REV-01
MSP/10/15

2024/05

SET A

M.Sc. PHYSICS
FOURTH SEMESTER
HIGH ENERGY PHYSICS II
MSP - 402A
[USE OMR FOR OBJECTIVE PART]

Duration: 3 hrs. **Full Marks: 70**

(Objective)

Time: 30 min. **Marks: 20**

Choose the correct answer from the following: ***1X20=20***

1. Which of the following phenomena is a direct consequence of the quantization of the electromagnetic field in QED? A) B) C) D)
   a. Photoelectric effect
   b. Exchange of Z0 boson between weakly interacting leptons
   c. Compton scattering of photons by electrons
   d. Hawking radiation from black holes

2. In Bhabha scattering, what happens?
   a. An electron and a positron annihilate each other
   b. A photon is absorbed by an electron, raising its energy level.
   c. An electron scatters off a positron, exchanging a virtual photon.
   d. A neutrino collides with an electron, producing a W boson.

3. What is the typical energy range of electrons used in Mott scattering experiments?
   a. Several keV to MeV
   b. Several MeV to GeV
   c. Several GeV to TeV
   d. Several TeV to PeV

4. According to Feynman rules for QED, which of the following represents the vertex factor for electron-photon interaction? A) $ieγμieγμ$ B) $igγμigγμ$ C) $-ieγμ-ieγμ$ D) $-igγμ-igγμ$
   a. $ieγ^μ$
   b. $igγ^μ$
   c. $-ieγ^μ$
   d. $-igγ^μ$

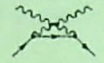
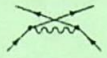
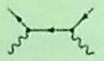
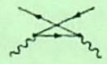
5. Which of the following represent a spin half incoming anti-fermion?
   a. 
   b. 
   c. 
   d. 

6. What is the Feynman rule for the electron propagator in QED?
   a. $\frac{i}{p^2 - m^2 + i\epsilon}$
   b. $\frac{-i}{p^2 - m^2 + i\epsilon}$
   c. $\frac{i}{p^2 + m^2 - i\epsilon}$
   d. $\frac{-i}{p^2 + m^2 - i\epsilon}$

7. If $f_i(x)$ denotes the parton momentum distribution then the value of $\sum_i \int x\, f_i(x) dx$ is (where, i is the sum over all the charged and uncharged partons)
   a. 0
   b. 1
   c. 1/2
   d. 3

8. Which of the following phenomena is a consequence of color confinement?
   a. Existence of color-neutral hadrons
   b. Production of isolated quarks in collisions
   c. Dominance of strong nuclear force over electromagnetic force
   d. Rapid decay of protons

9. Which of the following represents the Callan-Gross relation of proton structure function
   a. $2xF_1(x) = F_2(x)$
   b. $2xF_1(x) = -F_2(x)$
   c. $F_1(x) = F_2(x)$
   d. $F_1(x) = 2xF_2(x)$

10. Which of the following Feynman diagrams represents Moller scattering?
   a. 
   b. 
   c. 
   d. 

11. In deep inelastic scattering (DIS), what is the primary role of the virtual photon exchanged between the incident lepton and the target hadron?
   a. Induce electromagnetic interactions between the lepton and hadron
   b. Probe the internal structure of the target hadron by scattering off its constituents
   c. Transmit the weak force interactions between the lepton and hadron
   d. Generate color charge interactions within the hadron's quarks and gluons

12. If the Lagrangian (L) carries unit of energy, and the Lagrangian density ($\mathcal{L}$) carries dimension as
   a. $\sqrt{ML}/T$
   b. $ML^{-1}T^{-2}$
   c. ML^2T^{-2}
   d. $L^{-3/2}$

13. The Grand Unified Theory unifies
   a. only strong and electromagnetic force
   b. only electromagnetic and weak force
   c. only strong, electromagnetic and weak force
   d. all strong, electromagnetic, weak and gravitational force

14. Which of the following particles is not influenced by magnetic fields and can travel in straight lines across the universe?
   a. Cosmic rays
   b. Neutrinos
   c. Electrons
   d. Photons

15. What is the primary source of galactic cosmic rays?
   a. Black holes
   b. Solar flares
   c. Supernovae
   d. Planetary nebulae

16. Which of the following is not a characteristic of neutrinos?
    a. They interact weakly with matter
    b. They have a non-zero rest mass
    c. They have a half-integer spin
    d. They travel at the speed of light

17. What is the most abundant type of neutrino produced in the Sun's core?
    a. Electron neutrino
    b. Muon neutrino
    c. Tau neutrino
    d. Sterile neutrino

18. Which of the following particles make up the majority of cosmic rays?
    a. Protons
    b. Electrons
    c. Neutrons
    d. Alpha particles

19. Which of the following is not a type of cosmic ray detector?
    a. Cloud chamber
    b. Scintillation counter
    c. Bubble chamber
    d. Chromatography column

20. Where the highest concentration of cosmic rays is typically found on Earth?
    a. Near mountain peaks
    b. Directly above the equator
    c. At sea level
    d. Near the poles

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Descriptive

Time : 2 hrs. 30 min. Marks : 50

[Answer question no.1 & any four (4) from the rest]

1. a. Outline the key components involved in constructing Feynman diagrams for Quantum Electrodynamics (QED). **5+1+1+3=10**

   b. Discuss the primary sources of cosmic rays in the universe. What astrophysical processes are responsible for accelerating particles to cosmic-ray energies? Describe the composition of primary cosmic rays, including the types of particles and their relative abundances

2. Derive the differential cross-section for the QED process involving elastic electromagnetic interaction between an electron and a muon. What is the specific name of this interaction? **10**

3. **a.** Draw the lowest-order Feynman diagram and hence evaluate the corresponding scattering amplitudes for the following processes: **8+2=10**
   (i) Bhaba scattering
   (ii) Compton scattering
   (iii) Pair production
   (iv) Moller Scattering

   b. Describe briefly the concept of asymptotic freedom in QCD and its significance in the behavior of quarks and gluons within the nucleus.

4. Explain the process and essential parameters of deep inelastic scattering (DIS) within the framework of QCD, incorporating an illustrative diagram. **10**

5. Show that scaling violations of structure functions in Quantum Chromodynamics (QCD) lead to the Alterelli-Parisi equation. Explain the physical interpretation of the equation. **7+3=10**

6. **a.** Explain the concept of spontaneous symmetry breaking in the context of the Higg's mechanism. How does this relate to the electroweak symmetry breaking? **6+2+2 =10**

   b. Who were the key contributors of electroweak unification process? Whst was their breakthrough discovery?

   c. List four prominent theories or models that extend the Standard Model of particle physics.

7. **a.** Discuss energy distribution of primary cosmic rays. **4+2+1+ 3 = 10**

   b. Why the study of neutrino is important? What are the confirmed sources of neutrino? Discuss at least three methods of neutrino detection.

8. What are cosmic ray showers? Discuss the process of energy loss and theory of cosmic ray shower. **10**

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