



UNIVERSITY OF THE PUNJAB

Seventh Semester – 2019

Examination: B.S. 4 Years Program

Roll No. in Fig.

Roll No. in Words.

PAPER: Relativity and Cosmology
Course Code: PHY-404 Part-I (Compulsory)

MAX. TIME: 15 Min.
MAX. MARKS: 10

Signature of Supdt.:

Attempt this Paper on this Question Sheet only.

Please encircle the correct option. Division of marks is given in front of each question.

This Paper will be collected back after expiry of time limit mentioned above.

Q.1. Encircle the right answer, cutting and overwriting is not allowed. (1x10=10)

- i. Which of the following particles is subluminal?
(a) tachyon (b) elementary particles (c) Photons (d) Gravitons
- ii. Under which condition Lorentz transformation reduces to Galilean transformation?
(a) $v = c$ (b) $v = 0$ (c) $v \gg c$ (d) $v \ll c$
- iii. For $\Delta s^2 = c^2 \Delta t^2 - \Delta x^2$, the interval will be time like interval if:
(a) $\Delta s^2 = 0$ (b) $\Delta s^2 = 1$ (c) $\Delta s^2 > 0$ (d) $\Delta s^2 < 0$
- iv. If $F^\mu v_\mu$ is orthogonal then
(a) $F^\mu v_\mu = 1$ (b) $F^\mu v_\mu = -1$ (c) $F^\mu v_\mu = 0$ (d) $F^\mu v_\mu \neq 0$
- v. The red shift in the spectral lines of light reaching us from other galaxies implies that these galaxies
(a) are moving closer to one another (b) are moving farther apart from one another
(c) are in rapid rotation (d) consist predominantly of red giant stars
- vi. Gravitational red shift corresponds to
(a) Longer wavelength (b) Smaller frequency (c) Observer in weaker gravitational field
(d) All of the above
- vii. Theory which states that black hole is formed when sufficient compact mass can deform space time is known as
(a) theory of general relativity (b) theory of electromagnetic fields
(c) theory of gravitational fields (d) theory of particle radiation
- viii. Which one is true for the fourth component of current density
(a) $J_4 = ic\rho$ (b) $J_4 = ic/\rho$ (c) $J_4 = i\phi/c$ (d) $J_4 = ic\phi$
- ix. Simultaneity is
(a) dilated (b) absolute (c) invariant (d) relative
- x. Which one has zero divergence
(a) Four current density (b) Electromagnetic field tensor (c) Four vector potential
(d) All of these (e) None of these



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PAPER: Relativity and Cosmology
Course Code: PHY-404 Part – II

MAX. TIME: 2 Hrs. 45 Min.
MAX. MARKS: 50

ATTEMPT THIS (SUBJECTIVE) ON THE SEPARATE ANSWER SHEET PROVIDED

Q2. Write down short answers to the following questions.

2×10=20

- I. Show that the rapidities follow the Newtonian composition law of velocities.
- II. Discuss the four dimensional world view.
- III. Show that $\Gamma_{abc} + \Gamma_{bca} = \frac{\partial g_{ab}}{\partial x^c}$.
- IV. What is Nucleosynthesis?
- V. What is geodesic? Write its equation.
- VI. Show that the electromagnetic field tensor is an anti-symmetric tensor.
- VII. What is the difference between tensor and tensor field?
- VIII. Show that in general $\nabla_c g_{ab} = 0$, where g_{ab} is the metric tensor.
- IX. State principle of general covariance.
- X. The Minkowski line element in Minkowski coordinates

$$(x^a) = (x^0, x^1, x^2, x^3) = (t, x, y, z)$$

is given by

$$ds^2 = dt^2 - dx^2 - dy^2 - dz^2$$

- (i) What is the signature?
- (ii) Is the metric non-singular?
- (iii) Is the metric flat?

Q3. Give detail answers of the following questions.

- I. A stationary atom of proper mass m_0 is struck by a photon of frequency f and recoils. If the atom absorbs the photon, what are speed and mass of the recoiling particle? [9]
- II. Derive the relativistic velocity composition law using Lorentz transformation matrix. [6]
- III. Prove that the Christoffel symbol Γ_{bc}^a is not a tensor. [8]
- IV. What is critical density of universe. Show that the critical density is given by: [7]

$$\rho_c = \frac{3H^2}{8\pi G}$$