MANIPAL ACADEMY of HIGHER EDUCATION (Institution of Eminence Deemed to be University)

Reg.No.										

DEPARTMENT OF SCIENCES, IV SEMESTER M.Sc. (Physics)
END SEMESTER MAKE-UP EXAMINATIONS, MAY 2023
General Relativity and Cosmology [PHY 6202]
(CHOICE BASED CREDIT SYSTEM - 2020)

Time: 3 Hours | Date: 31-05-2023 | MAX. MARKS: 50

Note (i) Answer ALL questions

(ii) Draw diagrams, and write equations wherever necessary

		Marks	CO	BL
1A	Prove that four velocity and four acceleration are orthogonal	3	1	3
1B	Show that the covariant derivative of a covariant tensor transforms as a tensor	3	1	3
1C	Obtain Einstein's field equation using weak field approximation	4	2	2
2A	Find the Christoffel symbols of the *first* and *second kind* for the following line element: $ds^2 = a^2(dx^1)^2 + a^2 sin^2 x^1 (dx^2)^2$ where *a* is a constant	4	1	3
2B	Derive Killing equation for isometry	3	2	2
2C	Derive the general relativistic equation for precession of planetary orbits	3	2	2
3A	Obtain the general relativistic equation for the delay in radar echoes from planets	4	2	2
3B	Describe static limit and ergosphere of Kerr black hole. Explain Penrose process	4	3	2
3C	Describe Hubble's law with necessary equations	2	3	2
4A	Obtain all non-vanishing Chirstoffel symbols of second kind for Schwarzschild metric outside a spherically symmetric, static gravitational field. Show all steps and substitutions.	4	2	3
4B	Using the Christoffel symbols obtained in previous question, obtain $\boldsymbol{R_{00}}$,$\boldsymbol{R_{11}}$ $\boldsymbol{R_{22}}$ and $\boldsymbol{R_{33}}$	4	2	3
4C	Obtain curvature scalar **R** using the components of Ricci tensor obtained in previous question	2	2	3
5A	Obtain the Tolman-Oppenheimer-Volkoff (TOV) equation	4	3	2
5B	Describe Einstein's model of the universe with necessary equations	3	3	2
5C	Describe how flat, open and closed models of the universe can be obtained from Robertson Walker Line element	3	3	2

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