

M.Sc. PHYSICS
THIRD SEMESTER
HIGH ENERGY PHYSICS-I
MSP - 304A
[USE ONLY FOR OBJECTIVE PART]

SET
A

Duration: 1:30 hrs.

Full Marks: 35

Time: 15 min.

(Objective)

Marks: 10

Choose the correct answer from the following:

$1 \times 10 = 10$

- The quark content of Σ^- baryon is
a. uus
b. dss
c. dds
d. uss
- Which one of the following interactions is not allowed? (Check for conservation of charge, baryon number and lepton number)
a. $\Sigma^- \rightarrow \Lambda + \pi^-$
b. $n + \bar{n} \rightarrow \pi^+ + \pi^- + n$
c. $\pi^- + p \rightarrow \Lambda + K^0$
d. $e^- + p \rightarrow \bar{\nu}_e + \pi^0$
- Which quantum number helps describe the flavor of a quark?
a. Spin
b. Strangeness
c. Charge
d. Isospin
- In asymptotic freedom, what happens to the strength of the strong nuclear force as particles approach each other at higher energies?
a. It weakens.
b. It remains constant.
c. It becomes stronger.
d. It becomes electromagnetic in nature.
- What is the role of color factors in calculating cross-sections and amplitudes in high-energy physics experiments involving QCD?
a. They determine the mass of quarks.
b. They provide information about the particle's charge.
c. They help calculate probabilities of particle interactions.
d. They are unrelated to calculations in QCD.
- Identify the appropriate gluon exchanged in the following interaction.



- $B\bar{G}$
- $\frac{1}{\sqrt{6}}(R\bar{R} + G\bar{G} - 2B\bar{B})$
- $G\bar{B}$
- $G\bar{G}$

7. What is the mathematical structure of the special unitary group $SU(2)$ in particle physics?
 - a. Orthogonal matrices
 - b. Unitary matrices
 - c. Symplectic matrices
 - d. Rotation matrices
8. What does the $SU(3)$ group represent in the context of particle physics?
 - a. Flavor symmetry
 - b. Spin orientation
 - c. Color charge
 - d. Electric charge
9. In quantum field theory (QFT), what is the vacuum state characterized by?
 - a. Absence of particles
 - b. Maximum energy
 - c. Continuous motion
 - d. Constant temperature
10. What does the Euler-Lagrange equation describe in the context of quantum field theory (QFT)?
 - a. Particle trajectories
 - b. Field dynamics
 - c. Energy conservation
 - d. Wave function collapse

(Descriptive)

Time : 1 hr. 15 mins.

Marks : 25

[Answer question no.1 & any two (2) from the rest]

1. Describe the eightfold way of the meson nonet and baryon decuplet by correctly placing the symbols of mesons and baryons in their respective positions. 5

2. a. Explain the color factor involved in the interaction between a quark and antiquark in quantum chromodynamics (QCD). How does it affect the formation of color-neutral mesons? 4+3+3
=10
b. Draw the lowest order Feynman diagram(s) representing the interaction involving a B-R quark.
c. Calculate the equivalent value of 1 kg when expressed in natural units.

3. a. Define the special unitary group SU(2) in the context of particle physics. Briefly explain its mathematical structure and significance in the study of elementary particles. 4+6=10
b. Check whether the following interactions are allowed or not? Justify your answer in terms of conservation of charge, baryon number and lepton number.
(a) $\Sigma^- \rightarrow \Lambda + \pi^-$
(b) $\pi^- + p \rightarrow \Lambda + K^0$
(c) $e^- + p \rightarrow \bar{\nu}_e + \pi^0$

4. Describe the role of SU(3) in the context of color charge and quantum chromodynamics (QCD). How does SU(3) symmetry help in understanding the behavior of quarks and gluons? 10

5. a. Provide a concise mathematical representation of the Euler-Lagrange equation and discuss its role in determining the field equations in Quantum Field Theory (QFT). 6+4=10
- b. Derive the Klein-Gordon equation for a real scalar field ϕ when the Lagrangian is defined by

$$\mathcal{L} = \frac{1}{2}(\partial_\mu\phi)(\partial^\mu\phi) - \frac{1}{2}m^2\phi^2.$$

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