UNIVERSITY OF THE PUNJAB

Roll No. .....

M.A./M.Sc. Part – II Annual Examination – 2020

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 – I

Q.1. a) Write down an expression for the Fermi Dirac distribution function and describe the probability of occupation of state 'E' in the following cases using graphs to illustrate your answer.

i. T=0K , $E > E_F$

ii. T>0K , $E < E_F$

iii. T<0K , $E = E_F$ (6.5)

b) Discuss the motion of free electron in magnetic field. (6)

Q.2. a) Derive wave equation for electron under periodic potential and find the solution of this equation for a wave vector exactly at zone boundary. (6.5)

b) What factors affect the resistivity of electrical materials? (3)

c) What are the draw backs of classical theory in the calculation of heat capacity of electron? (3)

Q.3. a) Give quantitative explanation of energy gap formation under periodic potential. (6.5)

b) What is bloch function? What does it represent physically? (3)

c) What are the significances of Hall coefficient? (3)

Q.4. a) What are the principal sources of the magnetic moment of a free atom? (6.5)

b) Derive Langevin's expression for the paramagnetic susceptibility of a material and relate it to Curie Law. (6)

SECTION – II

Q.5. a) Distinguish between intrinsic and extrinsic semiconductors and show that intrinsic carrier concentration depends on temperature and energy gap. (6.5)

b) Differentiate between direct and indirect band gap materials. (3)

c) Differentiate between donors and acceptors. (3)

Q.6. a) How is $P - N$ junction formed? (3)

b) Derive expressions for the built in potential and the depletion width of an $P - N$ in thermal equilibrium. What is the effect of doping on the depletion width? (9.5)

Q.7. **Writes notes on the following.**

a) Effective mass of electron. (6)

b) Hall Effect. (6.5)

UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – II Annual Examination – 2020

Roll No. .....

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)** Find an expression for entropy of perfect gas using grand canonical partition function in classical statistical mechanics. (5.5)

(b) Derive Fermi-Dirac distribution function. (4)

(c) Briefly discuss three types of statistical ensembles. (3)

Q.No.2 **(a)** State and explain (3)

(i) zeroth law of thermodynamics (ii) Third law of thermodynamics

(b) Write down significance of canonical partition function. Find expressions for internal energy and Helmholtz free energy in terms of Canoniacal partition function for a canonical ensemble. (3.5)

(c) Define intensive and extensive variables. Give examples. (3)

(d) Describe the following terms:

(i) Phase space (ii) Ergodic Hypothesis (iii) Chemical potential (3)

Q.No.3 **(a)** Describe heat capacity of diatomic gases and crystals classically and quantum mechanically in detail. (6.5)

(b) Define entropy in classical statistical mechanics. Show that change in entropy is independent of the system of units used. (3)

(c) Also Show that $C_p = C_v + R$ (3)

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

(i) Bose-Einstein Condensation **(ii)** Liouville theorem

SECTION-II

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

(b) Define density matrix. Write down its properties. (4.5)

(c) What is the difference between mixed state and pure state? Also describe Von Neumann equation and its significance. (3)

Q.No.6 **(a)** Describe classical and quantum statistics. Which particles obey these statistics? Mention behaviour of quantum statistics at high temperatures. (6)

(b) Explain the behaviour of conduction electrons in metal on the basis of Fermi-Dirac distribution function. (3.5)

(c) State and explain Pauli Exclusion Principle. Write down its significance (3)

Q.No.7 **(a)** Define black body radiation. Draw energy distribution curves for black body radiation. Also derive Planck's radiation law. (6)

(b) Deduce Rayleigh-Jeans law from Planck's law of radiation. (3)

(c) Show that intensity emitted by a black body is directly proportional to fourth power of its absolute temperature. (3.5)

UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – II Annual Examination – 2020

Roll No. .....

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

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

Section – I

Q.1. (a) Find Lorentz transformation laws for the components of velocity and acceleration.[4]

(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) in a Minkowski space (t,x,y,z) **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 not invariant under Galilean transformations but is invariant under a special Lorentz transformation. [8 ½]

Q.2. (a) Explain how events are causally connected in Minkowski space and hence state the principle of causality. [6]

(b) In a frame S, two events occur at the origin and a distance X along the $x-$axis simultaneously at $t=0$. The time interval between the events in S' is T. Show that the spatial distance between the events in S' is $(X^2+Y^2)^{1/2}$ and determine the relative velocity v of the frames in terms of X and T. [6 ½]

Q.3. (a) Show that in Minkowski space: $v^\mu=(\gamma c,\gamma \underline{v})$ **and** $p^\mu=\left(\frac{E}{c},\underline{p}\right)$. By considering the invariant quantity $p^\mu p_\mu$, **show that** $E^2=c^2p^2+m_o^2c^4$. Also show that the components of 4-force are $F^\mu=(\gamma \underline{v}\cdot\underline{F},\ \gamma\underline{F})$. [6 ½]

(b) A particle of rest mass m_Λ decays into a proton of rest mass m_p and a negatively charged π-meson of rest mass m_π . Assuming that the particle Λ is at rest at the time of decay. Calculate the total energy of the proton and the pion. [6]

Section – II

Q.4. (a) What is a metric? Transform $ds^2 = dx^2 + dy^2 + dz^2$ into cylindrical coordinates using a metric. [7½]

(b) Show that the Christoffell symbols $\Gamma^{\lambda}_{\mu\nu}$ does not follow the coordinate transformation law of a $(1,2)$ tensor. [5]

Q.5. (a) What is a geodesic on a manifold? Use the principle of variation to derive the equation of geodesic on a manifold. [8 ½]

(b) If $\Gamma^{\mu}_{\nu\lambda} = 0$ at point p, then show that: $R^{\mu}_{[\nu\sigma\rho]} = 0$, where $R^{\mu}_{\nu\sigma\rho}$ is Riemann Tensor. [4]

Q6. (a) If $G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R$ is the Einstein tensor. Show that the contraction of the Bianchi identity implies $\nabla_\mu G^{\mu}_{\nu} = 0$. [4½]

(b) Use the fact that Einstein field tensor has zero divergence; derive Einstein field equations in General Relativity. [8]

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

(i) Metric tensor (ii) Hubble's law

UNIVERSITY OF THE PUNJAB

Roll No. .....

M.A./M.Sc. Part – II Annual Examination – 2020

Time: 3 Hrs. Marks: 50

Subject: Physics Paper: IV (Computational Physics)

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

Section – I

Q.1. (a)	Write a C++ program for the decay of current in a simple RL-circuit using Euler's method with initial conditions: r=10Ω, L=5H, initial time 0, time step 0.1, maximum time 2.5sec., initial current 5A and voltage v=0 volts. Print current against time values. How you can convert the same program for the growth of current in the circuit?	8 ½+4
(b)	Write C++ program to calculate momentum and kinetic energy of the particle using functions such that **P = mv** and **K.E= 1/2 mv²**.	
Q.2. (a)	Write C++ program to evaluate the $\int_1^6 \frac{1}{(x^2+1)^2} dx$ by Simpson Rule or by Weddle's Rule. Your program should ask options from the user to select the method for the solution. (Use n=6).	8+4 ½
(b)	Write C++ program to print the series and sum of the series: $S = \sum_{n=1}^{10} x^n$ Ask user to input value of x.	
Q.3. (a)	Suppose **A** and **B** be **3x3** matrices. Write C++ program which reads in entries of A & B and calculate (i) **C = (10A)^t - B,** (ii) **D= A x B** (iii) square of the elements of matrix **C** (iv) average of the diagonal elements of matrix **D**.	8+4 ½
(b)	Write C++ program which reads in a value as binary number and converts that number into decimal. Implement your program for 20 iterations.	

Section – II

Q.4. (a)	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/s², initial position zero and velocity 15 m/s, time step 0.1 sec. and maximum time 10 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. The necessary equations are as follows: a = (-k x – b v + f_0 cos (ωt))/ m, x = x + v h, v = v + a h, t = t + h	8 +4½
(b)	Write MATLAB to plot '**x**' against **f(x)** values using supbplot such that: **x** = [0 4π], **y(x)** = n***sin**(**x**), and n=1,2,3,4	
Q.5. (a)	The temperature measurement of containers A and B is given in the table. Write MATLAB program to determine: (i) number of times the temperature of A is greater than B with day (ii) number of times the temperature of B is equal to A with day (iii) number of times the temp. of A & B >28 with days	6+6 ½

Day	1	2	3	4	5
A	30	29	25.3	38.5	40
B	33	31	25.3	24	21

(b)	Write down the MATLAB syntax with example for: prod(), sum(), sort() and disp()	

P.T.O

Q.6. (a)	What are random numbers? Write syntax for random number generation in MATLAB. Write MATLAB program to plot graph for a particle describing Brownian motion. Also calculate total and average distances traced by the particle. Draw approximate output graph with proper labels.	8+ 4 ½
(b)	Write MATLAB program to determine corresponding force values for the work and distance values as give in the table. Also calculate total force, minimum distance and average work values.	

W (work)	50.3	27	69.4	81
D (distance)	11	14	23	46

Q.7. (a)	Create matrix D in MATLAB such that $D=\begin{bmatrix} 5 & 4 & 3 & 2 & 1 \\ 8 & 7 & 5 & 3 & 1 \\ 1 & 4 & 7 & 10 & 13 \\ 15 & 13 & 9 & 3 & 2 \\ 25 & 18 & 11 & 9 & 4 \end{bmatrix}$ (i) Write **v1** equals 5^{th} column of D. (ii) Find location of value 13 in **v1**, (iii) create a linear vector **k** containing all elements of D. (iv) create **v2** equals 3^{rd} row of D. (v) determine u= **v1** . **v2** (vi) plot 3^{rd} column against 1^{st} row of D (vii) select and sort in ascending order the 4^{th} and 5^{th} rows of D. (viii) select a 3x3 middle matrix as **m** out of D.	8+4 ½
(b)	Write MATLAB program code segment: a) to generate and plot complex numbers b) to find roots of a polynomial: $9x^3 + 5x^2 - 14x + 213$	

UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – II Annual Examination – 2020

Roll No. .....

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

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

Q.1. (a) What is Gauss's law? Write its integral and differential forms for a continuous distribution of charge ρ. *(10 Marks)*

(b) Two spherical conducting shells of radii r_a and r_b are arranged concentrically and charged to the potentials φ_a and $\varphi_b$respectively. If $r_b > r_a$, find the potential at points between the shells and at points $r > r_b$. *(10 Marks)*

Q.2. (a) Describe briefly Poisson's and Laplace's equations. *(4 Marks)*

(b) Briefly explain method of electrostatic images. Find potential for conducting sphere in a uniform electric field using zonal harmonics *(16 Marks)*

Q.3. (a) State Ampere's Circuital law? *(3 Marks)*

(b) Discuss the boundary conditions for electric field $\boldsymbol{E}$ and displacement vector $\boldsymbol{D}$ for two dielectric media with different properties. *(7 Marks)*

(c) A coaxial cable of circular cross section has a compound dielectric. The inner conductor has an outside radius 'a' which is surrounded by a dielectric sheath of dielectric constant K_1 and of outer radius 'b'. Next comes another dielectric sheath of dielectric constant K_2 and of outer radius 'c'. The outer conducting shell has an inner radius 'c'. If a potential difference $\Delta\varphi$ is imposed between the conductors, calculate the polarization at each point in the two dielectric media. *(10 Marks)*

Q.4. Show that the magnetic induction due to magnetized distribution of matter may be expressed as

$$\boldsymbol{B}(\boldsymbol{r}) = \mu_o \boldsymbol{M}(\boldsymbol{r}) - \mu_o \nabla \varphi^*(\boldsymbol{r})$$

where $\boldsymbol{M}(\boldsymbol{r})$ is the magnetization and $\varphi^*(\boldsymbol{r})$ is the magnetic scalar potential. *(20 Marks)*

[Use identities: $\nabla \times (\boldsymbol{F} \times \boldsymbol{G}) = (\nabla \cdot \boldsymbol{G})\boldsymbol{F} - (\nabla \cdot \boldsymbol{F})\boldsymbol{G} + (\boldsymbol{G} \cdot \nabla)\boldsymbol{F} - (\boldsymbol{F} \cdot \nabla)\boldsymbol{G}$

$\nabla(\boldsymbol{F} \cdot \boldsymbol{G}) = (\boldsymbol{F} \cdot \nabla)\boldsymbol{G} + \boldsymbol{F} \times (\nabla \times \boldsymbol{G}) + (\boldsymbol{G} \cdot \nabla)\boldsymbol{F} + \boldsymbol{G} \times (\nabla \times \boldsymbol{F})$]

P.T.O

Q.5. (a) Derive integral and differential forms of Faraday's law of electromagnetic induction. *(4 Marks)*

(b)Prove that the conservation of energy in a fixed volume may be expressed by the following relation *(16 Marks)*

$$-\int_v \boldsymbol{J}\cdot\boldsymbol{E}\,dV = \frac{d}{dt}\int_v \frac{1}{2}(\boldsymbol{E}\cdot\boldsymbol{D}+\boldsymbol{B}\cdot\boldsymbol{H})\,dV + \oint_s \boldsymbol{E}\times\boldsymbol{H}\cdot\boldsymbol{n}da$$

Q.6. (a) What is the magnetization current? Show that the magnetization current density $\boldsymbol{J_M}$ is the curl of the magnetization $\boldsymbol{M}$. *(10 Marks)*

(b) How does Maxwell corrected Ampere's law? Discuss in detail. *(10 Marks)*

Q.7. (a) Calculate reflectance and transmittance for the EM plane wave incident normally on an interface between two non-conducting media. *(17 Marks)*

(b) If conductivity of fine silver is $g = 3\times10^7 S/m$ at frequency of 10^{10} hertz. Calculate skin depth. *(3 Marks)*

Q.8. (a) what is Debye shielding in plasma physics. How is debye length calculated *(10 Marks)*

(b) What does a uniform magnetic field (B) and electric field (E) do to a charged particle in a plasma? *(10 Marks)*

Q.9. Discuss only two topics from the following: *(10+10 Marks)*

(a) Equation of continuity (b) Pinch effect (c) linear and circular polarizations (d) Lorentz gauge and the coulomb gauge

UNIVERSITY OF THE PUNJAB

Roll No. .....

M.A./M.Sc. Part – II Annual Examination – 2020

Time: 3 Hrs. Marks: 100

Subject: Physics Paper: VI (Nuclear Physics)

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

Q.1. (a) What is the parity of a electric and magnetic multipole moment operators? Show that multipole moments operators with odd parity have zero expectation value. [08]

(b) Use empirical mass formula to compute the charge number Z_0 for a given mass number (A) which will minimize the nuclear mass and hence maximize the nuclear binding energy. If A is even what effect it would have on the possibilities of Z_0? [12]

(c) The radius R of a nucleus with mass number A changes like $R \propto A^{1/3}$. How could one justify this behavior of the nuclear radius R? [05]

Q.2. (a) What are the possible ways of energy loss for a fast charged particle while passing through matter? [05]

(b) Explain the working principles of a semi-conductor detector. What are the similarities between a semi-conductor detector and a gas detector? [10]

(c) Explain the structure and working principle of a betatron? What are its limitations? [10]

SECTION – II

Q.3. (a) Give three evidences of nuclear shell structure in analogy with the atomic shell structure. [06]

(b) How could we choose a suitable form of the potential for nuclear shell model? Why do we need to include spin-orbit potential and how does it cause rearrangement of nuclear levels? Show that energy splitting increases with increasing the orbital angular momentum. [13]

(c) According to shell model the nuclear orbitals upto shell completion number 28 in increasing order of energy are $1s_{1/2}1p_{3/2}1p_{1/2}1d_{5/2}2s_{1/2}1d_{3/2}1f_{7/2}$. Give the expected shell model spin and parity assignments of

i. $^{11}_{5}B$;

ii. $^{17}_{8}O$;

iii. $^{41}_{20}Ca$. [06]

Q.4. (a) A unit decrease in positive charge of a nucleus may occur either through β^+ emission or an electron capture process. Use Q-value expressions for the two cases to show that if electron capture is energetically allowed process for a nucleus the β^+ may still be energetically unfavorable. [08]

(b) Why do we have a continuous energy distribution of electrons (positrons) emitted in a β decay? Use allowed approximation to derive an expression for the decay rate such that it can explain the energy spectrum of the particles emitted in β decay. [10]

(c) In the process $^{47}_{20}Ca \rightarrow {}^{47}_{21}Sc + e^- + \bar{\nu}$, what energy is given to $\bar{\nu}$ when the electron has kinetic energy of 1.100 MeV? $[m(^{47}_{20}Ca) = 46.954543\text{u},\ m(^{47}_{21}Sc) = 46.952409\text{u}]$. [07]

P.T.O

SECTION – III

Q.5. (a) What is reaction cross-section? How does it differ with geometrical cross-section? [08]

(b) What are resonance reactions? If reaction cross-section for a given orbital angular momentum l is given by

$$\sigma_{sc} = \frac{4\pi}{k^2}(2l+1)\sin^2\delta_l(E),$$

where δ_l the phase shift corresponding to l, show that when energy E is close to the resonance energy E_R the cross-section can be written as

$$\sigma_{sc} = \frac{\pi}{k^2}(2l+1)\frac{\Gamma^2}{(E-E_R)^2+\Gamma^2/4},$$

where width of resonance peak Γ is given by $E - E_R = \pm \Gamma/2$. Give the physical interpretation of this expression. [10]

(c) The Q value for reaction ^{9}Be(p; d)^{8}Be is 559.5 ± 0.4 keV. Find mass of ^{8}Be. [$m(p)$ = 1.007825 u, m(d) = 2.014102 u, $m(^9\text{Be})$ = 9.012182 u] [7]

Q.6. (a) Why do nuclei undergo fission? Can nuclei fission spontaneously? What would be the energy gain if ^{238}U is broken down to two fragments with equal number of nucleons? [10]

(b) Consider the fission reaction $^{235}U + n \rightarrow ^{236}U^* \rightarrow ^{93}_{37}Rb + ^{141}_{55}Cs + 2n$.. The Q value of the reaction is 181 MeV. Assuming that neutrons are taking negligible amount of energy compute the kinetic energies of $^{93}_{37}Rb$ and $^{141}_{55}Cs$. [$m(^{93}_{37}Rb) = 92.92172\text{u}$, $m(^{141}_{55}Cs) = 140.91949\text{u}$] [08]

(c) Given that the activation energy of ^{236}U is 6.2MeV , what is the minimum energy α particle that can produce fission following bombardment of a ^{232}Th? [07]

Q.7. (a) The sun is a natural thermonuclear reactor where protons are combined to get helium nuclei. Explain the CNO cycle in the solar fusion. [09]

(b) Consider the fusion reaction $^{20}_{10}Ne + ^{20}_{10}Ne \rightarrow ^{40}_{20}Ca$. What is the height of the coulomb barrier which needs to be penetrated for the fusion. If one wants to make this reaction occur thermally what is the required temperature? [08]

(c) Consider the fusion reaction $^2H + ^3H \rightarrow ^4He + n$. Is this reaction energetically possible? If so, what percentage of the available energy (Q value) is taken by the neutron? [m(n) = 1.0086649 u, m(^{4}He) = 4.002603 u, m(^{3}He) = 3.016029 u, m(^{2}H) = 2.014102 u]. [08]

UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – II Annual Examination – 2020

Roll No. .....

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) What is Hartree approximation? Derive both Hartree and Hartree Fock equations using variational principle and explain the difference in the outcome i.e., exchange energy. **(2+5+10)**

(b) The difference in the masses of electron and proton can lead to simplify the full crystal Hamiltonian. Describe comprehensively how Born Oppen Heimer approximation split the crystal Hamiltonian into two parts, one for electrons and the other for nuclei. **(8)**

Q.2. (a) What do you understand by the phenomenon of superconductivity? How do you differentiate between Types I and II superconducting materials? Describe heat capacity for a type I material comprehensively and what information does it give for the energy of electrons in superconducting state? **(2+5+8)**

(b) Describe comprehensively the phenomenon of flux quantization in a superconducting ring and evaluate the expression for fluxoids. **(10)**

Q.3. (a) Explain comprehensively the phenomenon of ferroelectricity? Discuss briefly the classes of ferroelectrics known as KDP and Perovskites. **(3+5+5)**

(b) Describe second order phase transition of ferroelectrics in context of Landau theory of phase transition, and discuss the free energy variations. Also, 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. Why Wannier Mott exciton is also called a free exciton? Using hydrogen atom model, describe the binding energy of the Wannier Mott excitons. **(5+8)**

(b) Derive two Kramers- Kronig relations for a linear passive system of harmonic oscillators with regards to real and imaginary components of a response function. **(12)**

Q.5. (a) Describe comprehensively the phenomenon of superconducting quantum interference for a superconducting junction. **(10)**

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

Q.6. (a) Discuss in detail Orthogonalised plane wave (OPW) method with regards to energy band structures in solids and explain why Pseudopotential is weak as compared to the true crystal potential. **(10+3)**

(b) What is tight binding approximation? Evaluate the eigen energy of electrons using nearest neighbour interactions following tight binding approximation. **(2+10)**

Q.7. Write notes on any two of the following **(12 ½, 12 ½)**

a. Local field approximation and evaluation
b. AC Josephson effect in superconductors
c. Frenkel Excitons

UNIVERSITY OF THE PUNJAB

Roll No. .....

M.A./M.Sc. Part – II Annual Examination – 2020

Time: 3 Hrs. Marks: 100

Subject: Physics Paper: VIII (Solid State Physics-II) (Opt.)

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

Q.1 (a) Derive dispersion relation for Magnons in a ferromagnet in one dimension with nearest – neighbor interactions.
(b) Show that thermal excitation of Magnons leads to **Bloch $T^{3/2}$ law.** **(13+12)**

Q.2 (a) Discuss important parameters, which can elaborate the optical properties of semiconductors.
(b) Discuss Debye model of specific heat. **(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) What is superparamagnetism? Discuss ferrimagnetic order in iron garnets and magnetite.
(b) Derive a dispersion relation for the antiferromagnetic magnons. **(12.5+12.5)**

Q.5 (a) How does the electron-electron interactions increase mean free path in metals.
(b) Find an expression for the antiferromagnetic resonance frequency of a uniaxial antiferromagnet. **(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 Write note on any two of the followings:
(a) De Haas – Van Alphen Effect
(b) Geomagnetism and Biomagnetism
(c) Electron Paramagnetic Resonance **(12.5+12.5)**

UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – II Annual Examination – 2020

Roll No. .....

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 + 10 +3 = 25)**

(a) Discuss the quantum numbers associated with elementary particles. Give the corresponding conservation laws. Give at least one example in support of each conservation law.

(b) What led to the origin of idea of strong nuclear force? Explain Yukawa's theory of the strong force and describe various properties of the quantum associated to it.

(c) Assign the isospin quantum numbers to nucleonic doublet and pionic triplet.

Question 2: **(8 + 9 + 8 = 25)**

(a) What are quarks? Why we cannot observe a free quark? How can we relate this fact to the non-linear behavior of the strong coupling constant?

(b) What do you mean by strangeness-changing weak interactions? Explain them with the help of examples. How theory of weak interactions can be modified in order to account such processes.

(c) What is Quark Model? How can we have so many hadrons with only three quarks.

SECTION – II

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

(a) Consider the reaction: $\pi^- + d \rightarrow n + n$ to determine the intrinsic parity of pion π^-.

(b) For a spin-1/2 particle, the state vector is defined by$|s,m_s>$. Using the eigen value equations for operators S^2 and S_z, find the matrix representation for the possible state vectors and operators S^2, S_x, S_y, S_z.

(c) Use Maxwell equations to derive the continuity equation.

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

(a): The propagation of electromagnetic waves in free space modify the field equation as

$$^2A^\mu = 0$$

Use this equation to discuss polarization states of photon.

(b) Define G-symmetry operation and G parity. Show that G-parity of all three pions is -1.

(c) Show that conservation of linear momentum is a consequence of homogeneity of space.

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) Derive the Dirac equation in the covariant form. Also derive the adjoint form of the Dirac equation.

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

(a) Show that if we assume the Dirac particle to be spinless then for that particle angular momentum is not conserved.

(b) Derive the completeness relations for Dirac spinors.

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

Question 7: **(10 + 10 + 5 = 25)**

(a) Derive the continuity equation using Dirac equation and show that probability density can never be negative for it.

(b) Show that in the ultrarelativistic limit, an eigenstate of a helicity operator will also become eigenstate of the chirality operator and vice versa.

(c) Show that $(\sigma \cdot p)^2 = |p|^2$

UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – II Annual Examination – 2020

Roll No. .....

ject: 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

Q.1. Discuss partial wave analysis in detail and obtain the expression for differential scattering crossection. (20)

Q.2. Briefly explain the Born Approximation for scattering cross section. (20)

Q.3. Define and explain mandelstam variables in detail. Show that for identical particle scattering, their sum is equal to four times m^2, where m is the mass of particles. (20)

SECTION – II

Q.4. Discuss Quark model in detail. (20)

Q.5. Find the transition amplitude and transition current for a spinless electron moving in an electromagnetic field. Define Fermi-Golden Rule. (20)

Q.6. For the case of electron electron scattering, obtain the invariant amplitude and also obtain the expression for differential scattering crossection in center of mass frame. (20)

SECTION – III

Q.7. Draw Feynman diagrams for the process $e^-e^- \rightarrow e^-e^-$. Label the diagram and write down the invariant amplitude for the process. find the value of $|\mathfrak{M}|^2$ in terms of s, t, u. (20)

Q.8. A spinless electron can interact with A^μ only via its charge; the coupling involves $(P_i + P_f)^\mu$. Show that

$$\bar{u}_f \gamma^\mu u_i = \frac{1}{2m} \bar{u}_f \left[(P_i + P_f)^\mu + i\sigma^{\mu\nu} (P_f - P_i)_\nu \right] u_i$$ (20)

(5+5+5+5)

Q.9. Prove the following:

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

ii. $\mathrm{Tr}(\gamma^k) = 0,\ k = 1, 2, 3$

iii. $\gamma_\mu \gamma^\alpha \gamma^\beta \gamma^\mu = 4g^{\alpha\beta}$

iv. $\mathrm{Tr}(\gamma^\mu \gamma^\nu \gamma^\alpha \gamma^\beta) = 4\left[g^{\mu\nu} g^{\alpha\beta} - g^{\mu\alpha} g^{\nu\beta} + g^{\mu\beta} g^{\nu\alpha}\right]$

UNIVERSITY OF THE PUNJAB

M.A./M.Sc. Part – II Annual Examination – 2020

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. Draw the internal structure of an operational amplifier. Also discuss the single ended and double ended mode of operation in detail. (5,15)

Q.2. Describe the construction, working and characteristics of the magnetron tube. (20)

Q.3. What is the latch? Draw the circuit of active low latch. Also design the JK, T and Master slave flip flops by using discrete components. (5,15)

Q.4. What are shift registers? Describe the working of shift register. Also design 4-bit PIPO, PISO and SIPO shift registers. (5, 15)

Q.5. a. Design the MOD 10 synchronous counter. (10)

b. Design 5-bit Johnson counter. (10)

Q.6. a. What is parity? How an error can be check if parity bit is even for 4- bit system? (10)

b. Draw the combinational logic circuit for Grey to binary code converter. (10)

Q.7. a. What is meant by modulation? How FM, AM and PM are differ with each other? (1,9)

b. Design and discuss the main features of super heterodyne receivers. (10)

Q.8. a. Differentiate between DRAM and SRAM memory cell structure. (5,5)

b. Draw the tree analysis of RAM family and discuss its features. (10)

Q.9. a. What is the basic role of Execution unit and Bus interface in microprocessor? (10)

b. Differentiate the main features of microprocessor and microcontrollers. (5,5)

Q.10. Write the note any **TWO** of the followings. (10, 10)

a. PLDs
b. RADAR system
c. Microwave