Reg. No.										

MANIPAL ACADEMY OF HIGHER EDUCATION

DEPARTMENT OF SCIENCES

FOURTH SEMESTER MSc: END SEMESTER EXAMINATION (MAY 2022)

SUBJECT: GENERAL RELATIVITY AND COSMOLOGY (PHY 6202)

(CREDIT SYSTEM)

TIME: 3 HOURS MAX. MARKS: 50

Note: Missing data may be suitably assumed

$G = 6.67 \times 10^{-11}\ m^3/kg/s^2$ $M_\odot = 2 \times 10^{30}$ kg

$R_\odot = 7 \times 10^8$ m $c = 3 \times 10^8$ m/s

$1pc = 3.08 \times 10^{16}$ m

Curvature tensor: $R^{\kappa}{}_{\lambda\mu\nu} = \partial_\mu \Gamma^{\kappa}_{\lambda\nu} - \partial_\nu \Gamma^{\kappa}_{\lambda\mu} + \Gamma^{\kappa}_{\mu\alpha}\Gamma^{\alpha}_{\lambda\nu} - \Gamma^{\kappa}_{\nu\alpha}\Gamma^{\alpha}_{\lambda\mu}$

Covariant derivative of covariant vector: $A_{\mu;\alpha} = A_{\mu,\alpha} - \Gamma^{\beta}_{\mu\alpha} A_\beta$

1A Derive Lorentz transformation equation for space-time coordinates. 5M

1B An astronaut must journey to a distant planet, which is 200 light-years from Earth. What speed will be necessary if the astronaut wishes to age only 10 years during the round trip? 3M

1C Discuss parallel displacement of vector A^μ in curved space (covariant differentiation). 2M

2A Show that four-velocity and four-acceleration are orthogonal. 5M

2B A muon has a lifetime of 2×10^{-6} s in its rest frame. It is created 100 km above the earth and moves towards it at a speed of 2.97×10^8 m/s. At what altitude does it decay? According to the muon, how far did it travel in its brief life? 3M

2C Show that, in non-relativistic system, expression for kinetic energy reduces to $mv^2/2$. 2M

3A	Obtain Riemann tensor for a curved surface.	5M
3B	Obtain an expression for Einstein angle and mention its significance.	3M
3C	What is the significance of geodesic coordinate system?	2M
4A	Obtain Schwarzschild solution for Einstein's equation inside a spherically symmetric gravitating matter made up of perfect fluid.	5M
4B	Find the gravitational redshift for radiation emitted from the surface of the Sun and for radiation emitted from a white dwarf, whose radius is 1% that of the Sun.	3M
4C	Suppose we observe the image of a quasar to be shifted by 5 arc sec on the sky. What is the mass of the intervening galaxy? Assume that the light passes past the edge of the galaxy's disk, which has a radius of 50 kpc. Note: Express mass in solar mass units.	2M
5A	Obtain Einstein's field equation from weak gravitational field approximation.	5M
5B	Calculate $\frac{\partial}{\partial x_k}\left(a_{ij}x_i(x_j)^2\right)$ where $a_{ij} = a_{ji}$ are constants.	3M
5C	Calculate Schwarzschild radius for an object of 2 solar mass.	2M

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