REV-01
MSP/10/15

2023/12

SET A

M.Sc. PHYSICS
THIRD SEMESTER
THEORY OF RELATIVITY-I
MSP - 304C

[USE OMR FOR OBJECTIVE PART]

Duration: 1:30 hrs. **Full Marks: 35**

(Objective)

Time: 15 mins. **Marks: 10**

Choose the correct answer from the following: ***1×10=10***

1. A particle of rest mass $3m_0$ moving with relativistic velocity 0.8c. Its moving mass will be
   a. $3m_0$ b. $4m_0$
   c. $5m_0$ d. $6m_0$

2. According to velocity addition theorem
   a. $u' = \frac{u-v}{1-uv/c^2}$ b. $u' = \frac{u-v}{1+uv/c^2}$
   c. $u' = \frac{u+v}{1-uv/c^2}$ d. $u' = \frac{u+v}{1+uv/c^2}$

3. Einstein's mass energy relation ($E = mc^2$) shows that
   a. Mass disappear to reappears as energy b. Mass and energy are two different forms of same entity
   c. Energy disappears to reappears as mass d. All of these

4. The relativistic velocity of a particle of proper-time τ in one inertial frame and time-interval t in another inertial frame moving along a particular direction is
   a. $v = c\sqrt{1-\left(\frac{\tau}{t}\right)^2}$ b. $v = c/\sqrt{1-\left(\frac{\tau}{t}\right)^2}$
   c. $v = c\sqrt{1+\left(\frac{\tau}{t}\right)^2}$ d. $v = c/\sqrt{1+\left(\frac{\tau}{t}\right)^2}$

5. The metric component $g^{\phi\phi}$ in the line-element $ds^2 = dr^2 + \alpha^2 r^2 d\varphi^2 + dz^2$ is
   a. $1/r^2$ b. $1/\alpha^2 r^2$
   c. [illegible] d. 1

6. The number of independent components of the curvature tensor in four-dimensions are
   a. 20 b. 18
   c. 19 d. 22

7. The covariant derivative of a second-rank tensor results a tensor of rank
   a. 2 b. 1
   c. 3 d. 0

8. The Kronecker delta δ^{μ}_{β} acts on the vector A^{β}_{ν} result a vector of

a. $-A^{\mu}_{\nu}$

b. A^{μ}_{ν}

c. $A^{\mu\beta}_{\nu}$

d. $-A^{\mu\beta}_{\nu}$

9. The determinant of the metric for the line-element $ds^2 = -c^2dt^2 + dr^2 + r^2d\phi^2 + dz^2$ is

a. c^2r^2

b. $-c^2r^2$

c. c^2/r^2

d. r^2/c^2

10. The divergence of a second-rank tensor results a tensor of rank

a. 2

b. 0

c. 1

d. 3

Descriptive

Time : 1 hr. 15 mins. Marks : 25

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

1. Show that divergence of the Einstein tensor G_{μ}^{ν} is identically vanishes. 5

2. a. Derive the relativistic kinetic energy expression 7+3=10
   b. $E_k = (m - m_0)\, c^2$ using the special theory of relativity.

   c. Show that $\Gamma^{\mu}_{\nu\mu} = \partial_{\nu}(\ln\sqrt{g})$

3. a. Find the momentum-energy transformation relations as measured by an observer relative to an inertial frame. 6+4=10
   b. Prove that the curvature tensor satisfies the relation $R^{\lambda}_{\mu\nu\sigma} + R^{\lambda}_{\nu\sigma\mu} + R^{\lambda}_{\sigma\mu\nu} = 0.$

4. a. Show that the quantity $c^2B^2 - E^2$ is invariant under Lorentz transformations. 7+3=10
   b. Prove the Bianchi identity: $R^{\lambda}_{\mu\nu\sigma;\rho} + R^{\lambda}_{\mu\sigma\rho;\nu} + R^{\lambda}_{\mu\rho\nu;\sigma} = 0$

5. a. Find all Christoffel symbols for the line-element $ds^2 = dr^2 + r^2\,(d\theta^2 + a^2\, sin^2\theta\, d\varphi^2)$. 6+4=10

   b. For the vectors A_{μ} and B_{ν}, show that $(A_{\mu}B_{\nu})_{;\alpha} = A_{\mu;\alpha}B_{\nu} + A_{\mu}B_{\nu;\alpha}$

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