REV-01
MSM/08/13

2023/06

SET A

M.Sc. MATHEMATICS
FOURTH SEMESTER
GENERAL THEORY OF RELATIVITY
MSM - 404A

[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. For the line element for object with spherical symmetry $ds^2 = -e^{\lambda(r,t)}dr^2 - r^2 d\theta^2 - r^2 \sin\theta d\phi^2 + e^{\nu(r,t)}c^2dt^2$,non vanishing christoffel's symbol $\Gamma^1_{11} = ?$

   a. $\frac{1}{2}\lambda$ b. $\frac{1}{2}\nu'$

   c. $-\frac{1}{2}\lambda'$ d. $\frac{1}{2}\lambda'$

2. Principle of Equivalence gives
   a. Accelerated mass b. Gravitational mass
   c. Accelerated field=Gravitational field d. Inertial mass

3. All laws of Physics must be expressed as covariant equations according to
   a. Principle of Equivalence b. Principle of covariance
   c. Principle of Special Relativity d. Principle of General Relativity

4. $\Gamma_{\alpha\beta\gamma} + \Gamma_{\beta\alpha\gamma} = ?$

   a. $g_{\alpha\beta}$ b. $g_{\beta\alpha,\gamma}$

   c. $g_{\alpha\beta,\gamma}$ d. $g_{\gamma\beta,\alpha}$

5. If Δt_A is the time measured by static clock A for the journey B and Δt_B the corresponding time measured by moving clock B, then which of the following is correct

   a. $\Delta t_A > \Delta t_B$ b. $\Delta t_B > \Delta t_A$

   c. $\Delta t_B \geq \Delta t_A$ d. $\Delta t_A \geq \Delta t_B$

6. Curved space is produced when velocity of the moving particle is
   a. zero b. Constant velocity
   c. Changing velocity d. None of the above

7. Which of the following expression is correct

a. $\partial A^{\mu} = -\Gamma^{\mu}{}_{\alpha\beta} A^{\alpha} dx^{\beta}$

b. $\partial A^{\mu} = -\Gamma^{\mu}{}_{\alpha\beta} A^{\mu} dx^{\beta}$

c. $\partial A^{\mu} = \Gamma^{\mu}{}_{\alpha\beta} A^{\alpha} dx^{\beta}$

d. $\partial A^{\mu} = -\Gamma^{\mu}{}_{\alpha\beta} A^{\alpha} dx^{\mu}$

8. $R^{\alpha}{}_{\mu\rho\sigma;\nu} + R^{\alpha}{}_{\mu\sigma\nu;\rho} + R^{\alpha}{}_{\mu\nu\rho;\sigma} = 0$ is known as

a. Contravariant Tensor

b. covariant tensor

c. Curvature tensor

d. Bianchi Identity

9. The Poisson's law is

a. $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = \pi G\rho$

b. $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = 4\pi G\rho$

c. $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = 4\pi\rho$

d. $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = 4\pi G$

10. According to Newton's law of Gravitation

a. $m_i a = G\frac{M_g m_g}{R^2}$

b. $m_i a = \frac{M_g m_g}{R^2}$

c. $m_i a = G\frac{M_g m_g}{R}$

d. $m_i = G\frac{M_g m_g}{R^2}$

11. Bianchi Identity is

a. $\left(R^{\alpha}{}_{\sigma} - \frac{1}{2} g^{\alpha}{}_{\sigma} R\right)_{;\alpha} = 0$

b. $\left(R^{\sigma}{}_{\alpha} - \frac{1}{2} g^{\alpha}{}_{\sigma} R\right)_{;\alpha}$

c. $\left(R^{\alpha}{}_{\sigma} - \frac{1}{2} g^{\alpha}{}_{\sigma} R\right) = 0$

d. $\left(R^{\alpha}{}_{\sigma} + \frac{1}{2} g^{\alpha}{}_{\sigma} R\right)_{;\alpha} = 0$

12. Cosmological Principle gives

a. At epoch t,the Universe is homogenous and Isotropic

b. At epoch t,the Universe is homogenous

c. At epoch t,the Universe is non-homogenous and Isotropic

d. At epoch t,the Universe is homogenous and non- Isotropic

13. $\frac{\dot{R}(t)}{R(t)}$ is known as

a. Tensor

b. Quotient law

c. Contraction

d. Hublle's law

14. Newtonian Gravitational potential is given by

a. $\psi = -\frac{GM}{r}$ b $\psi = -\frac{G}{r^2}$

c. $\psi = -\frac{GM}{r^2}$ d $\psi = \frac{GM}{r^2}$

15. From FRW metric we get open Universe for

a. $k > 1$ b. $k = 1$

c. $k < 1$ d. $k = -1$

16. The wavelength observed on the Earth λ' is longer than the wave length emitted from the Sun λ .This is known as

a. Gravitational waves b Clock paradox

c. Parallel displacement d Gravitational Redshift

17. Cosmology is the study of

a. Universe b. Dynamical evolution of Universe

c. Expansion of Universe d. Contraction of Universe

18. Equation of Geodesic in Flat Space time

a. $\frac{dv^{\mu}}{dx} = 0$ b $\frac{dv^{\mu}}{ds} = 0$

c. $\frac{dv}{ds} = 0$ d $\frac{dv^{\mu}}{ds^2} = 0$

19. $R_{\alpha\beta}$ is called

a Curvature tensor b. Contravariant tensor

c Ricci Tensor d. None of the above

20. A Geodesic is

a Space time b. Straight line

c Straight line in Space d. Curve

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(Descriptive)

Time : 2 hrs. 30 mins. **Marks : 50**

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

1. What are the four consideration for formulating Einstein's Field Equation. Find the Einstein's field equation **4+6=10**

2. What is flat space time. Prove that **2+8=10**

$$\frac{d^2x^\mu}{ds^2} + \Gamma^\mu_{\alpha\beta}\frac{dx^\alpha}{ds}\frac{dx^\beta}{ds} = 0$$

3. What are the condition of flat space time. Find the Bianchi Identity. **2+8=10**

4. What do you mean by weak gravitational field. Find the equation of motion of a test particle in weak gravitational field. **2+8=10**

5. **a.** Write Principle of General Relativity. **5+5=10**
   b. Prove that $a = g$ .i,e Inertial accelerated field=Gravitational field.

6. What are the three experimental test. Find the advance for Mercury ∂w. Write the difference of actual advance and observed advanced of Mercury. **3+6+1 =10**

7. Write the Definition of **2×5=10**
   a. Parallel displacement of vectors
   b. Intrinsic derivative
   c. Gravitational Wave
   d. Consequence of Birkhoff's Theorem
   e. Flat space time and Curved space time

8. Write the definition of FRW cosmology.Prove that **1+9=10**

$$ds^2 = c^2dt^2 - R^2(t)\left[\frac{dr^2}{1-kr^2} + r^2d\theta^2 + r^2\sin^2\theta d\phi^2\right]$$

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