth = *6,400 km*.

Q.7. (4.5)

(a) Give the approximate value of C_v and C_p for the following temperatures for hydrogen gas. $T_1=25K$; $T_2=250K$; $T_3=2500K$; $T_4=10,000K$.
(b) Assuming that the moment of inertia of the H_2 molecule is 4.64×10^{-48} $kg\text{-}m^2$, find the relative population of the $J = 0, 1, 2$ and 3 rotational states at 400K.
Hint: $I_o = 4.64\times10^{-48}$

(c) Suppose that at very low temperature the value of C_v for copper is approximately equal to $7\times10^{-4}\ T.\ JK^{-1}mole^{-1}$.

i. Show that if *1-erg* of heat is added to one mole of copper at *0K*, the temperature of copper rises to *0.0169K*.

ii. If the volume of copper is kept constant, what is the volume of phase space accessible to copper at this temperature *(i.e. 0.0169K)*?

(4,4.5,4)

UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: III (Relativity & Cosmology)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 50

NOTE: Attempt FOUR questions selecting at least ONE from each section.

Section-I

Q1(a) What is light cone? Discuss its different regions in detail. Why dose the world line of material particles always remain inside the light cone? [6]

(b) Show that the interval between two events (t_1, x_1, y_1, z_1) and (t_2, x_2, y_2, z_2) and defined by $S^2 = (t_1 - t_2)^2 + (x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2$ is invariant under a special Lorentz transformation. Deduce the Minkowski line element for infinitesimally separated events and discuss it. What does S^2 become if $t_1 = t_2$, and how is it related to the Euclidean distance between the two events? [6.5]

Q2(a) If a photon traverse a path in such a way that it moves in the xy-plane making an angle ϕ with x'-axis of the frame S'. Show that for the frame S, the following relation holds $v_x{}^2 + v_y{}^2 = c^2$, where S' is moving along x'-axis with velocity v with respect to S. [5]

(b) An atom at rest in a laboratory emits a photon and recoils. If its initial mass is m_o and it loses the rest energy E in the emission, show that the frequency of the emitted photon is given by $\nu = \frac{E}{h}\left(1 - \frac{E}{2m_o c^2}\right)$. [7.5]

Q3(a) Derive the transformations connecting the velocity in different inertial frames. Why are the components of the velocity transverse to the direction of motion, affected? [5.5]

(b) Using the radial Doppler effect for a moving source $\frac{\lambda}{\lambda_o} = \sqrt{\frac{1 + v/c}{1 - v/c}}$, λ_o is the wave length in the frame of source and λ is the wave length in the frame of the observer. Show that $\frac{E_0}{\nu_0} = \frac{E}{\nu}$, where E_o, ν_o are the energy and the frequency in the frame of the source and E, ν are the energy and frequency in the frame of the observer. [4]

(c) Can the order of occurrence of two events be claimed by two different observer? [3]

Section-II

Q4(a) Transform the metric tensor $g_{ab} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ into polar coordinates. Also find the R_{ab} corresponding to new metric tensor g'_{ab}. [5]

(b) A contravariant tensor is given by $\left(\frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt}\right)$. Transform this tensor into Cylindrical polar coordinates. [7.5]

Q5(a) What is meant by parallel transport of a vector. Define a geodesic and derive its equation for a general Riemannian manifold. [5.5]

(b) The metric tensor for $x^1 = q$, $x^2 = p$ is $\begin{bmatrix} q^2 & 0 \\ 1 & p^2 \end{bmatrix}$. Determine the Lie and Covariant derivatives of $T^a = (q, -p)$ along $S_b = (0, -q)$. [7]

Q6(a) The nontrivial solution of the Einstein field equations for spherical symmetry is represented by the following Schwarzchild metric

$$ds^2 = \left(1 - \frac{2\Lambda}{r}\right)dt^2 - \left(1 - \frac{2\Lambda}{r}\right)^{-1} dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta d\phi^2 \text{ where } \Lambda = \frac{GM}{c^2}, \text{ explain}$$

(i) How this metric explain the spacetime singularity?
(ii) How does this metric predict the formation of a black hole? [6.5]

(b) Discuss the concept of close and open Universe and describe the Friedmann models about the Universe. [6]

Q7(a) What is Hubble's law? Derive it from Friedman-Robertson-Walker metric. [6]

(c) Define the following cosmological terms: [6.5]
(i) Scale Factor (ii) Cosmological Principle

UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: IV (Computational Physics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 50

NOTE: Attempt FOUR questions in all selecting at least ONE from each section.

Section-I

Q.1.	Write C++ program to evaluate the $\int_1^6 \sqrt{x}dx$ by Trapezoidal Rule. (Use n=6). Write C++ program which read in a number from the user and prints out table of that number.	8+4 ½
Q.2. A B	Find the roots of the equation $x^2 - 2x - 2$ using Newton Raphson method using xo = 2. Write C++ program to implement the method correct to 3dp. Write C++ program which reads in a value in meters and convert it into kilometers using a function.	8+4 ½
Q.3.	Suppose **A** and **B** be 4x4 matrices. Write C++ program which reads in entries of the matrices and calculate (i) **A – B**, (ii) **A x B** (iii) sum and average of the elements of matrix **B** Write C++ program to calculate and print odd numbers in the list of numbers from 3 to 97. Also calculate sum of the numbers.	08 ½ +4
Q.4. A B	**Section-II** Write MATLAB program for the forced harmonic motion (FHM) of a mass attached with a spring using Euler's method under the following conditions: (g=9.8 m/s^2, initial position zero and velocity 15 m/s, time step 0.1 sec. and maximum time 15 sec., k = 1 N/m, m=1kg, damping coefficient = 0.5 N/ms, ω=0.01 s^{-1} and f_0=1.5N.). Calculate and print values for time, position, velocity and acceleration. How you can change the same program for Simple H.M., Damped. H.M. Draw approximate output graph with proper labels. Write MATLAB code to plot 'x' against y(x) values using supbplot such that: **x = [-10 10], y(x) = sin(nx).** Where n=[1 4] and step size =1	06 ½ +6

PTO

Q.5. (A) (B)	Write syntax for a user defined function in MATLAB? What is the advantage of a user define function? Write MATLAB program to implement function **f(x)** using arrays and function, the interval is given by: h= 0.5, such that : **f(x)** = $3x^3 - 24x^2 + 8x + 42$ for **[-15, 15]** Also, print values of ***x*** and ***f(x)***, find out sum, maximum and average of ***f(x)*** values. Write MATLAB program to calculate factorial of a given number. Implement your program using two different methods.	8+4 ½
Q.6. (A) (B)	Write down the MATLAB syntax with example for: linspace(), diff(), rem() and prod(). Write MATLAB program calculate and print equivalent resistor of five resistors connected in series.	8+ 4 ½
Q.7. (A) (B)	For an object thrown at an angle "Θ" and initial velocity "u", the horizontal range "**R**" is given by: $R = \frac{u^2 \sin(2\theta)^2}{g}$, where g=9.8 m/s^2 and u= [120 160] m/s, with h=10. Write a MATLAB program to print out **R** against angle **Θ** values. Take angle varies from 30^0 to 60^0 in step size of 3^0. Also calculate maximum value of **R** at the given data set. Write MATLAB program to solve the system of linear algebraic equations: 3x + 2y -9z = - 65 -9x – 5y + 2z = 16 6x + 7y + 3z = -5	8+ 4 ½

UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: V (Classical Electrodynamics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FIVE questions, at least TWO questions from each section. All questions carry equal marks.

Section-I

Q.1. By using Legendre Polynomials, discuss multipole expansion of potential in powers of $1/r$. 20

Q.2. (a) What is dielectric strength? 3
(b) Calculate total charge, volume and surface charge densities for the case of a point charge in a dielectric fluid. 17

Q.3. (a) Derive equation of continuity relating charge density $\boldsymbol{\rho}$ and current density $\boldsymbol{J}$. 10
(b) If current density $\boldsymbol{J}$ in a wire of circular cross-section with radius R is proportional to distance from the axis. Find total current in the wire. 10

Q.4. (a) What is magnetic dipole moment $\boldsymbol{m}$ of the circuit? 5
(b) Calculate magnetic field for a distant circuit. 15

Q.5. (a) Discuss briefly magnetization and magnetization current density. 4,4
(b) Discuss boundary conditions for the field vectors $\boldsymbol{B}$ and $\boldsymbol{H}$. 12

Section-II

Q.6. Show that by imposing the Lorentz condition, the vector potential A and scalar potential φ satisfy similar inhomogeneous wave equations. 20

Q.7. Discuss in detail the concepts of polarization of electromagnetic waves. 20

Q.8. Discuss in detail the reflection and refraction of EM plane wave incident normally on an interface between two non-conducting media. 20

Q.9. Discuss briefly only two topics. 10,10
(a) Plasma oscillations (b) Electric susceptibility and dielectric constant.
(c) Black body radiation (d) Generalization of Ampere's law.

UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics **TIME ALLOWED: 3 hrs.**
PAPER: VI (Nuclear Physics) **MAX. MARKS: 100**

NOTE: Attempt any FOUR questions selecting at least ONE from each section. All questions carry equal marks. Please read question carefully and answer accordingly.

Section I

Question 1: (15 + 10 = 25)

(a): What type of multipole moments exist for nuclei and why? Wite a note on electric Quadrupole moment of a nucleus? What kind of information does it provide about the nuclear shape?

(b): Explain in detail the nuclear spin. What can we guess about the spin of a nucleus by knowing its mass number?

Question 2: (10 + 15 = 25)

(a): Describe the principle, construction and working of Van de Gra accelerator.

(b): Wite down in detail the energy loss of heavy charged particles in matter.

Section II

Question 3: (15 + 10 = 25)

(a): For a beta-decay process, use Fermi's Golden rule to derive the relation for the partial decay rate.

(b): What is gamma decay? How do we measure energy of gamma rays?

Question 4: (15 + 10 = 25)

(a): What are basic assumptions of the shell model? Discuss use of various choices of nuclear potential to produce magic numbers.

(b): Wite down two main differences between scattering of identical nucleons (p-p, n-n) and the non-identical nucleons (n-p).

Section III

Question 5: (13 + 12 = 25)

(a): How does a nuclear reaction proceed according to compound nucleus theory? What are the fundamental assumptions of this theory? Give an example which shows that a compound nucleus forgets its mean of formation.

(b): For an endothermic reaction $a + X \rightarrow Y + b$, derive an expression for the threshold energy.

Question 6: (12 + 13 = 25)

(a): Explain fission cross sections for ^{235}U and ^{238}U. How would you account for the dffer - ence in the kinetic energy of the neutrons that can cause fission of ^{235}U and ^{238}U?

(b): Use Liquid Drop Model to explain the e ect of distortion in nuclear shape on the nuclear binding energy. How would these effects control the Fission probability of a nu- cleus? Show that the fission will proceed spontaneously if $Z^2/A > 49$.

Question 7: (15 + 10 = 25)

(a): Discuss in detail dfferent Solar Fusion Cycles.

(b): Discuss the photo neutron sources. What is the energy range of neutrons obtained from these sources? Explain with reasons.

UNIVERSITY OF THE PUNJAB

Part-II **A/2016**
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: VII (Solid State Physics-I)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FOUR questions. All questions carry equal marks.

Q. 1 What are the fundamental interactions that exist in a crystalline solid containing free electrons? Describe the Born-Oppenheimer approximation that takes into account all these interactions and formulate Schrodinger equation applicable to such a system. **(25)**

Q. 2 (a) What is principle of causality? Derive the Kramer-Kronig (k-k) relations for the response function 'd(ω)' for a linear passive system.
(b) Apply the k-k relations to optical reflectance from a solid considering reflectivity 'r(ω)'as a response function between the incident and reflected wave. **(15+10)**

Q. 3 (a) What approximations are employed in the Linear Combination of Atomic Orbitals (LCAO) method? Using the method, obtain an expression for the energy Eigen value for electron in a solid.
(b) Apply the above result to determine the width and shape of the energy band, and effective mass of electron in a cubic crystal. **(15+10)**

Q. 4 (a) What is Meissner's effect in superconductivity? Derive London equation and explain the occurrence of Meissner effect. Define the London penetration depth.
(b) Describe the physical basis of the London equation. **(15+10)**

Q. 5 (a) Find the frequency dependence of the electronic polarizability of an electron, in a dielectric, having the resonance frequency 'ω_o', treating the system as a simple harmonic oscillator.
(b) Derive the Clausius-Mossotti relation that relates the dielectric constant to electronic polarizability provided the condition of cubic symmetry holds. **(10+15)**

Q. 6 Using the free energy expansion in terms of polarization of ferroelectric crystal in one dimension, as given in the Landau theory of phase transition, describe the first order and second order phase transition of ferroelectric crystals. **(25)**

Q. 7 Write notes on any TWO of the followings; **(12 ½, 12 ½)**

I. Formation and binding energy of weakly bound (Mott-Wannier) exciton in a crystal
II. Flus quantization in a superconducting ring
III. Effective mass of electron in a solid

UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: VIII (Solid State Physics-II)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FOUR questions. All questions carry equal marks.

Q.1 (a) Discuss De Haas Van Alphen Effect.
(b) Explain quantum Hall Effect. (12.5+12.5)

Q.2 (a) Discuss important parameters, which can elaborate the optical properties of semiconductors.
(b) What are Magnons? Find the dispersion relation for quantized spin waves. (12.5+12.5)

Q.3 (a) Discuss anisotropic magnetic susceptibility for an antiferromagnet below its Néel temperature. (12.5+12.5)
(b) Show that the temperature variations, for quantized spin waves, leads to the Bloch $T^{3/2}$ law.

Q.4 (a) Derive Boltzmann transport equation in relaxation time approximation.
(b) Apply Boltzmann equation to find the conductivity equation. (12.5+12.5)

Q.5 (a) Explain magnetocrystalline energy. Also differentiate soft and hard ferromagnets.
(b) Explain the origin of ferromagnetic domains. (12.5+12.5)

Q.6 (a) What is phonon? Explain the screening of electron-phonon interactions.
(b) What is Hubbard model? How it can be used to differentiate metallic and insulating limits.
(12.5+12.5)

Q.7 Write note on any two of the following.
(a) Einstein model of heat capacity.
(b) Discuss calculation domain wall thickness
(c) Interactions between conduction electrons (12.5+12.5)

UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: IX (Particle Physics-I)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FOUR questions selecting at least ONE from each section. All questions carry equal marks. Please read question carefully and answer accordingly.

Section I

Question 1: $(10 + 12 + 3 = 25)$

(a): Differentiate between mesons and baryons. Draw meson and baryon octets for 8 lightest mesons and baryons. Also write values of their charge and strange quantum number.

(b): Discuss vacuum polarization in QED and QCD? How does it explain the variation of α_e and α_s as a function of distance of the interacting particles?

(c): Draw a Feynman diagram showing the mechanism for μ^- decay.

Question 2: $(10 + 10 + 5 = 25)$

(a): Explain strangeness-changing weak interactions with the help of examples. How theory of weak interactions can be modified in order to account such processes.

(b): What is isospin? Give its symmetry group. Assuming that the strong interactions conserve isospin, explain that all hadrons belong to isospin multiplets.

(c): For a system of two spin-1/2 particles, write down the spin triplet ($|1, 1>, |1, 0>, |1, -1>$) and spin singlet ($|0, 0>$) wave functions in terms of the individual particle spin functions.

Section II

Question 3: $(8 + 7 + 10 = 25)$

(a): Show that rotational symmetry in Quantum Mechanics implies the law of conservation of angular momentum.

(b): Show that the induce operator of time reversal is anti-unitary.

(c): Define electric-dipole moment of a particle. What kind of information does it provide about charge distribution of a particle? How can we use it to measure parity and time reversal violation?

Question 4: $(7 + 10 + 8 = 25)$

(a): Define helicity. How does helicity of neutrino implies parity violation in weak interactions?

(b): In Quantum Electrodynamics four vector potential becomes the wave function of photon. The free photon satisfies the equation

$$\partial^{\mu}\partial_{\mu}A = 0$$

Show that if we impose the Coulomb gauge then we get transversely polarized photon.

P.T.O.

(c): Using the Lorentz Gauge $\nabla \cdot \mathbf{A} = -\frac{\partial\phi}{\partial t}$, show that $\mathbf{A}$ and ϕ obey the following wave equations

$$\begin{aligned} \nabla^2 \mathbf{A} - \frac{\partial^2 \mathbf{A}}{\partial t^2} &= -\mathbf{j} \\ \nabla^2 \phi - \frac{\partial^2 \phi}{\partial t^2} &= -\rho \end{aligned}$$

Section III

Question 5: (10 + 15 = 25)

(a): Develop Klein Gordon equation using relativistic expression of energy. Also prove that the Klein Gordon equation remains invariant under Lorentz transformation if the state function $\phi(x)$ is Lorentz scalar.

(b): Show that in Dirac equation for an electron (charge -e) in an electromagnetic field $A^\mu = (A^0, \mathbf{A})$ reduces to Schrodinger-Pauli equation

$$\left[\frac{1}{2m}(\mathbf{P} + e\mathbf{A})^2 + \frac{e}{2m}\sigma \cdot \mathbf{B} - eA^0\right]\psi_A = E_{NR}\psi_A$$

where the magnetic field $\mathbf{B} = \nabla \times \mathbf{A}$ and $E_{NR} = E - m$. Assume $|eA^0| << m$.

Question 6: (10 + 10 + 5 = 25)

(a): Describe Dirac Hole theory and Feynman-Stuckelberg interpretation to explain the negative energy solutions. What is the difference between the two approaches?

(b): Show that

$$\begin{aligned} \Lambda^+ &= \frac{\not{p} + m}{2m} \\ \Lambda^- &= \frac{-\not{p} + m}{2m} \end{aligned}$$

are projection operators which project positive and negative energy states, respectively.

(c): Show that $\gamma^\mu\gamma^\nu + \gamma^\nu\gamma^\mu = 2g^{\mu\nu}$.

Question 7: (12 + 10 + 3 = 25)

(a): Modify Dirac equation for zero-mass fermions.

(b): For Dirac spinors, show that

$$\bar{u}^{(s)}u^{(s)} = 2m, \quad \bar{v}^{(s)}v^{(s)} = -2m; \quad \text{where } s = 1, 2.$$

(c): Show that $g_{\mu\nu}g^{\mu\nu} = 4$.

UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics **TIME ALLOWED: 3 hrs.**
PAPER: X (Particle Physics-II) **MAX. MARKS: 100**

NOTE: Attempt any FIVE questions selecting at least ONE from each section.

Section I

Q1. State and prove optical theorem for scattering theory.

(20)

Q2. (a). Explain the general process of scattering. Discuss the waveforms which we obtain for incident and scattered waves. Also write down the general expression for incident and reflected wave.

(b). What are the factors on which the total cross section depexplain in detail.

(12–8)

Q3. Define Mandelstam variables. Taking $e^-e^+ \to e^-e^+$ to be s channel process verify that

$$\begin{aligned} s &= 4\left(k^2+m^2\right), \\ t &= -2k^2\left(1-\cos\theta\right), \\ u &= -2k^2\left(1+\cos\theta\right), \end{aligned}$$

where θ is the center of mass scattering angle and $k = |\mathbf{k}_i| = |\mathbf{k}_f|$. Where $\mathbf{k}_i$ and $\mathbf{k}_f$ are momenta of incident and scattered electrons respectively. (20)

Section II

Q4. Discuss Quark model in detail. Explain its significance in Particle Physics.

(20)

Q5. (a). Define the generators of the group $SU(3)$. What are structure constants.

(b). Solve the following commutators

$$[T_1, T_2],$$
$$[T_2, T_5]$$

(12–8)

Q6. By using Dirac equation, obtain the expression for four-vector current j^μ for an electron in an electromagnetic field A^μ. (20)

Section III

Q7. Prove the following trace theorems

(a). $\text{Tr}(ab) = 4a.b$

(b). $\text{Tr}(abcd) = 4\left[(a.b)(c.d) - (a.c)(b.d) + (a.d)(b.c)\right]$

(c). $\text{Tr}(\gamma_5 ab) = 0$

(d). $\text{Tr}(\gamma_5) = 0$

(20)

Q8. (a) Starting with the expression

$$|\bar{\mathcal{M}}|^2 = \frac{e^4}{q^4} L_e^{\mu\nu} L_{\mu\nu}^{muon},$$

write down the expressions for $L_e^{\mu\nu}$ and $L_{\mu\nu}^{muon}$.

(b). Show by using trace theorems that

$$L_e^{\mu\nu} = \frac{1}{2} Tr\left((k'+m)\gamma^\mu (k+m)\gamma^\nu\right) \qquad (8+12)$$

Q9. (a) Draw Feynman diagrams for e^-e^- scattering.

(b) Show that for $e^-\mu^-$ at very high energies in center of mass frame

$$|\bar{\mathcal{M}}|^2 = 2e^4 \frac{s^2+u^2}{t^2} \qquad (6+14)$$

UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics **TIME ALLOWED: 3 hrs.**
PAPER: XIII (opt-iv) [Advance Electronics] **MAX. MARKS: 100**

NOTE: Attempt any FIVE questions, All questions carry equal marks.

Q1 a): What is an op-amp? Give its characteristics and also describe its use as an integrator. [14]

b): Define the offset errors in current and voltages of an op-amp. [6]

Q2 a): Design a synchronous counter which goes through the following sequence. [14]

```
      111 — 000
     /         \
  101           001
     \         /
      011 __ 010
```

b): Explain designing of full adder circuit using basic logic gates. [6]

Q3 a): Describe the construction and working of Digital clock as an application of synchronous counters. [15]

b): State the difference between Flip flops and Latches. [5]

Q4 a): State Demorgan's laws. [3]

b): Design a logic circuit to implement the operation specified by the truth table given below: [8]

A	B	C	OUTPUT
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

c): Simplify the following expression using K-Map. [9]

$$X = AC\bar{D} + \bar{A}B\,(CD + BC)$$

Q5 a): Design a combination logic circuit to convert BCD to access-3 code. [12]

b): Discuss the construction of various registers [8]

Q6 a): Explain the construction and working of Klystron Amplifier. [15]

b): Discuss the properties of Micro waves [5]

Q7 a): What is the role of Microprocessor in digital Computers? [12]

b): What are the Programmable and logic devices? Explain PAL and PLA. [8]

Q8 a): Explain the formation of ionospheric layers and their effect on radio waves. [10]

b): Describe the difference between FM and AM transmitter block diagram. [10]

Q9: Write short notes on any two of the following [10+10]

a): Microcontroller

b): Modulation and Demodulation.

c): Dual Ramp type Analog-to-Digital Convertor.

UNIVERSITY OF THE PUNJAB

Part-II A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: VII (xviii) Medical Physics/ Radiation Physics

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt any FIVE questions. All questions carry equal marks.

Q1. (a) Describe the Range-Energy relationship of beta rays. How Range-Energy relationship is important for Health Physicists? (8)

(b) State and explain Duane-Hunt law. (8)

(c) Calculate the lower wavelength limit of the X-ray spectrum from a tube with 100 kV across it. (4)

Q2. (a) What do you know about the term Bremsstrahlung? How can you differentiate it from characteristic X-Rays? (10)

(b) What are the absorption mechanisms of X-Rays to other planes? Briefly explain one of these mechanisms. (10)

Q3. (a) What are the contrast agents? How are they useful in conventional radiography and CT? (10)

(b) Are there any harmful effects of using contrast agents? Can we get same results without using them? (10)

Q4. (a) What is a basic principle of nuclear medicine? (10)

(b) How do we make radiopharmaceuticals? Give examples. (10)

Q5. (a) What are image artifacts? What is a reason of getting a ghost image? (10)

(b) What is the probability that an x-ray will interact with iodine-53 rather than soft tissue-7.4? (10)

Q6. (a) What is a difference between conventional and hybrid imaging? Give brief examples. (12)

(b) Write a principle and working of positron emission tomography (PET). (8)

Q7. (a) Define the following terms briefly. (i) Partial Volume effect (ii) Doppler Effect (12)

(b) Write the mechanism of energy loss by Gamma-Rays. (8)

Q8. (a) Explain the working principle and image formation of MRI. (12)

(b) Which is the most important phenomenon in X-Ray imaging i.e. Compton Scattering or Photoelectric Effect and why? (8)

Q9. (a) Write a note on diagnostic ultrasound. (12)

(b) Compare ultrasound imaging with other diagnostic modalities. (8)