UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – II Annual Exam – 2019

Roll No. ....

Subject: Physics **PAPER: I (Solid State Physics-II)** **Time: 3 Hrs.** **Marks: 50**

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

Section 1

Q.1 (a) What are the significances of Hall co-efficient. (3)

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

(c) Plot the distribution of probability ρ in the lattice for ψ^{-2} and ψ^{+2} and for a pure travelling wave. (3)

Q.2 (a) What factors affect the resistivity of metals? (3)

(b) Discuss Kroning Penny model for the motion of an electron in a periodic potential. (9.5)

Q.3 (a) Differentiate between Paramagnetic, Ferromagnetic and diamagnetic materials. (3)

(b) Explain the quantum theory of Paramagnetic susceptibility of a substance in an external magnetic field B, under the following condition. (9.5)

1. B_z is week and temperature is high.
2. B_z is strong and temperature is very low.

P.T.O.

Q.4 (a) What is meant by energy gap and why energy gaps appear due to brag reflection at zone boundary. (5.5)

(b) Define acceptors. Write down two impurities added as acceptors. (2)

(c) State Fermi Dirac distribution function and describe how it is affected by change in temperature. Use graphs to illustrate your answer. (5)

Section – 11

Q.5 (a) Differentiate between direct and indirect band gap materials. How does the optical absorption process differ between them. (4)

(b) Derive an expression for intrinsic carrier concentration in a semiconductor. (6)

(c) Prove that $E_F = E_g/2$ for intrinsic semiconductor. (2.5)

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

(b) How is an abrupt p-n junction formed? Draw schematic diagrams specially showing the relative positions of band edges and Fermi level for a p-n junction in thermal equilibrium. (6)

Q.7 Write notes on the following. (6.5, 6)

(a) Heat capacity of electron gas

(b) Donors and Acceptors

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Subject: Physics **PAPER: II (Statistical Physics)** **Time: 3 Hrs.** **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.No.1 (a) Write down classical and quantum canonical partition function. Derive Seckur-Tetrode formula for a perfect gas by making use of classical canonical partition function.

(6.5)

(b) Define Helmholtz free energy and enthalpy. Find Helmholtz free energy for a perfect gas from classical canonical partition function. Express result in terms of thermal de Broglie wavelength. (3)

(c) The volume of a perfect gas of N atoms is doubled, the energy being held constant. What is the change of entropy? (3)

Q.No.2 (a) Obtain the relation $C_p - C_v = R$ (3)

(b) Show that for a simple harmonic oscillator, the orbit in phase space is an ellipse. Also mention values of semi major and semi minor axes. (3.5)

(c) How can we understand general tendency for the entropy of a closed system to increase? (3)

(d) Give a brief comparison of various ensembles. (3)

Q.No.3 (a) State and prove "Liouville theorem". (6)

(b) For classical statistical mechanics, define entropy of a system in statistical equilibrium. Show that the changes in entropy are independent of the system of units used to measure volume in phase space. (3.5)

(c) What is Stirling Approximation? Use it to show that

$$\log[N!/(N/2)!]=\log(2N/e)^{N/2}$$ (3)

Q.No.4 Write a short note on each of the following: (6.5,6)

(i) Density Matrix **(ii)** Fully generate Fermi-Dirac Gas.

P.T.O.

SECTION-II

Q.No.5 (a) What is meant by Fluctuation? Find an expression of energy fluctuation in a canonical ensemble. (5)

(b) Write down the partition function for a non-degenerate two level system with energies E and -E, then (i) find expression for entropy (ii) evaluate heat capacity at constant volume.

(4.5)

(c) The average kinetic energy of hydrogen atoms in a certain steller atmosphere (assumed to be in thermal equilibrium) is 1 eV. What is temperature of atmosphere in kelvins? (3)

Q.No.6 (a) Discuss Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. Also mention their significance. (6.5)

(b) The thermodynamic entropy of a closed system is given by $S=(1/k_B)CV^{1/4}U^{3/4}$. Use basic definition of temperature to calculate temperature of system. Hence show that Pressure is $p=U/(3V)$. (3)

(c) The partition function of a system is given by $Z=\exp(aT^3V)$, where a is constant. Calculate enetropy and internal energy of system. (3)

Q.No.7 (a) Define Cavity radiation. Derive Planck's radiation law by using Bose-Einstein distribution function. (6)

(b) Derive Stefan-Boltzmann law from Planck's law of radiation. (3.5)

(c) The lowest energy level of O_2 is three fold degenerate. The next level is doubly degenerate and lays 0.97eV above the lowest level. Take the lowest level to have energy of 0. Calculate the partition function at 1000K. (3)

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Subject: Physics **PAPER: III (Relativity & Cosmology)** **Time: 3 Hrs.** **Marks: 50**

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

Section-I

Q1. (a) What is the physical significance of the quantity $c^2t^2 - x^2$ in relativity? Use K-calculus to show that $c^2t^2 - x^2$ is independent of the relative velocity of the particle. [6½]

(b) State postulates of Special Relativity. Use Maxwell equations to prove the postulate of Special Relativity "constancy of speed of light". [6]

Q2. (a) Why we require a light cone instead of whole space-time for the events? Explain the space-like, time-like and light-like intervals. [6½]

(b) A solid sphere of radius a is placed in the rest frame. If it is set into motion with velocity kc, calculate the percentage loss in volume of the sphere as observed by an observer at rest? [6]

Q3. (a) Use the four-momentum conservation to show that the Compton shift in wavelength is given by $\Delta\lambda = \left(\frac{2h}{mc}\right)\sin^2\left(\frac{\theta}{2}\right)$, where θ is angle with the photon is scattered by an electron. [6½]

(b) Use variational principle to derive the equation of geodesic on a manifold. [6]

P.T.O.

Section-II

Q4.(a) Show that the covariant derivative of a contravariant vector field is non-tensorial. Also prove that the definition of affine connection makes the derivative $\nabla_c X^a = \partial_c X^a + \Gamma^a_{bc} X^b$ tensorial. [8]

(b) Find the Christoffel symbols $\Gamma^r_{\varphi\varphi}$ and $\Gamma^t_{\varphi\varphi}$, also find the equations of geodesic corresponding to $\Gamma^r_{\varphi\varphi}$ and $\Gamma^t_{\varphi\varphi}$ for the metric $ds^2 = dt^2 - a^2(t)\left[\frac{1}{1-kr^2}dr^2 + r^2 d\theta^2 + r^2 \sin^2\theta\, d\varphi^2\right]$. [4.5]

Q5.(a) Show that the covariant derivative of a $(0,2)$ tensor is $A_{\mu\nu;\rho} = \partial_\rho A_{\mu\nu} - \Gamma^\sigma_{\mu\rho} A_{\sigma\nu} - \Gamma^\sigma_{\nu\rho} A_{\mu\sigma}$. [6½]

(b) Show that if the metric is diagonal then: $\Gamma^a_{bc} = \frac{\partial}{\partial x^b}\left(\frac{1}{2} \ln g_{aa}\right)$. [6]

Q6. (a) Show that the Ricci scalar is R = 2 for the unit 2-sphere. [4½]

(b) What is the counterpart of gravitational potential in General relativity? Logically explain how Poisson's equation for gravitational potential leads to the Einstein's field equations in General Relativity? [8]

Q7. Write notes on the following: [6½ , 6]

(i) Evidences of Big Bang Theory in General Relativity

(ii) Nucleosynthesis

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Subject: Physics **PAPER: IV (Computational Physics)** **Time: 3 Hrs.** **Marks: 50**

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

Section-I

Q.1	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 to calculate surface area and volume of the sphere using functions such that $A = 4\pi r^2$ and $V = 4/3\,\pi r^3$.	08 ½ +4
Q.2	Write C++ program to evaluate the $\int_1^6 \frac{1}{(2+x)}dx$ by Trapezoidal Rule or by Weddle's Rule. Your program should ask options from the user to select the method for the solution. (Use n=6). Write C++ program which read in a number from the user and prints out table of that number. Implement for 5 iterations	8+4 ½
Q.3.	The temperature values per day for two cities A and B are given in the table. Write program to determine: (i) number of times the temperature of A is less than that of B with day (ii) temp. of B not equal to that of A with day (iii) temp. of A & B > 57 with days (iv) find out the day with two temperatures are very close or apart from each other and (v) find average temperature per day and per week. Day: 1, 2, 3, 4, 5, 6 A: 60, 56.2, 63, 64, 58, 60.2 B: 54.6, 56.2, 64, 60, 59, 60.2 Write C++ program which reads in a value as a value in kilometer and converts that number into meters. Implement your program for 5 iterations with while loop.	7+5 ½

Day	1	2	3	4	5	6
A	60	56.2	63	64	58	60.2
B	54.6	56.2	64	60	59	60.2

Section-II

Q.4. A	Write down the MATLAB syntax with example for: diff(), polyder(), polyval() and expand().	8+04 ½
B	Write a program to generate two vectors a and b and calculate: sum, subtraction and multiplication of a and b.	

P.T.O.

Q.5. (A) (B)	Write general syntax for a user defined function in MATLAB. Write a program to implement a function **circle** to calculate area and circumference of a circle for r such that r is [1 10]. Write a program with function to calculate *f(x)*, given by: $f(x) = 8x^3 - 42x^2 + 5x + 3$. Calculate, print and plot values for x and *f(x)*. Also find out sum, average, minimum of f(x) values for ten different values of x.	6+6 ½
Q.6. (A) (B)	Write a program to show the curves for the half-wave rectifier circuit. How you can change the program to implement full-wave rectifier circuit? Write MATLAB program to calculate and print out factorial of a number taken from the user. Implement your program using function.	8+ 4 ½
Q.7. (A) (B)	Write MATLAB program for the damped harmonic motion (DHM) 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., forced H.M. The necessary equations are as follows: A = (-k x – b v + f_0 cos (wt))/ m, x = x + v h, v = v + a h, t = t + h, Write MATLAB program to plot time (t) against sin(t), 2sin(t) and cos(t) curves on the same graph with different colors. Use t = [0 4π] Where step size =0.5 Note: Plot estimate graph if any.	8+ 4 ½

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Roll No. ....

Subject: Physics **Paper: V (Classical Electrodynamics)** **Time: 3 Hrs.** **Marks: 100**

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

Section-I

Q.1. (a) Show that the electric multipoles are used to approximate the potential of a charge distribution.
(b) By an example of a point charge placed near a conducting plane of infinite extent, demonstrate the advantages of the image-charge method. 12, 8

Q.2. (a) Find the following expression for the electric field outside of a dielectric medium, where σ_p and ρ_p are polarization charge densities:

$$E(r) = \frac{1}{4\pi\epsilon_o}\left[\oint_S \sigma_p \frac{(\boldsymbol{r}-\boldsymbol{r}')}{|\boldsymbol{r}-\boldsymbol{r}'|^3} da' + \int_V \rho_p \frac{(\boldsymbol{r}-\boldsymbol{r}')}{|\boldsymbol{r}-\boldsymbol{r}'|^3} dv'\right]$$

(b) Evaluate expressions for the electric field and polarization for a point charge in a dielectric fluid. Also calculate the total surface polarization charge and the total charge. 10, 10

Q.3. (a) Calculate the electrostatic energy of a charge distribution with volume density ρ, surface density σ. Also assume charge distribution includes conductors.
(b) Derive equation of continuity for charge conservation. 12, 8

Q.4. (a) Discuss Biot-Savart law. Also show that for magnetic induction fields $\nabla \cdot \boldsymbol{B} = 0$ i.e. there are no isolated magnetic poles.
(b) Find magnetic field of a long, straight current carrying wire. 12, 8

Q.5. (a) Calculate magnetic vector potential and magnetic induction due to a distant circuit.
(b) What is magnetic scalar potential? Discuss briefly. 14, 6

P.T.O.

Section-II

Q.6. (a) What is Faraday's law? Derive its integral and differential forms.
(b) Derive the wave equations for H and E in a linear and charge free medium. 10, 10

Q.7. (a) What is skin depth? Show that a plane monochromatic wave propagating in a conducting medium is damped exponentially.
(b) Discuss skin depth for poor and good conductors. 12, 8

Q.8. (a) Discuss electric neutrality in plasma and also find the expression for Debye's shielding distance.
(b) What are plasma oscillations? Show that plasma frequency is given by $\omega_p = (e^2 n_o/\epsilon_o m_e)^{1/2}$. 10, 10

Q.9. Discuss only two topics.
(a) Magnetic mirror
(b) Zonal harmonics
(c) Covarient form of the EM equations
(d) Polarization of EM waves 10, 10

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Roll No. ....

Subject: Physics **PAPER: VI (Nuclear Physics)** **Time: 3 Hrs.** **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: $(8 + 12 + 5 = 25)$

(a): What is magnetic dipole moment? Establish a relation for nuclear magneton.

(b): For a nucleus of charge number, Z, and mass number, A, write down its semi-empirical mass formula and identify its different terms. Explain how it can be used to predict the isobar which does not undergo beta decay. This isobar will have the least mass of all possible isobars. Can evenness or oddness of "A" affect this prediction?

(c): Using the prediction established above, find the most stable isobar for $A = 100$.

Question 2: $(12 + 8 + 5 = 25)$

(a): Discuss the working of Cyclotron. Why it cannot accelerate particles to very high energies (> 25 MeV)? How do we overcome this problem in Synchrocyclotron?

(b): How does a fast moving electron lose energy while passing through matter? Compare it with a heavy charged particle passing through the same material.

(c): Explain the Dead Time of a gas counter.

Section II

Question 3: $(15 + 10 = 25)$

(a): Calculate the differential decay probability ($d\lambda$) for the beta decay in terms of momentum distributions P_e of beta particles as

$$d\lambda = \frac{G^2 M_{fi}^2}{2\pi^3 \hbar^7 c^4} P_e^2 (E_0 - E_e)^2 dp_e$$

using the Fermi theory of beta decay. Where G and M_{fi}^2 are the constants. Providing that $\rho(E_0)$ as the number of momentum states per unit energy at $E = E_0$ of final state for some assumed volume V and E_e is the end point energy in beta decay.

(b): In gamma decay process, describe the multipole radiations on the basis of angular momentum carried off by gamma ray photons and also by using the parity selection rule explain the electric and magnetic multipole radiations.

Question 4: $(10 + 10 + 5 = 25)$

(a): Describe the various types of potentials, suggested to understand the strong interaction among the nucleons inside the nucleus and explain, does the strong nuclear force depend upon charge? Also explain, what do you understand about the singlet and triplet states of one proton and one neutron system?

(b): What are the basic assumptions of shell model and collective model? Define the magic number nuclei, explain how the shell model is applied to understand the nuclear energy levels inside nucleus and magic numbers under the spin-orbit angular momentums interaction of nucleons?

(c): Describe any two outcomes of each model: liquid drop model, shell model and collective model.

P.T.O.

Section III

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

(a): State the salient features of direct reactions and compound nuclear reactions in detail.

(b): How a beam of deutrons can be produced to be used as a projectile in deutron-induced reactions? Explain $(d, p), (d, n)$ and (d, α) reactions in detail with the help of examples.

(c): Calculate the Q-value and threshold energy for the following reaction

$$He^4 + N^{14} \longrightarrow O^{17} + P$$

where He^4 is alpha particle and P is proton providing with masses $M(He^4) = 4.003873$ a.m.u, $M(N^{14}) = 14.007518$ a.m.u, $M(O^{17}) = 17.004529$ a.m.u and $M(P) = 1.008144$ a.m.u.

Question 6: $(12 + 13 = 25)$

(a): In neutron slow down process, the scattering of fast neutrons from the atoms of moderator is observed in Laboratory frame (L-frame) and Center of mass frame (C-frame). Let θ and ϕ are scattering angles of neutron after collision to the original direction of neutron in L-fram and C-fram respectively. Then show that the ratio of neutron energy E after collision to initial energy E_0 measured in C-fram can be expressed in terms of ϕ as

$$\frac{E}{E_0} = \frac{1+r}{2} + \frac{1-r}{2} cos\phi$$

with $r = (\frac{A-1}{A+1})^2$ and $A = \frac{M}{m}$ where M and m are the masses of moderator atoms and neutron respectively. Also show that which material can be used as best moderator made of light element or heavy element at $\phi = 180$.

(b): Describe in detail the practical problems involved in the construction of a controlled nuclear fusion reactor. Which type of fusion reactions is more favorable to be used in such reactors and why?

Question 7: $(12 + 8 + 5 = 25)$

(a): In a fission process a compound nucleus splits into intermediate nuclei with release of energy, discuss in detail mass and energy distribution of the fission products when fission is induced by thermal and fast neutrons.

(b): Explain in detail how many neutrons are emitted in a fission event and why? Also differentiate between prompt and delayed neutrons.

(c): Consider a gas of ^{10}B atoms undergoing fusion. Calculate the temperature required to overcome the coulomb barrier and the fusion energy released.

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Subject: Physics **PAPER: VII (Solid State Physics-I)** **Time: 3 Hrs.** **Marks: 100**

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

Q.1.(a) Derive Hartree Fock equation using variational principles, for independent electrons and apply to free electron gas to find the expression for energy. (10+6)

(b) What is Born Oppen Heimer approximation? Describe briefly how the dynamics of electrons and ions in solids can be decoupled, based on this approximation. (2+7)

Q.2.(a) What do you understand by the phenomenon of superconductivity? Give few examples. How do you differentiate between Types I and II materials? Explain very comprehensively the intermediate state in type I and vortex state in type II materials. (2+5+4+4)

(b) Describe comprehensively what is coherence length in superconductors? What do you understand by the energy gap in superconductors with regards to BCS theory? (5+5)

Q.3.(a) What is the phenomenon of ferroelectricity? Discuss briefly. Describe comprehensively the classes of ferroelectrics known as Rochelle salt and Perovskites. (3+5+5)

(b) Describe second order phase transition of ferroelectrics in context of Landau theory of Phase transition, and evaluate the susceptibility above and below the transition temperature. (6+6)

Q.4.(a) What is an Exciton? Describe the difference between Wannier Mott and Frenkel excitons with help of diagram. Consider a ID chain of atoms and evaluate the Eigen energy of Frenkel excitons. (5+8)

P.T.O.

(b) Evaluate comprehensively the energy loss of fast particles, such as photons and electrons, in solids. (12)

Q.5.(a) Describe comprehensively the phenomenon of Normal tunneling/single particle tunneling for a superconducting junction with help of schematic diagrams. (10)

(b) Discuss in detail thermodynamics of superconductors with regards to free energy, entropy and specific heat. (5+5+5)

Q.6.(a) Describe the concept of Pseudo potentials. Discuss in detail Orthogonalised plane wave method with regards to energy band structures in solids. (7+8)

(b) What is the muffin tin potential? Evaluate the Eigen energy expression for electrons using Augmented plane wave method. (2+8)

Q.7. Write notes on any two of the following: (12½ +12½)

a) Polarization catastrophe in ferroelectrics

b) Meissner Effect

c) Tight binding approximation

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Roll No. ....

Subject: Physics **Paper: VIII (Solid State Physics-II)** **Time: 3 Hrs.** **Marks: 100**

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

Q.1 (a) Derive Curie-Weiss law and differentiate it from Curie's law.
(b) How does the saturation magnetization vary with temperature and at absolute zero? **(5+20)**

Q.2 (a) Find the dispersion relation for the quantized spin waves
(b) Show that thermal excitation of magnons leads to Bloch $T^{3/2}$ law. **(12.5+12.5)**

Q.3 (a) Deduce Madelung energy term from the total lattice energy of an ionic crystal.
(b) Show that the measured Hall resistance becomes quantized at extremely low temperatures and high magnetic fields. **(12.5+12.5)**

Q.4 (a) How does the ferromagnetic resonance frequency depends upon the specimen shape?
(b) Find the expression for the total (domain) Bloch wall energy per unit area. **(12.5+12.5)**

Q.5 (a) Why magnetic moment of a metal oscillates with the applied magnetic field?
(b) Derive Bloch equation of motions and differentiate transverse and longitudinal relaxation times. **(12.5+12.5)**

Q.6 (a) Explain the technique that employs the diffraction phenomenon to reveal the magnetic structure of antiferromagnets.
(b) Differentiate chemical and magnetic unit cell and show that magnetic susceptibility below Neel temperature (T_N) exhibits anisotropy. **(12.5+12.5)**

Q.7 Elaborate any two of the followings:
(a) De-Haas Van Alphen effect
(b) Quantization of free electron orbits
(c) Debye model of specific heat **(12.5+12.5)**

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Subject: Physics **Paper: IX / VIII-1 (Particle Physics-I)** **Time: 3 Hrs.** **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: $(12 + 8 + 5 = 25)$

(a): Give the classification of all types of particles and elementary particles with examples. Also mention the types of interactions in which they participate.

(b): What are quarks? Explain the quark model. Also give two factors which do not support the existence of quarks.

(c): Keeping in view the conservation laws, choose appropriate type of neutrino/antineutrino in the following processes:

(i) $\mu^+ \to e^+ + 2\nu$

(ii) $n + e^+ \to p + \nu$

(iii) $\nu + p \to \mu^+ + n$

(iv) $\pi^+ \to \mu^+ + \nu$

(v) $\tau^- \to \mu^- + 2\nu$

Question 2: $(8 + 7 + 10 = 25)$

(a): How do you differentiate between leptonic, semileptonic and hadronic weak processes? Give one representative example for each case and draw the corresponding Feynman diagrams.

(b): Discuss the variation of strong coupling constant as a function of distance or energy of interacting particles. Also explain phenomena of asymptotic freedom and quark confinement.

(c): Give the ranges, force carriers, relative strengths and typical lifetimes for decays of strong, weak and electromagnetic interactions. Draw the primitive vertices for quarks and leptons and also give one representative example for each interaction.

Section II

Question 3: $(10 + 10 + 5 = 25)$

(a): Considering the capture of negative pions into deuterium explain in detail how its intrinsic parity was measured?

(b): Using Isospin symmetry prove the following result.

$$\frac{\Gamma(\Delta^+ \to p\pi^0)}{\Gamma(\Delta^+ \to n\pi^+)} = 2$$

(c): Write down the relation for π^+ decay and draw the corresponding Feynman diagram. Also comment on which type of process is this?

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

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

(b): Show that the four Maxwell equations are equivalent to the following field equation:

$$\Box A^\mu - \partial^\mu(\partial_\nu A^\nu) = j^\mu$$

(c): Show that homogeneity of space leads to the conservation of linear momentum.

P.T.O.

Section III

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

(a): Discuss in detail Dirac Hole theory and Feynman Stuckelberg interpretation to explain the negative energy solutions.

(b): The covariant form of the transition amplitude, T_{fi}, from an initial state i to final state f is given by

$$T_{fi} = -i \int dx^4 \phi_f^*(x) V(x) \phi_i(x)$$

use this expression to derive Fermi's Golden rule.

(c): Show that $[H_D, L_x] \neq 0$

Question 6: (10 + 12 + 3 = 25)

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

(b): Solve the Dirac equation and interpret all its four solutions.

(c): Show that $(\sigma^{\mu\nu})^\dagger = \gamma^0 \sigma^{\mu\nu} \gamma^0$.

Question 7: (15 + 10 = 25)

(a) Prove that the following Dirac bilinears

$$\bar{\psi}\psi, \quad \bar{\psi}\gamma^5\psi, \quad \bar{\psi}\gamma^\mu\psi, \quad \bar{\psi}\gamma^\mu\gamma^5\psi, \quad \bar{\psi}\sigma^{\mu\nu}\psi$$

are scalar, pseudo-scalar, vector, axial vector and tensor of rank 2, respectively.

(b): Write down the Dirac equation for a non-relativistic e^- of velocity v, and show that the u_A components of Dirac spinor are larger than u_B by a factor of order v/c.

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Roll No. ....

Subject: Physics **Paper: X / VIII-2 (Particle Physics-II)** **Time: 3 Hrs.** **Marks: 100**

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

Section I

Q1. Show that for a scattering process

$$\frac{d\sigma}{d\Omega} = |f(\theta, \phi)|^2 \qquad (20)$$

Q2. Discuss parital wave analysis and obtain the expression for $f(\theta, \phi)$

(20)

Q3. What is the difference between s, t, u channel processes. For the scattering process $1 + 2 \to 3 + 4$, show that

$$s + t + u = \sum_{i=1}^{4} m_i^2 \qquad (20)$$

Section II

Q4. Write down the matrix expression of the generators λ_i $(i = 1, 2, \cdots, 8)$ of the group $SU(3)$ .By solving the commutator, show that $f_{123} = 1$.

(20)

P.T.O.

Q5. For an electron moving in an electromagnetic field derive the expression for the transition amplitude T_{fi} and transition current j^{μ}_{fi}. Show that

$$j^{\mu}_{fi} = -e\bar{\Psi}_f\gamma^{\mu}\Psi_i \qquad (20)$$

Q6. For the case of spinless electron muon scattering, show that for very high energy ($\alpha = \frac{e^2}{4\pi}$, and θ is the scattering angle)

$$\left.\frac{d\sigma}{d\Omega}\right|_{CM} = \frac{\alpha^2}{4s}\left(\frac{3+\cos\theta}{1-\cos\theta}\right)^2 \qquad (20)$$

Section III

Q7. Draw Feynman diagram for the process $e^-\mu^- \to e^-\mu^-$. Label the diagram and write down the invariant amplitude for the process. Show that

$$|\mathfrak{M}|^2 = 2e^4\frac{s^2+u^2}{t^2} \qquad (20)$$

Q8. What are propagators? Derive the expressions for the propagators of Schrodinger particle, spinless particle and for electron.

(20)

Q9. Prove the following

1. i. $\mathrm{Tr}(\not{a}\not{b}\not{c}) = 0$

   ii. $\mathrm{Tr}(\gamma_5) = 0$

   iii. $\gamma_\mu\not{a}\gamma^\mu = -2\not{a}$

   iv. $\mathrm{Tr}(\gamma_5\not{a}\not{b}\not{c}\not{d}) = 4i\varepsilon_{\mu\nu\lambda\sigma}a^\mu b^\nu c^\lambda d^\sigma$, (where $\varepsilon_{\mu\nu\lambda\sigma}$ is an anti symmetric tensor)

(5+5+5+5)

UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – II Annual Exam – 2019

Roll No. ....

Subject: Physics **Paper: XIII (opt-iv) / IX-1 [Advance Electronics]** **Time: 3 Hrs.** **Marks: 100**

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

Q.1. a). Discuss the designing of differential operational amplifier and discuss its main features. (12,8)

b). Determine V_{OUT} for inverting amplifier, If R_F =7 KΩ, R_i =2KΩ and V_{in}= 25 mV

Q.2. Design and Draw the circuits of RS, D, JK, T and Master slave flip flops by using truth tables and timing diagram. (20)

Q.3. Describe the construction, working and characteristics of the Magnetron tube. (20)

Q.4. a). Design 16 to 4 line encoder by using combinational logic circuits. (10,10)

b). What is the basic difference between combinational and sequential circuits? Give circuit analysis of both techniques.

Q.5. a). Differentiate between clock and pulse. Design 4-bit Asynchronous counter. (10,10)

b). How shift registers works? Design 5 bit ring counter.

P.T.O.

Q.6. a). What is the term modulation? Draw the radio broadcasting receiver. (10,10)

b). What are superhetrodyne receivers? Discuss its working .

Q.7. a). Discuss the main features of Radio Communication? How Radar system works. (10,10)

b). Design R-2R ladder by using operational amplifier.

Q.8. a). What is the difference between CPLD and SPLD? Differential between PAL and PLA logics.(10,10)

b). What is the basic role of Execution unit and Bus Interface unit in microprocessor?

Q.9. Write the note any two of the following. (10,10)

i). Microprocessor system.

ii). Solar cell vs Photo conductor.

iii). UJT basic sweep circuit.