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M.A./M.Sc. Part – II Supply – 2020 & Annual – 2021

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.

Q.1.

a. Explain the quantum free-electron model of metals in terms of Pauli's exclusion principle (6)

b. Metallic silver is an excellent conductor. It has 5.86×10^{26} conduction electrons per cubic meter. (i) Calculate its Fermi energy. (ii) Compare this energy to the thermal energy K_BT of the electrons at a room temperature of 300K. (4.5)

c. What is the cause of failure of free electron theory? (2)

Q.2.

a. Calculate the heat capacity of the electron gas by using Fermi Dirac distribution. Explain why experimental results do not agree with the results obtained by using classical statistics. (6)

b. Explain Fermi Dirac distribution function. Show that Fermi curve at room temperature shows a little change from that at 0K. (6.5)

Q.3.

a. What is the reason and origin of the energy band formation in solids? (6.5)

b. In a solid, consider the energy level lying 0.01eV below fermi level. What was is the probability of this level not being occupied by an electron. (3)

c. What do you mean by Bloch theorem and state its significance in Physics? (3)

Q.4.

a. Differentiate between paramagnetic, ferromagnetic and diamagnetic materials (3)

b. Describe the quantum theory of paramagnetic susceptibility of a substance in an external magnetic field B_z under the following conditions. (9.5)

i. B_z is week and temperature is high

ii. B_z is very strong and temperature is very low

Section-II

Q.5.

a. How the carrier concentration in intrinsic semiconductor varies as a function of temperature? (6.5)

b. What is the primary difference between an n-type and a p-type semiconductor? (2)

c. Prove that Fermi level lies in the middle of the forbidden gap in case of intrinsic semiconductors. (4)

Q.6.

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

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

Q.7. Write notes on the following:

a. Effective Mass (6.5)

b. Electrical resistivity of metals (6)

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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)** Define Phase, Mu (μ), and Gamma (Γ) space for N-particle systems. Describe the density distribution in Phase space in detail. **(3, 5)**
(b) Explain the Ensemble average for a set of N-points and for a set of systems. **(4.5)**

Q. No. 2: **(a)** Prove that time rate of change of density of a fluid (P) along the flow line is zero. **(7)**
(b) By considering an ideal gas of N-non-interacting particles enclosed in a cubical box, illustrate the use of a micro- cannonical ensemble in order to calculate the energy of the system. **(5.5)**

Q. No. 3: **(a)** Describe the Entropy in Statistical mechanics explicitly. **(7.5)**
(b) If the volume of a perfect gas of N-atoms is doubled, while keeping energy constant. Then, what will be the change in entropy.? **(5)**

Q. No. 4: **(a)** Write a detail note on the principle of equipartition of energy for mono- and diatomic gases along with its discrepancies. **(8.5)**
(b) Explain the thermodynamic functions for cannonical ensemble. **(4)**

SECTION-II

Q. No. 5: **(a)** Discuss briefly the thermal wavelength by considering three different cases in quantum statistics. **(7.5)**
(b) State and prove the Fermi-Distribution law, which provides average no. of particles in a state j. **(5)**

Q. No. 6: **(a)** Drive a relation for Bose-Einstein statistics and discuss it at a finite temperature. **(7.5)**
(b) Write a note on the Bose-Einstein condensation. **(5)**

Q. No. 7: **(a)** By using Plank's law of radiation, prove the Stephen-Boltzman law categorically. **(7)**
(b) State and Explain the Pauli Exclusion Principle along with significance. **(5.5)**

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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) Show that the wave equation $\nabla^2 u - \frac{1}{c^2}\frac{\partial^2 u}{\partial t^2} = 0$ is invariant under the Lorentz transformation but not invariant under Galilean transformations. [9½]

(b) Differentiate between proper and improper Lorentz transformations. [3]

Q2. (a) Find Lorentz transformation laws for the components of velocity and acceleration. [7 ½]

(b) Two inertial frames S and S' are moving with velocity v relative to each other. A particle as observed by an observer in S' describes a circle:

$$x'^2 + y'^2 = a^2 , \qquad z' = 0$$

with constant speed. Show that as observed from S, the particle describes an ellipse. Find the center of the ellipse and draw it for S. [5]

Q3. (a) Find the components of four force and four momentum. [6 ½]

(b) Starting from the orthogonality of four force and four velocity, show that the total energy of a particle is the sum of its kinetic energy and the rest mass energy. [6]

Section-II

Q4. (a) Show that the covariant derivative of a contravariant vector field X^a is

$$\nabla_c X^a = \partial_c X^a + \Gamma^a_{bc} X^b$$ [7½]

(b) If $T_{\alpha\beta\gamma\delta}$ is a tensor of rank 4, then show that

$$T_{\alpha[[\beta\gamma]\delta]} = T_{\alpha[\beta\gamma\delta]}$$ [5]

Q5. (a) Show that the divergence of Ricci tensor is non-zero but divergence of Einstein tensor is zero. [8½]

(b) Using equation of geodesic, describe the spacetime in the following cases:

(i) Motion with gravity

(ii) Motion without gravity [4]

Q6. (a) What is gravitational red shift? Derive the quantitative relation showing that it depends upon gravitational acceleration. [6 ½]

(b) Discuss the cosmic microwave background. [6]

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

(i) Principle of Equivalence (ii) Friedmann's model

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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.~~ (A)	Write C^{++} program which reads in a number as decimal number and convert it into a binary equivalent number or as binary number and convert it into a decimal equivalent number due to option 1 or 2. Implement your program for 4 iterations.	8 ½+4
(B)	Write C^{++} program to calculate electric field ($E=Kq/r^2$) at certain point due to charge; ask user to input values of charge and corresponding distance; $K= 9x10^9$ $Nm^2.C^{-2}$. Implement for five iterations.	
Q.2. (A)	Write C^{++} program to evaluate the $\int_1^6 \frac{\sqrt{x}+4}{11}\,dx$ by trapezoidal rule. (Use n=6).	7+5 ½
(B)	Write C^{++} program to print the following series and sum of the series: $S = \sum_{n=1}^{20} \frac{x^{n/4}}{4}$ Ask user to input value of x.	
Q.3. (A)	Find the roots of the equation $3x - \cos x - 1$ using Newton Raphson method using xo = 0.5. Write C^{++} program to implement the method (i) correct to 2dp. (ii) How can you change same program to implement the method correct to 3dp?	8+4 ½
(B)	Write C^{++} program to calculate time period of simple pendulum ($T=2\pi\sqrt{\frac{l}{g}}$) using functions. Ask user to input value of l.	
	Section-II	
Q.4. (A)	Write MATLAB program to print time against the growth of Current and the decay of current values on a single graph in the RL-circuit using Euler's Method with initial conditions: r=10Ω, L=5H,	8 +4½

P.T.O

	initial time 0sec, time step 0.1sec, maximum time 2.5sec., initial current 0A and voltage v=4 volts. Also plot point of intersection of two curves. Draw estimate graphs with proper labels. How you can get the coordinates of the interaction point?	
(B)	Write MATLAB to plot '**x**' against **f(x)** values using supbplot such that: **x = [0 4π], y(x) = sin(n*x)** and n=1,2,3,4	
Q.5. (A)	Suppose **A** and **B** be **3x3** matrices. Write MATLAB program which reads in entries of the matrices and calculate (i) **C=10A–5B,** (ii) **D=3Ax4B** (iii) sum and average of the matrix **C and D** elements	6½+6
(B)	Write down the MATLAB syntax with example for: polyder(), polyint(), and polyval().	
Q.6. (A)	Write general syntax for user define function in MATLAB. Write a program to implement to calculate volume of a sphere of radius r, such that r = [5 15]; [Hint: $V=\frac{4}{3}\pi r^3$]	6+ 6 ½
(B)	Write MATLAB program to solve the system of linear algebraic equations using following methods: (i) Left division method. (ii) Cramer rule. (iii) Matrix inverse method. $3x + 2y - 4z = 6$ $-3x - 4y + 3z = -20$ $9x + 6y + 2z = 12$	
Q.7. (A)	A parallel plate capacitor is constructed from two or more parallel conducting plates such that its capacitance C can be computed from the formula $C = (n-1)\,\varepsilon\, A / d$ Where n is number of plates, $\varepsilon = 8.85 \times 10^{-12}$ farad/meter is dielectric constant, $A = 15\ cm^2$ is the area of each plate separated by distance d = 2 mm. Write MATLAB program to construct a table to print number of plates against capacitance values for a maximum of 5 plates.	8+4 ½
(B)	Write MATLAB program using arrays for conversions of (i) temperature from Celsius to Kelvin where **Kelvin = Celsius + 273.15** (ii) length from Meter to Yards where **1meter=1.0936 yards**	

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

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

Q.1. (a) State Gauss's law in dielectrics. How do you calculate total charge, volume and surface charge densities for a point charge in a dielectric fluid. *(13 Marks)*

(b) Two dielectric media with dielectric constants K_1 and K_2 are separated by a plane Interface. There is no external charge on the interface. Find a relationship between θ_1 and θ_2, where these are the angles that an arbitrary line of displacement makes with normal to the interface. *(7 Marks)*

Q.2. (a) Show that torque on a complete circuit, for uniform magnetic field, is given by $\tau = IA \times B$, where $m = IA$ is the magnetic dipole moment of the circuit. *(10 Marks)*

(b) When the conducting system is suddenly isolated from applied electric fields, explain how the equilibrium state is approached exponentially. *(10 Marks)*

Q.3. (a) Describe briefly method of images. *(4 Mark)*

(b) Calculate electrostatic energy of an arbitrary distribution of charge. *(16 Marks)*

Q.4. Find the following expression of potential for the conducting sphere in a uniform electric field:

$$\varphi(r,\theta) = -E_o r\cos\theta + E_o(a^3/r^2)\cos\theta \qquad \textit{(20 Marks)}$$

Q.5. (a) what do you understand by "magnetic susceptibility" and "permeability". *(4 Marks)*

(b) What is significance of Lorentz and coulomb gauges? By imposing the Lorentz condition, show that scalar and vector potentials satisfy the inhomogeneous wave equations of similar forms. *(16 Marks)*

Q.6. (a) What is magnetization current density J_M? Also prove that $J_M = \nabla \times M$ where M is the Magnetization. *(12 Marks)*

(b) If a current density J in a wire of circular cross section with radius R is proportional to the distance from the axis. Find an expression for the total current in the wire. *(8 Marks)*

Q.7. (a) Define Phase velocity and group velocity. *(3 Marks)*

(b) What is skin depth and its significance? Calculate the skin depth in the case of plane monochromatic waves travelling through a conducting media. *(17 Marks)*

Q.8. (a) What is difference between neutral gas and a plasma? *(4 Marks)*

(b) What does a uniform magnetic field (B) do to a charged particle in a plasma? *(16 Marks)*

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

(a) Faraday's law (b) Magnetic mirror (c) linear and circular polarizations (d) Ohm's law and conductivity

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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

1. (a) The empirical binding energy for a nucleus with Z protons and A total number of nucleons is given by

$$B = a_v A - a_s A^{2/3} - a_c Z(Z-1)A^{-1/3} - a_{sym}\frac{(A-2Z)^2}{A} + \delta,$$

where pairing energy is

$$\begin{aligned} \delta &= +a_p A^{-3/4} && \text{even } Z \text{ \& even } N, \\ &= -a_p A^{-3/4} && \text{odd } Z \text{ \& odd } N, \\ &= 0 && \text{odd } A. \end{aligned}$$

One suitable choice gives a_v =15.5 MeV, a_s =16.8 MeV, a_c =0.72 MeV, a_{sym} =23 MeV, and a_p =34 MeV. Use this relation to get empirical mass of the nucleus. How many protons in a nucleus with mass number A give most tightly bound structure? [10]

(b) What is nuclear binding energy? Use the semiempirical formula to compute the total binding energy and the binding energy per nucleon for (a) ^{7}Li; (b) ^{20}Ne; (c) ^{56}Fe; (d) ^{235}U. What percentage of the binding energy is a contribution from pairing energy? [10]

(c) What physical information do we get from the magnetic dipole moment of a neutron. [05]

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

(b) In a scintillation detector why do we need a scintillator which is blind to its own radiation? How could we accomplish this? [10]

(c) What is the basic difference between a cyclotron and synchrocyclotron? [05]

SECTION – II

3. (a) What evidences do we have for the shell structure of nuclei? Propose a reasonable potential function for shell model and justify it. Why do we need spin-orbit interaction to get the observed shell closure numbers? [10]

(b) Show that spin-orbit splitting for an orbital is directly proportional to its orbital angular momentum. [08]

(c) Give the expected shell-model spin and parity assignments for the ground states of (a) $^{7}_{3}Li$; (b) $^{11}_{5}B$; (c) $^{15}_{6}C$; (d) $^{17}_{9}F$; (e) $^{31}_{15}P$. [07]

4. (a) 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]

(b) The decay of $^{253}Es(I = \frac{7}{2}, \pi = +)$ leads to a sequence of negative-parity states in ^{249}Bk with $I = \frac{3}{2}, \frac{5}{2}, \frac{7}{2}, \frac{9}{2}, \frac{11}{2}, \frac{13}{2}$. For each state, find the permitted values of l_α. [10]

P.T.O

(c) Let's consider the decay of a nucleus of mass M at rest, from an initial excited state E_i to a final state E_f. What would be the energy of the photon emitted in this transition? [05]

SECTION – III

5. (a) What is compound nucleus theory for nuclear reactions? Explain with one example. How do compound nucleus reactions differ with direct nuclear reactions? [10]

   (b) It is desired to study the low-lying excited states of ^{35}Cl (1.219, 1.763, 2.646, 2.694, 3.003, 3.163 MeV) through the $^{32}S(\alpha, p)$ reaction. With incident α particles of 5.000 MeV, which of these excited states can be reached? [$m(^{35}Cl) = 32573.5565\text{MeV}/c^2$, $m(^{32}S) = 29783.7583\text{MeV}/c^2$, $m(\alpha) = 3727.409\text{MeV}/c^2$, $m_p = 938.280\text{MeV}/c^2$]. [10]

   (c) What are the physical meanings of reaction cross section? [05]

6. (a) Why do heavy nuclei release large amount of energy in fission? Use liquid drop model to find the condition for spontaneous fission of a nucleus. [10]

   (b) How much energy would be released if a ^{238}U nucleus is split into two equal mass fragments? Why do the fission fragments undergo several β-decay steps to transform into a stable nucleus? [10]

   (c) In ^{239}Pu, the thermal fission cross section is 742 b, while the cross section for other (nonfission) absorptive processes is 267 b. Each fission produces, on the average, 2.86 fast neutrons. What is the mean number of fission neutrons produced by ^{239}Pu per thermal neutron? [05]

7. (a) Why does fusion of light nuclei results in large energy release? [05]

   (b) The sun is a natural thermonuclear reactor where protons are combined to get helium nuclei. Explain the proton-proton cycle in the solar fusion. [10]

   (c) Consider the fusion reaction $^{12}_{6}C + ^{12}_{6}C \rightarrow {}^{24}_{12}Mg$.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? [10]

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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) Based on the concept of free electron gas, show that the electrical conductivity of a metal is $Ne^2 \tau / m$. (10)

(b) Show that the reciprocal lattice of a body centered lattice is a face centered lattice. (10)

(c) X-ray of wavelength 1.1 Å is found to be Bragg reflected from the (100) and (110) planes of a simple cubic structure. If the lattice parameter of the crystal is 3 Å, find the angles for first order diffraction from these planes. (5)

Q. 2 (a) State Block Theorem and obtain the energy spectrum of an electron in a one-dimensional periodic potential. Show that in the limiting case of vanishing potential barrier leads to the results obtained in a free electron model. (12)

(b) What is Meisener effect in superconductors ? Enumerate the properties of type I and type II superconductors. (8)

(c) The magnetic field in silicon is 1.2×10^5 Am^{-1}. Calculate the magnetization and flux density in silicon, if its magnetic susceptibility is -4.2×10^{-6}. Also calculate the value of relative permeability of the material. (5)

Q. 3 (a)Explain about exciton. Differentiate between Wannier Mott and Frenkel excitions with the help of diagram. Consider a ID chain of atoms and evaluate the Eigen energy of Frenkel excitions. (12)

(b) Explain in detail about the phenomenon of normal tunneling/singe particle tunneling for a super conducting junction with the help of schematic diagram. (8)

(c) A superconducting sample has a critical temperature of 4.1 K in zero magnetic field and critical field of 0. 0505 T at 0 K. Find the critical field at 2 K. (5)

Q. 4 (a) Discuss about Hartee approximation. Derive both Hartee and Haretee Fock equations using variational principle. (12)

(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. (13)

Q. 5 (a) Explain in detail about orthogonalized plane wave (OPW) method with respect to free energy entropy and specific heat. (13)

(b) Discuss about tight binding approximation and evaluate the eigen energy of electron using nearest neighbour interactions by following tight binding approximation. (12)

Q. 6 Explain about following: (5 x 5)

i. Maxwell equations
ii. Raman effects in crystals
iii. Soft optical phonons
iv. Ferroelectricity
v. Landau theory of the phase transition

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

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

Q.1 (a) What is Nuclear Magnetic Resonance (NMR)? Describe its applications.
(b) How does the motional narrowing effect affect NMR line-width?
(c) Show that at a fixed frequency, the nuclear spin resonance line in a metal and in a diamagnetic solid appears at different magnetic fields. **(5+10+10)**

Q.2 (a) Derive Curie-Weiss law. How would you differentiate it from Curie's law?
(b) Show that magnetic susceptibility is anisotropic with respect to the spin axis of an antiferromagnetic.
(c) What is neutron magnetic diffraction? Give details. **(5+10+10)**

Q.3 (a) Give a basic principle and construction of magnetic force microscopy (MFM).
(b) Discuss ferrimagnetic order in iron garnets and magnetite.
(c) Show that temperature dependent magnetization due to quantized spin waves leads to the Bloch $T^{3/2}$ law. **(5+10+10)**

Q.4 (a) Describe classical model for specific heat. Give experimental facts about its failure.
(b) Discuss Einstein model of specific heat for different temperature ranges.
(c) What are ferromagnetic domains? Explain their origin? **(5+12+8)**

Q.5 (a) How does the nuclear quadrupole resonance occur without any static magnetic field?
(b) Deduce Madelung energy term from the total lattice energy of an ionic crystal.
(c) Give details about the microscopic theory of frequency dependent dielectric constant. **(5+12+8)**

Q.6 (a) Discuss three level Maser system.
(b) Derive an expression for total magnetic susceptibility of a Pauli paramagnet.
(c) Explain the importance of the screening of electron-phonon interaction. **(5+10+10)**

Q.7 Write explanatory notes on any TWO of the following. **(25)**
(b) Optical properties of semiconductors
(b) De Haas-Van Alphen effect
(c) The quantum Hall effect

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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: $(12 + 7 + 6 = 25)$

(a): Make a table for the charge (Q), strangeness (s) and isospin (I_3) for the three quarks up, down and strange. Use these values to find the values of Q, s and I_3 of different states of delta (Δ) particle, proton (p), omega (Ω^-) and different states of pion (π). Also write down quark content of these hadrons.

(b): The time evolution of a state vector is formally written as

$$|\psi(t)>= U(t,t_o)|\psi(t_o)>$$

Using time dependent Schrodinger equation show that $U(t,t_o) = \exp[-iH(t-t_o)/\bar{h}]$.

(c): How is it possible that same combination of quarks can go to make a no of different hadrons. Explain it with the help of examples.

Question 2: $(12 + 13 = 25)$

(a): 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.

(b): Describe the phenomena of vacuum polarization. How the vacuum polarization implies the variation of coupling of electromagnetic, weak and strong interaction with distance or energy of the interacting particles. Explain the phenomena of asymptotic freedom.

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

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

(b): What is parity? How does the experimental fact that "all neutrinos are left-handed and all anti-neutrinos are right-handed" implies parity must not be conserved in a weak interaction?

(c): Draw the Feynman diagram showing mechanism of β-decay.

SECTION – III

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

(a): Derive the following completeness relations for Dirac spinors

$$\sum_{s=1,2} u^{(s)}(p)\bar{u}^{(s)}(p) = \not{p} + m$$
$$\sum_{s=1,2} v^{(s)}(p)\bar{v}^{(s)}(p) = \not{p} - m$$

(b): Working in the Dirac-Pauli representation of γ matrices show that

$$\gamma^5 u^{(s)} \simeq \begin{pmatrix} \sigma \cdot \hat{\mathrm{p}} & 0 \\ 0 & \sigma \cdot \hat{\mathrm{p}} \end{pmatrix} u^{(s)}$$

where $u^{(s)}$ is the electron spinor. How would you interpret this result?

(c): Show that $\not{p}\not{p} = p^2$ (where p is 4-momentum and $\not{p} = \gamma^\mu p_\mu$)

Question 6: $(20 + 5 = 25)$

(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): Show that $[\sigma^{\alpha\beta}, \gamma^\mu] = 2\,i(\gamma^\alpha g^{\beta\mu} - \gamma^\beta g^{\mu\alpha})$

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

(a): Modify Dirac equation for massless fermions.

(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?

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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. (a) Define differential scattering cross section and discuss the factors on which it depends.

(b) Write down the expression for the differential cross section for a general scattering process and obtain total cross section. (8 + 12)

Q2. Define Mandelstam variables. Show that for electron-positron scattering in s-channel in center of mass frame

$$s = 4(K^2 + m^2)$$

$$t = -2K^2(1 - \cos\theta)$$

$$u = -2K^2(1 + \cos\theta)$$

Where θ is the center of mass scattering angle and $K = |K_i| = |K_f|$ where K_i and K_f are the momenta of incident & scattered electron. (20)

Q3. State and prove optical theorem for scattering theory. (20)

SECTION – II

Q4. Discuss standard model of Quarks in detail. Explain its significance in particle physics. (20)

Q5. Find the transition amplitude and transition current for a spinless electron moving in an electromagnetic field. Define Fermi – Golden Rule. (20)

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

i. $Tr(\not{a}\not{b}) = 4\,a.b$
ii. $Tr(\gamma_5 \not{a}\not{b}) = 0$
iii. $Tr(\gamma_5) = 0$
iv. $Tr(\gamma^k) = 0$,k = 1,2,3 (20)

Q8. Show that for a Dirac particle

$$\overline{U_f}\,\gamma^\mu U_i = \frac{1}{2m}\overline{U_f}\left[(P_i + P_f)^\mu + i\sigma^{\mu\nu}(P_f - P_i)_\nu\right]U_i$$

Where, $\sigma^{\mu\nu} = \frac{i}{2}(\gamma^\mu\gamma^\nu - \gamma^\nu\gamma^\mu)$ (20)

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

(b) Show that for $e^- e^+$ at very high energies.

$$\sigma = \frac{4\pi\alpha^2}{3s}$$ (8+12)

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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). Define ideal characteristics of OP-Amp. Give the details of Differential mode of operation of Operational amplifier. (10,10)

b). Design the inverting and non inverting mode of operational amplifier.

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

Q 3).Differentiate between latch and flip flop. Discuss the designing features of RS Latch and RS Flip flop. Also draw the truth table and timing diagrams. (5,15)

Q 4 .a). How RADAR system works? Write down detail features of RADAR system.(10,10)

b).Define the measurement methodology to measure Microwave power of a system.

Q 5.a). Design 4-bit Asynchronous counter. Also draw the truth table and timing diagram. (10,10)

b).Differentiate between sequential and combinational circuit by giving suitable example.

Q 6.a). Draw the 4-bit table of binary to grey code conversion. Also explain the method of conversion.(10,10)

b).Design and explain the working of 4 to 16 line decoder.

Q 7.a). Draw the tree diagram of RAM and ROM Family and explain the key features. (10,10)

b).How error detection and error correction techniques works in digital system.

Q 8.a). Define the key role of execution unit in microprocessor . (10,10)

b). What is memory cell? How a memory cell can be addressed by its location?.

Q 9. Write down the note any two of the followings.

a. Master Slave Flip Flop
b. Quantum effect Devices
c. LASER Diode